Technical Directorate

Standards and Specifications Department

General Technical Specifications

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DIVISION 1: GENERAL PRELIMINARIES

1.1 General

The Conditions for Tender, the Conditions of Contract, the Drawings, and the Bill of Quantities shall be read in conjunction with the Technical Specifications and matters referred to, shown or described in any one are not necessarily repeated in the other(s). The Contractor shall comply with all the provisions contained within these Documents.

Notwithstanding the subdivision of the Specification into various headings, every part of it is to be deemed complementary to every other part and is to be read with it, so far as it may be practicable to do so, or when the context so implies.

In order to avoid needless repetition of such phrases as 'to the Engineer' and 'by the Engineer' or 'the Engineer's Representative' throughout the Specification, it shall be understood that when an order, instruction decision, exercise of judgement or other similar act is indicated, such order, instruction, decision, exercise of judgement or other similar act will be issued by, given to, made by or reserved to the Engineer or the Engineer's Representative. The Contractor shall include in his Tender for complying with the requirements of the Specification.

All materials submitted by the Contractor for the Engineer's approval should be certified from an approved laboratory accredited by PSI subjected to the Engineers approval.

1.2 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)

1. **Employer:** The party named in the Contract as the (FIRST PARTY) who will enter into the 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.
2. **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 in the Contract, and includes the Contractor's personal agents and his legal successors.
3. **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.
4. **Engineer:** The consulting office, or the 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 Employer in accordance with the conditions of the Contract, provided that the Contractor shall be accordingly notified in writing.

5. **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) 1. **Contract:** The documents constituting the Conditions, the Specifications, 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).

2. **Specifications:** The Technical Specifications of the works included in the Contract and any modifications thereof or addition thereto made or submitted by the Contractor and approved by the Engineer with the knowledge and approval of the Employer.

3. **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.

4. **Priced Bill of Quantities:** The priced and completed bill of quantities submitted by the Tender and forming part of the Tender.

5. **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 provision s of Contract, as accepted by Letter of Acceptance.

6. **Letter of Acceptance:** The formal acceptance by the Employer of the Tender.

(C) 1. **Commencement Date:** The date upon which the Contractor receives the notice to commence issued by the Engineer.

2. **Time of 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) 1. **Tests on Completion:** The tests specified in the Contract which are be made by the Contractor before the works or any section or part thereof are taken over by the Employer.

(E) 1. **Works:** The permanent works and the temporary works to be executed in accordance with the Contract, or either of them as appropriate.

2. **Permanent Works:** The permanent works to be executed (including plant) in accordance with the Contract.

3. **Temporary Works:** All temporary works or 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.

(F)

1. **Site:** Means the land and other places on, under, in or through which the works are to be executed, and any other lands and places provided by the Employer for working space or for any other purpose as may be specifically designated in the Contract. It shall also include any other place which may be agreed upon by the two parties during the execution of the works as forming part of the site.
2. **Contract Price:** Means the total sum named in the Award Decision or in the Contract, subject to such additions thereto or deductions therefrom as may be made under the provisions hereinafter contained.
3. **Constructional Plant or Equipment:** Means all appliances, tools, equipment and all other things required in or about the execution or maintenance of the works but does not include materials or other things forming part of the permanent work.
4. **Cost:** Means the expenses covering the costs of materials, labour, workmanship and goods, and any other expenses including overhead costs on and off the site, but not including profit.
5. **Approval:** Means approval in writing, including subsequent written approval or confirmation of previous verbal approval.
6. **Singular and Plural:** Words importing the singular only also include the plural and vice versa where the context requires.

1.3 Specifications

A. These General Technical Specifications should be read in conjunction with the Palestinian Product Standards which form a part of these Specifications.

B. The General Technical Specifications cover the materials and works of civil Engineering construction for water tanks.

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.

1.4 Works to be Executed

The works to be executed under the Specifications shall be as described in CONDITIONS FOR TENDER- DESCRIPTION OF THE WORKS.

1.5 Contract Drawings

The Contract Drawings 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.

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.

Contract Drawings should have the following drawings but not limited to:

- Architectural Plans and Elevations.
- Structural Plans and Sections.
- Structural Details.
- Mechanical Details.
- Lighting System Plans and Elevations.
- Electrical Details.

1.6 Abbreviations

A	Ampere
C	Concrete
CI	Cast Iron
DI	Ductile Iron
DIP	Ductile Iron Pipes
EGL	Energy Grade Line
GRC	Glass Reinforced Concrete
GRP	Glass Reinforced Polyester
GS	Galvanized Steel
GSP	Galvanized Steel Pipes
Hz	Hertz
ma	Millie Ampere
MCCBs	Moulded Case Circuit Breakers
O.D.	Outside Diameter
PCP	Pre-stressed Concrete Pipes
PE	Polyethylene
PP	Polypropylene
ppm	Part per million
PTFE	Poly Tetra Fluoro Ethylene
PVC	Polyvinyl Chloride
RC	Reinforced Concrete
SADIP	Saudi Arabian Ductile Iron
ST	Black Steel
UPVC	Unplasticized Polyvinyl Chloride
UV	Ultra Violet
V	Volt
W	Watt

1.7 Standards

In this Specifications, reference is made to Standards, Codes of Practice and Specifications issued by national, regional, or international bodies or organisations, hereinafter referred to by the following abbreviations:

- "PS" Palestinian Standards
- "PSI" Palestinian Standards Institution
- "ISO" The International Organization for Standardisation
- "IS" or "SI" Israeli Standards or Standard of Israel
- "JISM" Jordanian Standards

The below listed standards can only be used either if they are compatible with or better than the relevant Palestinian standard or when ISO, Israeli or Jordanian standards are not covering the product:

- 'AASHTO' American Association of State Highway and Transportation Official or 'AASHO'
- 'ACI' American Concrete Institute
- "AGMA" American Gear Manufacturers Association
- 'AISC' American Institute of Steel Constructions
- 'AISI' American Iron and Steel Institute
- 'ANSI' American National Standards Institute
- 'ANSI' American National Standards Institute
- 'API' American Petroleum Institute
- 'ASTM' American Society for Testing and Materials
- 'ASME' American Society of Mechanical Engineers
- 'AWS' American Welding Society
- 'AWWA' American Water Works Association
- 'BS' British Standards Institution
- 'DIN' Deutsches Institute fur Normalisierung
- 'FS' Federal Specifications
- 'IEC' International Electrotechnical Commission
- 'EN' European Standards
- 'IEEE' Institute of Electrical and Electronics Engineers
- 'NACE' National Association of Corrosion Engineers
- 'NEC' National Electrical Code
- 'NEMA' National Electrical Manufacturers Association
- 'SAE' Society of Automotive Engineers

- 'UL' Underwriters' Laboratories
- 'UTE' Union Technique de l'Electricite
- 'USBR' United States Bureau of Reclamation
- 'VDE' Verband Deutsches Elektrotechniker
- 'AS' Australian Standard

It is not identified which standard to be followed, however the actual standard to be followed should be mentioned in Tender Documents.

These references shall in every case be deemed to include the latest edition or issue of such standards and shall be submitted in their official English translations.

The reference to the above mentioned Specifications for the various materials to be furnished by the Contractor shall include in addition to the basic Specifications referred to all applicable amendments to the Specifications and all emergency alternative which have been promulgated and are in effect on the date Tenders are received.

Where more than one reference Specification is referred to for a material, the material may be furnished in accordance with any one of the referred Specifications at the Contractor's option and the written approval of the Engineer.

Where a specific standard is specified, a different but equivalent standard may be substituted if approved in writing by the Engineer.

The Contractor shall supply the Engineer with single copies of all standards referred to on the Drawings and/or in the Specifications and shall procure additional copies for his own use. All such copies shall be official printed versions published by the respective standards association (s).

1.8 Units of Measurement

All units of weight and measurements shall be based on the Metric System of Weights and Measurements except standard products which may be expressed in nominal units of the English system. It is the Contractor's responsibility to fit together different components of the works having different measurement standards. Unless otherwise stated, products are specified by their nominal sizes.

In this Contract the following units of measurements have the meanings hereby assigned to them:

- 'mm' millimeter
- 'cm' centimeter
- 'm' meter
- 'km' kilometer
- 'mm2' or 'sq mm' square millimeter
- 'cm^2' or 'sq cm' square centimeter

- 'm^2' or 'sq m' square meter
- 'ha' hectare or 10,000 square meter
- 'L' litter
- 'lin.m' linear meter
- 'm^3' or 'cu m' cubic meter
- 'g' gram
- 'kg' kilogram
- 'tonne' 1,000 kilograms
- 'L/s' litter per second
- 'm^3/s' cubic meter per second
- 'gpm' U.S. gallons per minute
- 'kg/cm^2' or 'kg/sq cm' kilogram per square centimeter
- 'psi' pounds per square inch
- '^{o}C' degrees Celsius
- '^{o}F' degrees Fahrenheit
- '%' percent
- 'o/oo' per thousand
- 'rpm' revolutions per minute
- 'MiIs' 1/1000 of an inch (25.4 X 10^{-3} mm)

1.9 Inconsistency in Contract Documents

The Contractor shall execute the works according to 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.

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.

1.10 Temporary Contractor's and Engineer's Offices

The Contractor shall provide offices for the use of his Agent and foremen on the site in an approved position, all communications delivered at the Contractor's temporary site office shall be deemed as having been delivered to the Contractor's formal registered address.

The Contractor shall also provide and maintain separate and proper offices for the Engineer and his representative on the site in an approved position.

The Engineer's office shall not be less than $32m^2$ floor area, shall have a minimum headroom of 2.4m and be divided into 2 rooms and shall have adequate car parking space.

The office shall have concrete floors and shall be water-tight, weather proof, properly ventilated, sanitary equipped, adequately lighted, painted and fitted with secure lockable doors and windows and shall be furnished with 2 tables (1.40 x 0.80 meters) 8 chairs, 2 cupboards.

The office shall be cleaned by the Contractor daily and the Contractor shall provide drinking water, heating and lighting if required, all at his own expense.

1.11 Temporary Water Electricity Supplies

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. Potable water according to *PS 41*. 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.

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.

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.

1.12 Contractor's Representatives

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.

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.

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.

1.13 Safety and Accommodation for Contractor's Staff

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.

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

The Contractor shall provide 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.

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.

1.14 First Aid Outfits

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

1.15 Precautions Against Contamination of the Works

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.

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.

Throughout the Contract; the site and all permanent and temporary works shall be kept in a clean, tidy and sanitary condition.

The Contractor shall at all times take measures to avoid contamination of existing water-courses and drains by petrol products or other harmful materials.

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.

1.16 Contractor's Yards and Stores

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.

1.17 Archaeological Site and Artefacts

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.

1.18 Notices of Commencement of Work Co-Operation with Authorities

Before commencing any excavation the Contractor shall:

In railway, public highways, footways or verges, give two weeks notice to the Engineer, 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.

In private lands or roads, give all necessary notices and make timely and reasonable arrangements with the occupiers before entry on the land.

Give notices to the concerned governorate, the municipality tele-communication corporation the electric company / authority, the police and military forces of work, Ministry of Public Work, and village councils 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.

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 the crossing of other services.
   - The reinstatement of excavated areas.

- The discharge of water from excavations.
- Public safety.

1.19 Access Roads

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

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.

1.20 Restrictions on Use of Roads

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.

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.

1.21 Site Along Pipelines in Roads

(i) General: 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.

The Contractor shall provide access to all properties including garages fronting on such roads.

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: Notwithstanding requirements stated elsewhere in the Specifications, the Contractor shall comply with the additional requirements contained in this clause whenever carrying out any work in connection with pipe laying in or adjacent to public roads.

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.

At no time shall the Contractor commence work in or adjacent to any public road without the prior approval of the Engineer.

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.

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.

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.

The Contractor shall at no time string pipes on the carriageway of any public road.

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.

1.22 Closing of Roads, Traffic Diversion and Control

(i) Closing of Roads: 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: 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: 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.

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 reflectorised 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.

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.

1.23 Site Cleanliness

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.

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.

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.

1.24 Operation of Existing Utilities

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.

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.

1.25 Location of Existing Subsurface Structures and Utilities

Before beginning excavation operations, the Contractor shall contact the specified departments and authorities and notify them of his intention to begin excavation operations.

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.

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 unintended broken or damaged, they shall be restored by the Contractor or the appropriate utility at the Contractor's expense.

The Contractor will be paid for all works necessary to complete exploration and relocation of subsurface and/or utilities by each linear meter of the measured pipeline.

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.

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.

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.

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.

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.

1.26 Signboards

The Contractor shall provide, erect and maintain signboards having messages written in both Arabic and English languages, as prescribed by the authority and installed at each site of work and at the office, or at such other places as directed by the Engineer, and remove the same on completion. The sign boards shall generally show the following:

- Name of Authority
- Name of Contractor
- Name of Work
- Date of Commencement
- Date of Completion

The minimum size of signboards shall be 1.0 X 1.5 meters, or as specified.

1.27 Lines and Grades

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 to 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.

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.

The Contractor shall be responsible for the stake-out survey, bench mark, elevations, … etc. 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.

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 date shown or required for accurately accomplishing the stake-out survey shall be referred to the Engineer who shall take whatever corrective measures be deemed necessary.

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.

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.

All labour, instruments, equipment, stakes and other material necessary to perform the work shall be provided by the Contractor.

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.

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.

1.28 Protection of Works

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.

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.

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.

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. 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.

1.29 Material Found on the Site

Sand, gravel, earth filling rock found on the site may be used free of charge in the works, subject to its meeting the Specifications being tested by the Contractor at his own expenses being approved by the Engineer, and providing that it is obtained from excavation necessary for the works. The Contractor will not be allowed to excavate elsewhere on site for the purpose of procuring materials.

1.30 Materials, Goods and Workmanship

(i) **General:** Materials, goods and workmanship shall be of the best quality of their respective kind. The Contractor shall carry out every thing necessary for the proper execution of the works, whether or not shown on the Drawings or described in Specifications.

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.

All equipment or materials shall be assembled, mixed, fixed, applied, installed or otherwise incorporated in the works in accordance with the printed instructions of the manufacturer of the equipment or materials and/or the relevant standards as specified. The installation, calibration, operation, and testing of all mechanical and electrical equipment shall be carried out under the supervision of one of the manufacturer's specialists in the field and approved in advance by the Engineer based on certification issued from approved laboratory accredited by PSI. The cost of the above test and calibration will be borne by the contractor.

The Contractor shall provide the Engineer with one soft and triplicate hard copies of all manufacturers instructions relevant to the operation and maintenance of the equipment incorporated in the works as well as of all guarantees issued by the manufacturer(s) and relevant thereto.

(ii) Customs and Local Dues: 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.

(iii) Specified Manufacturer's Products: 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.

Provided always the 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.

Any modification under such conditions shall not give the right to the Contractor to claim against any loss or extra cost incurred.

(iv) Alternative Materials: 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.

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 equivalent requirements of the originally specified material.

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.

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.

(v) Imported Materials: 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.

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.

1.31 Rejected Materials

Should any materials, equipment or manufactured articles prove to be, in the judgement of the Engineer or as a result of testing in accordance with related standards, unsound or of inferior quality or in any way unsuitable for the works in which it is proposed to employ them, such materials, equipment or manufactured articles shall not be used in the works but shall be branded, if in the opinion of the Engineer this is necessary, and shall forthwith be removed from the site and replaced within 24 hours at the Contractor's expense and in each case as the Engineer shall direct.

1.32 Responsibility of the Contractor

Where the approval of the Engineer is required under the Specifications such approval shall not relieve the Contractor of his duties or responsibilities under the Contract.

1.33 Orders to Assistants or Foremen

Whenever the Contractor's Project Manager or his Site Engineer (if so appointed) is not present on any part of the work when the Engineer or his representative may desire to give orders or directions, they shall be received by his assistant, foreman or person who may be in charge of the work. Such orders shall be fully complied with and shall be deemed to be given to the Contractor.

1.34 Right of Way

1.34.1 Extent

Unless otherwise shown on the Drawings, the Official Right of Way (OROW) of new roads should be according to the Ministry of Public Works recommendation or any other related authorities.

1.34.2 Expropriation

All negotiation and legal action required to expropriate property from owners, dwellers, lease holders or tenants for the execution of the works within the right of way shall be performed by the Employer who will also be responsible for settling all their claims. Cleaning of the right

of way shall not start until the Employer completes all expropriation procedures and the Contractor receives a written notice of the same.

1.35 Piping Works

Horizontal alignment of piping works is shown on the Layout Drawings. The pipeline profiles show the project level at bottom of trench, size and length of all pipes. The profiles also show the location and co-ordinates of points of intersection which determine the horizontal alignment of the pipelines. The hydraulic grade line is also shown on the profiles.

The Contractor shall prepare and submit to the Engineer's approval shop drawings for all pipelines. These drawings shall be in the form of a plan and profile and shall clearly indicate the location, co-ordinates and elevation of all points of intersection, the depth of trench, the pipe material, size, length and class as well as stationing, type and size of all fittings and valves.

Damages inflicted by the Contractor to the existing roads as a result of his operations/ activities shall be reinstated similar or better than the initial statement at his own cost.

1.36 Site Survey and Setting-Out of Works

Before commencing excavations the Contractor shall carry out a topographical and ground level survey (slopes, grade levels, borders, bench mark, elevations, …etc.) for the location of the water tank and alignment of all pipelines and other structures and shall set out the pipelines and structures according to data and/or the co-ordinates of the relevant points as provided by the Engineer.

Existing triangulation points and bench marks will be indicated to the Contractor and shall be used as datum for the works.

The survey made by the Contractor shall be produced in the form of drawings showing the alignment and profiles of all pipelines. These drawings shall be compared with the Tender Drawings and differences shall be brought to the attention of the Engineer. The Engineer shall then satisfy himself as to the differences and shall approve and sign the drawings with the profiles as approved by him. The approved profiles shall become, for the purpose of this Contract, the recorded survey which shall be used as the basis for measurement of the excavations and the preparation of shop Drawings.

The Contractor shall be responsible for preserving all base lines, P.I's, Theodolite stations and bench marks for the whole duration of the Contract.

Notwithstanding the Engineer's checking and approval of the site survey the Contractor remains solely responsible for the accuracy of his data.

The Contractor shall set out the works and secure the Engineer's approval before proceeding with the work. 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.

The Contractor shall order his materials, or revise any previously placed orders for materials, after he has completed his survey and drawings as above and has ascertained accurately the lengths of pipes etc. and the types and numbers of fittings.

1.37 Program and Methods of Working

(i) General: The Contractor shall submit to the Engineer full details of his proposed construction Programme 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 programme.

(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 two weeks 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. At the same time he shall provide a more detailed programme describing his proposal for the first month of work.

b. Every month, the Contractor shall submit to the Engineer and the concerned Authorities a detailed programme describing the areas in which he proposes to operate for the following two months period including descriptions of proposed road diversions.

c. The Contractor shall submit to the Engineer and concerned authorities a detailed programme describing the phases of the water tanks construction including excavation, formworks, reinforcement, concrete placement, curing, testing, and other related works for different parts of the water tanks.

(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.

1.38 Continuous Working

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.

1.39 Limits and Restrictions to Working Site

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.

1.40 Site Progress Meetings

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.

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.

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.

1.41 Construction Photographs

The Contractor shall provide 10 Colour Photographs in 4 copies per month made of the work during its progress. Each photograph will be 200mm x 250m (8in x 10in) size. The photographs shall be of such views and taken at such times as the Construction Manager directs. The Contractor will pay for all developing of the photographs taken by the Engineer's Representative. The Engineer's Representative will furnish all cameras.

All negatives shall be retained in a file by Contractor and turned over to Owner at the completion of the project.

Each Photograph shall have a label 60mm x 45mm (2-1/4in x 1-3/4in) on back containing typed lettering:

1. Contractor and Subcontractors name
2. Description of View
3. Photo date taken
4. Contract and Subcontract No. and name

No separate payment will be made to the Contractor for any photographic responsibilities. The costs of providing all photographs, film and developing of film, shall be included in the prices bid for the various items of work under this Contract. The Contractor shall also ensure that no unauthorized photography is allowed on the site.

1.42 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 or 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.

1.43 Other Construction Activities

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 organising 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.

1.44 Safety Adjoining Existing Buildings

The Contractor shall take all necessary precautions during the excavation for the works particularity 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.

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.

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.

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.

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.,

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.

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.

1.45 Tests for Water Tightness of Structures

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.

Water retaining structures shall be capable of withstanding the following tests for water tightness:

When ordered by the Engineer and before backfilling, the structures shall be filled with water by the Contractor at rates and to the depths ordered by the Engineer and kept filled for one week.

The water used need to be equal to normal drinking water but the source of the water shall be approved by the Engineer.

The structure when filled shall satisfy the test if at the end of one week no leakage is apparent.

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.

The tests referred to above, shall be performed at the Contractor’s expense and shall be considered incidental to the Contractor.

For testing water tank refer to Division 11 - WATER TIGHTNESS TEST FOR CONCRETE WATER TANKS.

1.46 Soil Investigation

Soil investigation should comply with the following standards*:*

Table 1.1
Soil Investigation Tests

No.	Property	Specification Name
1.	Moisture Content	ASTM D 2216-92, standard test method for "Laboratory Determination of Water (Moisture) Content of Soil, Rock and Soil Aggregates Mixtures"
2.	Atterberg Limits	ASTM D 4318-93, "Liquid Limit, Plastic Limit and Plasticity Index of Soils"
3.	Gradation	PS 399-1999, "Classification of Soils for Civil Engineering Purposes – Laboratory Classification – and Visual Specification".
4.	Gradation	PS 399-1999, "Classification of Soils for Civil Engineering Purposes – Laboratory Classification – and Visual Specification".
5.	Unconfined Comp Str.	ASTM D 2166-91, "Test for Unconfined Compressive Strength of Cohesive Soil".
6.	Classification	Soil Classification: Classification of all soil types encountered in the boreholes are to be carried out according to PS 399-1999, "Classification of Soils for Civil Engineering Purposes – Laboratory Classification – and Visual Specification".
7.	Sulphate Content	BS 1377: Part 3: 1990, Test 5, Determination of the Sulphate Content of Soil & Ground Water". Gravimetric method for acid extracts in which hydrochloric acid is used.
8.	Chloride Content	BS 1377: Part 3: 1990, Test 7.3, "Determination of Acid-Soluble Chloride Content". Nitric Acid is used.
9.	Bearing Capacity	ASTM D1586-67(1974) "Penetration Test and Split Barrel Sampling of soil
10.	Bearing Capacity	BS 1377: Part4:1990 " California Bearing Ratio"
11.	Compaction	BS 1377: Part 9: 1990 "Field D (Degree of Compaction)"

The Contractor should verify the results of the soil tests, if the results are different from the design results, the Contractor should carry out a new soil investigation, and revise the foundation design at his own expenses.

The Contractor shall carry out all the measures to execute the bearing capacity soil test to decide the final level of the foundations of the water tanks.

1.47 Inspection

1.47.1 Inspection of Site

Before starting any work on site, the Contractor has to provide the Engineer with two copies of a video type for the actual conditions of the site work including the water tank location, pipelines routing and any other parts of the project. The main concern of this video type is to ensure the actual condition of the site, obstacles, surface conditions, existing facilities and any other relevant issues, before starting any activity.

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. For additional inspection refer to *PS 399-1999.*

1.47.2 Inspection of Materials and Equipments

Materials and equipments furnished by the Contractor which will become a part of the permanent works shall be subject to inspection at any one or more of the following locations as determined by the Engineer at the place of production or manufacture, at the shipping point, or at the site. Inspection at the place of production, manufacture, or shipping point shall be carried out by a certified third party that will be nominated by the Employer. Cost thereof will be borne by the Contractor.

Within one week before submittal is turned to the Engineer for inspection, the Contractor shall submit to the Engineer, at the time of issuance, copies in triplicate of purchase orders, including Drawings and other pertinent information, covering materials and equipment on which inspection will be made as advised by the Engineer, or shall submit other evidence in the event such purchase orders are issued verbally or by letter. The inspection of materials and equipments or the waiving of the inspection thereof shall in no way relieve the Contractor of the responsibility for furnishing materials and equipments meeting the requirements of the Specifications.

1.47.3 Shop Inspection and Testing

All materials furnished by the Contractor shall be subjected, at the discretion of the Engineer, to the inspection and approval at the Manufacturer Plant.

1.47.4 Inspection of Adjacent Structures

Buildings and other structures in such close proximity to the water tank, 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.

1.47.5 Final Inspection of Works

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.

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.

1.47.6 Inspection During Maintenance Period

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 of all necessary equipment labour, etc., and for a responsible representative to be present at the times and dated 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.

1.48 Late Submission for Testing

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.

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.

1.49 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.

1.50 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.

1.51 Bill of Quantities and Bid Prices

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.

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.

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.

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 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.

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, make an assessment of 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.

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 labour, subsistence, travelling, 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.

1.52 Suppression of Noise and Pollution

The Contractor shall make every reasonable endeavour 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.

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.

1.53 Protective Equipment and Clothing

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

1.54 Cleaning Up

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.

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.

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.

1.55 Permits, Licenses and Fees

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.

1.56 Visitors on Site

The Contractor shall at all times give free and undisputed access and all facilities to any representative of the Employer or to any person authorised by the Employer or the Engineer wishing to view or inspect any part of the works or the materials to be incorporated therein. No unauthorised persons are to be allowed into any part of the site and the Contractor shall take steps to prevent this and instruct his watchmen and foremen accordingly.

DIVISION 2: EARTHWORK

2.1 Scope

The work covered by this Division comprises: site preparation, surveying, excavation, filling compacting and grading, construction of embankment, planking and strutting, gabions, stone and disposal of excess materials.

2.2 Site Preparation

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, foundations, fences, and manholes to be excavated.

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.

The Contractor shall obtain relevant excavation and road cutting permits as required prior to commencing work.

2.2.1 Clearing, Grubbing and Grading

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 300mm 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.

The ground surface under all embankments, as shown on the Drawings or where directed by the Engineer, and the surface of all excavation that is to be used for embankments shall be cleared of all concrete foundations, stumps, roots and vegetable matter of every kind. The stumps shall be pulled or otherwise removed and the roots grubbed and both shall be removed to an approved dump site.

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.

2.2.2 Demolition of Construction

All existing construction within the right of way shown on the Drawings to be demolished, shall be demolished and the site cleared by the Contractor. Construction existing on the right of way of the project and subject demolishing may comprise small houses, old concrete canals, concrete walls, concrete water tanks, chain link fences, drainage culverts and similar

small structures. The Contractor has to visit the site and make sure for himself of the extent of the work involved. No claims on such ground will be sustained.

No work shall start until the above clearing operation has been completed.

2.2.3 Measurement

Clearing and grubbing shall not be measured for direct payments, but shall be considered as subsidiary works the costs of which will be deemed to be included in the Contract prices for "unclassified excavation" except otherwise mentioned in Bill of Quantities.

Demolition of construction shall be paid for as a lump sum.

2.3 Setting-Out

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 routing, elevations, bench marks, 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.

If at any time during the progress of the works any error shall appear or arise in the position, levels, dimensions, elevations, bench marks, or alignment of any part of the works the Contractor, on being required in writing to do so by the Engineer or the Engineer's Representative, shall at his own expense rectify such error to the satisfaction of the Engineer or the Engineer's Representative. The checking of any setting-out or of any line, levels, elevations, bench marks …etc. by the Engineer's Representative shall not in any way relieve the Contractor of his responsibility for the correctness thereof and it shall not relieve him of the responsibility for the expenses for rectification or removal of faulty works.

2.4 Excavation

2.4.1 General

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.

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

The soil classes in every section of the pipeline will, if necessary, be determined by the Engineer on the basis of the following definitions:

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.

Excavation in sand shall include excavation in loose or dense sand, such as drifting sand(dunes).

Excavation in mixed soil shall include the removal of all material that cannot be classified as rock or sand as defined above(Heterogeneous Soil).

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.

2.4.2 Definition of Earth

Earth shall be defined as any naturally occurring or man made placed material that can be removed manually or by mechanical shovel, bulldozer or other mechanical equipment.

2.4.3 Definition of Rock

Rock shall be defined as any naturally occurring or man made or placed material that cannot be removed by the methods used for removal of earth as above defined, but requires the use of pneumatic tools, impact breakers or, if allowed, explosives for its removal.

2.4.4 Earthwork Support

The Contractor shall be responsible to uphold the sides of excavations in any materials with whatever method he elects to adopt subjected to the Engineer's approval. In the event of any collapse due to any cause the Contractor is to re-excavate and reinstate the excavation at his own expense.

2.4.5 Road Along the Line

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 pipe laying work. The Contractor shall also prepare access roads from the highway or other public roads to the said access road.

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.

The Employer's employees shall at times have the use of the roads prepared by the Contractor, free of charge.

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.

2.4.6 Excavation to Reduce Levels

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.

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.

Excavation for reduce level of the water tanks shall be done according to Drawings. The Contractor shall reduce the ground level according to levels shown in Drawings prior to commencement of excavation. Before starting excavation for reducing the level, the Contractor shall mark the levels in such a way that keeps the marks not be destroyed and will not interfere with the execution of the work.

2.4.7 Storing of Suitable Excavated Material

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 and base slab of the water tank.

2.4.8 Disposable of Unsuitable and Surplus Excavated Material

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.

2.4.9 Unauthorized Excavation

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.

2.4.10 Keeping Excavation Free from Water

The Contractor shall provide all necessary temporary drainage, pumping, power pumping, pipe work and any other measures required to keep the excavations free from water arising from rain, springs, irrigation or any other cause and shall maintain such drainage during the course of the work, shift and adapt as may be required and clear away and make good all disturbed surfaces at completion, all at the Contractor expenses.

2.4.11 Reconditioning of Loose Sub-Soil

The Contractor shall initially compact the loose sub-soil by light pneumatic type rollers or steel rollers prior to receiving concrete blinding or base material, as required by the Engineer. The cost of such work will be the Contractor responsibility.

2.4.12 Inspection

Excavated formations are to be inspected by the Engineer before new work is laid on them. The Engineer shall be given 24 hours written notice prior to the excavation being ready for inspection. If after inspection surfaces become unsuitable due to water or any other cause, the surfaces of excavations shall be made good by the Contractor at his own expense and as directed by the Engineer.

2.4.13 Measurement

Storage of suitable excavated materials and disposal of unsuitable and surplus excavated material shall not be measured for direct payments, but shall be considered as subsidiary works, the cost of which will be deemed to have been included in the Contract prices for ' unclassified excavation' at lump sum basis.

The cost of over excavation together with the cost of filling earth or and concrete shall be at the Contractor's expense.

2.5 Removal, Restoration and Maintenance of Surface

(i) Removal of Pavement: The Contractor shall remove pavement 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 200mm on each side of the trench. The widths and lengths of the area of pavement removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures shall not exceed the maximum linear dimensions of such structures by more than 300mm 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: 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 Excavation for Structures

Excavation for foundation of structures shall be to elevations shown on the Drawings or established by the Engineer, and to such width as will give suitable room for construction of the structures, for bracing and supporting, pumping and draining. The bottom of the excavation shall be rendered firm and dry and in all respects acceptable to the Engineer. Where compacted fill and/or blinding concrete under foundation is required, the depth of excavation shall be extended accordingly.

In common excavation the bottoms shall be levelled and trimmed to full width and neatly finished so as not to exceed by more than ±1cm the theoretical lines and levels and where under foundations and floors, shall be well watered and rammed before placing of concrete.

Excavation and dewatering shall be accomplished by methods which preserve the undistributed state of subgrade soils, subsequently the bottom layer of excavation of a minimum of 200mm in thickness shall be removed manually. Exposed subgrades shall be proof rolled with at least two coverages of the specified equipment. The Engineer shall waive this requirement if, in his opinion, the subgrade will be rendered unsuitable by such compaction. Subgrade soils which become soft, loose, quick, or otherwise unsatisfactory for support of structures as a result of inadequate excavation, dewatering, proof rolling, or other construction methods shall be removed and replaced by structural fill as required by the Engineer at the Contractor's expense.

In common excavation the last 15cm at the bottom shall be taken out not earlier than 48 hours before casting of concrete.

Where concrete is to be placed directly upon or against rock, the excavation shall be sufficient to provide for a minimum thickness of concrete at all points.

Over excavation shall be filled with concrete B150 to the required level at the Contractor own expenses.

During final excavation to subgrade level, take whatever precautions are required to prevent disturbance and remolding. Material which has become softened and mixed with water shall be removed. The Engineer will be the sole judge as to whether the work has been accomplished satisfactorily.

2.6.1 Excavation for Pipelines

(i) General: The minimum trench width at the bottom shall be equal to the external pipe diameter plus 500mm provided that the minimum clearance between the installed pipe and the trench side shall not be less than 250mm. The rest of the trench, unless

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

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.

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.

The graded material bedding under the pipe shall be not less than 150mm thick in any point and as shown on the Drawings and as directed by the Engineer.

The trench depth shall give the required minimum cover over the pipe as specified.

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.

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.
Separate excavations are to be made for manholes, pipe junctions, etc.

(ii) Types of Trench Excavation:

1. **Common and Sand Excavation:** 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:** 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:** 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: The use of mechanical equipment must be subjected to 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.

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 300mm 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: 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.

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: 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: 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 100mm thick of selected excavated material not containing stones larger than 30mm measured in any direction provided that the quantity of stones smaller than 30mm is not more than 20% by volume.

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.

2.6.2 Excavation for Concrete Valve Chambers

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.

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.

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.

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

Any over-excavation at the bottom of the structure shall be restored to the proper grade by filling the over-excavation 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.

2.6.3 Excavation for Concrete Blocks

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.

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.

2.6.4 Excavation for Borrow Pits

2.6.4.1 General

It shall be the responsibility of the Contractor to locate approved sources of borrow excavation material wherever needed which shall comply with the specified requirements of fill material and approved by the Engineer.

2.6.4.2 Measurement

Excavated material of whatever type shall be measured as 'unclassified excavation' which shall be deemed to include all materials encountered of any nature, including silts, clays, sand, gravel and granular materials and fractured, jointed and solid rock, and unsuitable material.

Structural excavation shall be measured by cu.m of material excavated for structures, hauled away and disposed of as directed, or stockpiled on or in the vicinity of the work, and the excavated areas backfilled completed and accepted.

Structural backfilling shall not be measured for direct payments, but shall be considered as subsidiary works the cost of which will be deemed to be included in the
Contract prices for 'structural excavation'.

No measurement shall be made of any borrow pits or any excavation from borrow pits.

2.7 Filling and Backfilling

2.7.1 Backfilling Around Structure

(i) General: Surfaces to receive backfill shall be cleared of debris and unsatisfactory materials prior to the placement of the backfill material.

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”.

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: 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 300mm 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.

Backfill or fill materials shall not be placed on surfaces that contain excessive moister, preventing specified degree of compaction.

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.

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: Structural fill shall be placed in layers having a maximum thickness of 200mm in open areas and 150mm 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 specified in these Specifications and approved by the Engineer. The limits of structural fill adjacent to structures shall extend as shown on the Drawings.

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.

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

2.7.2 Backfilling of Trenches

(i) General: 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.

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.

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.

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.

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.

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:

Soft Backfill (surrounding the pipe) shall consist of sand from any approved source or fine aggregates. This material shall be placed 150mm below the invert level up to 200mm over the crown of the pipe and for the full width of the trench, or to the depths specified in the Bill of Quantities.

Final Backfill for the remainder of the trench shall be by using well graded approved backfill material. (as specified in clause 2.8.3 (i, ii)).

The trench shall be filled to the level of the natural adjacent ground level in layers not exceeding 300mm, 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.

Other layer of the same material shall be mounded 150mm 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 :

Soft Backfill shall be done as specified before.

Final Backfill for the remainder of the trench shall be by using well graded approved backfill material. (as specified in clause 2.8.3 (i, ii)).

The selected backfill shall be up evenly on all sides, in layers not exceeding 250mm 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 10kg. The materials in this case being spread and compacted in layers not more than 150mm in thickness. If necessary, sprinkling shall be employed in conjunction with ramming.

The top 250mm sub-base for pavement replacement, shall consist of one layer of approved basecourse material, wetted and compacted to 95 percent of maximum dry density.

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 150m, 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: On trenches with slopes exceeding 15 percent, a 300mm wide, stone partitions shall be built across the trench every 10 meters length.

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 200mm from each side inside the ground.

The second backfill stage of the trench between the stone partitions shall be done as specified above.

(v) Restoring Trench Surface: 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.

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.

Where the pipes are laid in cross-country areas, and where the danger of erosion exists, the uppermost 300mm part of the trench may be backfilled with common backfill material containing fragments of ledge and boulders smaller than 150mm 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.

All road surfaces shall be broomed and hose-cleaned immediately after backfilling. Dust control measures shall be employed at all times.

2.7.3 Material Used in Backfill

(i) General: 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.

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.

Backfill and fill material shall have a maximum of one percent expansion when testing is performed on a sample remoulded to 95 percent of maximum dry density (as per ASTM D698) at a two percent below optimum moisture content under a 490kg/m^2 surcharge. Backfill material shall be placed as specified in clause 2.8.1.

(ii) Common Backfill Material: Common Backfill or fill material shall not contain granite blocks, broken concrete, masonry rubble, asphalt pavement, or any material larger than 150mm in any dimension provided that this material is not more than 25 percent of the backfill or fill material.

Common Fill shall have physical properties, as approved by the Engineer, such that it can be readily spread and compacted as specified in clause 2.8.1 (ii).

(iii) Selected Backfill Material: Selected backfill and fill material shall conform to the requirements of common backfill except that the material shall not contain any materials larger than 50mm in its largest dimension provided that this material is not more than 20 percent of the Backfill or fill material.

(iv) Structural Fill: Structural fill shall be gravel, sandy gravel, or gravely 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
Structural Fill Sieve Analysis

Sieve Size	Percent Finer by Weight
150mm	100
No. 4	20 - 70
No. 40	5 - 35
No. 200	0 - 7

Structural fill shall be placed as specified in clause 2.8.1(iii).

(v) **Crushed Stones:** 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 50mm and in a minimum of 12mm measured in any direction.

2.7.4 Measurement

All embankment of whatever type shall be measured as 'unclassified' which shall be deemed to include all materials of any nature including silts, clays ,sand, gravel and granular materials and fractured , jointed and solid rock. Embankment construction shall be measured by cu.m of approved unclassified material placed, spread watered as necessary, compacted and finished, and accepted.

No adjustments or allowances of any kind shall be made in respect of expansion or shrinkage (bulking) of earth volumes which may occur during excavation and compaction works.

Trench backfilling should be measured in linear meter or as indicated in Bill of Quantities. Backfilling around structure (water tanks) should be considered as part of the reinstatement works or as indicated in the Bill of Quantities.

2.8 Granular Material

2.8.1 Scope of Work

Furnish all labor, materials, equipment and incidentals necessary to obtain materials for filling and backfilling, grading and miscellaneous site work, for the uses shown on the Drawings and as specified herein.

2.8.2 Materials

Refer to item 2.8.3 (i).

Structural fill shall be gravel, sandy gravel, or gravely sand. Materials shall have a plasticity index of less than 15 and shall conform to the values in Table 2.1.

Selected fill shall conform to the requirements of common fill except that the material shall not contain any materials larger than 50mm (2 in) in largest dimension, provided that this material will not be more than 20% of the backfill or fill material.

Common fill shall not contain granite blocks, broken concrete, masonry rubble, asphalt pavement, or any materials larger than 150mm (6 in) in any dimension, provided that this material will not be more than 25% of the backfill or fill material. Common fill shall have physical properties, as approved by the Engineer, such that it can be readily spread and compacted.

Crushed stone shall be sound, durable stone, angular in shape, and free of any foreign material, structural defects and chemical decay. Crushed stone shall be maximum size of 50mm (2 in) and a minimum size of 12mm (1/2 in).

Peastone shall be screened, uniformly rounded stone, free from sand, loam, clay, excess fines and other deleterious materials. Peastone shall conform to the following gradation limits:

Sieve Size	Percent Finer by Weight
13mm (1/2 in)	100
9mm (3/8 in)	90
No. 4	30
No. 8	10
No. 16	5

Screened gravel shall be hard, durable, rounded, or subangular particles of proper size and gradation, and shall be free from sand, loam, clay, excess fines, and other deleterious materials. Screened gravel shall be graded within the following limits.

Sieve Size	Percent Finer by Weight
16mm (5/8 in)	100
13mm (1/2 in)	40-100
9mm (3/8 in)	15-45
No. 10	0-5

Granular base and shoulder material shall be sound, naturally occurring material, or angular crushed stone free from organic and unsuitable or deleterious substances and can be readily compacted under watering and rolling to form a stable base.

Granular base shall conform to the following graduation limits:

Sieve Size	Percent Finer by Weight
38mm (1-1/2 in)	100
25mm (1 in)	60-100
19mm (3/4 in)	55-85
No. 4	35-60
No. 10	25-50
No. 40	15-30
No. 200	8-15

Other requirements are as follows:

- Liquid Limit: 25 (max)
- Plasticity Index: 6 (max)
- Resistance to Abrasion ASTM C131: 50 (max)
- CBR: 50 (min)

Sand for concrete, grout, and masonry shall conform to *PS 48* for fine aggregate. For general purpose sand, use the Select Common Fill table.

Lean concrete shall be ready-mix, cast-in-place concrete conforming to the requirements of Division 3. Minimum compressive strength shall be 150kg/cm^2 after 28 days.

Bedding material shall be clean crushed rock to the following grading free from organic and other deleterious matter:

Sieve Size	Percent Finer by Weight
½ in	100
3/8 in	60-90
No. 4	15-45
No. 8	0-5

2.9 Stone Pitching in Concrete

2.9.1 General

Stone pitching shall consist of broken stones, placed as indicated on the Drawings or in locations as directed by the Engineer.

Stone pitching shall be constructed to the shape and dimensions shown on the Drawings in accordance with the provisions of the Specification or as directed by the Engineer.

Stone pitching shall be classified as stone pitching in concrete and shall have a thickness of 200mm, unless otherwise indicated on the Drawings.

2.9.2 Materials

(1) Rock: The stones for this work shall be durable, angular field or quarry stones of approved quality, sound, hard, free from seam and other structural defects and shall have a specific gravity of not less than 2.40. At least 60% of the stone pitching shall consist of pieces having a weight of not less than 15kg and of the remaining 40% no piece shall have a weight of less than 7kg. The thickness of each layer shall be achieved by the thickness of one rock piece. The thickness of the rock piece shall be within 50mm from the specified layer thickness, measured at the thinnest section of the rock piece.

(2) Concrete: Concrete used for filling the rock interstices shall be of class B150 as specified in DIVISION 3 - CONCRETE AND REINFORCED CONCRETE.

2.9.3 Placing

Ground surface to be protected by stone pitching shall be thoroughly compacted to the approval of the Engineer and covered with blinding concrete according to Tender Drawings prior to placing of the rock.

Rock shall be placed starting with the lowest point of slopes.

Approval of the Engineer is required for rock laying prior to pouring concrete. The rock shall then be flushed with water to provide adequate bonding with concrete. Concrete pouring shall start with the lowest point of the area to be protected. Where more than one layer of stone pitching is specified, or in keys, a layer of 50mm of concrete class B150 shall be placed below the first layer and between consecutive layers.

The finished surface of the concrete shall be flush with the top of the surrounding stone pieces.

2.9.4 Measurement

Stone pitching in concrete shall be measured by sq.m. furnished, constructed, completed and accepted.

2.10 Gabions

Gabions shall consist of furnishing and placing wire mesh mattresses rectangular in shape and filled with clean and uniform rocks larger than the mesh openings in accordance with the Drawings and the Specifications. Gabions shall be used where required and/or as directed by the Engineer.

2.10.1 Material

Wire mesh shall consist of hot dip galvanised steel in double twist woven hexagonal shape, fabricated in accordance with Specifications.

The wire mesh shall be in compliance with the following standards:

American Society for Testing and Materials (ASTM)

ASTM A 90 Zinc	(2001) Weight of Coating on coated (Galvanized) Iron or Articles.
ASTM A 239	(1999) Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Articles by the Preece Test (Copper Sulfate Dip).
ASTM A 641	(1998) Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A 764	(2001) steel Wire, Carbon Drawn Galvanized and Galvanized at Size for Mechanical Springs.
ASTM B 6	(2000) Zinc
ASTM B 117	Salt Spray (Fog) Testing-2002

Federal Specifications

FS QQ-W.461	(Rev H) Wire, Steel, Carbon, Round, Bare and Coated

The wire mesh for the mattresses shall have the following dimensions:

Wire Diameter (mm)	**Mesh Size** (mm)
2.2	60 x 80

The binding wire and the wire used for special selvedges shall consist of hot dip galvanised steel as recommended by the manufacturer, and galvanised. The diameter of wires used for binding and selvedges shall be approximately 30% greater than that used in the wire mesh fabric.

The rocks shall consist of clean solid rock nonfriable and resistant to weathering and frost action larger in size than the larger mesh dimension. The rocks in the middle of the unit shall have a minimum size equal to the smaller mesh dimension.

2.10.2 Construction

Excavation required for the placement of gabions shall be made in accordance with the dimensions shown on the Drawings or as directed by the Engineer. Gabions shall be constructed in units to the dimensions indicated on the Drawings.

The mesh is to be opened-up on the site and to be laid flat on the ground. All unnecessary creases shall be straightened. The sides, ends and diaphragms are then lifted into a vertical position, and laced together with binding wire to form the mattress. The binding should be carried out in continuous lacing operation, the wire being passed through each mesh and around both selvedges must be tied together, with two round turns after every second mesh.

When laying the mattresses and/or the boxes each length should be wired securely to the adjoining length, so that the final product is continuous, unjointed blanket.

The rocks inside the mattress on the side facing the water should be laid one next to the other in a form of building a wall. The total volume of voids in each box should not exceed 35% (thirty five percent).

The gabion boxes shall be slightly over-filled to allow for subsequent settlement. Then the lid is to be laced down with binding wire to the tops of the sides and to the tops of the diaphragm panels.

2.10.3 Measurement

Gabions shall be measured by cu.m furnished, installed, completed and accepted.

2.11 Temporary Soil Erosion Control

2.11.1 Scope

These works shall consist of temporary control measures, as shown on the Drawings or required by the Engineer during progress of the works, to control soil erosion and water pollution by use of dams and other erosion control devices or methods.

The temporary erosion control provisions shall be co-ordinated with permanent erosion control features to assure economical, effective and continuous erosion control throughout the period of the works.

2.11.2 Construction

A schedule of proposed temporary (and permanent) soil erosion control works shall be developed by the Contractor at the commencement of the contract, in consultation with the Engineer and to his satisfaction.

The Contractor shall carry out (and maintain) temporary erosion control to prevent soil erosion that will adversely affect construction operations, damage adjacent properties, or cause contamination of adjacent streams or other watercourses, ponds or other areas of water impoundment. Such works may involve construction of temporary dams, devices or methods as necessary to control erosion.

The Contractor shall incorporate all permanent erosion control features as shown on the drawings into the works at the earliest practicable time as outlined in his schedule, to minimise the need for temporary erosion control measures.

2.11.3 Measurement

The works prescribed in this Section 2.12, shall not be measured for direct payment, but shall be considered as subsidiary works the costs of which will be deemed to be included in the Contract for pay items.

2.12 Quality Assurance

2.12.1 Laboratory Testing

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 22kg to an approved soils testing laboratory accredited by PSI to perform:

1. Grain size analysis of the samples to determine their suitability for use as backfill or fill material in accordance to the material requirements specified in Section 2.8.3
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

Unless otherwise shown on the Drawings or mentioned in the Bill of Quantities, the Contractor shall restore all pavements, sidewalks, 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.

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

- 200mm (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 2kg of prime coat (MCO) per each square meter over the compacted base course, and applying a layer of asphalt mix of size ¾″, in a thickness not less than 50mm, after compaction which should satisfy the Specification of Palestinian Ministry of Public Works.

2.14 Road Crossing

Where water pipeline is crossing main roads, highways, or railways, the pipeline shall be installed inside a protective steel sleeve.

Skids must be used to prevent damage to the pipe coating and to provide proper long-term line support.

The water pipeline should not rest on the sleeve, skids should properly position the pipeline in the sleeve.

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.

Table 2.2 specifies sleeve size requirements for wall thickness and maximum skid support spacing for water pipes of various diameters.

Table 2.2
Sleeve Sizes

Normal Pipe Size Outside Diameter (in)	Sleeve		Maximum Skid Support Spacing (m)
	Outside Diameter (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

Upon completion of pipe insertion, cast in place concrete B-150 shall be used to restore the ground level to 50mm less than the previous asphalt level grade.

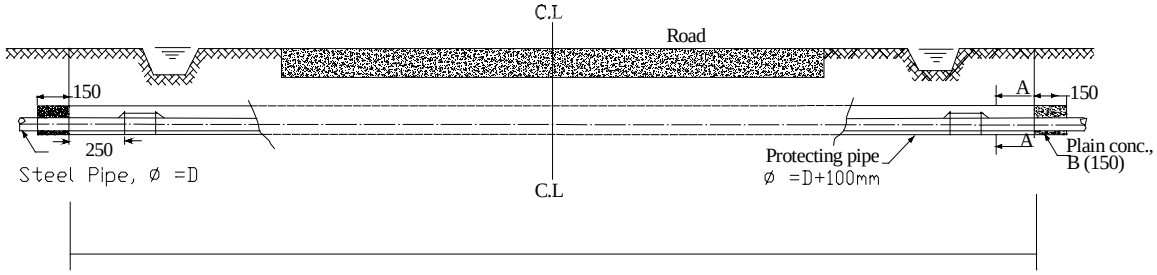
After the concrete surface is dry, the asphalt is reinstated by spraying 0.5kg of tack coat per each square meter prior to laying a 50mm asphalt mix that satisfies the Specifications of the Palestinian Ministry of Public Works over the concrete surface.

The ends of the sleeve shall be protected by casting concrete blocks B-150 for its full diameter and 150mm thickness.

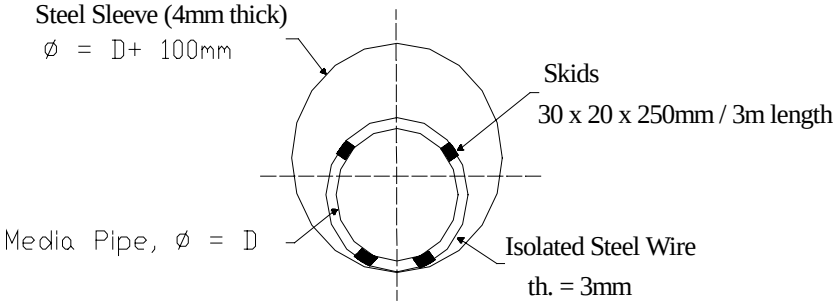
Insulating Casing Spacers:

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 premolded, insulating plastic skids. Modular casing spacers shall be as manufactured by Cascade, PSI, or equivalent.

Figure 2.1
Cross Section in Road



Cross Section In Road



Section A-A

DIVISION 3: CONCRETE AND REINFORCED CONCRETE

3.1 General

This section consists of furnishing all plant, equipment, appliances and materials and in performing all operations necessary casting of concrete and reinforced concrete in accordance with the Specifications, Drawings and Engineer's instructions and subject to the terms of the Conditions of Contract.

Unless approved by the Engineer to mix the concrete on site for small quantities, all types of concrete will abide with the requirements of Palestinian Standards PS 40 and will be furnished to the site as ready mixed concrete supplied from a certified ready mixed plant by PSI. Contractor must obtain Engineer's approval of the concrete plant prior to the delivery of concrete from same.

All concrete works except for foundations shall be executed as exposed fair faced concrete and will abide with all requirements for same.

All concrete casting will fully abide with "good" control conditions requirements and approved by the Engineer

3.2 Materials

3.2.1 Cement

The cement shall be ordinary Portland cement complying with the requirements of *PS 54*, unless sulfate-resisting cement (sea water cement) shall meet requirements similar to those of ASTM Specifications C150, latest edition, for type V is specified. Cement shall be fresh and suitable for use as approved by the Engineer.

The suppliers shall furnish a certificate with every consignment of cement, giving the results off all tests called for by the appropriate Standard. The Engineer may, however, require further tests to be made after the cement is delivered to the site and Contractor shall provide the cement for such tests, and bear the costs of tests.

3.2.2 Aggregates

A. Fine Aggregate and Sand: Sand for concrete, mortar and grout shall be furnished by the Contractor from any approved source and shall be natural sand or a mixture of natural sand and fine crushed stone. The sand shall meet the requirements of Palestine Standards PS 48-1997, with the additional requirement that the specific gravity of the sand shall not be less than 2.50.

Unless otherwise specified the sand shall be graded as shown in Table 3.1 below:

Table 3.1
Fine Aggregate and Sand Grading

Sieve Size mm	Percentage Passing by Weight
4.75	100
2.36	80-100
1.18	30-75
0.60	25-60
0.30	10-30
0.15	0-10

B. Coarse Aggregate: Coarse Aggregate for concrete shall be furnished by the Contractor from an approved source and shall consist of hard dense durable uncoated rock fragments and shall meet the requirements of Palestine Standards No. PS 48-1997, with the following limitations.

The Los Angeles Abrasion test should not exceed 32% according to PS 48 for grade B and 28% for grade A. Water absorption should not be more than 2.5 % more than the absorption of Bazelt aggregate retained a 9.5mm sieve i.e. the total absorption should not exceed 3.5 % and the specific gravity shall not be less than 2.50. The grading of coarse aggregate shall be as shown in Table 3.2 below:

Table 3.2
Coarse Aggregate Grading

Nominal Sizes 19.0mm	
Sieve Size mm	**Percentage Passing by Weight**
25.0	100
19.0	85-100
14.0	0-20
9.5	0-5
Nominal Size 25.0mm	
Sieve Size mm	**Percentage Passing by Weight**
37.5	100
25.0	85-100
19.0	0-20
14.0	0-5

The size of coarse aggregate used in any part of work shall be such that it does not contain any particles larger than 1/3 of the thickness of the thinnest concrete member or ¾ of the smallest distance between reinforcement bars whichever is smaller

C. Combined Aggregate: The grading of combined aggregate shall be approximately as shown in Table 3.3 below:

Table 3.3
Combined Aggregate Grading

Sieve Size mm	Percentage Passing by Weight		
	Grading No. 1	Grading No. 2	Grading No. 3
63	95-100	--	--
50	80-100	100	--
37.5	65-85	90-100	100
25	50-75	50-85	90-100
19	45-65	45-75	70-100
9.5	38-55	38-55	50-75
4.75	30-45	30-45	35-60
2.36	23-35	23-35	27-15
1.18	17-27	17-27	20-35
0.3	4-9	4-9	5-15
0.15	1-7	1-7	1-5
0.075	0-5	0-5	0-5

The Contractor shall carry out the sampling and testing of aggregates at frequent intervals as specified in *PS 687* and as required by the Engineer. The Engineer's Representative will carry out on site the following tests in accordance with *PS 687*:

- Sieve analysis.
- Clay, silt and fine dust.
- Specific gravity.
- Water absorption.
- Bulk density, voids and bulking.
- Moisture content.
- Organic impurities.
- Aggregate impact value.
- Aggregate crushing value.
- Ten percent fines value.
- Crushing strength.
- Aggregate abrasion value.
- Chemical properties (soluble salt content).

The Contractor shall provide the necessary apparatus required for carrying out the tests together with all necessary labour and materials used in conducting the tests.

The Contractor shall be deemed to have included in his rates for carrying out these test.

All aggregates supplied shall be subject to the approval of the Engineer, but certificates as to compliance with the relevant Palestinian Standard shall be provided by the Contractor before deliveries to site. Sample loads of each grade of aggregate shall be delivered to the Site in

sufficient time in advance of the commencement of concreting to allow for examination and testing and the preparation and testing of the concrete trial mixes.

Sample quantities of each grade of aggregate thus provided will be retained for comparison with subsequent deliveries. Any rejected sample or subsequent delivery of non-standard material shall be removed from the site forthwith at the expense of the Contractor.

Aggregates delivered to the site during the course of the construction shall conform to the sample loads.

3.2.3 Water

Water used in concrete either for mixing or curing shall be fresh potable water derived from an approved source of supply and shall be free from silt, oil, organic matter, acid, alkali-slare and other deteriouse substances. The temperature of the water shall not be less than 10° C. The water shall meet the requirement of Palestinian Standards No. PS 41-1997.

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

Mortar prepared with water submitted by the Contractor for approval, shall show no marked change in time of set, no indication on unsoundness and a reduction of not more than ten percent in mortar strength when compared with mortar made with distilled water.

3.2.4 Reinforcement

The steel bars to be used are of plain steel complying with *PS 50* and deformed ribbed steel bars complying with *PS 52*. Before bending the steel is to be straightened to the Engineer's satisfaction and cleaned of all rust loose mill scale, oil or any other dirt.

Spacers shall be made of precast concrete cubes which shall match the concrete into which they are cast in every way (strength proportion, colour).

Jointing of reinforcement bars shall be done with overlap not less than 40 times the larger diameter of the bar and shall be staggered.

All deliveries of steel reinforcement shall be accompanied by the manufacturer's certificate giving the results of tests carried out in accordance with the requirements of the relevant Palestinian Standard and the Contractor shall submit samples of steel from each delivery to an approved authority for testing, the cost of these being deemed to be included in the rates. Records of test results are to include all tests and information required in the corresponding PS Specification *PS 50, and PS 52*.

3.2.5 Epoxy Coated Reinforcing Steel

Plastic coated or epoxy coated bar supports and tie wires shall be employed to protect the coating from physical damage during placement and to prevent electrical coupling between mats.

Bars shall be carefully handled and installed so that patching at the job site will be kept to a minimum.

Where repair is required, the damage areas shall be cleaned, repaired and adequate cure time allowed before placing concrete. The installation shall be considered approved when patching has been done as outlined above.

Payment shall be included in Contract Tender Documents.

3.2.6 Tying Wire

Tying wire shall be either:

- No. 16 gauge soft annealed iron wire, or
- No. 18 gauge stainless steel wire.

3.2.7 Additives

Where required or approved by the Engineer, the Contractor shall use additives such as plasticisers or retarders in the concrete. Proportioning and mixing of additives thereof to be used in the concrete shall be in accordance with manufacturer's recommendations and subject to the Engineer's approval. Additives shall be added to the batch in solution in a proportion of the mixing water according to the manufacturer instructions. This solution shall be batched in such a manner as will ensure uniform distribution of the additive throughout the batch during the specified mixing period.

Additives shall be suitable for use in contact with potable water after 30 days of concrete curing.

All additives shall satisfy the requirements of *PS 125* accompanied with a certificate of compliance from approved laboratory.

The additives used shall be furnished by the Contractor, and the cost of the materials and all costs incidental to their use shall be included in the unit prices bid in the Bill of Quantities for concrete in which the materials are used.

If approved, to be used strictly in accordance with the manufacturer's instructions.

A. Water Reducing Admixtures: To be used in the production of all reinforced concrete unless otherwise specified and shall conform to *PS 125*.

B. Retarding/Water Reducing Admixtures: May be used in large volumes of concrete subject to approval or at the request of the Engineer and shall conform to *PS 125* with low sensitivity to warm weather.

C. Retarding Admixtures: May be used in large volumes of concrete subject to approval or at the request of the Engineer and shall conform to *PS 125*, solution based on organic hydroxyl or phosphate salts.

3.2.8 Total Chloride Content

In concrete mix arising from aggregates, admixtures and other sources is not to exceed the following percentage of chloride to cement by weight.

Concrete containing embedded metal and made with ordinary Portland cement	0.35% for 95% of test results with results no greater than 0.5%
Concrete made with sulphate resisting cement	0.2%

3.2.9 Total Sulphate Content

According to ACI 201.2R-92, concrete mix arising from constituents and other sources is not to exceed the lesser of 0.4% by weight of aggregates or 4.0% by weight of cement in the mix.

3.2.10 Storage of Materials

(i) Cement: The Contractor shall provide a container or building for storing the cement at the Site. The container or building shall be dry waterproof and adequately ventilated. If more than one type of cement is to be used on the works the container or building shall be suitably sub-divided to the satisfaction of the Engineer's Representative and great care shall be exercised to ensure that different types of cement do not come into contact with each other.

Bags of cement shall not be laid directly on a floor but on wooden slats or duckboards to allow the efficient circulation of air around the bags.

Each cement store shall be arranged to allow the cement to be used in the order in which the various consignments are delivered.

Cement shall not be kept in a temporary store except where it is necessary for efficient organization of the mixing plant and only when the prior approval of the Engineer has been obtained.

The Engineer's Representative shall be furnished with the means of identifying the several consignments of cement delivered.

The cement may, with the permission of the Engineer, be stored in a properly constructed bulk storage silo and delivered in approved bulk delivery vehicles.

The different types of cements shall be stored in separate compartments. If intermixing occurs all cement concerned will be condemned by the Engineer and shall be removed immediately from the site.

No cement, which in the opinion of the Engineer, has deteriorated or hardened shall be used on the works and such cement shall be immediately removed from the site.

Cement manufactured more than 12 months prior to its proposed use on the site shall not be used.

Any cement which is stored on the site for a period in excess of 28 days shall be tested in accordance with the relevant Standard prior to use.

(ii) Aggregates and Sand: Adequate stocks of tested and approved aggregates shall be maintained on site and the capacity of the bins for each type and grading of aggregate shall be sufficient to hold the respective quantities required for the maximum amount of concrete which the Contractor is obliged or intends to pour in any continuous operation in one day. Stockpiles shall be built in layers of 1.50 metres maximum height and segregation of the aggregates prevented. Concrete block walls shall separate different grades of aggregates.

Dense concrete or bituminous slabs shall be laid with sufficient falls to cover all aggregate stockpile areas or bins and shall extend to cover all surrounding areas where aggregates are likely to be discharged or handled. These areas shall be swept and kept clean at all times to ensure that the aggregates are not contaminated by the adjacent ground through trafficking or otherwise, and are to be constructed with adequate drainage for surplus water.

Windbreaks shall be provided where aggregates might suffer excessive contamination by windblown materials. During periods of heavy rain the bins or compounds shall be covered by tarpaulins or other approved means.

(iii) Admixtures: Admixtures shall be stored in such a manner as to avoid contamination, evaporation, or damage. For those used in the form of suspensions or non-stable solutions, agitating equipment shall be provided to ensure thorough distribution of the ingredients. Liquid admixtures shall be protected from freezing and from temperature changes which would adversely affect their characteristics.

(iv) Reinforcement: All bar or rod reinforcement shall be stored on suitable racks, each diameter and quality being kept separate. Fabric shall be stored on a level floor to prevent contamination by dirt or oil weatherproof and from undue exposure to the weather. High tensile rods or wire are to be stored in a damp resistant building to prevent rusting.

3.3 Workmanship

3.3.1 Washing and Processing of Aggregates

The Contractor may be required to carry out on site supplementary processing and/or effective washing of coarse and fine aggregates where the aggregate production methods, in the opinion of the Engineer may not result in end products to the specification, or where aggregates suffer unacceptable changes during loading at source subsequent to the site, or otherwise.

Aggregates which have been rejected may be re-processed by the Contractor on site, and then resubmitted for approval.

3.3.2 Types and Strength of Concrete

The water content of all concrete shall be rigidly controlled and kept to the minimum required to obtain a workable concrete suitable for the nature of the work to be executed.

The Contractor shall carry out preliminary tests before the commencement of the main concreting operations in order to determine the minimum water cement and the actual proportions of the fine and coarse aggregates required, the necessary allowance being made for the moisture content of the aggregates.

Slump tests shall be carried out in accordance with *PS 55 part 1,2*. Slumps for various types of construction shall be within the limits recommended by *PS 55 part 1,2*.

After the value of the water cement ratio and the mix proportions have been approved by the Engineer several sample batches of workable concrete shall be mixed and test cubes obtained therefrom.

The water cement ratio and mix proportions which have been determined as a result of the preliminary tests shall be used throughout the course of the works and no variation shall be made without the approval of the Engineer. Notwithstanding any such variation the Contractor shall ensure that the minimum cube crushing strengths specified in Table 3.4 are attained. The Contractor shall also determine the crushing strength at 7 days and from these results shall determine the relation between the 7 days and 28 days crushing strength for each class of concrete. The crushing strength at 7 days shall be 67% of the expecting strength at 28 days according to Arab Code section 4-2-3-1.

Further tests shall be carried out if materials or mixes are changed during the course of the work.

Weatherproof from undue exposure to the weather. High tensile rods or wire are to be stored in a damp resistant building to prevent rusting.

The quantities of all materials for concrete shall be accurately determined by weight in a weigh batching machine approved by the Engineer. In order to ensure the accuracy of weigh batching the machine shall be tested and adjusted if required before the commencement of the works and at frequent intervals thereafter and shall also be kept clean.

Where concrete is to be placed in or under water the actual mix proportions and selection of aggregates be such as to ensure a resulting concrete with good flow and cohesion characteristics. The cement content shall be 25 percent greater than for a comparable mix for use in dry conditions. The minimum concrete cube strength for all concrete shall be as given in Table 3.4 for the comparable mixes for use in dry conditions. The slump of the concrete when tested in the dry shall not be less than 100mm.

The addition of proprietary admixtures intended to change the flow characteristics, cohesion or the rate of setting or hardening of the concrete shall not be made without the written approval of the Engineer.

Cyclopean concrete shall consist of concrete B150 mixed with plums.

Plums shall consist of broken spalls or boulders ranging in size from 300mm down to 100mm. Plums shall be free from sharp or angular edges and shall be soaked in water prior to incorporation into concrete.

Plums shall comprise a maximum of 30% of the total volume of Cyclopean concrete in position and they shall be evenly placed in concrete. Plums shall have a minimum of 70mm of concrete cover around them.

The Contractor shall be free to fix the proportions of the mix provided that it could be demonstrated that the mixes used have the lowest possible water content consistent with proper grading and good workability for the sake of minimum drying shrinkage, and on condition that the Contractor can prove by advance testing carried out in approved laboratory accredited by PSI, that they are suitable, comply with all the requirements of the Specifications, and that they can be transported, placed and compacted by the methods and equipment used on site.

3.3.3 Sampling and Testing of Concrete

All testing shall be done in the presence of the Engineer's Representative either on Site or in an approved testing laboratory as directed.

The frequency of testing shall be noted in the Clauses of this Division and whenever required by the Engineer.

The work test cubes shall be made as follows depending on whichever is more frequent:

(a) At least three times weekly per mixing plant.

(b) At least once for each individual part of the structure as defined by the Engineer.

(c) At least once per 60 cubic meters of concrete.

For concrete blinding the rate shall be once per each 100 cubic meters or fraction thereof.

Table 3.4
Suggested Designed Concrete Mixes

Concrete Class	Cube Strength at 28 Days (kg/cm^2)	Minimum Cement Content (kg/m^3)	Maximum Water/Cement Ratio (%)	Purpose
B100	100	200	82	Plain Concrete, Cyclopean Concrete, Blinding Concrete
B150	150	220	80	Plain Concrete, Sloping Screeds, Fill

Concrete Class	Cube Strength at 28 Days (kg/cm^2)	Minimum Cement Content (kg/m^3)	Maximum Water/Cement Ratio (%)	Purpose
				below pipe trenches, Blinding concrete, Road crossing
B180	180	260	76	Foundation built from Plain Concrete
B200	200	300	70	Concrete reinforced with medium steel strength such as manhole chambers, Thrust blocks, encasement around pipes and others
B250	250	360	62	Concrete reinforced with high steel strength such as base and walls of the water tanks
B300	300	400	55	Reinforced Concrete
B350	350	400	48	Pre-stressed, Post Tensiled concrete
B400	400	400	43	Pre-stressed, Pre-tensiled Concrete

Notes:

1. Development of mix designs and testing shall be conducted by an independent testing laboratory accredited by PSI and acceptable to the Engineer according to properties of concrete materials components, such designs and tests shall be born by the Contractor at his own expense.
2. **Cubes are used for determining concrete compressive strength in accordance with *PS 55 part 4.***

At least six cubes shall be made at one time in accordance with *PS 55 Part 1, PS 55 Part 3*: "Methods or Testing Concrete". Two of the six cubes are to be cured as specified and tested at seven days, two others cured as specified and tested at 28 days and the last two cured under the same field conditions as the concrete structures and tested at 28 days. The cost of such tests will be born by the Contractor.

Strength tests shall be made in accordance with the relevant part of *PS 55 part 4*.

Whenever the result of the seven-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 Contractor's expense and shall not proceed further without the written permission of the Engineer.

When concrete fails to conform the requirements of laboratory cured specimens or when tests of field-cured specimens indicate a deficiency in protection and curing, the Contractor shall, in accordance with the instructions of the Engineer remove and test cores or conduct in-situ load tests on suspect portions of the works. Concrete judged by the Engineer to be defective shall be cut out, removed and replaced by the Contractor at his own expense.

Procedure used for drilling and testing cores should comply with *PS 55 part 6*:

Evaluation of adequacy of concrete in area represented by core tests shall comply with *PS 55 part 6.*

Static load tests shall be carried out and evaluated in accordance with *ACI 318-2002 Part 6-Chapter 20 or BS CP 110: Part 1 Section 9.6.*

In the event of strengths consistently higher than those specified being obtained, a reduction in the number of tests may be authorised by the Engineer and should not be in contradiction with the related PS Standards requirements.

Notwithstanding anything contained in this Clause the Engineer may at any time request samples for testing. The Contractor shall carry out such tests at his own expenses.

Testing of cement aggregates, steel or other, material used in concrete shall be according to the appropriate Palestinian Standard or British Standard.

Slump shall be kept to the minimum compatible with placing requirements, but in no case shall exceed 100mm when tested in accordance with *PS 55*. If additives are used the slump value will be adjusted accordingly.

3.3.4 Concrete Carpet

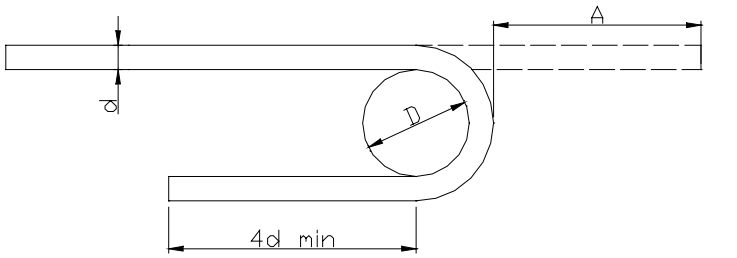
Immediately upon completion of the excavation and where shown on the Drawings or ordered by the Engineer's Representative, a blinding layer of concrete Class B150 not less than 700mm thick or to the depth shown or ordered shall be placed to prevent deterioration of the formation and to form a clean working surface for the structure.

3.3.5 Reinforcement

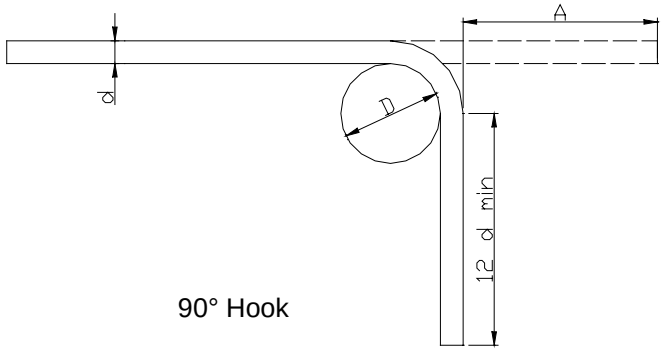
Reinforcement shall be stored clear of the ground and adequately supported to prevent distortion.

Bar steel reinforcement shall be bent cold to forms and dimensions shown on the Drawings and in accordance with *PS 51*. No heating will be allowed to facilitate bending. Tack welding is not allowed to position bars crossing at right angles or for any other reason. Reinforcing steel showing transverse cracks shall not be used.

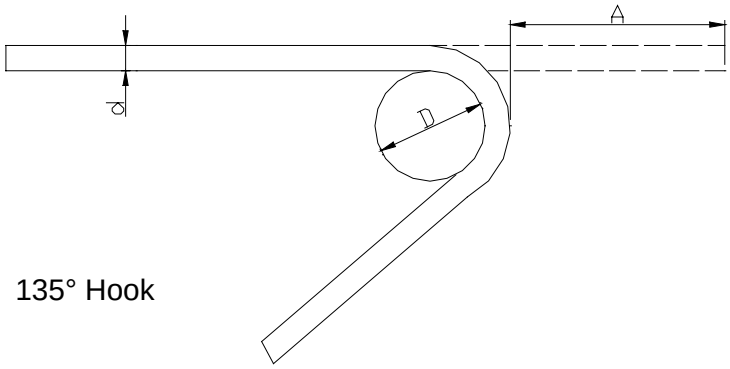
Standard Bends:



180° Hook



90° Hook



135° Hook

Table 3.5
Standard Bends

Bar Dia (mm) (d)	180 Bend		90 Bend		135 Bend	
	D mm	A mm	D mm	A mm	D mm	A mm
10	60	130	60	130	40	105
12	75	155	75	180	50	115
16	95	180	95	215	65	140
18	115	205	115	255		
22	135	255	135	305		
25	150	280	150	345		
30	240	380	240	395		
32	275	430	275	455		

Tolerances: for diameter of bends, “D”, the tolerance ranges around plus or minus the diameter of the bar. Standard fabricating tolerances shall be in accordance with the Manual of Standard Practice of the Concrete Reinforcing Steel Institute. No weight allowance will be made for tolerances.

Reinforcement shall be clean and free from loose mill scale, loose rust, oil, grease, tar, paint or other deleterious matter and shall be maintained free from concrete droppings up to the time of concreting.

Reinforcement shall be placed in accordance with the Drawings and shall be supported and maintained in position by the provision of wire ties or clips at bar intersections and by spacers to maintain the reinforcement in its correct position. The spacers must be securely fixed to the reinforcement at the time of placing.

Cover spacers shall be of concrete made with 10mm aggregate and shall match appearance on surrounding concrete in exposed work. Proprietary plastic spacers may be used subject to the approval of the Engineer .The Contractor shall obtain approval of type, size and position of cover spacers.

The Contractor shall adopt effective measures to ensure that reinforcement remains accurately in position during the placing, consolidation, and setting of the concrete.

In slabs provided with two or more layers of reinforcement the parallel layers of steel shall be supported in position by the use of steel chairs. Spacers shall be placed at each chair to support layers of reinforcement from the concrete carpet or formwork. The rates for reinforcement shall include for the provision and fixing of stools.

Reinforcement projecting from work already concreted shall be bent out of its correct position for any reason unless permitted by the Engineer's Representative and shall be protected from deformation or other damage.

Except where otherwise shown on the length of lap joints shall be not less than 40 times the diameter of the largest bar and should be staggered.

Except where otherwise shown on the Drawing the minimum concrete cover to the nearest reinforcement exclusive of plaster or other decorative finish and concrete blinding shall be as follows:

(a) For works against earth faces and in liquid retaining structures 35-40mm (external isolated structure).

(b) For internal work in non-liquid retaining structures:

i. For a beam 25-35mm.

ii. For a column wall or strut 25-35mm.

iii. For slab reinforcement in building - 25mm, or the diameter of the main bar, whichever is greater.

iv. For slab reinforcement subject to chemical attack - 40mm.

(c) The minimum concrete cover in no case should not be less than the maximum diameter of steel reinforcement bars used.

The distance between any two parallel bars shall not be less than 50mm, or 4/3 maximum aggregate size, or 1/5 the minimum width of member whichever is greater.

No concreting shall be commenced until the Engineer's Representative has inspected and approved the placed reinforcement.

Splices of reinforcement shall be made only as specified or determined by the Engineer. Spiral reinforcement shall be spliced by lapping 1.5 turns. A material sample of spirals up to 0.8m long, if taken from an end of the spiral, need not be replaced. Bars of diameter 45mm and 55mm shall be spliced with approved mechanical connectors. Mechanical connectors shall be capable of developing 125 percent of the yield strength of the bars connected. Bars used to replace random samples shall be lapped as follows in Table 3.6.

Table 3.6
Lap Length

Lap Length (mm)		
Bar Size	**Uncoated**	**Epoxy Coated**
12	560	690
16	740	890
18	870	1040
22	1090	1320
25	1450	1750
30	1830	2210
32	2340	2820

3.3.6 Forms and Shuttering

All forms for casting of concrete shall be made of steel, plywood, mazonite or similar material providing a completely smooth surface of the face coming in contact with the concrete. Only new, strong and smooth timber shall be used for shuttering and scaffolding.

The Contractor shall bear the sole responsibility for the safety and stability of the forms, scaffolds etc., and in the case of collapse, excessive deflections, buckling and /or any other changes in shape, the damage shall be repaired by the Contractor at his expense.

Form ties shall be internal where possible. The typing of forms in the walls shall be made with special accessories fitted with cones or accessories of approved type by the Engineer so as to ascertain complete sealing after stripping of forms, and avoid any seepage of water at the ties. After the tie fittings have been removed, the holes shall be filled with epoxy on the inside and cement grout of the approved type by the Engineer on the external face.

Shuttering shall be constructed to attain the required surface textures of the structures as mentioned in Tender Documents, and be such that it remains rigid during the placing and setting of the concrete.

The Contractor shall design and construct formwork to avoid high intensity point loads and to withstand:

- Total weight of formwork, reinforcement and concrete.
- Construction loads including dynamic effects of placing compacting and construction traffic.
- Wind loads.

The Contractor shall advise the Engineer of construction load of each deck. He shall prop through decks if construction load on particular deck exceeds:

- Design loading, or
- Reduced loading agreed with the Engineer for decks cast less than 28 days.

The Contractor shall submit to the Engineer for approval details of proposed:

- Prop bearings for checking the effects on the structure.
- Cambers to soffits of beams and slab with adequate allowance for deflection off formwork under weight of fresh concrete to achieve the agreed cambers.

The maximum permissible deflection of formwork under loads is not to exceed 3mm or 1/600 of free span, whichever is less.

Formwork shall be fixed in perfect alignment and to the true shape and dimensions of the permanent work shown on the Drawings. Methods of support which would result in holes or tie wires extending the whole width of a member will not be permitted. Tie wires are permitted only for concealed or rendered surfaces in buildings.

Top shuttering is to be provided to concrete faces where the slope exceeds one in two and a half.

Before each concreting operation is commenced shuttering shall be carefully examined and cleaned out and the concrete contact faces of the shuttering shall be treated with approved mould oil. The quality of the shuttering materials should be approved by the Engineer before concreting.

The Contractor shall submit the design and details of shuttering for the Engineer's approval.

No concreting shall be commenced until the Engineer's Representative has inspected and approved the erected shuttering.

3.3.7 Shuttering Release Agents

All forms in contact with concrete shall be coated with an approved nonstaining proprietary release agent before reinforcement is placed. The release agent shall be carefully applied in such a manner that there is no contamination of reinforcement or previously placed concrete. The release agent shall be effective and have no effect for water potable quality after exposure to high temperature, sun and wind.

3.3.8 Finish of Concrete Surfaces

A. Fair Faced Concrete: For exposed surfaces and those in contact with liquid, the surface texture required shall be that obtained from the use of a smooth impervious face of metal, hardboard or the like. The quality of the fairfaced concrete shuttering materials should be approved by the Engineer before and after the installation of the shuttering.

B. Concealed Surfaces: For concealed surfaces the surface texture required shall be that obtained from the use of sawn close jointed timber or the like.

C. Exposed Upper Surfaces: The exposed upper surfaces of floor slabs or surfaces in contact with water shall be floated with a steel trowel to a smooth finish. Other exposed upper surfaces shall have a smooth finish with a wood towel. The trowelling shall be executed so that an excessive amount of fine material is not brought to the surface.

D. Asphalted Surfaces: For asphalted surfaces the surface texture required shall be that obtained from the use of the "mechanical face" of hardboard or the like or as (b) above.

E. Rendered or Surfaced Areas: Areas to be subsequently rendered or to receive a surfacing other than as (d) shall be adequately scored to provide an effective key.

F. Unless otherwise shown on the Drawings, exposed arrises shall be formed with a chamfer 40mm by 40mm.

3.3.9 Shuttering Tolerances

Formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits according to (ACI 117) and listed below:

(a) Variation from plumb:

i. In the lines and surfaces of columns (internal), walls and in arrises:

In any 3m of length	4mm
Maximum for the entire length (From the base up to the bottom Slab of the water tank)	20mm

ii. For exposed corner columns, control-joint grooves and other conspicuous lines:

In any 6m length	5mm
Maximum for the entire length	10mm

(b) Variation from the level or form the grades specified in the Contract Documents:

i. In slab soffits, ceilings, beam soffits and in arrises, measured before removal of supporting shores:

In any 3m of length	5mm
In any bay or in any 6m length	10mm
Maximum for the entire length	20mm

ii. In exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines:

In any bay or in any 6m length	5mm
Maximum for the entire length	10mm

(c) Variation of the linear building lines from established position in plan and related position of columns and partitions:

In any bay	10mm
In any 6m length	10mm
Maximum for the entire length	20mm

(d) Variation in the sizes and location of sleeves, floor openings and wall openings — 5mm

(e) Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls:

Minus	5mm
Plus	10mm

(f) Footings (concrete dimensions only).

i. Variation in dimensions in plan:

Minus	10mm
Plus	50mm

ii. Misplacement or eccentricity:
Two percent of the footing width in the direction of misplacement but not more than 50mm.

iii. Thickness:

Decrease in specified thickness	2%
Increase in specified thickness	No Limit

(g) Variation in steps:

i. In a flight of stairs:

Rise	±3mm
Tread	±6mm

ii. In consecutive steps:

Rise	±2mm
Tread	±3mm

The Contractor shall establish and maintain in an undisturbed condition and until final completion and acceptance of the project sufficient control and benchmarks to be used for reference purposes to check tolerances.

3.3.10 Mixing of Concrete

Contractor will have to submit for Engineer's approval a scheme of the proposed forms and shuttering as well as a detailed schedule for casting proceedings.

Contractor must inform the Engineer of any scheduled casting at least 48 hours prior to the casting and must obtain Engineer's approval to the proposed schedule.

When mixing on site is approved by the Engineer, concrete shall be furnished according to these specifications and shall be mixed with approved machines. The location of the mixing

plants shall be agreed on with the Engineer and the Contractor must submit to the Engineer for approval before erection of any mixing plant his proposed arrangements for the storing of aggregates, batching and mixing of the concrete.

The concrete materials shall be mixed in an approved mechanical batch mixer of adequate size and type. Mixing for each batch continues until there is a uniform distribution of the materials and uniformity of colour and consistency of the concrete.

The Contractor shall take particular care to ensure that no residual materials remain in the mixer after depositing each batch of concrete and he shall wash and clean out the mixer drum immediately following the completion of each concreting operation or when changing to a mix using a different type of cement.

Ready mixed concrete may be truck or plant mixed as specified in *PS 40*. The use of ready mixed concrete shall only be allowed with the prior approval of the
.
The Contractor shall submit to the Engineer his proposals for the organization and control of the manufacture and delivery of all ready mixed concrete and shall not take delivery until the requirements of the Engineer have been met and his approval granted.

For the standard mixes the following mixes are assumed to contain enough water to yield a plastic mix with the shown slump:

Table 3.7
Standard Mixes

Proportions by Weight		Slump (cm)
	Cement : Sand : Gravel	
Ordinary Mixes	(a) 1 : 2 : 4 (150-300kg/m^3 cement)	Plastic concrete with slump 5-6cm
	(b) 1 : 1.75 : 3.5 (350kg/m^3 cement)	
Special	to be designed according to the requirements and properties needed in design	Plastic concrete with slump 3-4 cm

Table 3.8
Quantities Required for Ordinary Mixes

Mix	Cement	Sand	Gravel	Water/ Cement Ratio	Quantity of Water L/bag of Cement
Ordinary type (a) B300	One bag 50kg	0.066m^3	0.132m^3	0.55	27.5
Ordinary type (b) B350	One bag 50kg	0.058m^3	0.116m^3	0.48	24.0

Clauses herein covering concrete shall apply equally to the supply of ready mixed concrete.

3.3.11 Transporting Concrete

Concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by methods, which will prevent the segregation or loss of any ingredient.

Wherever practicable the concrete shall be emptied from a mixer directly into a skip. The skip shall then be transported to the place of final deposit and the concrete tipped as nearly as practicable into its final position to avoid rehandling or flowing. No concrete shall be thrown or dropped from a height not more than 2.0m.

The concrete transported by transit mixer or agitators, the time elapsing from the time water is added to the mix until the concrete is deposited in place shall not be greater than the time taken for 300 revolutions of the transit mixer or agitator or 20 minutes, whichever is the least.

Driver of delivery trucks shall be provided with trip tickets, which shall be signed by a responsible member of the central plant staff, for submission to the Engineer. The ticket shall contain name and address of the central plant, serial number of the ticket and date, truck number, class and/or strength of concrete, cement content of the mix, loading time, slump and any other type of relevant information. The Engineer may send his representative to the central plant to check the batching and mixing, verify loading time and take a copy of the trip ticket.

Should the Contractor propose to use concrete pumps for the placing of concrete he shall submit full particulars of the equipment and methods he proposes to adopt to the Engineer for his approval. In the event of the Engineer approval being obtained, placing concrete by pumping methods shall comply with Title No. 68-33 by ACI Committee 304. The Contractor shall also pay particular attention to elimination of shock transferred from the pipe line to the formwork and previously placed concrete and he shall provide alternative means of supply and transport so as to cater for the possible breakdown of the pump or pumps during concreting operations. The initial discharge from a pump shall not be incorporated in the permanent works. When concreting slabs or similar structures by means of pumps the point of discharge shall be moved at intervals of about 15 minutes.

Where the concrete is conveyed by chuting or pumping the plant shall be of such a size and design as to ensure continuous flow in the chute or pipe. The slope of the chute or pressure at the pump shall be such as to allow the concrete to flow without the use of any water additional to that ordered by the Engineer to produce the required consistence and without segregation of the ingredients. The delivery end of the chute or pipe shall be as close as possible to the point of deposit. The chute or pipe shall be thoroughly flushed with water before and after each working period; the water used for this purpose being discharged outside and away from any permanent works or irrigation conduit.

3.3.12 Placing and Compacting Concrete

The placing of concrete in any element is to be carried out continuously without pause, in a manner which will not produce construction joints or cold joints due to partial drying of compacted concrete.

The placing of fresh concrete will be gently placed in position and will not be allowed if the free fall is more than 2.0m. Concrete shall not be placed in such a manner that it displaces

reinforcing bars, ties, etc. The fresh concrete is to be placed in its final destination in accordance with the above mixing and batching procedures. Any concrete that has become so stiff that proper placing cannot be assured shall be wasted.

The Contractor shall obtain the approval of the Engineer to his proposed arrangements before commencing concreting.

The Contractor shall regard the compacting of the concrete as work of fundamental importance, the object of which shall be to produce a watertight concrete of maximum density and strength.

Concrete shall be thoroughly compacted during the operation of placing and shall be thoroughly worked around the reinforcement and any embedded fixtures and into corners of the shuttering and moulds.

Concrete shall be consolidated to a maximum practicable density, by means of vibration, so that it is free from pockets of coarse aggregate and entrapped air, and closes snugly against all surfaces of forms, reinforcing steel bars and embedded materials. The slump for concrete thus consolidated must be fairly high and the cement quantity increased accordingly to achieve specified strength.

3.3.13 Placing of Concrete in or Under Water

The method of placing concrete in or under water shall be such as to keep as much as possible of the concrete being placed out of direct contact with the water so as to avoid any rapid movement or agitation of the exposed surface.

The work shall where possible be carried out in one operation. Where this is impracticable laitance, washed out aggregate or foreign matter which may have accumulated on the previously placed concrete shall be completely removed prior to additional concrete being placed. This concrete shall then be placed directly on the cleaned surface.

Tremie pipes shall be smooth bored and water-tight fitted with quick release joints and have an adequate cross-section for the size of aggregate to be used.

Bottom opening skips shall be straight sided perfectly smooth and fitted with externally operated bottom opening double doors and overlapping canvas flaps.

Toggle bags shall be used for small pours and for depositing small discrete quantities of concrete. Bagged concrete shall not be used for permanent work.

The Contractor shall submit and obtain the approval of the Engineer to his detailed proposals for concreting.

3.3.14 Protection and Curing of Concrete

(i) Materials:

– ***Hessian or Burlap:*** They shall be clean and free from harmful materials. Their unit weight shall be not less than 230g/m^3.

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

1. Clear polyethylene film with no holes, tears, scratches and contamination of any type.
2. 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 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 3.2.3 of the Specifications.

(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^{o}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.

1. 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.
2. 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.
3. 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.
4. 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:

1. ***Low Pressure Steam Curing:*** This shall be in accordance with recommendations of ACI 517.
2. ***High Pressure Steam Curing:*** This shall be in accordance with the recommendations of ACI 516.

(iii) Curing Time:

The minimum curing time shall be the number of days given in Table 3.9 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:

Table 3.9
Normal Curing Periods

Minimum Periods of Protection for Different Types of Cement		
Conditions under which concrete is maturing	Number of days (where the average surface temperature of the concrete exceeds 10^{o}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

Minimum Periods of Protection for Different Types of Cement						
				surface temperature of the concrete exceeds minus $10^{o}C$		
	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 Portland Cement
RHPC = Rapid-hardening Portland Cement.
SRPC = Sulfate Resisting Portland Cement.

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.

Concrete shall be cured in such manners and for such periods as the Engineer may direct having regard to the climatic conditions prevailing at the time of placing any individual batch of concrete.

(iv) Requirements: The following requirements shall be strictly complied with by the Contractor except in those instances where the Engineer shall issue separate instructions modifying such requirements, or where the Contractor has obtained the prior approval of the Engineer's Representative to a modification thereto.

a. Top Surfaces of Horizontal Slabs Etc. (Other than Concrete Carpets): Covering the surface with a 50mm carpet of sand kept constantly wet or spraying the whole surface with water continuously or pounding of the surface with water to a minimum depth of 20mm for a period of 14 days after casting.

b. Sloping Unshuttered Surfaces: In cases where the Engineer's Representative considers the ponding of slopping surfaces to be impracticable on account of the degree of the slope, such surfaces shall be covered with a carpet of wet sand or sprayed with water as above specified or treated with membrane curing compound provided such compound is applied immediately after casting of the concrete member in compliance with ASTM C309, and protected by such additional methods as the Engineer's Representative may consider necessary having regard to the climatic conditions. These may include shading of the work during the warmer season.

c. Undersides of Horizontal and Sloping Members: Spray the whole surface with water immediately after the formwork is struck.

d. Timber or Steel Shuttered Vertical and Sloping Surfaces. (Other than undersides). Drape the formwork with Hessian during setting in the warm season and drape the concrete with Hessian immediately after striking the formwork. Spray the concrete surface and the Hessian continuously with water from spurge-pipes or from a trough accurately set to level for a period of 21 days during the summer months (April to October inclusive) so as to produce a continuous film of water on the surface of the concrete. During other seasons the same procedure shall be adopted but the Engineer's Representative may permit a reduction in the period of spraying if conditions in his opinion justify such a procedure.

e. Pipe Joints and Concrete Bedding, Haunching and Surround to Pipes. Immediately after a pipeline has been laid it shall be completely shaded from the sun with a length of Hessian running the length of the trench. Should the pipeline contain any cement mortar in the joints or be protected with concrete, additional wet Hessian shall be placed directly over the mortar or concrete portions immediately following the placing of the mortar or concrete in each section of the pipeline and such Hessian shall be kept continuously wet until the pipeline is ready to receive the first layer of backfill. If removal of the Hessian is necessary to inspect or test the pipeline such removal be for the shortest practicable time.

f. Concrete Test Cubes. The Contractor shall establish a small locked room for storing concrete test cubes or cylinders prior to testing and the key shall be in the custody of the Engineer's Representative. Cubes shall be stored in water in this room unless the Engineer's Representative should direct that cubes be stored in conditions simulating those under the concrete of which the cubes are representative is maturing.

No placing or traffic of materials, passage of men, further construction or temporary works shall be allowed on any concrete until it has matured sufficiently to permit such placing or traffic without detrimental effect on the concrete.

3.3.15 Concreting in Extreme Weather Conditions

No concrete shall be mixed at an air temperature of less than 5ºC unless proposals to counteract the effect of cold weather have been submitted by the Contractor and agreed in writing by the Engineer. Exposed surfaces of concrete shall be efficiently protected to maintain its temperature above 5ºC until it has hardened.

The Contractor shall provide a thermometer suitable for measuring the temperature of aggregates and a maximum and minimum thermometer which shall be hung in a position indicated by the Engineer's Representative.

The Contractor shall take great precautions during hot weather to prevent the cracking or crazing of concrete and if evidence of cracking should appear he shall so organise his programme as to arrange for concrete pouring to take place during the early morning or late evening. He shall also arrange for the formwork to be shaded from direct exposure in the sun both prior to the placing of the concrete and during its setting. Particular regard shall also be taken to the curing of concrete as herein specified.

When the air temperature in the shade is expected to exceed 32 degrees C, the Contractor shall schedule his operations to place and finish the concrete during the hours that the air shade

temperature will be below 32 degrees C. This should preferably be in the latter part of the day after the maximum temperature has been reached, and subject to the approval of the Engineer.

The temperature of the concrete at the time of placing shall not be permitted to exceed 32 degrees C. Concrete materials shall be stored in a cool shaded position away from the direct rays of the sun and be kept cool. Concreting water shall be stored in a tank that is kept cool by efficient lagging, air conditioning or chilling or located underground. Both water and aggregate shall be cooled if necessary prior to mixing and ice water shall be used if ordered by the Engineer's Representative. The forms and reinforcing steel shall be cooled to a temperature of not more than 32 degrees C by spraying them with water.

The time available for handling and placing of concrete during periods of high temperatures may be considerably reduced and the Contractor must take appropriate precautions. Concrete should be protected during transportation by use of damp Hessian or similar means. No additional water may be added at the time of mixing without the approval of the Engineer as this may lead to additional shrinkage of the concrete. On no account shall water be added during transportation or placing of the concrete. Retarding admixtures or water reducing and retarding admixtures shall conform to *PS 125* or (ASTM C 494 for admixtures not covered in PS 125) and shall be used if required and approved by the Engineer.

Hot weather concreting shall conform to the requirements of "Recommended Practice for Hot Weather Concreting" (ACI 305, latest edition).

For the more massive types of heavy construction, i.e those whose dimensions are such that significant heat is generated through hydration of cement, a temperature of 16 degrees C is the maximum allowable temperature at placing of concrete. When this temperature is exceeded, the above measures for hot weather concreting shall apply. The temperature of the forms and reinforcement shall be lowered to below 16 degrees C. Moreover, pipe cooling of concrete during the curing might be required by the Engineer. This consists of a series of evenly spaced pipe coils through which refrigerated or cold water is circulated. The Contractor shall submit his design of the pipe cooling system conforming to Title No.67-17 by ACI Committee 207 to the Engineer for approval.

The prices for concrete work in the Bill of Quantities shall be deemed to cover all such special work.

3.3.16 Concrete Tests

Concrete tests shall be carried out in accordance with *PS 55*. Preliminary tests shall be made by the Contractor to determine suitable mixes, refer to Section 3.3.3. Routine tests shall be taken for cube strength according to *PS 55-part1- 1997* as shown in Table 3.10 below:

Table 3.10
Minimum No. of Concrete Samples

Quantity of Concrete (m^3)	No. of Samples
Up to 40	3
From 40 up to 60	4

Quantity of Concrete (m^3)	No. of Samples
60 up to 80	5
80 up to 100	6
100 up to 130	7
130 up to 160	8
160 up to 200	9
For each additional $50m^3$ above 200	Additional sample

Note: every sample consists of two cubes one to be tested at 7 days and the other at 28 days. Refer to Section 3.3.3

If the mean value of strength does not comply with the requirement of *PS 45* the particular structural element must be core tested according to *PS 55 part 6-1997*, if the cores don't comply with the requirement, Engineer shall have the right to require strengthening or replacement of that element which fail to develop the required strength. All remedies associated costs shall be at the expense of the Contractor.

All costs in connection with the tests shall be at the Contractors own expense.

3.3.17 Removal of Shuttering

Shuttering shall only be removed with the permission of the Engineer's Representative and the work of striking after the receipt of such permission shall be carried out under the personal supervision of a competent foreman. Great care shall be exercised during the removal to avoid shocks or reversal of stress in the concrete.

In cases where the Engineer's Representative considers the Contractor's proposal for the removal of shuttering to be premature either on account of the weather or for any other reason he may order the Contractor to delay such removal and the Contractor shall have no claim for delay in consequence thereof.

Notwithstanding any advice, permission or approval given by the Engineer, the Contractor shall be responsible for any injury to the work and any consequential damage caused by or arising from the removal of shuttering.

The minimum period from completion of casting to commencement of stripping will be as follows:

Walls- 48 hours
Roof- 14 to 21 days.

Final decision for the removal of shuttering should be according to the Engineer's approval.

3.3.18 Repair of Surface Defects

All repair works that might be required on sections of the cast concrete shall be performed by the Contractor not later than 24 hours after removing of forms.

If not otherwise instructed, Contractor will cut all projecting tie wires to a depth of 15mm, into concrete face and fill the recess with fresh concrete. Concrete projection caused by

roughness of forms will be chiselled away or otherwise removed by a polishing carborundum stone. Gravel pockets, holes or faulty spots shall be chiselled out until clean and healthy concrete is exposed. All recesses shall be filled up with fresh concrete of approved cement grout and properly repaired. The repaired section will merge with the concrete of the structure and smoothened level with its surface.

All repair works will be performed only after damaged part has been checked by the Engineer.

All finish works shall be performed by the Contractor at his expense and he would not be entitled to any compensation for the same.

The defected area to be patched and an area at least 150mm wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. A bonding grout shall be prepared using a mix of approximately one part cement to one part fine sand passing a No. 30 mesh sieve, mixed to the consistency of thick cream, and then well brushed into the surface. Particular care shall be taken to colour match patches with the bulk concrete.

If permitted or required, proprietary compounds for adhesion or as patching ingredients may be used in lieu of or in addition to the foregoing patching procedures. Such compounds shall be used in accordance with the manufacturer's recommendations. Specific approval of the Engineer is required to use proprietary compounds for patching.

Painting with epoxy after the repairing process should be applied and the cost of such work should be born by the Contractor at his own expense.

3.3.19 Construction Joints

Where construction joints are required in slabs or beams these shall be made at one-third of the span and at right angles to the member except where otherwise approved by the Engineer. Where slabs are supported by beams then both beams and slabs shall be constructed in one operation.

In all cases vertical stop boards of a form to be approved by the Engineer shall be provided at the end of each section of work which is to be concreted in one operation and the concrete shall be thoroughly consolidated against these stop boards.

Where slabs, beams and walls are divided by construction joints they shall be constructed in alternate bays and an interval of seven days shall elapse before the concrete is placed in the intervening bays.

Construction joints in slabs and beams shall be of the vertical butt type. Provision shall be made for transfer of shear and other forces through all construction joints.

Before placing new concrete against concrete which has already set, the latter shall be treated to expose the aggregates over the full section and leave a sound irregular surface. This shall be done while the concrete is still green by means of water spray and light brushing with or without the use of a retarding agent approved by the Engineer.

Immediately before the fresh concrete is placed, all foreign matter shall be thoroughly cleaned away and the surface moistened.

Before continuing concreting against or on top of the face previously cast the vertical faces of construction joints shall be covered with a thick grout of neat cement and the horizontal faces shall be covered with a layer of 1:1 cement and sand grout approximately five mm thick immediately prior to placing new concrete against the joints. New concrete shall be thoroughly tamped into the grout or mortar layer. In the case of a joint between new concrete and a surface other than concrete similar treatment as specified above shall be carried out.

Working joints will not be measured for payment and Contractor will incorporate their cost in the unit prices for concrete works.

3.3.20 Movement Joints Generally

The Contractor shall pay particular attention to the effects of climatic extremes about the works on any material which he may desire to use in any movement joint and shall submit for approval by the Engineer his proposals for the proper storage handling and use of the said materials having due regard for any recommendations in this connection made by the manufacturers.

Water stops shall be incorporated into all expansion and contraction joints in units which retain or exclude liquids as shown on the Drawings.

Different types of water stop material shall not be used together in any complete installation. Water stops shall be fabricated into the longest practical units at the supplier's works and shall be continuous throughout the structure below highest water level.

Intersections and joints shall be factory made unless otherwise approved by the Engineer.

Horizontally placed surface type water stops shall have an interposing sliding plane.

Water stops shall be carefully maintained in the position shown on the Drawings supported on accurately profiled stop boards to create rigid conditions.

The joint filler shall be fixed to the required dimensions of the joint cross section and shall provide a firm base for the joint sealer.

The joint sealer groove shall be formed to the profile shown on the Drawings by profile battens fixed to stop boards during construction. On horizontal joints, battens shall be left in place until the joints are to be sealed.

Sealing of movement joints shall be carried out only when adjacent concrete surfaces are perfectly dry.

Immediately before the application of the joint sealer the groove protection batten shall be removed in lengths that represent a single days work for sealing the joints.

The joint grooves shall be cleaned, adequately primed and filled with approved sealer strictly in accordance with the manufacturers instructions.

On permanently exposed areas of structures, joint sealing is to be carried out with the aid of masking tape to form neatly defined surface limits to the sealer.

3.3.21 Water Stop Joints

Joints with water stops will be constructed as marked on the Drawings or requested by the Engineer.

- **Materials:**

  Plastic waterstop - Expansion joints; Non-expansion joint; liquid retaining structure. Ribbed type waterstops with a center bulb made by extruding elastomeric plastic compound with virgin polyvinyl chloride as the basic resins. The compound shall contain no reprocessed materials. Minimum tensile strength of waterstop shall be 125kg/cm^2 (1750 psi) unless otherwise indicated.

  Water stops will be furnished to the site as complete units having the shape and dimensions as indicated on the Drawings.

  The edges of the water stop shall be joined by welding since no overlap will be permitted.

  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 3mm. 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.

- **Installation:**

STEP 1

Place concrete below waterstop first, remove all air voids by vibrating thoroughly. Install waterstops for all joints where indicated on the Drawings. Waterstops shall be continuous around all corners and intersections so that a continuous seal is provided. Splices shall be made by welding in accordance with the manufacturer's recommendations, subject to acceptance of the Engineer. Only manufacturer's special approved tools shall be used for welding. The finished splices shall provide a cross-section that is dense and free of porosity.

STEP 2

Properly secure waterstops in wall joints before concrete is placed. Clamp both edges of the waterstop to reinforcing steel with black annealed steel tie wire as specified for tying reinforcing steel and secure in place so that the waterstop will be perpendicular to the joint and remain in the required position during concrete placement. Confirm there are no air voids, lift waterstop. A continuous impression of the waterstop, including edge of bulb, should be visible in the fresh concrete, Continue this procedure along the entire poured joint, end to end.

If a continuous impression is confirmed, with step 4. If a void larger than 6mm in diameter is present anywhere in the waterstop impression, proceed with step 3.

STEP 3

If a void larger than 6mm in diameter is present in the waterstop impression, additional concrete shall be placed under the waterstop, vibrated and step 2 repeated.

STEP 4

Finish placing concrete above the waterstop to top of slab.

STEP 5

The spacing of the waterstop ties shall match the spacing of the adjacent reinforcing, but need not be spaced closer than 300mm (12in) on center.

STEP 6

Each piece of the waterstop shall be of maximum practicable length to provide a minimum number of splices.

STEP 7

Waterstops shall be installed so that half of the width will be embedded on each side of the joint. Care shall be exercised to ensure that the waterstop is completely embedded in void-free concrete.

Figure 3.1
Water Stop Joint

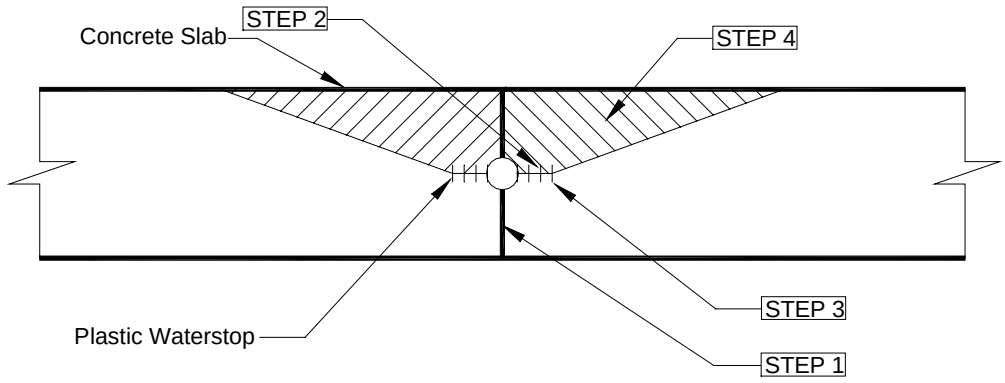
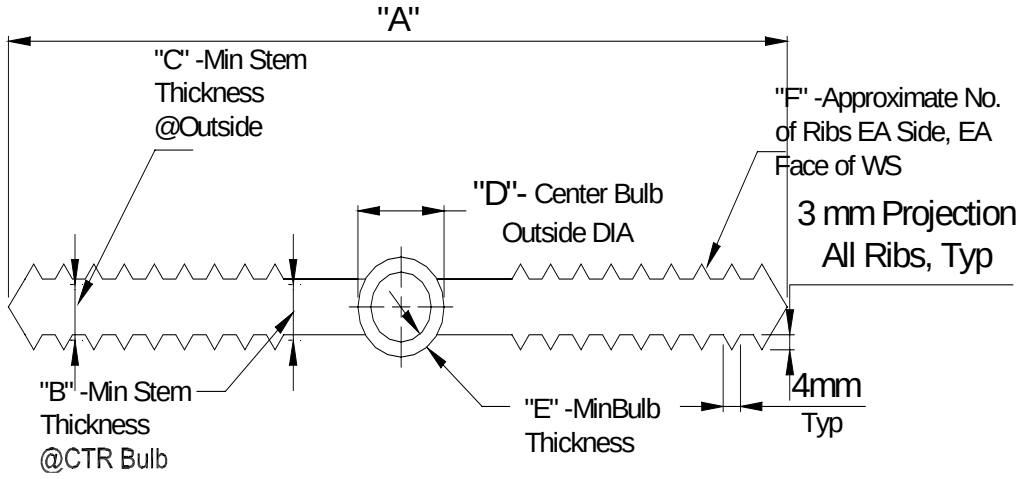


Figure 3.2
Water Stop



Size	"A"	"B"	"C"	"D"	"E"	"F"
100mmX5mm	100mm	5mm	5mm	19mm	6mm	4
150mmX10mm	150mm	10mm	10mm	22mm	6mm	6
225mmX10mm	225mm	10mm	10mm	25mm	6mm	8

3.3.22 Joint Filler

The joint filler shall be compressible cellular and resilient and shall not become brittle in cold weather.

Joint filler for use in potable water service water tanks shall be of granulated cork bound insoluble synthetic resin. For other water retaining structures the joint filler shall be granulated cork bound with bitumen. For all other structures joint filler is bitumen impregnated fibreboard.

3.3.23 Joint Sealer

The joint sealer shall be non-degradable for its particular application. It shall be elastoplastic and shall possess a movement accommodation factor of at least 25 percent. Exposed joint sealer consists of polysulphide rubber based compound complying BS 4254. Concealed joint sealer shall consist of an oil based mastic compound. The joint shall have a minimum life expectancy of 15 years.

Where the joint sealer is to be contact with a protective coating as shown on the Drawings the Contractor shall satisfy the Engineer that the sealer and the protective coating are compatible.

The sealer shall be stored in accordance with the manufacturer's instructions and no sealer shall be used after its shelf life has elapsed.

To ensure non-adhesion to the back of the joint cavity a bond breaker tape is to be fixed where this is specified by the manufacturer of the sealer.

Primer shall be obtained from the same manufacturer as the sealer.

3.3.24 Machinery Bases and Grouting in

Bases to take machinery and associated pipework shall be constructed in fair face concrete to the dimensions shown on the approved Machinery Drawings or as ordered by the Engineer. The mounting surface of the base shall be steel floated to true and level planes.

The structural concrete on which the bases are to be erected shall be prepared by hacking and cleaning off.

Bolt pockets and lead-ins for grout shall be formed by a means which shall have the approval of the Engineer's Representative.

The complete bases shall be offered for inspection to the machinery supplier. When the machinery has been erected the bolt pockets shall on the instruction of the Engineer's Representative be completely filled an approved non-shrink grout.

Non-shrink grout shall be premixed cementitious grout having a minimum compressive strength of 350kg/sq.cm at 28 days.

The machinery will be run under the supervision of the Engineer's Representative one the grout has hardened. When so directed the Contractor shall complete the grouting operation by filling the space between the top of the concrete and the underside of the machinery base plate with non-shrink grout.

3.3.25 Fix and Build into Concrete and Blockwork

Openings left in concrete walls for the subsequent fitting and concreting in of pipework and fittings shall have the soffit of the opening inclined at not less than one in four to the horizontal. The periphery of the opening shall be formed as specified construction joints.

After placing the pipe or fitting the remaining void shall be carefully packed with concrete of the appropriate class, or with non-shrink grout every care being taken to produce a watertight joint. The concrete shall be retained by a shutter which shall be up as concrete filling proceeds. The Contractor shall ascertain from the suppliers of prefabricated or manufactured goods any special fixing instructions and shall refer them to the Engineer for approval.

Capstan heads and intermediate guides shall be set so that the spindles operate smoothly in true alignment.

Where fixing bolts are positioned by means of a template they shall be supported and braced to remain in perfect alignment during the setting of the concrete or grout. Where boxing out for horizontal bolts or fittings is provided, the boxing out and refilling shall be as specified above for pipes and fittings through walls.

The Contractor may use expansion bolts instead of anchor bolts with bolt pockets subject to the approval of the Engineer.

In fixing penstocks or flanges to concrete or blockwork the gate or door shall be in closed position. The frame shall be support against the face of the concrete or blockwork and the nuts tightened by hand. The space between the wall and the frame shall be filled solid with cement mortar or hard setting butyl mastic not in strip form. After the hardening of the mortar or mastic the nuts shall be properly tightened in a sequence to prevent any distortion of the frame and ensure bearing against the wall. Aluminium penstocks or fittings shall be bedded in hard setting mastic.

Care must be taken to protect faces and other working parts from mortar and other droppings. Under no circumstances shall aluminium be built in wet concrete or be fixed to green concrete.

3.3.26 Tie Holes

Tie holes, after being cleaned and dampened, shall be filled solid with patching mortar such as high build epoxy reinstatement mortar.

3.3.27 Floor Hardener

Floor hardener shall be industrial flooring aggregate. It shall be mixed with cement and sand (1:3) and shall be applied monolithically to the concrete base within two hours of casting to a finished thickness of 20mm and steel trowelled to an even and smooth surface all in accordance with the manufacturer's instructions.

3.3.28 Granolithic Screed

Material for granolithic paving shall be mixed using the following ingredients: One part of Portland cement to two parts or weight of clean granite chippings graded 10mm down bur excluding dust with clean water sufficient to form a stiff but workable mix and such proportions of sharp silicious and to BS 882 as is required to fill all voids and proving.

The paving shall be laid to a minimum thickness of 50mm. Expansion joints shall be of the simple butt type formed at maximum intervals of four meters or as otherwise shown on the Drawings.

3.3.29 Plasterwork

Mixing of Ingredients:

Except where hand-mixing of small batches is approved by the Engineer, mechanical mixers of an approved type shall be used for the mixing of plaster. Frozen, caked or lumped materials shall not be used.

Mechanical mixers, mixing boxes and tools shall be cleaned after the mixing of each batch and kept free of plaster from previous mixes. Plaster shall be thoroughly mixed with the proper amount of water until uniform in colour and consistency. Retempering will not be permitted and all plaster which has begun to stiffen shall be discharged.

All tools, implements, vessels and surfaces shall at all times be kept scrupulously clean and strict precautions shall be taken to avoid the plaster or other materials becoming contaminated by pieces of partially set material which would tend to retard or accelerate the setting time.

Preparation of Surfaces:

All surfaces to be plastered shall be clean and free from dust, grease, loose or projecting mortar and all traces of salts are to be thoroughly sprayed with water, but all free water shall be allowed to dry and disappear form the surface before the plaster is applied.

Plastering shall not be commenced until the background has been suitably prepared.

Before plastering is commenced all junctions between differing materials shall be reinforced. This shall apply where walls join columns and beams, particularly where flush, and similar situations where cracks are likely to develop and as directed by the Engineer. The reinforcement shall consist of strip of non-metallic wire mesh 15cm wide which shall be plugged, or stapled as required at intervals of not exceeding 45cm at both edges or as per manufacturer instructions.

Environmental Conditions:

Maintain a minimum temperature of 10 deg C (50 deg F) in spaces being plastered. Maintain adequate continuous ventilation in plastered spaces until plaster is dry. Protect plaster from freezing and too rapid drying. Do not plaster on rusted metal materials.

Plaster Materials:

1. Portland cement shall conform to *PS 54*.
2. Lime shall be special finishing hydrated lime conforming to *PS 136*.
3. Sand shall be clean, sharp, washed, natural and free from soluble salts and organic matter. Sand shall comply with *PS 48* and when dry shall pass No. 4 sieve.
4. Fiber shall be pure manilla, glass or synthetic fiber, good quality 13 to 50mm (1/2 to 2in) in length, free from grease, oil, dirt and other impurities. No asbestos will be allowed.
5. Water shall be clean, fresh, potable water, complying with *PS 41*.

Plastering Execution:

All plastering shall be executed in a neat workman like manner and internal and external angles shall be true, straight and plumb. Plaster shall be made good adjacent to wood or metal frames,

Skirting and around pipes or other fittings. The finish surface shall be true to shape and angle even in all directions, with straight arises frees of cracks and trowel marks and to the satisfaction of the Engineer.

On all external surfaces and on all smooth internal surfaces spatter dash of cement and sand which shall contain 450kgs of cement per one-meter cube of sand shall be applied and allowed to dry before rendering is commenced. All surfaces of walls shall be wetted immediately prior to applying the first coat of rendering and this shall be allowed to thoroughly dry out before the next coat is applied. The minimum thickness of this coat shall be 5mm applied with sufficient pressure to force it through and completely embed metal lath, or to form a good bond on concrete or masonry.

After the application of the spatter dash, the base coat shall be applied after the spatter dash coat has set but in no case before 24 hours after its application. The base coat shall be composed of 450kgs. of cement per one cubic meter of sand, this coat shall be applied with sufficient force to prevent air pockets and to secure a good bond with the wetted receiving surfaces, the thickness shall be designed approximately at 15mm. but governed by the guide screeds, curing with clean water shall continue for five consecutive days.

The Contractor shall from vertical guide screeds 10cm wide. The spacing shall not exceed 1.50 meters.

The screeds shall be plumb and in the same plane with each other. The sides of the screed shall be left rough to bond with plaster, the surface shall be smooth.

The finishing coat shall only be applied after the base coat has seasoned, where cement plaster with a trowelled finish is specified; the finish coat shall be first floated to a true, even and wetted surface, then trowelled in a manner that will force the sand particles down in to the plaster and with the final trowelling leave the surface finished smooth and free from rough areas, trowel marks, checks or other blemishes. The finishing coat shall have a reasonably uniform thickness of approximately 3-5mm. curing with clean water shall continue for seven days.

Patching plasterwork shall conform to all of the above procedures and the finishing coat shall be flush with old plaster and of the same appearance. All patching shall be carried out under the Engineer's supervision and to his satisfaction, and according to manufacturer instructions.

The finished surface shall be true to shape and angle oven in all directions, with straight arrises free of cracks and trowel marks and to the entire satisfaction of the Engineer.

Proportions of Internal and External Plaster:

Internal and external plaster shall be composed of 450kg of cement per one cubic meter of sand. However the spatter dash application shall be composed of 450kg of cement per one cubic meter of sand.

Plastering shall be applied in three coats unless otherwise specified or indicated on the Drawings.

Screed shall be laid and ruled as necessary to allow for a total thickness of 15mm for external and internal plaster and the rendering shall be applied to the required thickness.

Waterproofing Plaster:

Mixing of plaster ingredients and preparation of surfaces to be plastered with waterproofing plaster shall be as specified above.

Rendering coat shall contain 450kg of ordinary Portland Cement per cubic meter of clean coarse salt free sand and with admixture of waterproofing compound as specified added in accordance with the printed instructions of the manufacture, shall be applied and the surfaces shall be trowelled hard smooth and allowed to dry. All surfaces of plastered areas shall be cured for minimum of 7 days.

Cutting and Patching:

Cut, patch, point-up and repair plaster as necessary to accommodate other work and to restore cracks dents and imperfections. Repair or replace work to eliminate blisters, excessive crazing and check cracking, dryouts, effllorescence, sweat-outs and similar defects, including areas of the work which do not comply with specified tolerances, and where bond to the substrate has failed.

Cleaning and Protection:

Remove temporary protection and enclosure of other work. Promptly remove plaster from door frames, windows, and other surfaces which are not be plastered. Repair decks, walls and other surfaces which have been stained, marred or otherwise damaged during the plastering work. When plastering work is completed, remove unused materials, containers, equipment and clean decks of plaster debris.

Provide approved procedures for protection of plaster from deterioration and damage during the remainder of the construction period.

Appropriate Epoxy paint should be applied for the internal walls of the tank according to manufacturer requirements and to the satisfaction of the Engineer.

3.3.30 Precast Elements

Precast elements shall be either of concrete or mortar as shown on the Drawings and as specified hereinafter

(i) Materials:

a. Precast Concrete Elements: Precast concrete elements shall be of plain or reinforced concrete dimensions, thickness and reinforcement rods and bars shown on the Drawings and stated in the Bill of Quantities.

b. Precast Mortar Elements: Moist tamped mortar precast elements shall be of a mixture of ordinary or tinted cement and sand (fine aggregate) approximately in the proportions of one part cement to two and one-half parts of sand. The sand shall be specially selected for color and grading. The sand shall be screened through 3mm square meshes and all oversize particles shall be discarded. Only sufficient water shall be used in mixing to permit the immediate removal of the

member from the mould. The pattern, dimensions and thickness shall be as shown on the Drawings and/or as directed in writing by the Engineer.

c. Mortar: Mortar for joining the precast elements shall be composed of one part of Portland cement and three parts of clean sand unless otherwise specified. The cement and sand shall conform to the requirements Portland cement and aggregate for mortar specified hereinbefore.

(ii) Fabrication: Precast concrete or mortar elements shall be cast in Mortar tight metal lined timber moulds and shall be mechanically vibrated when cast. The Precast elements shall be removed from the moulds as soon as practicable and shall be kept damp for a period of at least 10 days. Any elements that show checking or soft corners or surfaces shall be rejected. The method of storage and handling shall be such as to preserve true and even edges and corners, any precast element which becomes chipped, marred or cracked before or during the process of placing shall be rejected, sampling of precast elements shall be submitted to the Engineer for approval, prior to fabrication, at the Contractor's own expense.

(iii) Workmanship: All precast concrete or mortar elements shall be well cleaned and thoroughly wetted with clean water before placing in their positions shown on the Drawings. The precast elements shall be bedded and jointed in cement and sand mortar (1:3) mix and the joints raked out on both faces to receive plaster or pointing as indicated on the Drawings and/or stated in the Bill of Quantities to the satisfaction of the Engineer.

3.3.31 Prestressed Concrete Construction

(i) Purpose: Prestressed concrete shall be used for long spans where ordinary reinforced concrete technically and economically is not feasible.

(ii) Scope: The works shall consist of the specifications for prestressing steel, prestressing components, prestressing equipment and plant and construction requirements of prestressed concrete.

(iii) Materials:

a. Concrete: Concrete for prestressing shall be in accordance with the requirements of Section 3.3 above.

b. Prestressing Steel:

Steel Wire: Steel wire shall comply with ASTM A421, or with BS5896.

Stress-Relieved Seven-Wire Strand: Stress-Relieved Seven-Wire Strand shall comply with ASTM416 or with BS5896.

High Tensile Steel Bar: High tensile steel bars for prestressed concrete shall comply with ASTM A722 or with BS4486.

Nineteen-Wire Strand: Nineteen-wire strand shall comply with BS4757.

c. Prestressing Components: Prestressing components, such as cable ducts, anchorages couplers, shall be of approved types suitable for types of cables and bars used.

d. Grout: Grout shall be water and cement complying with the requirements of Section 3.2.

Epoxy Bonding Agents for Precast Segmental Construction:

Epoxy bonding agents for match cast joints shall be thermosetting 100% solid compositions that do not contain solvent or any non reactive organic ingredient except for pigments required for colouring. Epoxy bonding agents shall be of two components, a resin and a hardener. The two components shall be distinctly pigmented, so that mixing products a third colour similar to the concrete in the segments to be joined, and shall be packaged in preportioned, labelled, ready-to-use containers.

Epoxy bonding agents shall be insensitive to damp conditions during application and, after curing, shall exhibit high bonding strength to cured concrete, good water resistivity, low creep characteristics, and tensile strength greater than the concrete. In addition, the epoxy bonding agents shall function as a lubricant during the joining of the match cast segments, as a filler to accurately match the surface of the segments being joined, and as a durable, watertight bond at the joint.

The physical, chemical and mechanical properties of epoxy bonding agents shall satisfy the recommendations of Federation Internationale de la Precontrainte (FIP) "Proposals for a standard for acceptance tests and verifications of epoxy bonding agents for segmental construction".

(iv) Definition:

a. Prestressed Concrete: Concrete in which internal stresses of such magnitude and distribution are introduced that the tensile stresses resulting from the service loads are counteracted to a desired degree; in reinforced concrete the prestress is commonly introduced by tensioning the tendons.

b. Prestressing Steel: Steel wire, strand or bars used for prestressing of concrete.

c. Post-Tensioning: The process when the prestressing steel is tensioned after the concrete has hardened.

d. Pre-Tensioning: Process when the prestressing steel is tensioned against independent anchorages before the concrete is placed rounds.

e. Cable and Tendon: Cable and tendon both refer to a bundle of prestressing steel of the same type and size bundled together to be contained within a duct and stressed, individually or collectively, from the same anchorage.

f. Prestressing System: A proprietary system of applying prestress and included anchorages, couplers and jacks but does not necessarily includes prestressing steel and cable ducts.

(v) Construction:

a. General: The Contractor shall submit to the Engineer for his approval full details of the proposed prestressing system and suppliers of the basic materials and

components. No system shall be incorporated in the works until approved by the Engineer.

Prestressing operations shall be carried out only under the direction of an experienced and competent supervisor and all personnel operating the stressing equipment shall have been properly trained in its use. As an addition to the normal precautions against accident for the whole of the work, special precautions shall be taken when working with or near tendons which have been tensioned or are being tensioned.

b. Cable Ducts: Ducts shall be maintained in their correct positions during placing of the concrete. Where members are made up of precast units stressed together, the ducts in the joints between the units shall be in perfect alignment and joined securely so as to allow unimpeded cable threading and pulling and prevent the ingress of the epoxy mortar used for gluing the several units together before stressing. Details of such joints shall first be approved by the Engineer. The tolerance in the location of the sheath shall be plus or minus 3mm.

Joints shall be kept to a practicable minimum and each joint adequately sealed against the ingress of any material. Joints in adjacent sheaths shall be staggered by at least 300mm.

Ducts shall be kept free of any matter detrimental to the bond between the sheath and the grout and, except for material sealing a sheath joint, between the sheath and the concrete.

The ends of all ducts shall be sealed and protected until the tendon is threaded through and the stressing operations are commenced. Where tendons in sheath on its own are left exposed to atmosphere rust inhibitors shall be used per the maker's specification to prevent rusting and corrosion of the inside of sheaths. They shall be flushed with clean water before the tendons are grouted. The Contractor is responsible for carrying out these measures at his own expense.

c. Prestressing Steel: All wires or strands stressed at the same time shall be taken from the same parcel. Each cable shall be tagged with its number and the coil number of the steel used.

Tendons shall not be welded within the length to be tensioned and, unless other methods of cutting are approved by the Engineer, tendons shall be sawn or cropped using an abrasive disc cutter.

Tendons shall be built into the work strictly in accordance with the system which is being employed.

Tendons shall not be kinked or twisted and individual wires or strands shall be readily identifiable at each of the members. No strand which has become unravelled shall be used in the work.

d. Anchorages: All anchorages shall be approved cast anchorages. Anchor cones, blocks and plates shall be positioned and maintained during concreting so that the centreline of the duct passes axially through the anchorage assembly.

All baring surfaces of the anchorages shall be clean prior to concreting and tensioning.

If proprietary forms of anchorage are used, the anchoring procedure shall be strictly in accordance with the manufacturer's instructions and recommendations.

Any allowance for draw-in of the tendon during anchoring shall be in accordance with the Engineer's instructions, and the actual slip occurring shall be recorded for each individual anchorage.

e. Jacks for Prestressing: All jacks used for prestressing shall be of the type applicable to the system adopted. The accuracy of the load metering equipment shall be checked to the satisfaction of the Engineer at the start of the work each day it has to be used and whenever the equipment is moved to a different job.

Documentary proof shall be provided confirming that all jacks have been fully over-hauled and checked by an agent approved by the manufacturer of the equipment. Each jack shall be accompanied by a test certificate indicating that is has been tested and calibrated by the manufacturer or by an approved testing laboratory up to a load equal to the full capacity of the jack within a period of two years prior to the commencement of prestressing.

All gages, load cells, dynamometers and other devices used for measuring the stressing force shall have an accuracy of within plus or minus 1.5 percent. Pressure gages shall have a capacity and calibrated cell such that the working pressure required to stress the tendons to the fully stated load lies within the central half of the range of the gage.

Each gage shall have a calibration certificate issued by an approved test laboratory. All pressure gages shall be so constructed that they may be calibrated, either directly by an approved testing laboratory, or by compressing with a meter gage which has itself been calibrated by an approved testing laboratory.

All pressure gages shall be re-calibrated before use and at intervals of 14 days during the prestressing operation. The Engineer will order re-calibration of any pressure gage at any time should be have reason to suspect damage to or faulty operation of the gage.

The accuracy of all prestressing and load measuring equipment shall be checked whenever required by the Engineer. The Contractor shall provide a rig suitable in the opinion of the Engineer, for all checking and calibration of any jacking system consisting of jacks and associated load devices, pressure gages and dynamometers.

f. Grout for Ducts: Unless otherwise directed or agreed as a result of grouting trials, the grout shall consist only of ordinary Portland cement and water. The water cement ratio shall be as low as possible consistent with necessary workability and under no circumstances be higher than 0.45 and not be subject to bleeding in excess of 2 percent after 3 hours, or 4 percent maximum. When measured at 18 degrees C in covered glass cylinder approximately 100mm water shall be reabsorbed after 24 hours.

Grout shall be mixed for a minimum of two minutes and until a uniform consistency is obtained. The pumpability of the grout may be determined in accordance with the US Corps of Engineers Method CRD-C79 in which case the efflux time of the grout sample immediately after mixing shall not be less than 11 seconds.

Admixture containing chlorides or nitrates shall not be used. Other admixtures may be used only with the written permission of the Engineer and shall be applied strictly in accordance with the manufacturer's instruction.

The design for grout mix shall be tested in accordance with ASTM C490 for longitudinal change. Each design mix and each batch mix shall be tested for vertical dimensional change.

g. Plant for Grouting: The grout mixer shall produce a grout of colloidal consistency. The grout injector shall be capable of continuous operation with a sensibly constant pressure up to 0.7 Newton per square millimetre and shall include a system of circulating or agitating the grout while actual grouting is not in progress. All baffles to the pump shall be fitted with sieve strainers of 1.0mm nominal aperture size to ASTM E11. The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a nozzle which can be locked off without loss of pressure in the duct.

The pressure gages shall be calibrated before they are first used in the work and thereafter as required by the Engineer. All equipment shall be thoroughly washed with clean water at least once every 3 hours during the grouting operations and at the end of use each day.

(vi) Post-Tension Construction:

a. General: Immediately before tensioning, the contractor shall prove that all tendons are free to move between jacking points and that members are fee to accommodate the horizontal and vertical movements due to the application of prestress.

Unless otherwise specified, concrete shall not be stressed until it has reached the age at which at least 2 test specimens taken from it attain the specified transfer strength. The test specimens shall be cured in similar conditions to the concrete to which they relate. The Contractor shall cast sufficient specimens to demonstrate that the required strength of the concrete at transfer has been reached.

Where members consist of jointed elements the strength at transfer of the jointing material shall be at least equivalent to the specified transfer strength of the member.

b. Tension Procedures: The Contractor shall establish the datum point for measuring extension and jack pressure to the satisfaction of the Engineer.

The Contractor shall add to the specified forces and allowance where necessary for anchorage friction, wedge pull-in, jack losses and friction due to duct alignment and curvature. The total forces and calculated extensions shall be agreed with the Engineer before stressing is commenced.

Immediately after anchoring, the stresses in the tendons shall not exceed 75 percent of their ultimate tensile strength. During stressing the value shall not exceed 80 percent.

The tendons shall be stressed at a gradual and steady rate until they attain the force and extension specified.

If the measured extension differs by more than 5 percent from the estimated extension, corrective action shall be taken as directed by the Engineer.

The force in the tendons shall be obtained from reading on a load cell or pressure gage, and the extension of the tendons measured. Due allowance must be made for taking up slack in the tendons.

Stressing shall be from both ends unless otherwise specified or agreed by the Engineer.

Where stressing from on end only, the pull-in at the end remote from the jack shall be accurately measured and the appropriate allowance made in the measured extension at the jacking end.

When the specified force, including any overload of short duration, has been applied, to the satisfaction of the Engineer, the tendons shall be anchored. The jack pressures shall then be released in such a way as to avoid shock to the anchorage of tendons.

If the pull-in of the tendons at completion of anchoring is greater than that stipulated by the Engineer, tensioning shall be carried out afresh.

If it is necessary to cut the tendons to enable the ducts to be grouted, this shall be delayed as long as practicable up to the time of grouting. In all other cases, unless agreed otherwise by the Engineer, the tendons shall not be cropped less than 3 days after grouting.

The Contractor shall keep full and detailed records of all tensioning operations, including the measured extensions, pressure gage or load cell readings and the amount of pull-in at each anchorage. Copies of these records shall be supplied to the Engineer within 24 hours of each tensioning operation.

c. Grouting Procedures: Grouting trials shall be undertaken when required by the Engineer. All anchorages shall be sealed before grouting. Ducts shall not be grouted when the air temperature in the shade is lower than 3 degrees C. Grout shall not be above 32 degrees C during mixing or pumping and, if necessary, the mixing water shall be cooled.

All ducts shall be thoroughly cleaned by means of compressed air. Ducts formed without sheathing shall be filled with water at least one hour before grouting. Sheathed ducts shall not be filled with water unless required by the Engineer. Where ducts have been filled with water it shall be blown out by compressed air.

Ducts shall be grouted as soon as practicable after the tendons have been stressed and the Engineer's permission to commence has been obtained. The ducts shall be completely filled with grout. Grout shall be injected in one continuous operation and allowed to flow from the vents until the consistency is equivalent to that being injected.

Vents shall be sealed consecutively in the direction of flow and the injection tube sealed under pressure until the grout has set. The filled ducts shall be protected to the satisfaction of the Engineer to ensure that they are not subjected to shock or vibration for 1 day and that the temperature of the grout in them does not fall below 3 degrees C for three days after its injection. Two days after grouting, the level of grout in the injection and vent tubes shall be inspected and made good if necessary.

The Contractor shall keep fully detailed records of grouting including the date each duct was grouted, the proportion of the grout and any admixtures used, the pressure, details of any interruptions and topping up required. Copies of these records shall be supplied to the Engineer within three days of grouting.

Where required by the Engineer, the Contractor shall provide facilities and attendance for the radiographic testing of ducts.

(vii) Pre-Tension Construction:

a. If Pretensioned members tendons are specified as debonded from the concrete, they shall be covered with sleeves of PVC or other material approved by the Engineer. The ends of the sleeves shall be taped to the tendon to prevent the ingress of grout.

b. Unless otherwise agreed by the Engineer, tendons shall be stressed in accordance with the requirements of this Specifications.

c. Members shall be free to accommodate the horizontal and vertical movements due to the application of prestress.

d. When the concrete has attained the specified strength, the load shall be transferred gradually without severance of the tendons. The tendons shall then be trimmed back flush to the face of the concrete and specified protection applied to their ends.

e. All members shall be indelibly marked to show the specified member mark, the production line on which they were manufactured, the date on which the concrete was cast, the load applied and, if they are of symmetrical section, the face which will be uppermost when the member is in its correct, position in the work. The makings shall be so located that they are not exposed to view when the member is in its permanent position.

(viii) Testing:

a. Prestressing Steel: Before approval, at least two samples of the prestressing steel shall be tested at an approved independent laboratory for chemical composition, mechanical strength, relaxation and physical characteristics to the following standards:

1. Wires – AASHTO M204 (ASTM A421) or BS5896.
2. Bars – AASHTO M275 (ASTM A722) or BS4486.
3. Seven-Wire Strands – AASHTO M203 (ASTM A416) or BS5896.
4. Nineteen-Wire Strands – BS4757.

Subsequently, the Engineer may require additional samples, selected at random from materials on site, to be similarly tested.

When compression grips are used, not less than six, selected at random, shall be tested to failure using strands to be sued in the Works. The test will be witnessed by the Engineer or his appointed representative.

b. Anchorages: Before approval, at least two anchorages shall be tested at an approved laboratory to BS4447. Subsequently, the Engineer may require

additional samples, selected at random from materials on site, to be similarly tested.

For each anchorage type used in the works, the characteristic value of anchorage efficiency, determined in accordance with BS4447, shall be not less 90%.

c. Epoxy Bonding Agents: Epoxy bonding agents shall be tested for and satisfy the requirements of all the tests listed in the recommendations of FIP "Proposal for a standard for acceptance tests and verification of epoxy bonding agents for segmental construction".

d. Grout: Where the grouting operation is interrupted or where a blockage or suspected blockage occurs or where leakage of grout occurs or where leakage of grout occurs at locations other than at grout tubes, the Engineer shall order radiographic tests to be carried out at specific locations. Strict safety precautions shall be taken during radiography, and the storage, transportation and handling of radioactive materials shall meet current World Health recommendations.

(ix) Measurements:

a. What to Measure: Prestressing steel shall be measured by the weight in tonnes for each size and quality of wire, strand or bar installed and accepted.

In post-tensioning work, the prestressing steel shall be the actual length between the outermost surface of the anchorages except where couplers are used in which case, the prestressing steel shall be assumed to be continuous, without any flares, through the coupler.

In pre-tension work, the prestressing steel shall be the actual length between the outermost faces of the member.

b. Items not Measured: Cable ducts, duct couplers, grout tubes and steel chairs for the correct duct/tendon location are not measured for payment.

Anchor blocks for use in pre-tension work are not measured for payment.

Prestressing steel used in connection with temporary works are measured for payment even if such steel is left permanently in the member.

Epoxy bonding agent used in precast segmental construction shall not measured for payment.

Shear keys and location dowels used in precast segmental construction shall not be measured for payment.

Prestressing steel and anchorages used for applying temporary present to glued segments shall not be measured for payment.

Anchorages and couplers shall be measured by the number for each and capacity installed and accepted.

c. Inclusion in the Rates: The rates for items entered in the Bill of Quantities shall include for:

1. Items not measured.
2. Cement, water and additive used in making the grout.
3. All prestressing equipment and its calibration.

4. Plant, equipment and labour for all stressing and grout operations including making good all anchorage pockets as shown on Drawings or as directed by the Engineer.
5. All testing required in the Specifications.

Table 3.11
Unit of Measurement

Pay Items	Unit of Measurement
(1) Prestressing wires (state size and type)	Tonne
(2) Prestressing strands (state size and type)	Tonne
(3) Prestressing bars (state size and type)	Tonne

3.3.32 Measurement and Payment

All concrete structures shall be measured by volume in cubic meters of each type of concrete according to dimensions marked on the Drawings or as specified by the Engineer. Anchor or thrust blocks shall be measured for payment by no. of units.

Different classes of concrete shall be measured separately.

Concrete formed by different types of form and/or falsework shall be measured separately.

Concrete of the same class requiring the same falsework but different class of surface finish shall be measured separately.

All recesses, openings or any other space not actually filled with concrete shall be deducted in calculating the volume for payment. Any extra concrete which was cast due to the Contractor's negligence and is not marked specifically on the Drawings shall not be measured for payment.

Unit price quoted by Contractor shall include all works required to obtain designated concrete quality as well as supply of cement admixtures, and all aggregates, installing of forms and shutters and dismantling same, casting, vibrating, and compacting of concrete forming curved shapes as well as grooves or sleeves for pipes as may be required. Prices will include also taking samples, performing any laboratory tests that may be required by the Engineer and providing certificates of test results.

Reinforcing steel shall be measured for payment by weight as per Drawings or Engineer's instructions. No overlaps, neither any odds nor leftovers shall be counted as part of the total approved weight. Reinforcing bars shall not be measured for deduction.

Unit price for reinforcing steel shall include: supply, cleaning, bending, cutting, shaping, placing and tying of steel bars as well as overlaps, chairs and spacers.

No payment will be due for working joints. Joints with water stops will be measured for payment in meter length of complete joint. Price shall include: supply of P.V.C water stop,

placing, tying and jointing of water stop, applying of asphalt coat on joints face and protecting of exposed part of water stop.

The rates for items entered in the Bill of Quantities shall include for:

- Cement, aggregates, water and additives, including their testing, storage, handling and transportation.
- Washing of aggregates, if required.
- Ice, if required, added in the mix water.
- Plant, machinery and equipment required for the production of concrete.
- Design of mixes, taking samples and testing specimen.
- Transportation and delivery of concrete to work areas.
- Placing, vibrating and finishing of concrete.
- All formwork irrespective of the material used and the quality of surface finish specified.
- All falsework supporting and stabilising formwork.
- Curing of concrete.
- Corrective measures and the means of carrying them out required in the event of the concrete being not in accordance with the Drawing and/or Specifications.

Where granolithic skirtings are shown on the Drawings or ordered by the Engineer they shall be formed using the materials specified above. A concave fillet of 500mm radius shall be run at all junctions and the top edge of the skirting shall be rounded to a radius of 15mm.

1. Measurement of different grades of steel reinforcement will be based on the theoretical quantity of metric tonnes complete in place as shown on the Drawings or placed as ordered by the Engineer. No allowance will be made for clips, wire or order fastening devices for holding the reinforcement in place. Measurement will not be made of reinforcement chairs to separate slab steel or similar reinforcement to retain wall steel or similar usage elsewhere. Measurements of splices in reinforcement not shown on the Drawings will not be made, unless such splices were agreed or authorized by the Engineer.
2. Calculated weights shall be based upon Table 3.12.

Table 3.12
Weights and Areas of Reinforcing Bars

Diameter mm	Weight kg/m	Area mm^2	Diameter mm	Weight kg/m	Area mm^2
6	0.222	28	25	3.850	491
8	0.395	50	28	4.830	616
10	0.617	79	30	5.550	707
12	0.888	113	32	6.310	804
14	1.210	154	36	7.980	1018
16	1.580	201	40	9.870	1257
18	2.000	254	45	12.500	1590
20	2.470	314	50	15.400	1963
22	2.980	380			

3. Separate measurement for bars of different diameter but of the same grade shall not be made.

DIVISION 4: FENCES, GATES, PAINTING, LINING, COATING AND MISCELLANEOUS WORKS

4.1 Scope

The work covered under this Division shall include supplying all materials, accessories equipment labour and supervision for erecting and installing all work items, complete in accordance with these Specifications or as shown on the Drawings.

The fences and gates items shall comprise the following:

A. Chain link fence and gates.

B. Miscellaneous metalwork: Ladder rungs, access ladders, frames and gratings, frames and plate covers, safety racks, steel guides for emergency stop planks, valve boxes, standard steel pipes and anchors, and all other items of miscellaneous manufactured metalwork where shown on the Drawings.

Except as otherwise provided in this Division of the Specification or as shown on the Drawings, all surfaces of fences and gates shall be treated, coated and painted in accordance with the requirements of painting, lining and coating section of these Specifications or as shown on the Drawings.

4.2 Chain Link Fence

4.2.1 General

The fence shall be standard chain link fence with gates and a guard of stands of barbed wire in accordance with the details shown on the Drawings.

The Contractor supply all materials for the chain fence including fabric and barbed wire, posts, gates and accessories, cement, sand and coarse aggregate and other materials for complete erection of the fence, and padlocks.

The Contractor shall submit to the Engineer; for approved shop Drawings showing layout and details of construction and erection of fence and accessories required before starting any works.

4.2.2 Materials

A. Chain Link Fabric: The chain fabric shall be galvanised (zinc coated) steel fabric No. 11 gauge 3.05mm nominal wire diameter after coating. The Zinc coating should be according to *PS 442, PS 107, PS 141.*

B. Fence Posts, Top Nails and Braces: Except as otherwise provided in this paragraph or shown on the Drawings fence posts, top rails and braces shall be galvanised (zinc coated) standard steel pipes in accordance with *PS 442, PS107, PS 141*.

C. Gates and Gate Accessories: Except as otherwise provided in this paragraph, gates and gate accessories shall be furnished in accordance with Contract Tender Drawings.

Gates shall be swing-type gates with zinc coated, round tubular frames. The gate fabric shall be the same as furnished under paragraph (a) above.

Each gate leaf shall be equipped with one pair of malleable iron hinges not less than 75 mm (3") in width that will provide full gate opening between gate posts. The hinges shall be designed to neither twist or turn under gate action and shall allow the gates to swing a full 180 degrees to lie along the parallel to the fence line. The gate latches shall be of the fulcrum type with center drop rod or of the plunger- bar type latches shall be constructed so that the center drop rod or plunger bar cannot be raised when locked .

Gate hinges latches, stops, keepers and other accessories shall be zinc- coated steel, ductile iron, or malleable iron, except that wire ties and clip bolts and nuts may be of aluminium alloy. The zinc coating shall be according to *PS 442, PS 107, PS 141*. The barbed -wire guard at the top of each gate shall be in accordance with the Drawings.

D. Chain Link Accessories: Except as otherwise provided on the Tender Documents Drawings, chain link fence accessories shall be in accordance with the above mentioned related PS Standards.

Post caps, rails ends and barbed-wire support arms shall be zinc-coated steel malleable iron, or ductile iron. Rail sleeves, wire ties and clips, tension truss and shall be zinc coated steel, except that wire ties. Clip bolts and nuts may be of aluminium alloy.

The barbed wire shall be zinc coated according to ISO 7900, ISO 7989 or EN 10223-1.

4.2.3 Erection

Brush, ground surface irregularities, and other obstacles which would interfere with proper erection of the fence shall be cleared and removed in advance of starting other fencing work. The Contractor shall perform all required excavating, backfilling, and compacting of backfill for posts and gate stops. Posts shall be plumb and in alignment. Post and gate stops shall be set in concrete as shown. Where the nature of the material to be excavated is such that the holes for the footings cannot be excavated to the required dimensions and the concrete placed directly against the surfaces of the excavation, forms shall be used for the concrete.

Concrete used as footing for fence posts shall be class B250 in accordance with Division 3 of these Specifications.

Gates areas of galvanising shall be repaired in accordance with Section 4.4 of the Specifications. Except for painting damaged areas of galvanising, no other painting of the fence is required.

4.2.4 Measurement

Chain link fence shall be measured by linear meter furnished, installed, completed and accepted. Measure shall be of the horizontal (plan) length and height of fence, from center to center of end or corner posts . Gates and other gaps shall be excluded from measurement.

Gates shall be measured by the square meter of gate furnished, installed and accepted. Measurements shall be of the nominal height of the gate times the specified distance between the adjacent fence and gate support posts.

Payment shall include all excavation and concrete works used in casting the footing of the fence and gates posts.

4.3 Miscellaneous Metalworks

4.3.1 General

Furnishing and installing miscellaneous metalwork in item 4.1.b includes all items specified in this Division complete with all bolts, nuts, washers and anchors required for the installation in accordance with the Specification.

4.3.2 Materials

A. Structural Steel: Steel shapes, plates, flat and round bars, and straps shall conform to ISO 630 or EN 10056-1,2 or approved equivalent subjected to the Engineers approval.

B. Nuts, Bolts and Anchors: Bolts shall comply with ISO EN 4014, ISO EN 4016. Nuts shall comply with ISO EN 4032, ISO EN 4034, ISO 8992 or approved equivalent subjected to the Engineers approval. The bolts shall have square heads or hexagon heads. The length of bolt threads for anchor bolts shall be as required and the length of bolt threads for all other bolts shall be in accordance with ISO 8992 or EN 26157-1.

C. Ladders:

1. Out side ladders for water Tanks shall be of Galvanised steel or as specified in the Tender Documents. Ladders in side water tanks shall be of stainless steel or Aluminium or any other approved equivalent materials.
2. Ladders, ladder accessories and ladder clearances shall conform to the requirements of OSHA. Ladders shall be either aluminium or stainless steel.
3. Aluminum ladders shall be fabricated with 65mm by 13mm (2-1/2in by 1/2in) aluminum bar side rails spaced a minimum 460mm (18in) apart. Rungs shall be 19mm (3/4in) diameter aluminum bars spaced 300mm (12in) on center. Wall support brackets shall be Type 316 stainless steel spaced 2400mm (8ft) on center with Type 316 stainless steel fasteners. Where possible, the side rails shall be fastened to the floor with 13mm (1/2in) diameter Type 316 stainless steel expansion bolts.
4. Stainless steel ladders shall be fabricated with 65mm by 13mm (2-1/2in by 1/2in) stainless steel bar side rails spaced a minimum 460mm (18in) apart. Rungs shall be 19mm (3/4in) diameter stainless steel rods spaced 300mm (12in) on center. Ladders shall be fabricated from Type 316 stainless steel. The rungs shall be pass through the side rails, be plug welded on the exterior surface and the weld ground flush and smooth with the exterior surface. Wall support brackets shall be Type 316 stainless steel spaced 2400mm (8ft) on center with Type 316 stainless steel fasteners. Where

possible, the side rails shall be fastened to the floor with 13mm (1/2in) diameter Type 316 stainless steel expansion bolts.

5. Ladder cages shall be constructed as shown on the Tender Document Drawings.
6. Ladder safety post extensions shall be provided on all fixed ladders occurring below hatches and at locations indicated by the Drawings. The telescoping tubular safety post extension shall be secured to the ladder rungs with stainless steel fasteners and brackets.
7. Manhole rungs for cast-in-place and precast concrete shall be according to Tender Documents.

D. Steel Pipes: Steel Pipes shall be conform to *PS 141, PS 107 or PS 186* according to the Contract Drawings.

E. Fixed and Removable Handrail: Except as otherwise provided in this paragraph or shown on the Drawings: handrails shall be galvanised (zinc coated) standard steel pipe conforming to *PS 442, PS 107, PS 141.*

F. Materials for miscellaneous metalwork and specifically, covered herein by detailed specifications shall be new and of good commercial quality approved by the Engineer.

4.3.3 Fabrication Steel

Fabrication of metalwork shall be in accordance with the applicable provisions of the latest "Specification for the Design, Fabrication and Erection of Structural Steel for Building" including all supplementary provisions of AISC. All steel welding and work related thereto hall be performed in accordance with the 'American Welding Society Structural Welding Code'.

Surfaces to be welded shall be clean and free from scale and foreign matter, and all welding shall be done by the shielded-arc method. Welds shall be made as shown on the Drawings. All welds shall be ground smooth.

Before being laid out or worked, material shall be straight and free from sharp kinks and bends. Shearing and cutting by torch or electric arc shall be performed carefully and all portions of the work which will be exposed to view after completion shall be finished neatly. After fabrication, all materials shall be straight and true and free from kinks, twists and warps. If straightening is necessary, it shall be done by methods that will not injure the metal.

Unless otherwise noted, all items of ferrous metalwork shown on the Drawings shall be galvanized.

The surfaces of metalwork to be embedded in concrete shall be thoroughly cleaned of all dirt, grease, loose scale, grout, mortar and loose rust or other foreign substance immediately before the concrete is placed. All embedded metalwork shall be set accurately in position and shall be supported rigidly to prevent displacement during the placing of the concrete. The Contractor shall drill or drill and tap, as required all holes in metalwork required for installation of the metalwork.

The Contractor shall drill all holes in concrete required for the installation of expansion anchors. The Contractor shall slot, cut or split metalwork on site as required for installation with out affecting the water tightness of the structure.

4.3.4 Measurement

Structural and fabrication steel shall be measured by the ton, complete in place and accepted.

All metal fixings such as bolts and anchors and nuts shall not be measured for direct payment, but shall be considered as subsidiary works born on the metal works.

Steel pipes and hand rail shall be measured by the linear meter complete in place and accepted.

4.4 Painting, Lining and Coating

4.4.1 Scope of Work

The work covered by this section of the Specifications comprises furnishing of all materials, cleaning surfaces and applying the paint, protective coatings and lining to all metal surfaces as tabulated and specified herein. Items or surfaces not required to be painted or coated but which are adjacent to surfaces to be cleaned and painted shall be protected against contamination and damage during the cleaning and painting operations.

4.4.2 Painting and Coating

(i) General:

Painting, coating and priming should be applied according to Tender Documents requirements and Manufacturer instructions.

Particular care shall be taken to prevent sand or cleaning agents from entering moving mechanical linkage joints, bearings, and any cabinet or enclosure containing motors, pumps, electrical or other equipment, or accessories. Nameplates, instruction plates and similar plates shall be masked or otherwise protected during cleaning and painting operations.

Cleaning and painting operations shall be conducted in such a manner that dust or other contamination will not fall on wet, newly painted surfaces, and newly painted items shall not be moved until the paint is dry through.

All Contractor-applied coatings exposed to view, including any touch-up repair painting, shall present a uniform texture and colour-matched appearance.

Any items or surfaces damaged or contaminated by the Contractor's operations shall be returned to their original condition by and at the expense of the Contractor.

Before top coating any coated surfaces the Contractor shall re-clean any exposed surfaces and apply paint as necessary to restore damaged or defective surfaces to the specified condition.

Items which have been painted shall be handled with care and protected as necessary to preserve the coating in good condition.

Temporary or permanent welding for the convenience of the Contractor will not be permitted on areas where the welding will damage paint or other protective coatings unless the areas of coatings which would be damaged thereby are accessible for repairing and inspection.

Unless otherwise specified, the Contractor will not be required to disassemble machinery, equipment, or other metalwork for the purpose of painting the interiors.

The Contractor shall provide adequate ventilation, lighting, and the necessary safety equipment for the protection of the workmen during painting and coating operations.

(ii) Materials: All pigmented paints and primers shall be purchased in containers (recommended not larger than 19 Litre) or as packaged by the manufacturer. Containers shall be labelled with the material specification number , the batch number and the product expiring date.

Colours of finish paints shall be in accordance with paragraph V.

All colours and tints shall be prepared by the manufacturer. Tinting at the site will be permitted only with colours-in oil where specified for slight contrast between coats.

Materials shall be in accordance with the Palestinian Standards provided that the samples or certifications are identified with the proper Specification. The Contractor should provide samples for Engineers approval before ordering any material.

The Contractor should provide a certificate to ensure suitability and validity of the materials to be used for painting metal surfaces in contact with potable water have no hazardous effect on health.

a. Palestinian Standards*: PS 43, PS 91, PS 97 part1-part24, PS 97 part26-part31, PS 97 part33,PS 107, PS 114, PS 141, PS 154, PS 288, PS 442, PS 461, PS 471, PS 480, PS 528.*

(iii) Sampling, Testing ad Certification of Materials: The Engineer will require at the expense of the Contractor tests and/or certification of each type, batch, or colour of paints or related materials prior to use or application.

The Contractor shall furnish two copies of all purchase orders for paint or related materials to the Engineer. Copies of purchase orders shall be furnished far enough in advance of planned use so that samples, if required, will be available to the Engineer to allow a testing period of at least two weeks.

If required, manufacturer’s certification for each type, batch or colour of material shall state that the material is of the same composition as material which previously has been found to comply with the Specification. If requested, certifications shall also include the manufacturer's quality control test data.

The Contractor shall be responsible for the accuracy of all certifications submitted or data contained therein whether submitted by him, a manufacturer, a supplier, or a sub-contractor.

Each sample, purchase order, and/or certification shall be identified with the material specifications, the batch and quantity represented, the specification number schedule, production and expiry date under which the material is to be used.

The Contractor shall purchase the total quantity of each material that is expected to be used in a reasonable length of time (i.e., 1 year, or the minimum specified storage stability period of the material) to avoid repetitive purchases that would impose additional testing. The costs and delays from additional testing required as a result of either unnecessary small purchases or rejection of the materials submitted shall be the responsibility of the Contractor.

(iv) Preparation of Surfaces: Surface preparation shall be in accordance with the following methods. The method to be used for each item is indicated in the painting schedule.

Weld spatter, slag burrs, or other objectionable surface irregularities shall be removed or repaired before cleaning. Any contaminants to the paint coating, from cleaning operations or other sources, shall be removed before the surfaces are painted. Cleaning solvent shall be mineral spirits or xylene except that xylene shall be used for surfaces which require coal-tar coatings. Cleaning cloths and solvents shall be discarded before they become contaminated to the extent that a greasy film would resin on the surface being cleaned. The coating shall be applied soon after preparation of the surface.

If rust forms or the surfaces become otherwise contaminated in the interval between cleaning and painting, or between coats of paint, re-cleaning will be required. Any coatings not required by and not shown in the painting tabulation shall be removed from the surfaces by suitable and effective means, unless otherwise directed. All surfaces not specifically covered herein shall be prepared by methods common to good practice for the particular surface.

All oil and grease shall be removed from steel surfaces to be painted by the use of clean solvent and clean, lint-free wiping material.

The following are the stages for preparation of surfaces prior to application of painting:

a. Stage A: Dirt, scum, and any other contamination shall be removed by solvent cleaning, water washing, or other effective means. Surfaces with gloss or semi-gloss paints shall be sanded lightly.

b. Stage B: The surfaces shall be cleaned of all defective or damaged areas of existing paint, and of all loose rust, loose mill scale and other foreign substances by scraping, chipping, wire brushing, grit blasting, commercial grade sand blasting, or other effective means.

c. Stage C: The surfaces shall be blast cleaned to base metal, using dry, hard, sharp, sand or steel grit, to produce a grey-etched surface free of all foreign substances.

d. Stage D: Loose corrosion products or other foreign substances, if any, shall be removed by chipping, scraping, wire brushing, light etch blasting, or other equally effective means and the surface again cleaned with solvent. After the second solvent cleaning, the surfaces shall be treated with metal conditioner which has been diluted in acid-resistant containers with three parts (by volume) of clear water to one part (by volume) of metal conditioner. The solution shall be applied by spray, dip, or brush, allowed to remain on the metal surface for 2 to 10 minutes, then vigorously rinsed off with water (preferably hot), and the surface allowed to

dry thoroughly. (Note: Solution is strongly acidic and proper safety precautions shall be exercised in handling and use).

(v) Application: Materials shall be thoroughly mixed at the time of application. Surfaces shall be clean and, unless otherwise specified, free from moisture at the time of application. Items of metalwork to be painted that are not thoroughly dry at the time of paint application shall be heated to a sufficient temperature (27 C°) to dry off any moisture present before paint is applied. Heating, if used, shall be by a method which does not bring products of combustion into contact with surfaces being coated.

Effective means shall be provided for removing free oil and moisture from the air supply lines of all spraying equipment. Care shall be exercised during spray application to hold the nozzle sufficiently close to the surfaces being painted to avoid excessive evaporation of the volatile constituents and loss of material into the air, or the bridging over of crevices and corners. Spray equipment shall be equipped with mechanical agitators, pressure gauges, and pressure regulators. Nozzle pressure consistent with acceptable finish results shall be employed when spray painting.

Each coat shall be applied in such a manner as to produce an even film of uniform thickness which will completely cover irregularities, fill crevices, and be tightly bonded to the substrate or previous coat. Each coat shall be free from runs, pinholes, sags, laps, brush marks, voids, and other defects. Each coat shall be allowed to dry or to harden before the succeeding coat is applied.

The thickness of steel surfaces shall be measured by approved gauges and shall not be less than the minimum specified thickness at any point on the coating. Acceptance will be based on specified coverages, total dry-film thickness as measured by an Elcometer, Mikrotest, or other suitable dry-film thickness gauge, after the complete paint system has thoroughly dried.

If necessary to improve application properties, cold-applied paints may be heated by means of a hot-water bath to temperatures not exceeding 38 C°. Paint shall not be applied when the temperature of the item to be painted or of the surrounding air is under 7 C° except that vinyl resin paints shall not be applied when metal or air temperatures are above 43 C° or below 4 C°. Painting shall proceed only when the humidity and the temperatures of atmosphere and of surfaces to be painted are such that evaporation rather than condensation will result. Brush coats may be applied by the conventional brushing procedure, or the paint may be delivered to the surface in a fluid stream by means of spray equipment employing air pressure only on the material and the paint then spread immediately by brushing to a smooth uniform coating.

Unless otherwise specified, coatings on metalwork, part of which is to embedded after being coated, shall extend approximately 15cm into the concrete.

Red lead priming paint, enamels, and oil-base paints may be thinned if necessary to permit satisfactory application, in which event mineral spirits shall be used and the amount of thinner shall be kept to a minimum but in no event shall exceed 0.12 litres per litre of paint.

Tinting, where required for colour contrast, shall be accomplished by using not more than 23g of tinting colour per litre of paint.

Methods of preparing and applying paints and coatings not included in this Specification shall be in accordance with the manufacturer's instructions and the general requirements of this Specification.

4.4.3 Priming Paints

Priming paints should be applied according to Tender Documents requirements and *Manufacturer* instructions.

Prime paints should be according to PS 154.

4.4.4 Measurements and Payments

The cost of furnishing, preparing, and applying all materials for the cleaning, paint repairing, painting, or coating operations, and of furnishing and submitting purchase orders, certifications, and samples of paint shall be included in the applicable prices bid in the schedule for furnishing and installing the items to be painted.

DIVISION 5: PIPES MATERIALS

5.1 Work Included

This Division governs the Fabrication of Ductile, Steel, Polyethylene, GRP and PVC pipes in the diameters and pressure classes required under the Tender Documents requirements.

Pipes, fittings, accessories, and specials including protective coatings and joints materials shall be according to the latest editions of Standards and References specified in this Specifications or shall be equivalent and compatible to these Standards and References subjected to third party accredited (by the PSI) testing laboratory.

5.2 Submittals

The Contractor shall submit:

A. Manufacture valid quality certificates ISO or equivalent.

B. Detailed manufacturer's proposals for pipe and fitting manufacture, coating, lining and catalogs.

C. Certified copies of manufacturers' quality control test results and reports.

D. Certified copies of compliance for steel plate, rubber rings, coating and lining materials and other components of finished pipes and fittings.

E. Instruction manual.

With every consignment of pipes, fittings, accessories, and specials delivered under this Contract, the Contractor shall furnish a certificate worded as follows:

"This is to certify that the pipes, fittings, accessories, and specials delivered in this consignment comply with the required specifications and Standards".

No payment shall be made in respect of any consignment of pipes and specials, which is not accompanied by such certificate.

5.3 Quality of Pipes, Fittings, Accessories and Specials

The Contractor shall have a Quality Assurance System including:

A. Records of tests performed by manufacturers on materials brought in.

B. Sequential numbering of pipes and fittings.

C. All goods or materials supplied by the Contractor shall be new of first class quality and of the best workmanship and design.

The quality assurance system records shall be open to inspection by the Engineer, and shall be maintained in such a way that any pipe or fittings is identified by a unique sequential production number and can be uniquely related to each stage of its

manufacture including material origin and quality, date and time of each operation, operator(s) involved and results of relevant quality tests.

Testing of materials should be according to the Relevant Standards. The Contractor shall pass a complete set of the quality assurance records to the Engineer.

D. Pipes, fittings, accessories, and specials including their protective coating and joints materials, that will or may come into contact with potable water shall not constitute a toxic hazards, shall not support microbial growth, shall not cause taste or odor, cloudiness or discoloration of water, and shall be approved by a recognized certifying authorities as being suitable for use in portable water supply systems.

E. Pipes, fittings, accessories and specials are recommended to be furnished by a single Manufacturer.

5.4 Marking of Pipes and Specials

All pipes and specials supplied shall be bearing the following markings in triplicate on the outside of the pipe or special according to the Relevant Standards, that includes:

- Name or Trade Mark of the manufacturer.
- Date of manufacturing.
- Class or pressure rating.
- Nominal Diameter.
- Wall thickness.

The letters of the length of the pipe shall be painted on only after the pipes or specials have found to satisfy the tests and all other requirements of the Specifications and Standards. The sequential manufacturing number shall not only be painted on the pipe, but shall also be stamped indelibly onto the inside of the socket, or other approved location.

Approved, clearly identifiable colored bands shall be used to differentiate between sized and unsized pipes.

5.5 Spun Ductile Iron Pipes and Fittings

A. Spun ductile iron pipes and fittings (Flanged, Socket) of the various diameters shall be manufactured according to ISO 2531 or EN 545 with working pressure according to Tender Documents requirements.

B. The fittings and accessories shall comply with same specifications as for the pipes (ISO 2531 or EN 545).

C. All pipes shall have an internal cement mortar lining according to ISO 4179 or EN 545, odorless, tasteless, and suitable for the passage of chlorinated potable water.

For fittings, internal cement lining shall be according to ANSI/AWWA C104/A21.4.

The Contractor in accordance with the Manufacturer’s instructions shall repair small areas of damage in the lining.

The pipes shall be Zinc coated according to ISO 8179-1,2 or Zinc Aluminum coated pipes according to EN 545.

The thickness of the internal cement mortar lining of the pipes shall be according to ISO 4179 or EN 545 as follows:

Table 5.1
Internal Cement Mortar Lining Thickness

Pipe DN (mm)	Lining Thickness, e Mortar (mm)	Tolerance* (mm)
40-300	4.0	-1.5
350-600	5.0	-2.0
700-1200	6.0	-2.5
1400-2000	9.0	-3.0

* There is no upper limit

Pipes Coating:

A. The pipes and fittings shall be coated externally with a coating of applied bitumen conforming to the requirements specified in ISO 8179-1,2 or EN 545.

B. Polyethylene Sleeving shall be in accordance with ISO 8180 or EN 545.

C. Polyethylene external coating for pipes shall be in accordance with ISO 2531 or EN 545. Extruded Polyethylene external coating shall be in accordance with EN 545.

D. Polythurethane external coating shall be according to ISO 2531 or EN 545.

E. The gaskets shall comply with ISO 4633, ISO 7483 or EN 12560 (Joint rings, gaskets and Yarm for water pipeline shall not allow for bacterial growth).

F. Restrained Joints shall comply with ISO 10804-1.

G. The joint rings and rubber seals should be stored in accordance with ISO 2230.

H. The pressure rating of all fittings and components (including bends, tapers, flexible couplings, etc.) and specials shall be equal or greater than the test pressure of the respective pipeline in which they are to be fitted.

Flanged Joints:

Flanges shall be faced and drilled to conform with the dimensions specified in ISO 7005-2, ISO 2531 or EN 1092-2 for the nominal working pressures stated in the particular Specification BOQ and/or the Drawings and shall be of the raised face type. The requisite number suitable bolts, nuts, washers and gaskets shall be supplied for each flanged joint.

Bolts hole pitch circle shall comply with ISO 7005 or EN 1092. Bolts shall comply with ISO EN 4014, ISO EN 4016. Nuts shall be in accordance with ISO EN 4032, and ISO EN 4034.

Mechanical Couplings:

Mechanical couplings for jointing plain-ended pipes shall be of the Viking Johnson or similar approved type, which central register on the sleeve unless otherwise specified.

The joints (express joints, standard joints) shall be manufactured according to ISO 2531 or EN 545.

The joint rings and rubber seals shall be of natural rubber in accordance with ISO 4633, ISO 10221 or EN 681-1. All mechanical couplings shall be painted with a coat of shop primer.

Flange adapters for jointing flanged valves and fittings to plain-ended pipes shall also comply with the general requirements of this clause.

The nominal working pressure should be as in the Tender Documents.

5.6 Steel Pipes

Pipes shall be manufactured according to *PS 107, PS 141, PS 186*, high tensile, welded, with normal working pressure for pipes and fittings etc, of pressures according to Tender Documents requirements. Lining and coating shall be according to *PS 325, PS 325 Part 1-Part 6* or any other equivalent compatible standard.

The Contractor shall be responsible for ensuring that the pipe ends are suitably prepared in the works or in the field for each joint, according to the jointing method to be used in each case.

The manufacturer as required by the Palestinian Standards or any other equivalent and compatible standard shall supply a product data.

5.6.1 Joints

Joints shall be made at plant either by forging or by another process provided that the pipe and joint shall meet all radiography, x-ray, thickness dimension, mechanical stresses, chemical and other requirements of the Palestinian Standards. The thickness of the slop joint, which must be part of the pipe, shall be greater than or equal to the pipe thickness.

The joint shall be welded externally in the field and shall be completed internally by a rubber ring built into socket. The length of the socket shall be such that the rubber ring cannot undergo any damage during the field welding operation.

The gaskets shall comply with ISO 7483 or any equivalent compatible approved standard.

The jointing ring shall be of Ethylene Propylene Rubber (EPDM) or Styrene Butadiene Rubber (SBR) an approved shape and shall be securely fitted, by gluing in the plant, into the sockets against the cement mortar lining. The joint rings and rubber seals shall be according to ISO 4633.

5.6.2 Fittings

All fittings, bends, tees and tapers shall be manufactured of seamless of butt-welded steel pipes and shall comply with the relevant parts of ISO 3419 or EN 10224 (Draft), and EN 10253-1,2.

The wall thickness of fittings shall be the same as that of pipes as a minimum.

All fittings shall be internally cement lined at factory and externally coated with polyethylene.

The flanges shall be according to ISO 7005-1 or EN 1092-1. The working pressure shall be PN 10, PN 16, or according to Tender Documents requirments.

Each set of flange jointing materials shall be complete with nuts, bolts and washers. Joint rings and rubber seals shall be Ethylene Propylene Rubber (EPDM) comply with ISO 4097 or Styrene Butadiene Rubber (SBR) reinforced with two-ply flex fabric and complying with ISO 2322. Bolts shall be hexagonal and shall be in accordance with ISO EN 4014, ISO EN 4016 or EN 1515. Nuts shall comply with ISO EN 4032, and ISO EN 4034.

5.6.3 Internal Lining

The steel pipes and fittings shall have an internal cement mortar lining applied centrifugally. The lining shall be odourless, tasteless and suitable for conveyance of chlorinated potable water, using Portland cement to *PS 54* and conforming to all relevant requirements of *PS 325-1*, as well as being tested to that standard.

The sand shall consist of inert granular material having durable uncoated grains and shall meet the requirements of *PS 421* when sampled and tested.

The cement mortar lining shall cover the whole internal surface at the spigot end. At the socket end the cement mortar lining shall be stopped in the bevel of the socket at the jointing ring.

The internal unlined wall of the sockets shall be protected by suitable non-tainting approved bituminous or epoxy paint, applied to a properly prepared substrate.

The internal lining of joints shall be at least equal to that approved for pipes, and shall be applied by hand in the works after all welding, machining and fettling operations have been completed. Table 5.2 in this Division shows the internal cement mortar lining thickness according to PS 325-1.

Table 5.2
Internal Cement Lining Thickness

Pipe DN (mm)	Lining Thickness, (e) Mortar (mm)	Tolerance (mm)
50	2	+0.5
75-150	4	-1,+2
200-250	6	-1.5,+2.0
300-550	8	-1.5,+3.0
600-900	10	-1.5,+5.0
>950	13	-1.5,+5.0

5.6.4 External Coating

External coating of buried steel pipes and fittings shall be polyethylene sheathing according to *PS 325-2 to 6.*

The polyethylene coating shall be applied at manufacturers work plant.

In addition to tests for coating and coating material, the coating shall be tested for cathodic disbonding, all in accordance with *PS 325-2 to 6.*

Pipes and fittings that are not buried shall be externally coated with epoxy to suit site weather condition. Repairing the joints of pipes should be done by heated shrinkable sheets.

5.6.5 Size Pipes

Where required sized pipes shall be supplied truly circular throughout their length for cutting to provide closing lengths and to accept flexible couplings.

The tolerances on the outside diameters of such pipes shall be as set out in *PS 107, PS 141, and PS 186.*

5.6.6 Flexible Couplings and Flange Adapters

Flexible couplings and flange adaptors shall be of mild steel and shall be Viking-Johnson couplings or other similar approved type suitable for making a watertight flexible connection between plain-ended pipes or between a plain-ended and a flanged fitting.

Flexible mechanical couplings shall be without the center register. Unless otherwise specified, the external surfaces of couplings and adaptors shall be cleaned down to metallic finish and primed and painted with two coats of red lead oxide paint. The internal surfaces shall be similarly treated and protected with two coats of non-toxic approved epoxy bituminous paint.

All mechanical coupling shall be of appropriate internal diameter and shall be capable of withstanding the maximum works test pressure specified for the pipes they are to connect, at a joint deflection of up to 3 degrees in any direction.

All mechanical couplings and flange adaptors shall be supplied complete with all necessary coupling rings, nuts, bolts, washers and rubber rings. Joint rings and rubber seals shall comply with ISO 4633, and shall be made of Ethylene Propylene Rubber (EPDM) or Styrene Butadiene Rubber (SBR). The gaskets shall comply with ISO 7483.

Bolts shall be hexagonal with dimensions in accordance with ISO EN 4014, ISO EN 4016 or EN 1515, nuts shall comply with ISO EN 4032 and ISO EN 4034.

Where a harnessed steel flange adapter is shown on the Drawings, the bolts connecting the flange of the flexible flange adapter to the flange of the adjacent fitting shall be replaced by the bars threaded at both ends.

One threaded end of each tie bar shall pass through holes in the abutting flanges and be anchored by two nuts to make the flanged joint in the normal way. The other threaded end shall be anchored by two further nuts in a corresponding bolthole on the flanges soundly welded integrally onto the fitting which it is intended to harness to the adaptor.

The integrally cast flange on the flange-spigot shall be located such that, after the joint has been made and all nuts fully tightened, the integrally-cast flange is about 400mm axially from the abutting flanges.

The bolt circles on all the flanges shall comply with ISO 7005-1or EN 1092-1.

The threaded tie bars shall be machined from steel at least equal to that specified for flange bolts of corresponding duty and treaded in the same way. The threaded lengths shall allow the nuts to be run forward sufficiently to permit complete withdrawal of the tie bars from the flange of the abutting fitting without requiring any other joint to be dismantled.

The strength of the threaded tie-bars in both tension and compression shall be appropriate to the pressure rating of the flanged joints.

5.7 PVC Pipes

A. The major types of plastic pipes used for water-work industry are PE and PVC pipes. Plastic pipes are made by extrusion of compounded thermoplastic materials through specially designed extruders. Stabilizers, plasticizers, lubricants, pigments and other additives are mixed with the resins before extrusion of the end product.

B. PVC pipes shall comply with ISO 4422-1,2,5 or EN 1452-1,2,5. PVC fittings shall comply with ISO 4422-1,3,5, ISO 264, ISO 727-1 or EN 1452-1,3,5.

C. The joint rings and rubber seals shall comply with ISO 4633. Flanges shall comply with ISO 2536 and the adapters shall comply with ISO 3460.

5.7.1 PVC Joints

A. The joining of one pipe to another may be performed using various methods. Gasketed joints and solvent cement joints are covered in the following paragraphs.

B. Gasketed Joints: The assembly of the gasketed joint should be performed as recommended by the pipe manufacturer. The elastomeric gaskets may be supplied separately in packages or propositioned in the bell joint or coupling at the factory. Note that some joint designs provide permanent factory-installed gaskets. When gaskets are color coded, it is important that the pipe manufacturer or the manufacturer's literature be consulted for the significance. Lubricant should be applied as specified by the pipe manufacturer. Damage to the gaskets or the pipe may result from the use of unapproved lubricants. Use only lubricant supplied by the pipe manufacturer for use with gasketed PVC pipe in potable water systems.

C. Solvent Cement Joints: In special applications, solvent cemented joints may be required. Solvent cemented joints should be made in accordance with manufacturer's recommendations. Proper training of installation crews in the technique of solvent

cementing is advised to ensure reliable Joints. Techniques must be modified to accommodate significant changes in the environment. (For example, wind, moisture, dust, and temperature require proper consideration).

5.8 PE pipes

A. Polyethylene pipes shall be manufactured from high-density polyethylene containing only those antioxidants, UV stabilizers and pigments necessary for the manufacture of potable water black pipes, and comply with ISO 4427 or EN 12201-1,2,5 and EN 13244-1,2. Third party certificate should be provided to verify this. Polyethylene fittings shall be furnished according to ISO 11647, ISO 10508, ISO 12162 or EN 12201-1,3,5 or EN 13244-3 or any other equivalent compatible approved standard.

B. Mechanical joint, compression fittings, for the use with Polyethylene pressure pipes in water supply shall comply with EN 14236.

5.8.1 PE Joints

A. PE pipelines can be jointed by butt fusion, electro fusion and mechanical joints. The advantages of a PE integrated end load resistant system are usually achieved most economically by jointing using fusion-welding techniques. Butt fusion is perhaps more commonly applied although electro fusion may be preferred where butt fusion is impractical due to lack of space.

B. Only similar materials and similar wall thickness should be jointed by butt fusion. Guidance should be sought before attempting to join materials with different pressure ratings or with different diameters.

5.9 Fittings and Appurtenances

A. Piping systems include pipe and various appurtenances required in the control, operation, and maintenance of the systems. Proper design, installation, and operation of PVC and PE piping systems must relate to appurtenances as well as pipe.

B. Plastic service connections vary in size from small services supplying individual homes to large outlets for industrial users. Service lines are connected to water mains using one of the following methods, depending on the size and material type of the main:

- Tapping through service clamps or saddles,
- Tapping sleeves and valves for larger service connections, and
- Direct tapping.

C. Service clamps or saddles: Service connections may be made using a service clamp or saddle. When making this type of connection with the line under pressure, equipment is used which attached to the corporation stop and permits a cutting tool to be fed through the corporation stop to cut a hole in the main pipe. Cutting tools should be sharp and should not apply excessive pressure. No threading of the pipe wall is required since the corporation stop is threaded into the service clamp. Service clamps and saddles should be installed in accordance with manufacturer's recommendations.

D. Service clamps or saddles used with PVC water pipe mains should:

- Provide full support around the circumference of the pipe, and
- Provide a bearing area of sufficient width along the axis of the pipe, 2in. (50mm) minimum, ensuring that the pipe will not be distorted when the saddle is tightened.

E. Service clamps should not:

- Have lugs that will dig into the pipe when the saddle is tightened,
- Have a U-bolt type of strap that does not provide sufficient bearing area, or
- Have a clamping arrangement that is not fully contoured to the outside diameter of the pipe.

F. Tapping sleeves and valves: Tapping sleeves and valves are used when service connections larger than 2in. (50mm) must be made in the water main. Tapping sleeves may be used for making large taps under pressure. When tapping sleeves are ordered from the manufacturer, the outside diameter of the pipe being tapped, the size of the outlet desired, and the working pressure should be specified to ensure that the sleeve furnished will be satisfactory.

G. Tapping sleeves should be assembled in accordance with the manufacturer's directions. Drilling equipment can be purchased from sleeve manufacturers, who will also furnish instructions and/or instructors trained in making such taps. (Contractors who specialize in this type of work are also available in some areas).

H. Tapping sleeves should be well supported independently from the pipe during the tapping. Support used should be left in place after tapping. Thrust blocks should be used as with any other fitting or appurtenance.

I. *Direct tapping:* For some sizes of plastic and other types of pipes, service connections may be mad by the direct tapping of pipe wall and the Insertion of a corporate on stop. In direct tapping, proper use of specified direct tapping equipment, corporation stops, and a torque wrench is recommended. This procedure should be used with proper direction and instructions from the manufacturer of the pipe and the manufacturer of the direct tapping equipment.

5.10 Glass-Reinforced Polyster (GRP) Pipes

A. The high corrosion resistance and many other benefits of glass-reinforced polyster (GRP) pipes will be realized if the pipe is properely installed. GRP pipes and fittings shall comply with ISO 7370 or any other equivalent compatible approved standards.

B. GRP Fittings shall comply with ISO 7370.

C. GRP pipe, like virtually all pipes made with petrochemicals, can burn and is, therefore, not recommended for use in applications, which are exposed to intense heat or flame.

5.10.1 GRP Joints

A. GRP pipe sections are typically joined using GRP double bell couplings. Pipe and couplings may be supplied separately or the pipe may be supplied with a coupling installed at one end.

B. The couplings may be supplied with or without an elastomeric center stop registe.

C. Other joining systems such as flanges, mechanical couplings and layup joints may also be used with GRP pipes.

5.10.2 Fittings and Appurtenances

A. Special fittings for GRP pipes, such as "T", "Y", reducers, etc…, are available on request for various purposes.

B. The length of GRP pipe can be adjusted by cutting at the appropriate location using a circular saw with a masonry blade. Also, the pipe diameter can be slightly adjusted to suit the acceptable tolerance range by using a field lathe or grinder.

5.11 Measurements and Payments

All pipes shall be measured by linear meter, and the bends and other fittings should be measured by number (piece) or as specified in the Contract Tender Documents.

DIVISION 6: CHLORINATION SYSTEM AND PUMP ROOM

6.1 Scope

The work under this Division covers the chlorination system and the erection of operator's room (s) and the valve house, and other valve chambers. The exact location and layout of the blocks is shown on the Contract Drawings. The design of the operator's dwelling block and the valve house is standard in all works: civil, mechanical and electrical.

The Specifications of the works given in other Divisions shall apply to the works covered by this Division only in so far as their technical aspects are concerned. Although no reference is made to the specific Clauses of Divisions, the Contractor shall for every item of work, comply with the corresponding technical specification detailed elsewhere in the Specification.

Where differences appear between this Division and other Divisions of the Specification the requirement of this Division shall prevail.

6.2 General

Furnish all labour, materials, equipment and incidentals and install complete, ready for operation and field test the chlorination system as shown in the Tender Documents' Drawings and as specified herein.

6.2.1 Quality Assurance

1. All Chlorination system components shall be furnished by a certified qualified manufacturer.

2. The manufacturer shall have an international standard certification as ISO or equivalent.

3. The manufacturer shall furnish the chlorination system components services according to the operation and maintenance of each type of unit furnished and to instruct plant personnel in the proper care, maintenance and operation of each type of unit for full and adequate training of the system operators.

4. Equipment supplied shall conform to all aspects of the Specifications.

6.2.2 System Description

All of the equipment specified herein shall be furnished by a single manufacturer. The proper functioning of the chlorine system shall be the responsibility of the manufacturer and the Contractor. Chlorine solution from the chlorinators will flow via suitable, anti-corrosion type of pipes according to approved workshop drawings.

The dosage adjustment for the chlorinators will be at the chlorinators. The chlorine solution feed will be constant for the same flow rate, manual or automatic adjustment will be done according to variations in water flow rate as specified in Contract Tender Documents.

All of the equipment specified herein is intended to be standard equipment for use in a Chlorination system.

The injection device should operate only when water is being pumped, and the water pump should shut off the chlorination equipment fails or chlorine supply is depleted. Chlorine solution pressure at the point of injection should be not less than three times the pressure in the injected mainline

Follow manufacturer instructions and regulations regarding the liquid chlorine solution while standing or while standing, exposure to air and sunlight to ensure solution quality and performance.

A free chlorine residual of 0.2-0.8mg/l should be maintained after 30 minutes of contact time at the consumer tap.

For capacities and quantities of chlorination equipment, refer to the Contract Drawings.

6.3 Chlorination Systems

6.3.1 Gas Chlorine System

6.3.1.1 Chlorinators

The Chlorinators shall be of the vacuum operated, solution feed type. The chlorine gas control system shall operate under vacuum to prevent gas leakage. The dispenser shall contain a vacuum regulator, a positive acting gas shut-off valve, pressure reducing valve, a diaphragm operated pressure relief valve, and an excess vacuum shut-off valve.

Manual dosage adjustment shall be made locally. The Chlorinators shall operate both manually and automatically. Automatic start and stop of the Chlorinator shall be simultaneous with the start and stop operation of the water pumps supplying water for chlorine solution.

A flow meter shall be provided to indicate chlorine gas flow. The dispenser shall be furnished with gauges for indication of chlorine gas vacuum and injector vacuum. Loss of vacuum and out of gas alarm switches shall be provided.

Chlorinator accuracy shall be plus or minus four percent (4%) of indicated flow rate over a 20:1 range. The vacuum regulators shall be remotely mounted to reduce the possibility of pressure leaks to minimum. The regulator shall be mounted at the chlorine cylinders. The regulator shall be provided with an integral liquid trap and inlet heater to prevent the possibility of liquid chlorine reaching the regulator. The heater shall operate on 230 VAC(volt alternating current), 50 Hz power. An externally mounted variable orifice water injector shall be furnished with each Chlorinator. The injector shall be provided with bath a ball check valve and a diaphragm actuated drain valve to prevent backflow of water into the Chlorinator.

The Chlorinator shall be constructed entirely of materials resistant to the corrosive attack of chlorine gas. The unit shall be wall mounted with all operating components.

6.3.1.2 Flexible Cylinder Connectors

Flexible cylinder connectors shall be provided. One for each flexible cylinder connector shall be constructed of 10mm (3/8in) outside diameter (O.D.) cadmium plated, dichromate dipped, copper tubing, 1.85m (6ft) long minimum. The connector shall be provided with an isolating valve and header valve, constructed of brass.

6.3.1.3 Manifolds

The manifold shall be installed of 25mm (1in) schedule 80 (Extra Heavy Wall Schedule Pipe) stainless steel, Polymer or any anti corrosion pipes resistant to chemical materials as shown on the Tender Documents Drawings and shall be suitable for use with chlorine.

Fittings shall be 1 ton forged steel.

6.3.1.4 Injectors

Each injector shall be of the variable orifice type to provide operating vacuum for a solution feed, vacuum type gas dispenser. The injector shall be water operated. The gas inlet connection shall be complete with integral ball check and diaphragm back check valves. Pressure gauges shall be provided for mounting on each side of each injector with suitable isolation diaphragms.

6.3.1.5 Chlorine Gas Leak Detector

An electro-chemical chlorine gas leak detector shall be mounted in the chlorine room to detect and provide a warning of the presence of chlorine gas in air. Upon detection of the chlorine cylinder valves are to be closed, an alarm to be sounded, a signal is to be sent to the main control panel, and a chlorine scrubber is to be automatically started, this scrubber will withdraw air from chlorine room, chemically remove the chlorine and will discharge the clean air to atmosphere. Upon the start of the scrubber , an outside fresh air damper will open to provide make up air to the chlorine room.

The chlorine gas leak detector shall be sensitive to chlorine gas at concentrations of 1.0mg/l by volume. The unit shall be provided with a self-contained sample air pump, a sample flow rate meter and a sample flow rate control valve. The unit shall be provided with manual switches for both alarm reset and test to allow checking of operation of the alarm circuit. The detector shall be housed suitable for wall mounting with all control devices mounted on the front panel. It shall be suitable for mounting in the chlorine area.

6.3.1.6 Valves

Line valves for liquid or gaseous chlorine shall be forged steel globe valves having bolted bonnet. Disk stem ring and body sear ring, monel stem. Valves shall be tested at 20 bars with air under water.

6.3.1.7 Automatic Changeover System (Switch Over)

An automatic changeover (switch over) system for gaseous chlorine shall be supplied to transfer from an exhausted source or chlorine to a standby source without interruption of Chlorination. The system shall be completely furnished and shall have as a minimum two vacuum regulators and automatic changeover valves, both suitable for wall mounting.

6.3.1.8 Residual Chlorine Analyser System

The residual chlorine analyser system shall consist of an amperometric type analyser, a mille volt to current transducer and recorder for the measurement of free or residual chlorine. The residual chlorine analyser system shall be wall mounted. One unit shall be furnished per location.

The analyser shall incorporate a measuring cell of the flow-thru type with two dissimilar metal electrodes, which shall produce a signal proportional to chlorine residual. An audible external alarm shall be provided for a common high and low residual alarm. The electrode surfaces shall be continuously cleaned by the action of non-abrasive pellets propelled by a motor driver noble metal electrode. The analyser shall also include automatic temperature compensation, a sample flow rate meter and positive displacement feed pump type. Dilution of sample shall not be permitted. All materials in contact with the water sample shall be corrosion-resistant.

The analyser components shall be housed in anti-corrosion case(cast aluminium, stainless steel etc.) with a casketed door and glass window. The analyser shall have a sensitivity of 0.01 ppm chlorine and shall operate over an ambient temperature range of 5 to 50 deg C (40 to 120 deg F). The unit shall be suitable for operation on 230 Volts (plus or minus 10 percent), 50 Hz.

The mille volt to current transducer shall be of the completely solid state, two-wire type, deriving its input from the signal generated by the analyser. The transducer shall transmit a proportional 4-20 maDC (mille ampere direct current) signal to the process instrument console compatible. The analyser transducer and indicator shall be mounted type. Analyser should be equipped with chart recorder to record chlorine residual in water, high and low alarm system for chlorine residual in water. The contractor shall provide one kit for measuring of the chlorine concentration in the hypo-chlorite solution.

6.3.1.9 Test Kits

One of the following test kits should be supplied as shown by the Tender Documents Drawings and BOQ:

(i) Chlorine Colour Disk Test Kit: Colour disk comparator for chlorine and pH measurements. Range 0-3.5mg/l, smaller increment of 0.1mg/l , complete with 200 reagent test for total chlorine, 200 reagent test for residual chlorine, 200 pH reagent test.

(ii) Colorimeter Potable:

- Wavelength: 340-900nm (manometer).
- Wave Length Resolution: 1nm.
- Light source: halogen tungsten lamp detector.
- Manual wave length selection.
- Digital display, cell holder.
- Reagent test kit: 200 test each for chlorine (Cl), nitrate (NO_3), ammonium(NH_4), total chlorine, free chlorine.
- Power requirement: battery supplied and line adapter for 220/50-60Hz complete with hard field carrying case, set of sample cells, instruction manual.

6.3.1.10 Scales

Two chlorine cylinder weighting scales shall be provided. The scales shall be self-contained with pillar dials and metal frame construction, scale shall be suitable for weighting of two chlorine cylinders.

Scale Capacity = 2 X Cylinder Weight

6.3.1.11 Wooden Cradles

The wooden cradles shall be provided to support chlorine cylinders.

6.3.1.12 Chlorine Booster Pumps

General

The booster pumps should be stainless steel model.

Installation

Location: Locate the pump as close as possible to the incoming liquid source. Be sure to leave ample area around the pump for inspections and maintenance, if for some reason the pump should need to be removed. Never position the pump in such a way that a person possibly use either the pump housing or motor as some type of step.

Mounting: All booster pumps should be bolted down to a secure and rigid base. In doing so, unnecessary noise, vibration or creeping will be prevented.

Piping: When installing a pump in a system, keep the inlet line short and with as few elbows or bends as possible, to keep friction losses to a minimum. The inlet line to the pump should be as least one size larger than the threaded inlet size used in the pump inlet housing.

Whenever debris is present on the inlet side of the pump, some type of strainer should be used to prevent the pump from clogging up.

Never use quick closing valves in either the inlet pipe or the discharge pipe. If the pump is going to be located above the level of the incoming water supply, a check valve or foot valve should be installed in the inlet line so that the pump will not lose prime.

A priming tee should be located at the highest point of the suction inlet line and as close to the pump inlet as possible in order to completely fill the suction pipe and pump.

Install a pressure gauge in the inlet pipe, close to the inlet housing. This gauge will tell if enough water is being supplied to the pump. Whenever possible, place a pipe union as close to the pump inlet housing and pump discharge body as possible. This will make removal of the unit easier, should it ever need to be replaced.

6.3.1.13 Emergency Equipment

A. Safety Measures for the Chlorinating Storage Room:

General: Safety measures should take into consideration the requirements of the following responsible bodies:

- The Civil Defence Department
- Municipalities and Water Utilities

- Ministries of Health and Environment

  - Chlorine gas cylinders and liquid containers should be stored in a separate independent, proper ventilation system, tightly closed room, the room should be away from electric network, transformers, and direct sunlight.
  - Breathing Apparatus: There are two types of breathing apparatus, the canister type gas mask and the oxygen or air-type breathing apparatus unit, the first type is appropriate for changing clarion cylinders/containers or normal maintenance work, while the air breathing unit (30 minutes air supply) is used for long emergencies. This unit shall be placed in a prominently marked, easily accessible location outside the chlorinating room.
  - Chlorine Container/Cylinder Emergency Kit: Every chlorinating station should have at least one chlorine emergency kit. These kits are designed to seal off, leaking fusible plug, a leaking outlet valve, or a moderate size rupture in the container shelf. This unit must be also located in an easily accessible location outside the chlorine room.
  - Ammonia Bottles: This unit is very useful to pinpoint a leak.
  - Chlorine Gas Neutralisation System: The most popular method is to use an absorption tank. The absorption tank should be filled with enough caustic to neutralise all the chlorine contained in the piping system and its components downstream from the chlorine supply up to the shutoff valve. The size of the tank and the quantities of caustic shall be as shown in the Tender Drawings.
  - Leak Detector: The chlorine station should be provided with two types of leak detectors, one for continuous monitoring of the working environmental ambient air and the other of hand-held personnel leak locator for searching or checking for leaks in the fabricated components of the chlorinating system.
  - Eye Wash Showers: This shall be installed outside the chlorinating room in appropriate location.
  - First Aid Kit Complete.
  - Operator Clothes, Safety Cap, and Safety Shoes should be of the anti-absorption type.
  - Hypochlorite solution should be stored in dark area, cool dry place where the temperature does not exceed 30 C° and should be stored in a manner that prevents any possible contact with other materials that are flammable as soil or grease. Light, heat, organic matter and certain heavy metalscations as copper, nickel and cobalt accelerate the decomposition of the Hypochlorite. It is preferable that the storage room to be fireproof. Storage near gangways or in sub-surface locations should be avoided.
  - Room Materials: Concrete is the preferred material for the construction of the room since it presents a good heat isolation and sunlight prevention.

B. The Chlorinating Room Should Contain the Followings:

- Water connection.
- Drainage system.

- Electricity and lights.
- Water safety pit.
- The temperature inside the room should be maintained between 22-25C°and well ventilated**.**
- Well locked door.
- Fire fighting extinguisher powder type.
- Precaution signs to prevent smoking.
- Gas cylinders/liquid containers handling instruments.

6.3.1.14 Spare Parts / Special Tools

The Contractor shall provide all spare parts and special tools necessary for the operation and maintenance of the gas Chlorination system as shown on Drawings and Bill of Quantities.

1. Each piece of equipment shall be furnished with the manufacturer's recommended spare parts.

2. Furnish one year's supply of chemicals for operation of each chlorine gas detector and chlorine analyser furnished.

3. Furnish all special tools and spare parts in containers clearly identified with indelible markings as to their contents. Each container shall be packed with its contents protected for storage. All tools shall be furnished in steel toolboxes.

4. Spare parts should be furnished according to the manufacturer instructions.

5. The following spare parts shall be furnished:
   a. For each Chlorinator:
      1) One set of gaskets.
      2) One valve body.
      3) One injector diaphragm.
      4) One tube lubricant.
      5) One bottle of ammonia solution.
   b. For the residual chlorine analyser:
      1) 2.5m (8ft) plastic tubing.
      2) One set of O-rings.
      3) One diaphragm unit.
      4) One sight glass tube.
      5) One set of electrodes and sleeves.
      6) One metering tube.
      7) One float 50mm (2in) rod.
      8) One year's supply of all reagents.

6.3.2 Liquid Chlorination System

6.3.2.1 Chlorine Dosing Pump (Hypo Chlorinator)

A. Chlorine dosing pump shall be full automotive positive metering type or diaphragm type pump complete with ball checks and diaphragm. Pump shaft to be driven by motor driven cam unit. Pump should be supplied with lubricating oil, plastic tubing, anti-siphon valve, foot valve, strainer check valve with pipe fitting for injection into the water main and diffuser.

B. Chlorine dosing pump is recommended for low and fluctuating water pressure.

C. Chlorine to be drawn into device then pumped to water delivery line.

D. Pump capacity shall be such that a minimum 5-mg/l disinfection dose can be added on the maximum day and it should work accurately over the desired feeding range. The rate of Hypochlorite solution feed could be set manually or automatically according to Contract Tender Documents. Rate control knob shall permit adjustment of feed rate while the unit in operation.

6.3.2.2 Sodium Hypo Chlorite Solution- NaOCl

Sodium Hypo Chlorite is a powerful oxidising agent (Ph=12, specific gravity 1.10-1.12 at 20^0 C, soluble in cold water, decomposes in hot water) contained in glass, PVC, reinforced fibreglass, polyethylene, polypropylene or any other anti-corrosion containers. This liquid solution contains approximately 10%-15% chlorine. Each container should be complete with cover and plastic measuring cup.

6.3.2.3 Calcium Hypo-Chlorine Solution

Calcium Hypo chlorite is a white or yellowish-white granular powder, granule, or tablet of sizes not larger than 6.3mm (1/4") that contains 65% to 70% chlorine by weight, dissolves easily in water.

The bulk density of the granular powder is about 0.51 g/cc to 0.80 g/cc and the bulk density of the granules is approximately 1.1 g/cc to 1.3 g/cc. It is manufactured by adding chlorine to milk of lime slurry, which may be prepared by mixing hydrated lime with water or by slaking quicklime with water.

Calcium Hypo Chlorite granular powder or granules shall be substantially free of lumps, not more than 10% of the powder shall pass a 100-mesh screen. It shall not contain any dirt or other foreign material, and shall be of uniformed shape. The weight of the tablets shall not vary by more than 5% from the average value stated on the label. Not than more 2% of the tablets shall be broken.

Calcium Hypochlorite may be dissolved in a mixing/ holding containers and injected in the same manner as Sodium Hypochlorite. Alternatively, where the pressure can be lowered to atmospheric such as at storage tanks, tablets of Calcium Hypochlorite can be directly dissolved in the free flowing water.

6.3.2.4 Residual Chlorine Analyser System

As stated in item 6.3.1.8.

6.3.2.5 Standby Equipment

The Contractor shall provide a stand by Pump (recommended diesel Pump) of sufficient capacity as shown on Drawings to replace the main pump. The system shown shall be complete with automatic change over to the standby pump in case of any failure.

6.3.2.6 Automatic Changeover System (Switch Over)

An automatic changeover system for hypo-Chlorination system shall be supplied to transfer from the exhausted source to the stand by container without interruption of dosing feed. The system shall be furnished complete and shall have a minimum two automatic changeover valves complete with all fittings and accessories.

6.3.2.7 Surface Preparation and Prime Coating

Prior to prime coating, all metal surfaces of the equipment within the Chlorination system shall be thoroughly clean, dry and free from all mill-scale, rust, grease, dirt, paint and other foreign substances to the satisfaction of the Engineer.

6.3.2.8 Test Kits

Refer to Item 6.3.1.9.

6.3.2.9 Spare Parts for Liquid System

The Contractor shall provide all spare parts and special tools necessary for the operation and maintenance of the liquid Chlorination system as shown on Drawings and Bill of Quantities.

1. Each piece of equipment shall be furnished with the manufacturer's recommended spare parts.

2. Furnish one year's supply of chemicals for operation of each chlorine detector and chlorine analyser furnished.

3. Furnish all special tools and spare parts in containers clearly identified with indelible markings as to their contents. Each container shall be packed with its contents protected for storage. All tools shall be furnished in steel toolboxes.

4. Spare parts should be furnished according to the manufacturer instructions.

5. The following spare parts shall be furnished:
   a. For each Chlorinator:
      1) Dosing Pump Suction Valve.
      2) Dosing Pump discharge Valve.
      3) Foot Valve (NRV), (Valve & Filter).
      4) Injection Valve (Injector).
      5) Hose.
   b. For the residual chlorine analyser:
      1) 2.5m (8ft) plastic tubing.
      2) One set of O-rings.

3) One diaphragm unit.
4) One sight glass tube.
5) One set of electrodes and sleeves.
6) One metering tube.
7) One float 50mm (2in) rod.
8) One year's supply of all reagents.

6.3.3 Execution

6.3.3.1 Installation

Chlorine dosing pump should be installed and mounted according to the manufacturer instructions and Tender Documents. All equipment shall be installed in accordance with the manufacturer's instructions and accurately aligned in orientation with related equipment.

All pressure gas or liquid piping shall be of Schedule 80, black steel pipe with ammonia type flanged fittings or Polypropylene pipes according to Tender Documents requirements. Piping shall be blown out with compressed air and cleaned with a cloth soaked in trichloroethylene, or other suitable chlorinated solution, after assembly and prior to placing in service. All pressure gas or liquid piping shall be tested at 20 bars for 30 minutes. All vacuum gas piping shall be Teflon and shall be solvent welded.

6.3.3.2 Inspection and Testing

Chlorination System:

a. Upon completion of installation and in the presence of the Engineer and a qualified manufacturer's representative, the Contractor shall perform a preliminary test on the Chlorination system to insure the functioning of all component parts to the satisfaction of the Engineer. All labour, equipment, water and power required to perform each test shall be furnished.
b. Approval of the preliminary test by the Engineer, shall not constitute final acceptance of the equipment furnished.
c. After the plant is in operation, a full load-operating test shall be performed in the presence of the Engineer and a qualified manufacturer's representative on the Chlorination system. All labour, materials and equipment required for such tests and correction of any deficiencies noted by repairing or replacing the defective component and retesting as required shall be furnished until the equipment meets the satisfaction of the Engineer.
d. All tests shall be furnished at the Contractor own expense.

6.3.3.3 Measurements and Payments

All chlorinating system works shall be considered on the basis of Lump Sum.

6.4 Pump Room

6.4.1 Excavation and Backfill Around Structures

Reference is to be made for appropriate and applicable items in Division 2- EARTHWORKS of these Specifications.

6.4.2 Concrete Work

Reference is to be made for appropriate and applicable items in Division 3-CONCRETE AND REINFORCED CONCRETE of these Specifications.

The materials used, the storing and handling of materials, the proportioning and mixing the conveying, placing, forming, curing and finishing of all concrete work shall be in accordance with the applicable technical specifications.

Ordinary Portland cement shall be used in all works.

6.4.2.1 Hollow Filler Blocks

The hollow filler blocks used in suspended ribbed slabs shall be 40 x 20 x 14 cm, or 40 x 20 x 17 or as specified by the Tender Documents composed of and manufactured as the concrete blocks described under 'BLOCK WORK'.

6.4.2.2 Block Works

Block work is to be built in the positions and to the dimensions and sizes shown on the Drawings.

6.4.2.3 Cement

Cement shall be as specified in Division 3 CONCRETE AND REINFORCED CONCRETE of these Specifications.

6.4.2.4 Water

Water shall be as specified in Division 3 CONCRETE AND REINFORCED CONCRETE of these Specifications.

6.4.2.5 Aggregates

Aggregates shall be as specified in Division 3 CONCRETE AND REINFORCED CONCRETE of these Specifications.

6.4.2.6 Sand

Sand shall be as specified in Division 3 CONCRETE AND REINFORCED CONCRETE of these Specifications and shall be properly washed and mechanically graded.

6.4.2.7 Reinforcement

Reinforcement shall be as specified in Division 3 CONCRETE AND REINFORCED CONCRETE of these Specifications.

6.4.2.8 Concrete Blocks

Blocks shall be made up of cement, aggregates and sand mixed in the ratio of 300kg of cement for one cubic meter of aggregates and sand, and manufactured in vibrated pressure machines. They shall be hard, sound, square, and clean with well defined arises, and shall be 40cm ±5mm long and 20cm ±5mm high, unless otherwise shown on the Drawings. The tolerance for thickness shall be ±3mm. The Engineer shall approve the design of hollow blocks. All concrete blocks shall comply with *PS 24, PS 6 Sec1*.

Blocks for test shall be selected by the Engineer and shall be made and tested according to *PS 6 Part 1*. Should any sample of blocks fail to pass the compressive strength tests defined above, or fail to meet with the requirements regarding shape, size etc. then whole of the delivery from which the unsatisfactory sample was taken shall be condemned and shall be removed from the site by the Contractor and replaced with satisfactory blocks.

6.4.2.9 Mortar

Mortar for blockwork shall be made up of cement and sand mixed 350kg of cement should be added to one cubic meter of sand. This ratio is for dry sand and due allowance shall be made for moisture content.

Materials for mortar shall be measured in approved gauge boxes, and the amount of mixing water shall be sufficient to give a good workable mix.

The mixing shall be done in a mechanical batch mixer unless otherwise approved and shall be carried out for two minutes before water is added and shall continue for two minutes after water is added.

Mortar shall be used before the initial set has begun or within two hours of the addition of the cement.

6.4.2.10 Workmanship

Blocks shall be soaked in water before use, and shall be spread with mortar before laying and joints shall be solid through the full thickness of the wall. Joints shall be flushed up as the work proceeds and racked out to a depth of 15mm.

Walls shall be bonded in accordance with the best constructional practice. Where required, bond blocks shall be carefully cut to size.

Walls shall be carried up regularly and no portion shall rise more than one meter above adjacent portions and at such changes in levels, work shall be raked back.

Courses shall be properly levelled. Perpendicular joints, quoins, jambs and angles shall be plumbed as the work proceeds.

6.4.2.11 Measurements and Payments

Concrete blocks shall be measured by square meter complete in place and accepted or as specified in BOQ.

6.4.2.12 Sundries

The Contractor shall cut and fit, build in, wedge up, pin or otherwise secure walls to openings, columns, beams, slabs, steelwork and the like. The contractor shall leave or form chases, rebates, openings, and holes for all trades, and shall cut and pin or build in inlets, cramps, plates, and the like.

6.4.2.13 Cement Based Screed

Mix proportions 1-3 parts cement-sand fine aggregate according to *PS 40, PS 54* grading limit.

6.4.2.14 Cement Based Screed Workmanship

Do not use admixtures other than plasticisers and water-retaining agents without prior approval. Do not use calcium chloride or any admixtures containing calcium chloride.
Unless otherwise specified cast screeds continuously as far as possible without joints, dense screeds are to be fully compacted by vibrator or where this is not practicable, by hand. Use a wood float or power float to give an even surface with no ridges or steps. The curing should be as specified in Division 3 – CONCRETE AND REINFORCED CONCRETE.

6.4.3 Metalwork

6.4.3.1 Aluminium

Wrought aluminium and aluminium alloys, in the works shall comply with *PS 44 Sec1 and PS 44 Sec2,*.

The aluminium for windows, etc. shall be treated to comply with *PS 114,PS 44 for* Anodic oxidation coatings on aluminium and Anodised wrought aluminium for external architectural applications in addition to *PS 461*.

All aluminium elements for windows, etc. shall be manufactured of extruded sections of aluminium alloy having a thickness of not less than 2.5mm. Window frame profile shall be of extruded sections the main sections shall have a minimum thickness of 2-mm secondary sections to have a minimum thickness of 1.6mm. Fittings shall be aluminium alloy in accordance with ISO 6362, ISO 6363.

Aluminium shall be treated to comply with *PS 114* to provide an anodisation not less than 18 microns.

All aluminium sections shall present clear straight and sharply defied lines and shall be free from defects and imperfections that may impair their strength.

All screws bolts and other necessary accessories shall be of aluminium or other non-corrodable material and shall match in colour and consistency the finish of the anodised aluminium.

6.4.3.2 Sealing Compound

Sealing compound (mastic) shall generally conform to ISO 11600 or EN 3624 (Draft). "Two-part Polysulphide Based Sealing Compound for the Building Industry". They shall be non-staining, elastic, waterproof and non-corrosive and be firm after setting but not brittle.

A. The mixing of the material and its application shall be in strict accordance with the manufacturer's instructions.

B. All joints and spaces to be sealed shall be clean and dry before the compound is applied.

C. Joints and spaces shall be completely filled with sealing compound to form a smooth finish with the adjoining faces.

6.4.3.3 Flyscreen Panels

Flyscreen panels shall be of detail and materials as shown on the Drawings and shall be approved by the Engineer before fixing.

6.4.3.4 Fabrication

A. All frame and sash members to aluminium windows, and panels shall be assembled in a secure and workmanlike manner and shall be delivered to the site ready for erection. Junctions of sills and jambs, stiles and rails shall be made with permanently watertight joints. All necessary reinforcement for integral hardware shall be supplied with them.

B. Aluminium windows shall be furnished complete with all necessary neoprene weather-strips and all hardware required and which shall be finished to match the window.

3-mm neoprene strip packing shall separate aluminium elements from steel, concrete or wood structures.

C. Aluminium elements shall be arranged to receive glazing or flyscreen with the proper type and thickness required and the frames shall be designed to receive caulking.

D. Sills shall generally be of the same material and finish as the windows and shall be extruded to the sections shown on the Drawings.

E. Provisions shall be made in the design of the windows, etc. to receive all caulking.

6.4.3.5 Workmanship

A. All aluminium work shall be first class workmanship, accurately set in position, true and plumb and securely anchored to the structure.

B. Drilling, cutting and fitting shall be properly and carefully carried out and the aluminium elements cleaned of all filings.

C. Aluminium frames shall be used with a dry wall construction to suit the specific requirements of the constructional system.

D. The burying of aluminium in plaster shall be avoided by screwing the frame to the ground after the plastering has been completed.

E. The Contractor shall be responsible for checking the dimensions of aluminium elements on Drawings and on site for correct execution of dimensions shown on the Drawings before manufacturing is started.

F. Louver windows shall be complete with frames carriers, jambs, sills, heads, saddles, mullions, etc. Louver windows shall be fixed in the positions shown on the Drawings.

G. Flyscreen panels shall be complete with frames, beads, neoprene strips, flyscreen, etc., and shall be fixed in the positions shown on the Drawings.

6.4.3.6 Defects

Damaged materials and manufactured items shall not be installed in the works and any materials or manufactured items damaged after installation shall be removed and replaced at the Contractor's expense and to the entire satisfaction of the Engineer.

6.4.3.7 Shop Drawings

The contractor should submit for Engineers approved shop drawings for all metal and Aluminium works. Wherever dimensions or details of metal windows and frames are not very clear on the Drawings the Contractor shall prepare shop drawings and submit them to the Engineer for approval. No windows or frames shall be manufactured or installed before the respective shop drawings are signed and approved by the Engineer.

The Contractor shall submit one transparent copy of all shop drawings to the Engineer for approval before the places his order.

Shop drawings shall indicate elevations of each element, type, full size sections, thickness and gauge of metal, fastenings, proposed methods of anchoring, the size and spacing of anchors, details of construction, method of glazing, details of hardware, mullion details, method and materials for weather stripping etc.

Where metal subframes, stools, casings, sills etc, are required shop drawings shall show the assemblage and connection for windows and adjacent work.

After approval of shop drawings the Contractor shall supply three prints and one soft copy of the approved transparency to the Engineer for record purposes.

6.4.3.8 Fabrication and Storage

Facilities shall be given to the Engineer to inspect all work in progress in the workshops and on the site.

All manufactured items shall be delivered in the original package and containers etc. and bear the name of the manufacturer and the brand. Each piece of material shall bear the official grade and trademark of the association under whose rules it is graded or a certificate of inspection shall accompany the material by that association.

Materials and manufactured items shall be stored in an approved manner and shall be protected from exposure to weather or dampness during transit to and after delivery to the site.

6.4.3.9 Protection and Cleaning

During and after installation metalwork shall be protected adequately as approved by the Engineer from any construction hazards that may interfere with its operation or damage its appearance or finish.

All surfaces shall be carefully cleaned after erection and after glazing is completed the windows, doors etc. shall be properly adjusted and left in perfect operating condition.

6.4.3.10 Sampling and Testing

Prior to ordering or delivering any materials or manufactured items to the site the name or names of the manufacturers and where required by the Engineer adequate samples, sample schedules or manufacturer's certificates of all the materials that are to be used in the metalwork shall be submitted to the Engineer for approval.

If judged necessary by the Engineer the sample may be tested for compliance in a certified laboratory accredited by PSI and approved by the Engineer.

Prior to commencing fabrication the Contractor shall fix and install one window to a reduced dimension but complete with hardware and glass for the Engineer's approval.

6.4.3.11 Measurements and Payments

Aluminium works shall be measured by square meter complete in place and accepted or as specified in BOQ.

6.4.4 Plasterwork and Other Floor, Wall and Ceiling Finishes

6.4.4.1 General

The Contractor shall execute and complete the plasterwork, and other floor, wall, and ceiling coverings and finishing shown on the Drawings and/or described in the Specifications.

6.4.4.2 Cement, Water, Aggregate and Sand

Cement, aggregate and water shall be as specified in DIVISION 3 – CONCRETE AND REINFORCED CONCRETE.

6.4.4.3 Lime

Hydrated lime shall conform to *PS 136* 'Building Lime'.

6.4.4.4 Plasticisers, Additives and Chemical Admixtures for Concrete

Plasticisers to improve the workability of cement-sand mix may be used in the plaster if it is so warranted.

Plasticizers shall be used in the proportions and manner recommended by the manufacturers, and shall comply with *PS 125*.

6.4.4.5 Workmanship

Materials shall be measured in approved gauge boxes. The proportions referred to in this Clause of the Specifications are for dry sand and due allowance shall be made for moisture content.

The amount of mixing water shall be sufficient to give a good workable mix, and the mixing shall be carried out in a mechanical batch mixer, unless otherwise approved, for not less than two minutes after the water is added.

Materials containing cement must be used before the initial set has begun and not later than two hours after the addition of water.

6.4.4.6 Plaster to Walls and Soffits

Plaster to walls shall be of cement and sand mixed in the ratio of 350kg of cement for one cubic meter of sand. Plaster shall be 15mm thick, and shall be applied in two coats. Plaster works should comply with *PS 240 -1,2*.

Surfaces to be plastered shall be cleaned of dust, loose mortar, and traces of salt. They shall then be dashed with cement and sand mixed in the ratio of 1:1, to form a key.

Immediately prior to the application of plaster, surfaces shall be thoroughly sprayed with water and all free water allowed to run off.

All junctions between differing materials and forms of construction, and all places where potential making good occurs, shall be reinforced with a strip of galvanized wire mesh (10-15mm hexagonal mesh) at least 15cm wide, plugged and nailed or stapled on both edges, at intervals of not more than 50cm.

Undercoats shall be of the same mix as the finishing coat and shall be well scratched or scored to form a key. Undercoats shall be allowed to set hard before the application of subsequent coats.

Unless otherwise shown on the Drawings, all plastered surfaces shall be trowelled with a steel or celluloid trowel to a smooth, even and true finish. All arises, corners and internal angles shall be straight and level or plumb. Plaster shall be made good up to frames and skirting and around fittings and pipes, and angles shall be rounded to a 5mm radius.

6.4.4.7 Measurements and Payments

Plaster works shall be measured by square meter complete in place and accepted or as specified in BOQ.

6.4.4.8 Sand Beds

Sand beds shall be to the thickness shown on the Drawings and shall consist of properly compacted sand, raked smooth to receive the bedding mortar.

6.4.4.9 Cement and Sand Mortar Beds

Cement and sand mortar beds shall be minimum 2cm thick and shall consist of cement and sand mixed in the ratio of 350kg of cement 1 cubic meter of sand. Cement Shall comply *PS 54*.

6.4.4.10 Pre-Cast Terrazzo Tiles and Skirting

Pre-cast terrazzo and skirting tiles shall be according to Tender Documents. Both tiles and skirting shall be obtained from an approved manufacturer. They shall consist of 8 mm thick facing of coloured cement and marble Chipping's mixed in the ratio of 1:3 by weight and laid on a backing of cement and sand mixed in the ratio of 300kg of cement for one cubic meter of sand. Pre-cast Terrazzo Tiles and Skirting should comply with *PS13, PS 47, PS 60, PS 225*.

Tiles and skirting shall be cast in metal moulds under pressure and shall be cured by totally immersing them in a tank of water for at least 24 hours after the initial set has taken place.

6.4.4.11 Heavy Duty Concrete Screeds

The mix for heavy-duty concrete screeds shall be 1:3 (by weight) sulphate resisting Portland cement, fine coarse aggregate (10mm nominal maximum aggregate size). The water content shall be kept to the minimum consistent with the required workability.

Heavy duty concrete screeds should preferably be placed and compacted within three hours of casting the base in which case the base concrete shall be left rough and the screed shall be spread and consolidated on to the whole of each bay or structure.

Where this cannot be achieved the base concrete shall be cast with a rough surface. Weak surface laitance and any other contaminating material must be completely removed and the coarse aggregate cleanly exposed. This surface shall be thoroughly cleaned and then soaked overnight, any surplus water being removed. The surface shall then be brushed with 1:1 sand/cement grout and the heavy-duty concrete screed applied.

The concrete shall be compacted and screeded to levels or falls with a screeding board and wood float. Further trawling shall be done with a steel trowel after about two hours.

Where benching and channels are to be protected by epoxy mortar the final surface of the concrete shall be left rough.

6.4.4.12 Ceramic Tiles

Ceramic floor tiles produced from clays, flints and vespers shall be matt finish plain clay flooring first quality tiles 10mm thick, with keyed back conforming in all respects with. Skirting tiles shall be square at the top with a coved base. Ceramic tiles shall comply with *PS 53*.

Ceramic floor tiles shall be laid on a cement sand mortar bed (1:5 by weight) to produce the total thickness as shown on the Drawings. Tiles shall be fixed in perfect alignment in level form to slope where shown on the Drawings. Joints shall be grouted and pointed neatly with white or coloured cement . Surplus grout shall be cleaned off as the work proceeds. Ceramic base tiles shall match the floor tiles joint and in colour.

Ceramic base tiles shall have a square top edge on a cove at the junction with floor tiling, neatly end and fit all angles, corners, abutments and the like.

6.4.4.13 Glazed Wall Tiles

Glazed wall tiles shall be according to Tender Drawings dimensions and of the best quality glazed clay tiles obtained from an approved manufacturer, and of a colour approved by the Engineer. Glazed wall tiles should comply with *PS 178*.

Tiles shall be immersed in water until they are saturated and all surplus water shall be drained off before bedding. Tiles shall be bedded in cement and sand mixed in the ratio of 1:4 to produce a total thickness of 15mm. They shall form a true, vertical face with close, tight, continuous horizontal and vertical joints unless otherwise shown on the Drawings. Joints shall be grouted and pointed in neat white or coloured cement. Surplus grout shall be cleaned off as the work proceeds. Angles, edges and junctions with paving shall be made with rounded or hollow rounded purpose made tiles. Cutting and fitting shall be carefully and nearly executed to ensure a close, neat joint.

6.4.4.14 Protection and Cleaning

All wall, floor and ceiling finishes shall be protected from damage. Should any damage be caused, it shall be made good to the satisfaction of the Engineer at the Contractor's expense.

All floors skirting and unpainted wall finishing shall be cleaned and left perfect on completion.

6.4.5 Guard Rails

6.4.5.1 General

Steel Plates, and structural steel shaped sections shall conform to the requirements of ISO 630 or EN 10056-1.

The contractor shall be responsible for the correctness and accuracy of the dimensions of the finished articles.

He shall therefore carefully check the dimensions indicated in the Drawings, verify any change ascertain the sizes at site which will enable him to prepare final working drawings for fabrication and erection purposes. Such drawings should be submitted to the Engineer for his verification and approval.

Fabrication orders can only be placed after the Contractor has obtained in writing the approval of the Engineer on the above drawings.

The steel sections where specified to be factory rustproof shall be rustproof by hot dip galvanized, metalizing or sheradizing process. The rustproofing shall be sufficient to withstand the 72 hours salt-spray test as provided in BS 1391. If the rustproof coating shall be damaged during the progress of work, the damaged part shall be recoated to minimum the original thickness to the satisfaction of the Engineer.

All steel parts shall be accurately set out, cut framed, assembled and executed using proper bolts or welding electrodes. All cut parts shall be saw cut; no oxygen burning shall be permitted except for pipe's supports. All welding shall be electrical welding, clean and of

proper workmanship. All cut parts and welded sections shall be ground, even and filed smooth with rounded edges.

Guardrails shall be given at least one coat of approved rust inhibiting primer before delivery to site in addition to the final paint coats as per Tender Documents requirements.

Frames for windows shall be provided with not less than three adjustable type anchors on each jamb, maximum distance between anchors shall be eight hundred mm.

All joints shall be machined to a close fit and all pins and screws shall be countersunk and dressed flush after assembly.

Forging shall be sharp and true curbs and intersections, members of the same size shall be halved together.

The plain surfaces shall be smooth, free from wrap or buckle. Molded members and miters shall be clean, cut straight and true. Construction joints shall be welded their full length and cleaned off flush on exposed surfaces.

All work shall be erected plumb and true to lines and rigidly secured to walls, floors or ceilings as shown on Drawings and to the satisfaction of the Engineer.

6.4.5.2 Measurements and Payments

Guardrails shall be measured by linear meter complete in place and accepted or as specified in BOQ.

6.4.6 Glazing

6.4.6.1 General

The Contractor shall supply and fix complete glazing, mirrors, and the like of the type, quality, dimensions, sizes, thickness, in the manner and the locations shown on the Drawings and/or described in the Specifications.

6.4.6.2 Glass

All glass shall be of the best quality, free from waves, bubbles, and other defects. Glass shall be obtained for an approved manufacturer, and shall comply with requirements of ISO EN 12543.

Translucent glass shall be figured, rolled translucent glass, 3/16 inch (4mm) thick (ISO 9051, EN 357).

Mirror glass shall be silvering quality polished plate glass 1/4 inch (6mm) thick (EN 1036).

6.4.6.3 Workmanship

For all metal windows, the glass shall be inserted in the glass carrier and fixed with clips.

Edges of mirrors shall be polish bevelled, and mirrors shall be fixed with chromium plated, dome headed screws.

6.4.7 Painting and Decoration

6.4.7.1 General

The Contractor shall apply the paint, finish, or decoration to the surfaces shown on the Drawings or described in the Specifications. The materials used in painting work shall be obtained from an approved manufacturer. All painting works shall comply *PS 97 Sec1.Sec33, PS 471, PS 91, and PS 480.*

6.4.7.2 Priming Paints, Undercoating and Finishing Paints

Painting works shall comply with *PS 12, PS 43, PS 97, PS 442, PS 528, PS 91, PS 154, PS 471, and PS 288.*

Priming paints shall be either the primer recommended by the manufacturer of the finishing paint, or one of the following and shall comply:

A. Lead-based priming paint for woodwork.

B. Red oxide priming paint, for steelwork.

C. Grey zinc chromate priming paint for galvanized work should comply with.

D. Alkali resisting priming for concrete, block work, plaster, ceiling boards and the like.

Undercoating shall be either the undercoating recommended by the manufacturer of the finishing paint or white lead-based undercoating.

Finishing paints shall be one of the following:

A. Zinc oxide base oil paint.

B. White lead-base oil gloss finishing paint.

C. Polyvinyl acetate emulsion paint.

6.4.7.3 Knotting, Stopping, Fillers and Linseed Oil

Knotting shall be obtained from an approved manufacturer.

Stopping shall be hard stopping composed of paste, white lead, gold size and whiting.

Fillers shall be obtained from an approved manufacturer.

Linseed oil shall be refined.

6.4.7.4 Workmanship

Every precaution shall be taken to eliminate dust before and during painting and decorating operations. No paint shall be applied to surfaces structurally or superficially damp and all surfaces shall be free from condensation, efflorescence and the like before the application of each coat.

Primed or undercoated wood or metal shall not be left in an exposed or unsuitable situation for an undue period before completing the painting. No exterior or exposed painting shall be carried out during adverse weather conditions.

Metal fittings not required to be painted shall first be fitted and then removed before any painting processes are commenced. When all painting is completed the fittings shall be cleaned and re-fixed.

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

The Contractor shall use the undercoats, primers and the like recommended by the manufacturer of the finishing paint or specified in this Clause; and shall prepare the surfaces and mix and apply the materials in accordance with the manufacturer's specification to give the finish on the Drawings.

The mixing of materials of different brands will not be permitted. No dilution of materials will be allowed except as detailed by the manufacturer.

6.4.7.5 Painting Concrete, Blockwork or Plaster

Concrete, blockwork, or plaster surfaces to be painted or decorated shall have all cracks cut out and made good to the satisfaction of the Engineer. The surfaces shall be completely dry and shall be brushed free of impurities immediately prior to the commencement of the painting work.

The surfaces shall receive one or more applications of putty filler until a smooth surface is obtained and approved by the Engineer.

Emulsion paint shall be applied by brush or roller and shall consist of a priming coat and two coats of paint internally and a priming coat and three coats of paint externally.

Oil paint shall be applied by brush or roller and shall consist of a priming coat, two undercoats and one finishing coat of paint.

The finishing coat of paint shall be applied after the completion of the electrical installation.

No oil paint shall be applied when the humidity exceeds 70% R.H.

6.4.7.6 Measurements and Payments

Painting works shall be measured by square meter complete in place and accepted or as specified in BOQ.

6.4.7.7 Painting Woodwork

Woodwork to be painted shall be cleaned of impurities. Teak veneered surfaces shall, after being cleaned, be rubbed down with white spirit and coated twice with linseed oil.

Knots shall be treated with two coats of knotting.

Priming paint shall be applied by brush. Two coats shall be applied to end grain. Priming paint shall be applied on site after the Engineer has approved the joinery and before it is fixed.

When the priming paint is dry, all cracks, holes open joints and the like shall be filled with stopping and rubbed down with fine glass paper.

Two undercoats and one finishing coat of oil paint shall be applied by brush.

The priming paint and undercoats shall be lightly rubbed down with fine glass paper to remove blemishes and shall have all dust removed before the application of subsequent coats.

6.4.7.8 Measurements and Payments

Painting works shall be measured by square meter complete in place and accepted or as specified in BOQ.

6.4.7.9 Protection and Cleaning

All painting finishing and decorating shall be protected from damage until the completion of the Works. Should any damage be caused, it shall be made good to the satisfaction of the Engineer at the Contractor's expense. The Contractor shall also repaint, at this own expense, any work, which is incorrectly painted.

The Contractor shall prevent damaging other work by the painting and decorating operations and shall provide dust sheets or covers wherever necessary. All paint droppings shall be cleaned up as the work proceeds.

The Contractor shall leave all paintwork clean and perfect at the completion of the works.

6.4.8 Doors

6.4.8.1 Timber Doors

6.4.8.1.1 General

Doors shall incorporate ironmongery to include opening and closing arrangements, latching, locking, staying, checking, self-closing, and other devices necessary for the proper functioning of doors as appropriate to their particular use, in accordance with the door schedules and ironmongery given herein after and the Drawings.

6.4.8.1.2 Internal Timber Doors

All internal doors shall be flush doors, except where other types are specifically required.

Flush doors shall not be less than 44mm thick, and may be of greater thickness where required.

Flush doors to general use shall be of timber core construction, having pine (sweed) stiles and rails forming timber core, with lock rail, kicking rail and other furnishings according to Drawings and schedules. Both sides of the core shall be covered with plywood, bonding, pressed and glued on mechanically under pressure. The Plywood should be according to *PS 641 Part 1*.

Where required melamine shall be bonded to the surface of the plywood on both sides of the doors, as specified here above.

Timber doors shall have pine (sweed) frame, softwood sub-frame and pine (sweed) architraves as shown on the Drawings.

Unless otherwise stated all doors shall have kickplates of anodised aluminium, as specified and shown on the Drawings.

Unless otherwise directed, flush doors shall be hung on three brass hinges and fitted with approved mortice lock and lever-type handles and pulls handles, as indicated in the ironmongery schedule.

Glazed apertures in flush doors shall be made in accordance with detailed drawings, and shall be provided with Swedish pine glazing beads on both sides, neatly mitred and twice-rebated section, and as shown on the Drawings.

6.4.8.1.3 Workmanship for Doors

Doors shall be installed in accordance with the best workmanship practices, conforming to BS 1186 Part 2. No scuffed, scratched or damaged doors will be accepted.

Samples of doors shall be submitted to the Project Manager for approval before delivery to site.

6.4.8.1.4 Painting

Doors and frames shall be painted with one priming coat and three of approved oil paints, with a semi-gloss or mat finish as indicated.

6.4.8.1.5 Ironmongery

a. General:

The Contractor shall provide and fix the ironmongery required by the Specifications 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 work in a finished state and to the satisfaction of the Project Manager.

All ironmongery shall be of the first quality and equivalent or superior to the appropriate British Standard quoted hereunder. ISO 8554, 8555, EN 912+.

BS 455-1975:	Locks and latches ford doors-schedule of sizes and dimensions
BS 7352:	Hinges
BS 1228-1945:	Door bolts-iron, steel and non-ferrous

The Contractor shall be required to submit for approval samples of all types of ironmongery he proposes to use.

All doors shall be provided with an approved door stop plugged and screwed to the floor or wall, and all the size materials, finishes, type and quality of ironmongery shall be as specified or shown on the Drawings.
Locks shall be cylinder or mortice type as specified. Locks shall be furnished in a satin chrome finish.

b. Finish of Ironmongery:

The finish of the various items of ironmongery shall be satin-chrome finish.
Ironmongery to metal windows and doors shall generally match the general framing, and shall be supplied and fixed with matching metal fixing screws and bolts and additional plates.

c. Fittings and Testing:

All screws used for fixing ironmongery shall be of the correct type, material, finish, size and shape to the satisfaction of the Project Manager.

The hinges on which doors, windows, flyscreen doors, etc., are hung shall be carefully housed or let into the door, window, flyscreen door, etc., and to the frame.

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 handing over.

On completion of all locks, catches and similar items of ironmongery, they shall be properly cleaned, tested and oiled, and all keys shall clearly labelled with metal tags approximately 50 X 20mm. And security fastened to the keys and handed over to the Project Manager.

Door closers shall be fitted and fastened a maximum of two weeks before hand-over.

All floor and door spring shall be fully charged with oil and their operation checked to the satisfaction of the Project Manager.

All locks shall be provided with three keys on a key ring and neatly labelled.

All knobs sets shall include for the appropriate mortise latch or lock with a 70mm. Backset and standard faceplates and roses unless noted.

d. Ironmongery Schedule for Doors:

The Contractor shall submit for the Engineer's approval samples of all types of ironmongery and fittings and has to make a schedule showing each door accessories.

e. Door Close and Kickplates:

The door closer and kickplates shall be of the best quality and material and shall all be approved by the Engineer before fixing.

6.4.8.2 Steel Doors

6.4.8.2.1 General

- Steel doors shall be manufactured in accordance with detail drawings and subject to the Engineer's approval. Full workshop drawings for doors shall be submitted to the Engineer well in advance of delivery to site for his approval.
- Steel doors leaves shall be constructed from hollow steel tubes 85 X 34mm stiles and transoms, 60 X 34mm intermediates, with 1.5mm thick steel sheets pressed on both sides of the leaves, unless otherwise indicated on Drawings.
- Door frames shall be 95 X 34mm hollow steel tubes unless otherwise indicated on Drawings.
- Louvre steel doors shall be constructed as specified above with door blades for louvre fabricated from 1.5mm thick steel sheets unless otherwise stated on Drawings.
- Ironmongery and door furniture shall be in accordance with the relevant schedules and approved by the Engineer.

6.4.8.2.2 Ironmongery for Steel Doors

The Contractor shall provide and fix the ironmongery complete, including all necessary screws, bolts, plugs and other fixings. The use nails of fixing shall not be allowed.

All ironmongery shall be of first quality and according to as quoted below:

BS 455-1975:	Lock and latches for doors schedule for sizes and dimensions.
BS 7352:	Hinges.
BS 1228-1945:	Door bolts-iron, steel and non-ferrous.

The Contractor shall be required to submit for approval samples of all items of ironmongery he proposes to use.

6.4.8.2.3 Glazing

Steel doors casement shall be prepared for inside glazing. All glass shall be of an approved make and quality, 8mm thick Georgian wired glass, and in accordance with Section (6.4.6).

6.4.8.3 Measurements and Payment

Doors shall be measured and paid for by the number. The Unit price shall include for all hardware; locks; glazing, all furniture listed in door schedules such as push plates, door closers and all ironmongery; and painting in accordance with Specifications.

The quantities as provided above shall be paid for at the Contract Price per door, which price and payment shall be the full compensating for furnishing and installing all materials, including all labour, equipment, tools and incidental necessary to complete the work prescribed in this section.

6.4.9 Lighting

Refer to DIVISION 13 - ELECTRICAL WORKS in this Specification.

DIVISION 7: VALVES

7.1 General

All valves and accessories are recommended to be furnished by a single manufacturer and should be subjected to the Engineers approval before ordering the valves. Valves shall be compatible with pipes and fittings specified in Division 5 of these Specifications. Compatibility should be the Contractor's responsibility at his own expense, and should be approved by a third party accredited by PSI certified Testing Laboratory.

Two copies of manufacturing and installation manuals shall be provided at time of materials delivering.

All valves shall be supplied according to the latest editions of standards and references specified in these Specifications. Valves shall be fabricated according to Standards and References specified in these specifications or shall be equivalent and compatible to these standards and references subjected to third party accredited testing laboratory.

The type and size of valve to be used at any location shall be as indicated on the Contract Documents or specified herein and shall be rated to at least the same pressure as the pipeline in which they are to be installed. All valves shall be designed to avoid cavitations and vibration in all positions, to minimize head loss in the open positions and to seal the water passage when completely shut.

All operating spindles and gears shall be provided with adequate points for lubrication. Unless otherwise specified, all valves shall be closed in a clockwise direction. Head loss curves through the valves for throttled flow conditions shall be provided for all valve sizes.

Bolts, nuts, rubber seals (joint rings), gaskets, and flanges shall be in accordance with standards specified in Division 5.

Valves of different types in general can be listed as follows:

1. Gate valves and appurtenances for yard piping.
2. Gate valves for inside service.
3. Ball valves.
4. Check valves (None Return Valve).
5. Butterfly valve.
6. Fire hydrants.
7. Surge relief valves.
8. Quick connect couplings.
9. Service clamps.
10. Pressure gauges.

11. Flap valves.
12. Expansion joints and dressers.
13. Air release and vacuum valves.
14. Propeller flow meters.
15. Sluice gate.
16. Float valve.
17. Flow control valve.
18. Altitude valve.
19. Pressure reducing valve.
20. Strainers.
21. Water meter.
22. Globe Valves

7.2 Submittals

The contractor shall submit the following:

- Assembly drawings.
- Manufacturer Valid quality certifications ISO or equivalent.
- Certified copies of Manufacturer quality control Test results and reports.
- Assembly shop drawings.
- Instruction manuals.
- Catalogues.
- With every consignment of valves, accessories and specials delivered under this Contract, the Contractor shall furnish a certificate worded as follows:

"This is to certify that the valves, accessories and specials delivered in this consignment comply with the required specifications and Standards".

7.3 Marking of Valves and Water Meters

The valves and water meters shall be clearly labeled and marked with the following information:

Valves:

- Class or Pressure rating.
- Nominal Diameter
- Arrow showing the flow directions (for valves designed for one way flow only).
- Name or trade mark of the manufacturer.
- Date of manufacturing.

Water Meter:

- Pressure rating.
- Nominal diameter.
- Meter class.
- Arrow showing the flow direction.
- Serial number.
- Name or trade mark of the manufacturer.

7.4 Valve Coatings

Unless otherwise indicated in the Tender Documents for an alternative coating system, the internal and external surfaces of valves shall be prepared and coated with epoxy paint. The final coat shall be applied to external surfaces after installing the valves.

7.5 Works Tests

All valves shall be hydrostatically tested at the place of manufacture. The Contractor shall supply a certificate stating that the valves supplied have satisfactorily passed the specified tests and comply in all respects with these Specifications or BOQ.

All valves shall be subjected to pressure test in accordance with ISO 5208 and shall be drop tight.

7.6 Packing

All valves shall be securely packed in crates or boxes for protection against damage during transit, and shall be accompanied by the materials necessary to secure all flanges to adjacent pipe work. These materials shall also be suitably packed and shall be stored away from sunlight at all times.

7.7 Gate Valves and Appurtenances

7.7.1 Gate Valves and Appurtenances for Buried Service

Ductile Iron gate valves for water shall meet the requirements of ISO 7259, ISO 5996 or EN 1171. Steel gate valves should comply with ISO 6002 or EN 1984.

Valves shall be rated for 16 bars (250 psi) working pressure and a minimum 24 bars (375 psi) test pressure or as specified in the Drawings or BOQ. Valves shall be steel body, or ductile bronze-mounted, double disc, parallel seat; non-rising stem type fitted with "O-Ring" seals. The operating nuts shall be 50mm (2in) square. All valves shall open left, or counterclockwise. Stuffing boxes shall be the "O-Ring" type.

Valves shall be equipped either with hand-wheel or the spindle as specified in the Drawings or BOQ.

Tapping sleeves shall have cadmium-plated low alloy steel nuts and bolts. Sleeves shall be of cast iron, designated for working pressures not less than 30 bars (435 psi). Lead gaskets shall be provided for the full area of the sleeve flanges.

Tapping valves shall conform to the requirements specified above for gate valves except that one end shall be flanged and one mechanical. Tapping valves shall be provided with an oversized opening to permit the use of full sized cutters.

Valve boxes shall be provided for each buried valve. They shall be cast iron, of heavy pattern, adjustable type and provided with cast iron cover. The upper section of each box shall have a bottom flange of sufficient bearing area to prevent settling. The bottom of the lower section shall enclose the stuffing box and operating nut of the valve. Boxes shall have barrels of not less than 130mm (5in) in diameter and be of length adapted to pipe cover.

Valve boxes shall be adjustable, with a lap of at least 150mm (6in) when in the most extended position. Covers shall have lettering indicating the type of service.

Four tee-handled gate wrenches of suitable length shall be furnished to operate all valves with valve boxes. Valves greeter than 300mm in diameter supposed to be actuator operated or fixed in a horizontal position should be fitted with mechanical gear on the wedge working in machined gunmetal channel in the body.

7.7.2 Gate Valves for Non-Buried Service

Gate valves, shall have flanged, screwed, or solder ends as required; and shall be bronze, solid wedge, rising-stem-type gate valves or none rising-stem type as specified in the Tender Documents.

Gate valves, shall be iron body, steel or as specified in the Tender Documents, bronze mounted, solid wedge gate valves with flanged ends. Ductile Iron Gate valves for water shall meet the requirements of ISO 7259, ISO 5996 or EN 1171. Steel gate valves should comply with ISO 6002 or EN 1984.

Valves shall be rated for 16-bar pressure and a minimum of 24 bars test pressure or as specified in the Drawings or BOQ.

A. Valves shall be outside screw and yoke type with rising stem.

B. Face to face metal valves dimension shall conform to ISO 5752 or EN 558-1,2.

C. Bronze gate rings shall be fitted into grooves of dovetail or similar shape in the gates. For grooves or other shapes, the rings shall be firmly attached to the gates with bronze rivets.

D. Handwheels shall turn counterclockwise to open the valves. Handwheels shall be of ample size and shall have an arrow and the word OPEN cast thereon to indicate the direction of opening.

E. Stuffing box follower bolts shall be of steel and the nuts shall be of bronze.

F. The design of the valves shall permit packing the valves without undue leakage while they are wide open and in service.

G. O-ring stuffing boxes may be used.

7.8 Ball Float Valve

Ball float level control valve shall be right angle pattern suitable for siting inside the reservoir.

It shall be designed to ensure a slow rate of valve closure to avoid the danger of pressure rise. All internal parts shall be easily removable for replacement. Steel ball float valve shall conform to ISO 7121.
Ball float valves shall be rated for 16 bar nominal working pressure and factory tested against 25 bar pressure or as specified in the Tender Documents.

7.9 Check Valves

Check valves shall be swing type and shall meet the material requirements of ISO 5781 or EN 1074-3. Steel check valves should comply with EN 13709. Ductile iron check valves should comply with EN 12334. The valves shall be iron body, bronze mounted, single disc, 16 bars (250 psi) working water pressure, nonshock, and hydrostatically tested at 24 bars (375 psi) or as specified in the Drawings or BOQ.

A. When there is no flow through the line the disc shall hang lightly against its seat in practically a vertical position. When open, the disc shall swing clear of the waterway.

B. Check valves shall have bronze seat and body rings, extended bronze hinge pins and bronze nuts on the bolts of bolted covers.

C. Valves shall be so constructed that disc and body seat may easily be removed and replaced without removing the valve from the line. Valves shall be fitted with an extended hinge arm with outside lever and spring. Springs with various tensions shall be provided and springs approved by the Engineer shall be installed.

7.10 Butterfly Valves

Metallic butterfly valves shall be manufactured in strict accordance with ISO 10631 or EN 593. Valves shall be bubbles tight at rated pressures specified in the Drawings or BOQ. Valve discs shall rotate 90 degrees from full closed to open. The valve manufacturer shall assemble operators to the valve. The valve manufacturer shall test the valve/operator as a complete assembly.

Valves bodies shall be constructed of cast iron according to ISO 10631, ISO 5752 or EN 593, EN 1503. Valves in vaults shall be flanged. Laying length shall be short body as listed in ISO 10631, ISO 5752 or EN 593, EN 1503.

Valve discs shall be constructed of cast iron according to ISO 10631, ISO 5752 or EN 593, EN 1503. Disc edge shall be either ni-chrome or stainless steel.

The seat shall be located in the valve body. If seat retaining hardware such as screws and segments are used they shall be monel. If screws are used, monel plugs shall be affixed in the valve body and tapped to receive these screws.

Shaft seals shall be provided where the shaft projects through the valve body. Shaft seals shall be standard split-V type packing.

Valves shall be fitted with sleeve type bearings contained in the trunnions of the valve body. Bearing material shall be nylon for valve through 500mm (20in) and fiberglass with Teflon lining for valve 600mm (24in) and larger.

All valves shall be hydrostatically and leak tested.

7.11 Surge Relief Valves

Surge relief valves shall be in accordance with ISO 6264 and shall be installed on the plant water lines as shown on the Drawings.

The surge relief valve shall be heavily constructed cast iron valve body, with integral end flanges and full unobstructed flow through area. The disc shall be cast iron having a replaceable resilient seat for tight shut-off. The Pivot shaft shall be stainless steel and be a single unit (not stubs), extending through the valve body with a weight and lever mounted on one or both ends.

The surge relief valve shall be adjusted at the factory to hold closed against the normal operating system pressure. When the system pressure exceeds this setting, the surge relief Valve shall open immediately to relieve the pressure rise, but closes slowly at an adjustable rate as the system pressure returns to normal.

A heavy-duty oil dashpot system and stainless steel oil reservoir shall be externally mounted on the valve to control the rate of closure, in such a manner, to positively prevent any slam. The closing rate shall be externally and infinitely adjustable thru a color-coded flow control valve having a locking device to prevent tampering, once the close rate is set.

Prior to shipment of the valves the manufacturer shall factory test the valves under the pressure and flow conditions specified above. The manufacturer shall submit to the Engineer with certified copies of the factory test results.

Surge relief valves shall be installed where indicated on the Drawings. Valves shall be rated 40 bars (600 psi) working pressure or as specified in the Contract Tender Documents.

7.12 Quick Connect Couplings

Couplings for the Coagulant, Sodium Hypochlorite, and Septage Holding Tank fill lines shall be of the cam and groove type consisting of a male adapter conforming to ISO 6150, ISO 2861, ISO 7241-1, ISO 16028. Male adapters shall be designed to receive a female coupler without requiring threading, bolting, or tools. Connections shall remain tight and leak-proof under working pressures. Each adapter shall be furnished with a dust cap complete with security chain of corrosion resistant material.

7.13 Mechanical Type Seals

A. Mechanical rubber seals (joint rings) shall be in accordance with ISO 4633, ISO 2230, ISO 10221 or EN 681 and shall be modular, adjustable, bolted, mechanical type consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve. The seal shall be rated by the manufacturer for the specified head, or as otherwise provided.

B. Mechanical seals shall be specifically designed for the following service conditions:

1. Standard service (insulating type): EPDM rubber.
2. Standard service (non-insulating): EPDM rubber.
3. Corrosive service – highly resistant to most inorganic materials (water, acids, alkalis) and most organic materials (acetic, acetone, aniline, etc), minus 40 to plus 121 deg C (minus 40 to plus 250 deg F): EPDM rubber, 18-8 stainless steel bolts and nuts.
4. Oil resistant service – nitrile rubber, good resistance to oils, aromatic fuels, solvents and other petroleum based products.
5. High or low temperature service, minus 55 to plus 232 deg C (minus 67 to plus 450 deg F) – silicone rubber ele0ment suitable for 1 hour fire rating.
6. Fire rated service – double seal configuration: 3 hours – access to both sides of wall or access to only one side, as applicable.

C. Selection of mechanical seals to be installed at each location shall be as Manufacturer instructions and as directed by the Engineer.

7.14 Pressure Gauges

Pressure gauges shall be manufactured in accordance with ISO 5171 or EN 837-1,2,3 and shall be furnished and installed in each pump suction and discharge nozzle in accordance with Tender Documents requirements. Where gauge taps are not available in the pump's suction or discharge nozzle, the necessary taps in the adjacent piping shall be made for installation of gauge connections. Pressure range 60 bars (870 psi). Each pressure gauge should be equipped with a stop valve of the same pressure rating.

7.15 Flap Valves

Flap valves to be used in the overflow system discharge lines shall be as specified or as per Contract Drawings and, shall be flanged end.

7.16 Air Relief Valves

Air relief valves shall be of the double orifice pattern with ductile cast iron bodies, the inlet flange shall be fitted and drilled in accordance with EN 1074-4.

The valves shall be adequately sized for the release of air from the pipeline (or other container) without restriction of rate of filling or flow due to backpressure. Air shall be allowed to enter at a rate sufficient to prevent excessive reduction of pressure in the pipe during pipeline emptying. The "aerokinetic" type shall be provided, air valves with internal operating linkages shall be avoided.

Valves shall be designed to prevent the operating elements being in contact with the pipeline liquid by approved means such as the provision of an auxiliary float and chamber sufficiently large to isolate the orifice valves and seats throughout the rated operational range.

Air valves shall be fitted with a separate isolating sluice valve and gearing shall be provided, where necessary, to facilitate operation.

In applications where the pipeline characteristics may lead to liquid column separation with consequent possibility of surge conditions, a vented non-return valve shall be provided which allows air to enter freely on separation but controls expulsion of air as the liquid column rejoins.

All air relief valves and associated isolating valves shall be works tested and capable of withstanding the same test pressure as the pipeline or vessel on which they operate. All materials used in the manufacture of the valve shall conform to EN 1074-4.

7.17 Sluice Gate Valves

Sluice gate valves shall be for waterworks purposes in accordance with ISO 7259 with inside non-rising spindles.

Sluice gate valves shall be of the double-flanged cast iron wedge-gate type unless otherwise specified. They shall have a cast iron body with renewable gunmetal faces on body and wedge, and a bolt-on cast iron bonnet.

Unless otherwise specified, each valve shall be provided with a suitable hand-wheel of adequate diameter for the duty required. Gearing shall be supplied where necessary, to ensure that the required operating force applies by hand to the rim of the wheel not exceed 55kgf.

Hand wheels shall have smooth rims and the direction of closing, which shall be clockwise, cast on the, Vandal and weatherproof clear polycarbonate tube covers shall be securely fitted to protect the threads of rising stems and spindles. The tubes shall be clearly and permanently engraved to indicate the position of the valve.

Valve stems shall be of forged aluminum bronze or stainless steel, machined all over with a machine cut, robust trapezoidal or square form thread, operating in a gunmetal nut. Stem seals shall be of the stuffing box and gland type, arranged for easy replacement of packing and shall be accessible for maintenance without removal of the valve from service.

Extension spindles, headstocks and foot brackets shall be provided where specified. Where possible, providing the valve is not subject to submergence, the extension spindle shall be of the non-rising type. Extended spindle installations shall include all necessary brackets, intermediate support, etc. Where extended spindles require to be operated at open flooring level, spindle guides or guides brackets shall be provided close to flooring level.

Headstocks for non-rising spindle installations shall incorporate a valve position indicator. Extension spindles shall be of stainless steel or manganese bronze and shall conform with the requirements for valve stems with the exception of non-threaded sections, which may be of

mild steel. Extension spindle couplings shall be of the drilled “muff” type and provided with a nut and bolt for securing the spindle to the valve stem, which shall likewise be drilled to accept the bolt.

Where valves are required to be operated by tee keys spindle caps shall be fitted. The caps shall be drilled and each provided with nut and bolt for securing to the spindle, which shall likewise be drilled to accept the bolt. Each cap where fitted shall be supplied complete with operating tee key.

All hand-wheels, headstocks, foot brackets, guide brackets and thrust tubes shall be of cast iron. Valves greater than 300mm diameter shall have integral gate-valve by-pass arrangements, 50mm on valves up to 400mm and 80m on larger.

Valves shall carry identification marks and/or plates in accordance with British Standards. Those for use on process plant shall carry and additional brass plate carrying a valve identification and a brief description of its function.

7.18 Float Valves

Control valves should comply with ISO 6263 or EN 1074-5.

The float valve shall be installed on the rising main, in concrete chamber and on the eaflin suction of the pump at the suction line. The valve shall operate through a remote float control installed in the water storage or balancing tank, as shown on Drawings. The valve shall be hydraulically operated, diaphragm actuated. All necessary repairs shall be possible without removing the valve from the line. The remote float control shall be connected to the main valve through copper tubes to control the valve opening such that when float rises gradually with water surface the main valve will close gradually until it is tightly closed when water level reaches the specified high water level in the tank.

Altitude Valve:

Altitude valve shall be the pilot control type, which controls high level in the reservoir, the pilot control system and valve trim shall be bronze. Altitude valve shall stay open as long as the water level of the reservoir is below a preset level. As the water level rises the valve gradually closes.

The altitude control valve should be of one way flow with an automatic control valve designed to control the high water level in reservoirs and tanks without the need for external control devices such as floats, etc. Control valve should be rated at 16 bars and factory tested at 25 bars unless otherwise indicated. It should be pilot controlled, hydraulically operated, diaphragm actuated globe valve in either the oblique (Y) or angle pattern design. Valve differential pressure powers the diaphragm actuator open or closed.

The lower control chamber shall be connected through a fixed orifice to the downstream pressure, which serves to cushion the closing of the valve. The upper control chamber, which operates on a three-way control principal, has pressure applied from or pressure vented through the three-way altitude pilot.

The altitude pilot senses reservoir or tank pressure head. It closes at a pre-set pressure head and opens on decreasing pressure head.

The closing and opening of the pilot alternatively pressurizes or vents the pressure in the upper control chamber causing the main valve to close or open thus maintaining a constant pressure head in the reservoir or tank.

When the head pressure falls below the pilot setting the pilot opens, pressure in the upper control chamber decreases and the main valve opens to refill the reservoir or tank. When the head reaches the set point of the pilot the pilot closes, pressure in the upper chamber increases and the main valve closes to stop flow into the tank or reservoir. The altitude pilot shall have an adjusting screw to preset the desired head pressure.

7.19 Globe Valves

Steel globe valves shall comply with ISO 12149 or EN 13709. Ductile iron globe valves shall comply with EN 13789.

7.20 Flow Control Valves

Control valve should comply with ISO 6263 or EN 1074-5.

The valve shall be set to maintain a constant rate of flow regardless of fluctuations in upstream pressure. Rate of flow shall be adjustable at any time. The valve shall be hydraulically operated, diaphragm actuated globe pattern. Valve shall be installed in concrete chamber as shown on Drawings. Rate of flow shall be set as specified in the Tender Documents.

Valve trim and pilot control system shall be stainless steel. Rubber parts shall be synthetic rubber.

7.21 Pressure Reducing Valves

Pressure reducing valves shall comply with ISO 5781 or EN 1567. Pressure reducing valves shall be factory tested. Outlet pressure shall be easily field adjustable over the pressure ranges and meet the criteria noted on the Drawings.

All pressure reducing valves shall have flanged connections, or shall have unions mounted in the pipe on each side of the valve.

Strainers for installation upstream of pressure reducing valves are specified elsewhere. The pressure reducing valve manufacturer shall specify the screen mesh or size of perforations that are required to protect the reducing valve. The valve supplier shall furnish both valve and strainer.

Pressure Reducing Valves 75mm and Larger:

A. Valves 75mm and larger for pressure reducing shall be flanged with a double chambered diaphragm actuated cast-iron “Y” pattern body and replaceable bronze valve seat. The

valve shall be external pilot operated, diaphragm type single seat with seat base equal to size of valve. The valve shall be supplied with an internal spring to assist in closing the valve and keeping the valve seated when the inlet and outlet pressure differential is near zero. The valve shall also be supplied with a "V" port-throttling plug to facilitate control of the outlet pressure.

B. The valve shall be packed with material acceptable to the Engineer to insure tight closure and prevent metal to metal friction and sticking. The valve shall be furnished with indicator rod, to show position of opening of the piston, and pet cocks for attachment to valve body for receiving gauges for testing purposes.

C. The pilot valve, controlling operation of the main valve, shall be easily accessible and so arranged to allow for its removal from the main valve, while the main valve is under pressure. The pilot valve shall be easily adjustable without removal of the springs, weights or use of special tools. The control piping on the valves shall have strainers to prevent plugging of control mechanisms.

D. The design shall be such that repairs and dismantling internally of main valve may be made without its removal from the line.

E. The unit shall be flanged. The valve body shall be constructed of cast iron.

F. The valve shall maintain pre-adjusted downstream pressure for varying rates of flow through the positioning of the diaphragm by the pilot without causing water hammer or waste of water and without cavitation.

Pressure Reducing Valves 50mm and Smaller):

A. Threaded Pressure reducing valves 50mm and smaller shall be rated 150 psi working pressure or as specified in the Tender Drawings and BOQ, with bronze and brass body; renewable stainless steel seat and flexible diaphragm of suitable material. Outlet pressure shall be easily field adjustable over the pressure ranges tabulated on the Drawings.

7.22 Strainers

Strainers will be made of ductile iron or cast iron. Strainer body will be coated with an epoxy powder minimum thickness 120 microns. Screen shall be made of stainless steel.

For maintenance purposes, covers shall be provided to allow ample access to inspection, cleaning and servicing. A drain bend at the bottom of the body, fitted with a stopcock shall be incorporated.

Due to particularly hard conditions of service – high speed, high-pressure, presence of solid elements in the network – bidders are requested to pay particular attention to the quality of the protection provided by the strainers to the regulation valves and meters placed downstream.

Head loss shall not be more than 0.1 bars, when clean, at the nominal flow rate of the control valve or water meter protected by the strainer box.

7.23 Water Meters

7.23.1 General

This Section includes providing general requirements for meters and flow measurement devices with associated instrumentation and controls designed for indicated functions including flow measurement (current flow, accumulative volume, flow velocity), density determination, and batch metering of water.

Water meters shall be manufactured in accordance with PS 402, PS 447 with a copper, bronze main case and shall register flow in liters. Each meter shall be supplied with a cast-iron meter box, which shall be constructed with a slotted, open-bottom base section of length to fit over the service piping. The meter box shall have the words “WATER METER” in Arabic cast into the lid.

Shop Drawings and Samples:

The contractor shall submit the following.

1. Manufacturer's product data including catalogue cuts.
2. Shop drawings showing details and dimensions.
3. List of special tools.
4. Schedule of meter identifications and locations.

Product Manual:

The following shall be included in the product manual:

1. Certified performance data including curves showing flow and pressure drop.
2. Manufacturer's installation instructions.
3. Manufacturer's maintenance and operating instructions including step-by-step troubleshooting procedures with necessary test equipment.
4. Manufacturer's certification that meters comply with published accuracy’s for the flow ranges indicated.
5. Certification that meters have been field-calibrated, under flow conditions.

Inspection, Testing and Accuracy:

Inspection and Testing: The manufacturer shall provide an experienced factory service representative to inspect and test meters for proper performance and installation and field calibrate meters under flow conditions.

Accuracy: Except as otherwise indicated, flow meters shall be designed and fabricated for an accuracy of plus or minus 2 percent of actual flow throughout the range indicated. Density measuring devices shall have an accuracy within plus or minus 2 percent of actual solids content over the range indicated.

7.23.2 Products

Special Tools:

The product shall include special tools recommended by the manufacturer and one extra steel spool for each size of meter. Spools shall be labeled and shall show meter identification, size and service.

7.23.3 Execution

Installation:

Meters shall be installed in accordance with the manufacturer's installation instructions.

Meters shall be installed in easily accessible locations and oriented for ease of reading and maintenance, and, where shown, for balancing of flow. Wherever possible, meters shall be installed in such a way to comply with the manufacturer's recommendations.

Meters, shut-off and balancing valves shall be properly supported. In-line meters shall be installed to ensure full-line flow and not less than the manufacturer's recommended head at all times.

Testing:

Equipment shall be prepared for operational use in accordance with manufacturer's instructions after field calibration. The Engineer reserves the right to observe field calibration.

Meters shall be field tested at no less than 3 flow conditions over the total range of capability of the equipment. Where applicable, tests shall be conducted in accordance with the relevant Palestinian Standards.

7.24 Valves Installation

All valves shall be installed in accordance with the Specifications and shall be installed on the pipelines in the positions and to the details shown on the Drawings.

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 45mm on the other side.

Flanged gate valves installed on black steel lines with welded joints shall be provided on one side with the appropriate Viking Johnson flange adapter or dresser with tie rods or as shown on Tender Drawings and those installed in galvanized steel threaded pipelines shall be preceded or followed by the appropriate galvanized iron union.

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.

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.

DIVISION 8: PIPE LAYING

8.1 General

Handling, transporting, installation, jointing and backfilling of steel, Ductile, Polyethylene, UPVC and GRP Pipes shall be governed by this Division and by the related requirements of other Divisions, particularly as regards:

(i) Handling and transportation of pipes.

(ii) Storage and protection of materials.

(iii) Pipe laying in trenches.

(iv) Pipes installation.

(v) Backfilling and compaction.

(vi) Compaction and testing.

The Contractor shall submit to the Engineer for approval and maintain up-to-date:

(i) Lists of approved welders and their identification marks.

(ii) Approved welding and repair procedures.

(iii) Approved bedding and backfilling materials and procedures.

Handling and installation of pipe and fittings shall be in accordance with the manufacturer's instructions; referenced standards and as specified herein.

8.2 Handling and Transporting of Pipes

8.2.1 General

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.

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 Contractor has to provide new pipes and in case of any delay in providing the need pipes. The Employer will provide a new pipe in place of the damaged one, and the Contractor shall pay the cost thereof to the Employer.

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.

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.

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.

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. Hooks or other equipment liable to injure or distort pipe ends, its coating and lining, shall not grip pipes.

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.

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.

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 100mm wide.

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.

No steel cables or ropes likely to injure the coating shall be used for handling the pipes, but only belts at least 250mm wide or such special tackle as will not damage the coating.

8.2.2 Ductile Iron Pipes

Considering all above mentioned general instructions, for ductile iron pipes, slings of canvas, rubber belting or other non-abrasive material, or special fittings shaped to fit the pipe ends and approved by the Engineer shall be used for lifting and lowering pipes and specials. Pipes shall not be lifted by hooks nor shall they be dropped or dragged.

Handling and installation of pipe and fittings shall be in accordance with the manufacturer's instructions, referenced standards and as specified herein.

Ductile iron pipes being transported shall be supported on timbers, sand bags or padding arranged so the pipes do not rest on their sockets and adjacent pipes do not touch.

8.2.3 Steel Pipes

Considering all mentioned above general instructions, steel pipe shall be transported from the manufacturing plant to the job site on padded bunks with nylon tie-down straps or padded banding to adequately protect the pipe and coating.

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.

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. All cost intiteled shall be born by the Contractor.

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.

Handling and installation of pipes and fittings shall be in accordance with the manufacturer's instructions; referenced standards and as specified herein.

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

Considering all mentioned above 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.

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.

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.

8.2.5 Glass Reinforced Polyester (GRP) Pipes

Pipes 600mm and smaller may be packaged as a unit. Manufacturer's instruction for handling unitized loads should be strictly followed. When handling single pipes, use pliable straps, slings, or rope to lift. Do not use steel cables or chains to lift or transport the pipe. Do not lift pipes by passing a rope through the section end to end.

Maximum stack height is approximately 2 meters. Strap pipe to the vehicle over the support points using pliable straps or rope. Using steel cables or chains is prohibited without adequate

padding to protect the pipe from abrasion. Also, maximum diametrical deflection must not exceed the values shown in the Table 8.1 below.

Table 8.1
Maximum Storage Deflection

Stiffness Class SN	Maximum Deflection (% of Diameter)
2500	2.5
5000	2.0
10000	1.0

Bulges, flat areas, or other abrupt changes of curvature are not permitted.

Unloading the pipe is the responsibility of the Contractor, he should be sure to maintain control of the pipe during unloading. Guide ropes attached to pipes or packages will enable easy manual control when lifting and handling. Spreader bars may be used when multiple support locations are necessary. Do not drop, impact, or bump the pipe, particularly at pipe ends.

If at any time during handling or installation of the pipe, any damage occurs, the pipe should be segregated and not used.

8.3 Storage and Protection of Materials

8.3.1 General

All ductile, steel, PVC, GRP, PE pipes, fittings, valves as well as flanges, seals, gaskets and other accessories shall comply with standards mentioned in Divisions 5 and 7 of this specifications or any other equivalent approved standards.

Storage and protection of materials (pipes, fittings and accessories) shall be in accordance with manufacturer instructions, reference standard as specified herein.

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.

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.

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.

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.

The outermost pipes in each course shall be secured against rolling by sandbags or by wedges. 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.

8.3.2 Ductile Iron Pipes

Materials, when stored, shall be kept safe from damage. The interior of all pipe, fittings and other appurtenances shall be kept free from dirt or foreign matter at all times.

Pipe shall not be stacked higher than the limits recommended by its manufacturer. The bottom tier shall be kept off the ground on timbers, rails, or concrete. Pipe in tiers shall be alternated. At least two rows of 100mm x 100mm (4in x 4in) timbers shall be placed between tiers and chocks affixed to each end in order to prevent movement.

Gaskets for mechanical and push-on joints to be stored according to ISO 2230 and shall be placed in a cool location out of direct sunlight. Gaskets shall not come in contact with petroleum products. Gaskets shall be used on a first-in, first-out basis.

8.3.3 Steel Pipes

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.

8.3.4 PVC and PE Pipes

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 8.2.

Table 8.2
Pipe Storage Arrangements

Pipe Diameter (mm)	Max. No. of Rows Stacked
200 or less	5
300 - 530	4
600 - 760	3
840 - 1220	2

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.

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.

8.3.5 Glass Reinforced Polyester (GRP) Pipes

All pipes should be inspected upon receipt at the job site to insure that no damage has occurred in transit. Depending on length of storage, amount of job site handling and other factors that may influence the pipes condition, the Engineer may reinspect the pipe just prior to installation.

If the load has shifted or indicates rough treatment, carefully inspection should be made. Generally, an exterior inspection will be sufficient to detect any damage, but if pipe size permits, an interior inspection of the pipe surface at the location of an exterior scrape may be helpful to determine if the pipe is damaged. If any imperfection or damage is found, immediately the effected pipes should be segregated and disposed of the site.

It is generally advantageous to store pipe on flat timber to facilitate placement and removal of lifting slings around the pipe. When storing pipe directly on the ground, the area should be flat and free of rocks and other potentially damaging debris. All pipes should be checked to prevent rolling in high winds.

If it is necessary to stack pipes, it is required to stack on flat timber support at maximum space centers 6 meter spacing (3 meter for small diameter) with a maximum overhang of 2 meters. Chock the pipes to maintain stability and separation. Insure no pipes contact other pipes, so vibration during transport will not cause abrasion. Insure the stack will be stable for conditions such as high winds, unleveled storage area or other loads. Stacking of pipes larger than 1400mm diameter is not permitted.

Rubber ring gaskets, when shipped separate from the couplings, should be stored in the shade in their original packing and should not be exposed to sunlight except during the pipe joining. Also, the gaskets must be protected from exposure to greases and oils which are petroleum derivatives, and from solvents and other deleterious substances.

Gasket lubricant should be carefully stored to prevent damage to the container. Partially used buckets should be resealed to prevent contamination of the lubricant.

8.4 Materials Supplied by the Employer

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 .

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, 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.

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.

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.

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.

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.

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.

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.

8.5 Pipe Laying in Trenches

8.5.1 General Trench Excavation Requirements

The excavation shall include the clearing of all surfaces of all refuse and obstruction, and excavation of all materials of whatever nature encountered as required to complete the work. The equipment and construction methods used shall be to the approval of the Engineer, and all excavation shall comply with Division 2, Earthworks of these Specifications.

Before commencing excavation on any length of pipeline route, the Contractor shall agree with the Engineer a record of the pre-existing condition of the surface, this pre-excavation survey shall be supported by photographs and video tape except where the Engineer agrees these are not necessary.

All excavation shall be carried out in such a manner as to create a minimum of inconvenience and interference with pedestrian and vehicular traffic and with access to buildings or other properties.

To provide the public with the necessary safety and protection, the Contractor shall at his expense provide barricades, lights, warning signals, guard rails, pedestrian crossings over trenches and watchman services to the satisfaction of the Engineer.

Before beginning excavation on any street or site Contractor shall obtain permission from the Engineer and he must check with the Engineer to establish space requirements for possible future sanitary or storm sewers as set out in the special conditions.

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.

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.

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 wash-out valves will be the minimum necessary to secure efficient operation and economy in excavation.

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. The Contractor 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.

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.

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.

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.

All pipes 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.

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.

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.

In order to prevent the pipes from "creeping" from the mechanical joints and to protect the welds against thermal stresses, which are especially 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.

Hand excavation must be applied where existing cables, water mains, sewers, etc., cross or are in the main roads where traffic is likely to be unreasonably dislocated by use of machine or where instructed by the Engineer. In other places hand or machine excavating may be employed at the discretion of Contractor in narrow roads or according to site conditions as directed by the Engineer.

Mechanical Excavation approved mechanical equipment shall be so operated that:

- The rough trench excavation bottom can be controlled.
- When accurately laid to specified alignment, pipe will be centered in the trench with adequate clearance between the pipe and sides of the trench.

8.5.2 Excavation Permits

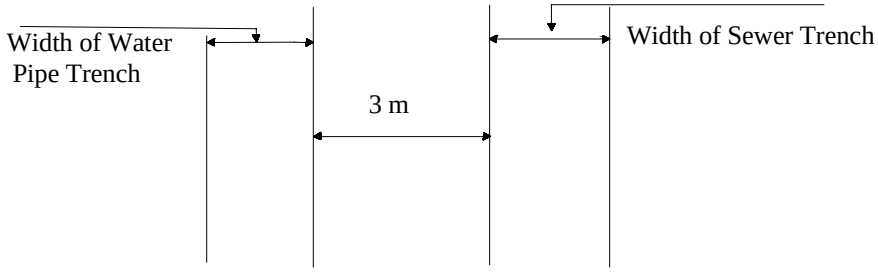
Before proceeding with excavation on each section of the work, the Contractor shall obtain all required excavation permits from the municipality or issuing authority. Copies of these permits shall be given to the Engineer prior to the commencement of the excavation.

8.5.3 Pipe Installation

8.5.3.1 Parallel Installation

As a general rule, water pipes and any existing or proposed sewers should not be laid in the same trench. They should be laid in separate trenches at least 3000mm apart in a horizontal direction, as shown in Figure 8.1 (a).

Figure 8.1 (a)
Plan View

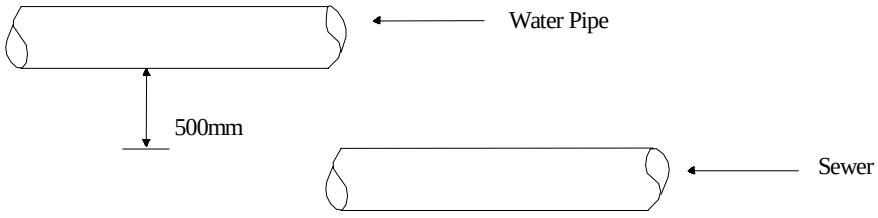


Additional protection should by provided by layind the water pipe not less than 500mm higher than the sewer line, as shown in Figure 8.1 (b)

Laying the water pipe not less than 500mm higher than the sewer line will provide an additional precaution.

In cases where it is not practical to maintain a 3000mm separation and where local conditions, such as in very narrow streets, do not permit this minimum separation, the responsible authority may allow deviation on a case-by-case basis, if supported by data from the design. Such deviation may allow installation of the water main closer to a sewer. This distance could be decreased but the bottom of the water pipe must be kept at least 500mm above the top of the sewer pipe, as shown in Figure 8.1 (b).

Figure 8.1 (b)
Sectional View



But if the vertical separation of not less than 500mm cannot be obtained, sewer material and joints should be ductile iron type (pressure pipes) and should be pressure tested to ensure water tightness before back filling. The least pressure shall be 1.5 times working pressure of the water pipe.

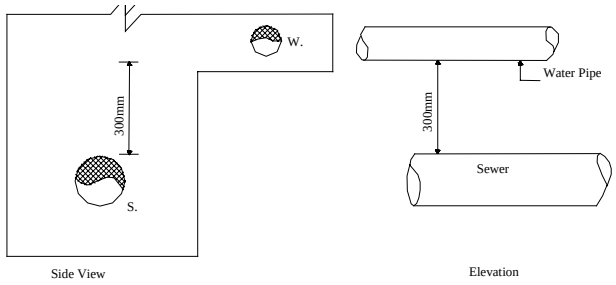
In cases where there is no alternative but to lay both water pipes and sewers in the same trench, the following should be observed:

(i) The water main should be offset of an undisturbed earth shelf.

(ii) The bottom of the water main should be at least 300mm above the top of the sewer line as shown if Figure 8.1 (c).

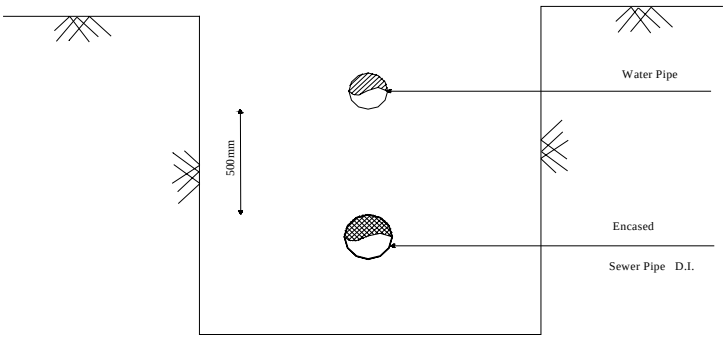
(iii) Both water and sewer lines should be sealed with mechanical joints or equal construction.

Figure 8.1 (c)
Sectional View (Water & Sewer Pipes)



In situations where water pipes are in close proximity of sewers and no adequate horizontal or vertical separations can be provided, considerations should perhaps be given to encasing sewer lines with reinforced concrete in addition to using pressure-types for sewers as shown in Figure 8.1 (d).

Figure 8.1 (d)
Water & Sewer in One Trench



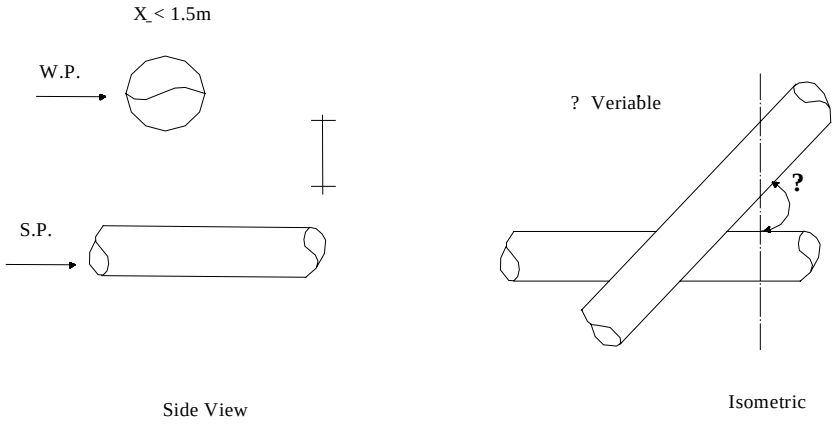
All the above mentioned clear distances should be measured edge to edge.

8.5.3.2 Crossings

In the case where the water main is above the sewer:

- Water mains crossing sewers shall be laid to provide a minimum vertical distance of 500mm between the bottom of the water main and the top of the sewer.
- One full length of water pipe shall be located so both joints will be as far from the sewer as possible.
- Where sewers cross water pipes (100mm in diameter or more) and the vertical projected distance between them is equal or less than 1.5m, then sewers for a distance at least 3m on each side of the water line should be constructed of materials and joints shall be ductile iron type and shall be pressure-tested to 1.5 times the working pressure of the water pipe to assure water tightness before back-filling, as shown in Figure 8.1 (e).

Figure 8.1 (e)
Water Pipes Cross Sewer Pipes



In the case where the water main is below the sewer:

- Water mains crossing sewers shall be laid to provide a minimum vertical distance of 500mm between the bottom of the sewer and the top of the water main.
- Sewer should be constructed from ductile iron pipes and shall be pressure tested to ensure water tightness before backfilling.
- Special structural support for the sewer pipes may be required to prevent excessive deflection of joints and settling on the water main. Full reinforced concrete encasement could be provided for the part of the sewer crossing the water main.
- One full length of water pipe shall be centered at point of crossing so both joints will be equidistant and as far from the sewer as possible.

8.5.3.3 Sewer Force Mains

There shall be at least a 3m horizontal separation between water mains and sanitary sewer force main, i.e. pressurized line.

There shall be a 500mm vertical separation at crossings as required in the Crossing installation case above.

8.5.3.4 Separation of Water Mains from Other Sources of Contamination

No water pipe shall pass through or come in contact with any part of a sewer manhole.

In the design, caution should be exercised when locating water mains at or near certain sites such as sewage treatment plants or industrial complexes.

Individual septic tanks must be located and avoided.

It is necessary to contact the reviewing authority to establish specific design requirements for locating water mains near any source of contamination.

There shall be no connection between the distribution system and any pipes, pumps, hydrants, or tanks whereby unsafe water or other contaminating materials may be discharged or drawn into the system.

8.5.4 Trench Dimensions

8.5.4.1 Width of Pipeline Trenches

The width of the trench should satisfy the following requirements:

Where the sides of the trench can afford reasonable side support, the trench width at the top of the pipe should be maintained at the narrowest practical width and the same as that afforded by the single-pass capabilities of normally available excavating equipment regardless of the depth of excavation. This will:

- Allow compaction of the backfill to be placed as specified.
- Allow proper densification of pipe-zone bedding,
- Allow proper installation of the pipe,
- Avoid excessive external loads on the pipe.

In this case, trenches shall be excavated with approximately vertical sides between the elevation of the center of the pipe and an elevation 300mm above the top of the pipe.

The width at the joint should permit easy working space without damaging the coating of the pipe.

Pipe trenches shall not be widened by scraping or loosening materials from the sides. Every effort shall be made to keep the sides of the trenches firm and undisturbed until backfilling has been completed and consolidated.

If the sides of the trench in the vertical section remain vertical after excavation, and if bedding and backfill are to be consolidated by hydraulic methods, then the minimum trench width at the top of the pipe should be pipe outside diameter plus 500mm.

If the pipe-zone bedding and backfill require densification by compaction, the width of the trench at the bottom of the pipe; should be:

- Determined by the space required for the proper and effective use of tamping equipment.
- At least pipe outside diameter plus 500mm.
- The minimum clearance between the installed pipe and each trench side shall not be less than 250mm.

Table 8.3
Minimum Trench Width, Cover and Depth

Pipe Diameter mm (in)	Trench Width (mm)	Cover (mm)	Depth (mm)
50 (2)	550	700	900
75 (3)	575	700	925
100 (4)	600	700	950
150 (6)	650	900	1200
200 (8)	700	900	1250
250 (10)	750	900	1300
300 (12)	800	900	1350
350 (14)	850	900	1400
400 (16)	900	900	1450
450 (18)	950	900	1500
500 (20)	1000	900	1550
550 (22)	1050	900	1600
600 (24)	1100	900	1650
650 (26)	1150	900	1700
700 (28)	1200	900	1750

The rest of trench shall be excavated with approximately vertical sides as much as possible.

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.

Additional width may be required to permit the convenient placing of timber supports, sheathing, bracing, and handling of appurtenances in accordance with the safety requirements of the agency having jurisdiction.

Separate excavations are to be made for manholes, valve chambers, pipe junctions, etc.

8.5.4.2 Depth of Trenches

Trenches should be dug to grade as shown in the profile of Tender Drawings. The profile should be selected to minimize high points where air may be trapped.

The minimum cover should be generally provided for the following reasons:

- Protect the pipeline from transient loads where the climate is mild. The profile should give cover not exceeding the load carrying capacity of the pipe. The dead load of the backfill and the life load resulted from traffic load, railroad, and temporary structures should be considered.
- Avoid freezing in very cold climates which ever govern by providing the depth of the frost line.

Trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe. The required minimum cover for pipes should be according to Table 8.4 below.

Table 8.4
Minimum Cover Limits

Diameter mm (in)	Min. Cover (mm)
≥150mm (6)	Not less than 900
< 150mm (6)	Not less than 700

The trench should be excavated to a depth not less than 150mm below the bottom of the pipe and refilled with loose material (crushed rock or sand, screened earth) from which all stones and hard lumps have been removed.

Greater pipe cover depths may be necessary at certain locations, such as along or across roads and where heavy load traffics are expected. Passing through critical safety area such as railway, motor way or Wadi crossing requires special precautions.

Existing utilities or other conditions in city streets may govern depth of trench (such as gas, sewer, cables, other water pipelines, etc.) or other structures (like bridges, tunnels, culverts, etc.

Where there is no adequate minimum cover, concrete encasement will be used as hereinafter.

Bell holes in the bottom of the trench may be provided at each joint, when mechanical joints are assembled on pipe in the trench. They should be no larger than necessary for proper joint assembly to assurance that the pipe barrel will lie flat on the trench bottom. Push-on type joints require only minimum size bell holes to ensure that the pipe is not resting on the bells.

A slight depression may be provided, however, for withdrawing pipe slings or other lifting tackle without damaging the coating or polyethylene encasement.

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.

8.5.4.3 Limits of Trench Opening

Trenches shall not be kept open for lengths exceeding a total of 100 meters within urban areas and 500m in rural areas unless otherwise permitted by the Engineer. A shorter limit may apply in towns if the municipality or other authority dictates. In urban areas the contractor has to backfill all trench before the end of the day work unless otherwise written approval issued by the Engineer.

8.5.5 Drainage of Trenches

The Contractor shall at his own expense maintain all excavations or trenches free from water, including groundwater and sewage from whatever source while the excavation or construction is in progress. Water shall not be disposed of onto streets without the consent of the municipality, or onto private property without the consent of the Owner. Sewage shall be disposed of only in a manner approved by the Engineer.

8.5.6 Existing Drainage Courses

Where the excavation interferes with existing drainage courses, the Contractor shall be responsible for rerouting or pumping or otherwise preserving the flow and such work shall be at the Contractor's expense.

8.5.7 Shoring of Trenches

Where required for the safety of life, property or the work; sides of trenches and excavations shall be supported with suitable shoring. Any cave-ins, with or without shoring, and any damage to life and property resulting therefrom shall be the sole responsibility of the Contractor.

8.5.8 Precautions

In the event that the Contractor encounters quicksand, subsurface streams, or other such dangerous situations, or where structures for any reason may bring excessive pressures upon trenches, he shall take all necessary precautions to prevent cave-ins and damage to life and property. Any damage to life and property resulting from such situations shall be the sole responsibility of the Contractor.

All excavated material and material to be used for backfilling of trenches shall be piled neatly along the sides of excavations and trenches, provided they do not unduly interfere with pedestrian and vehicular traffic or with access to buildings or other properties, otherwise the Engineer may order that these stockpiles be removed, and such removal shall be done immediately and at the Contractor's expense.

8.5.9 Disposal of Surplus Materials

Surplus excavated material shall be disposed of at the Contractor's expense, in areas designated by the municipality, or at locations on the Site as directed by the Engineer. After deposit, the material shall be leveled to a uniform surface and to the grade designated by the Engineer at the Contractor expenses.

8.5.10 Existing Pavement

Where trenches are excavated in or across existing pavements, the trenching shall be performed carefully so that no more than the minimum width required is excavated. The Contractor shall use such methods as will assure breaking pavement with a vertical face and at original grade, by using the asphalt-cutting machine.

Measurements and Payments:

Asphalt-cutting measurements and payments shall be included in trench excavation works or as specified in BOQ.

8.5.11 Pipe Installation

8.5.11.1 General

The Contractor shall notify the Engineer and permit him to inspect each pipe joint prior to lowering into the trench.

Non-abrasive, canvas-padded slings shall be used in lowering coated pipe sections. Protective shields of plywood (or equivalent material) shall be placed alongside walls of trench containing rock or other hard objects, and shall be removed when the pipe is in its final position.

As the pipe is suspended for lowering into the trench, the lining and coating shall be inspected by a holiday detector using special inspection services independent from, but paid for by, the Contractor.

Any defects shall be repaired by the Contractor at his expense and shall be re-inspected and approved (if possible) before continuing further with the pipe installation.

8.5.11.2 Ductile Iron Pipes

Ductile iron pipes and fittings shall be installed in accordance with requirements of manufacturer and as shown on the Tender Drawings.

Fittings, in addition to those shown on the Drawings, shall be provided when required by the site utility conditions. When cutting pipe is required, the cutting shall be done by abrasive saw. Any damage to the lining shall be repaired to the satisfaction of the Engineer. Cut ends of pipe to be used with a bell shall be beveled to conform to the manufactured spigot end. Joints shall be made in strict accordance will the manufacturer's instructions.

Restrained joint or suitable tie-rods shall be provided where there is a possibility of pulling the joint under pressure. Concrete anchors and thrust blocking shall be provided where there are thrust forces resulting from change of pipe direction in either horizontal or vertical planes. Thrust block bearing area against the soil shall be as shown on the Drawings.

All pipes 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.

After installation, the pipe shall be tested for compliance with the Specifications. Furnish all necessary equipment and labor for the pressure test and leakage test on the pipelines.

Submit detailed test procedures and method for Engineer's review. In general, testing shall be conducted in accordance with Division 9 of these Specifications.

8.5.11.3 Steel Pipes

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.

Except as otherwise provided herein, pipe and fittings shall be installed in accordance with the requirements of the manufacturer as shown in Tender Drawings.

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.

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

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.

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.

Before bedding of galvanized pipes, in situ cold bitumen coating, of minimum thickness (0.5mm) should be applied for underground installations, and extended at least 200mm for pipes partially laid above the ground. Buried galvanized pipes should be coated with polyethylene from the external surface.

Field joints shall be wrapped in accordance with AWWA C209 and the manufacturer requirements. The joints shall be cleaned, primed and wrapped with two wraps of tape with a 0.89mm (35mils) thickness each and holiday tested. When the alternative extruded polyethylene coating is used, field joints shall be coated in accordance with AWWA C216.

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.

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.

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 Division 9 requirements of these Specifications.

8.5.11.4 PVC and PE Pipes

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.

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 pipes 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.

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 beveled to conform to the manufactured spigot end.

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.

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 perform 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.

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 drive 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.

8.5.11.5 PE Joints

PE pipelines can be jointed by butt fusion, electro fusion and mechanical joints. The advantages of a PE integrated end load resistant system are usually achieved most economically by jointing using fusion-welding techniques. Butt fusion is perhaps more commonly applied although electro fusion may be preferred where butt fusion is impractical due to lack of space.

Only similar materials and similar wall thickness should be jointed by butt fusion. Guidance should be sought before attempting to join materials with different pressure ratings or with different diameters.

8.5.11.6 Fittings and Appurtenances

Piping systems include pipe and various appurtenances required in the control, operation, and maintenance of the systems. Proper design, installation, and operation of PVC and PE piping systems must relate to appurtenances as well as pipe.

Plastic service connections vary in size from small services supplying individual homes to large outlets for industrial users. Service lines are connected to water mains using one of the following methods, depending on the size and material type of the main:

- Tapping through service clamps or saddles,
- Tapping sleeves and valves for larger service connections, and
- Direct tapping.

8.5.11.7 Service Clamps or Saddles

Service connections may be made using a service clamp or saddle. When making this type of connection with the line under pressure, equipment is used which attached to the corporation stop and permits a cutting tool to be fed through the corporation stop to cut a hole in the main pipe. Cutting tools should be sharp and should not apply excessive pressure. No threading of the pipe wall is required since the corporation stop is threaded into the service clamp. Service clamps and saddles should be installed in accordance with manufacturer's recommendations.

8.5.11.8 Tapping Sleeves and Valves

Tapping sleeves and valves are used when service connections larger than 2in. (50mm) must be made in the water main. Tapping sleeves may be used for making large taps under pressure. When tapping sleeves are ordered from the manufacturer, the outside diameter of the pipe being tapped, the size of the outlet desired, and the working pressure should be specified to ensure that the sleeve furnished will be satisfactory.

Tapping sleeves should be assembled in accordance with the manufacturer's directions. Drilling equipment can be purchased from sleeve manufacturers, who will also furnish instructions and/or instructors trained in making such taps. (Contractors who specialize in this type of work are also available in some areas).

Tapping sleeves should be well supported independently from the pipe during the tapping. Support used should be left in place after tapping. Thrust blocks should be used as with any other fitting or appurtenance.

8.5.11.9 Direct Tapping

For some sizes of plastic and other types of pipes, service connections may be mad by the direct tapping of pipe wall and the Insertion of a corporate on stop. In direct tapping, proper use of specified direct tapping equipment, corporation stops, and a torque wrench is recommended. This procedure should be used with proper direction and instructions from the manufacturer of the pipe and the manufacturer of the direct tapping equipment.

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

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. Joints shall be comply with ISO 4422-3, ISO 264, ISO 727 or any other equivalent approved standards.

Precautions shall be taken to prevent flotation of the pipe in the trench.

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.

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.

Restrained joints shall be installed where shown on the Drawings.

Joints shall be made in strict accordance with the manufacturer's instructions.

8.5.11.10 Glass Reinforced Polyester (GRP) Pipes

GRP pipe, like virtually all pipes made with petrochemicals, can burn and is, therefore, not recommended for use in applications, which are exposed to intense heat or flames. During installation, care must be taken to avoid exposure of the pipe to welder's sparks, cutting-torch flames or other heat / flame / electrical sources which could ignite the pipe material. This precaution is particularly important when working with volatile chemicals in making lay-up joints, repairing or modifying the pipe in the field.

All pipes 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.

The type of installation appropriate for GRP pipe varies with pipe stiffness, cover depth and native soil characteristics. The native material must adequately confine the pipe zone backfill to achieve proper pipe support. However, the designated type of installation, as stipulated by the manufacturer shall be followed, and consequently, the permissible must not be exceeded.

The bed must be over-excavated at each joint location to ensure that pipe will have a continuous support and does not rest on the coupling. However, this area must be properly bedded and backfilled after the joint assembly is completed.

GRP pipe sections are typically joined using double bell couplings. Other jointing systems such as flanges, mechanical coupling and lay-up joints may also be used with GRP pipes.

The manufacturer's instructions for installation should be strictly followed. The coupling grooves and the rubber gasket rings must be thoroughly cleaned to insure no dirt or oil is present. Insertion the gasket into the groves should be done with uniform pressure to insure for well-distributed compression of the gasket. Tapping with rubber hammer will be helpful to use. Next, using a clean cloth, apply a thin film of lubricant to the rubber gaskets as per manufacturer's instructions. Petroleum base lubricant shall not be used.

Immediate backfilling after joining is desirable, as it will prevent two serious hazards - floating of pipe and thermal movements. During backfilling, the granular material should flow completely under the pipe to provide full support. A blunt tool may be used to push and compact the backfill under the pipe, without raising the pipe up. Proper backfilling compaction of each layer is important to ensure that the pipe will have an adequate support. Care must be taken to avoid excessive compactive effort above the pipe crown, which may cause bulges or flat areas.

Installations of GRP pipes should be in accordance with manufacturer requirements, and ISO 10465-1, ISO 8572.

8.6 Pipe Welding

8.6.1 General

Welding of circumferential joints in the pipeline shall comply with the latest edition of API Standard 1104 and AWS D 10.12 and as further specified herein.

All welding shall be carried out in accordance with the specific procedures prepared by the Contractor and approved by the Engineer.

Adequate precautions shall be taken to protect welding operations from the adverse effects of weather, such as wind, rain and blowing sand.

Longitudinal seams of joined pipe shall be staggered by not less than 20 degrees, where the Contractor chooses to weld pipes and / or fittings together outside the trench prior to installation, the resulting joint shall be straight within the limits by API Standard 5L.

Welds rejected by the Engineer may, at his discretion, be repaired in accordance with API Standard 1104, Section 7, subject to the following:

(i) Repairs to the filler weld, which would penetrate the stringer bead, will not be permitted.

(ii) All burns shall not be repaired by welding, but shall be removed by grinding provided that no reduction in wall thickness is made in excess of that permitted by the specification.

(iii) The Contractor shall maintain records of all repairs of whatever nature to pipe and pipeline describing and locating such repairs.

Welding pipe together where welds have been cut shall be done with one weld if it is practical to pull the line into position; otherwise, two welds shall be made by setting in a piece of pipe at least 2m in length.

8.6.2 Welder Qualification

All welders employed on the works shall be fully qualified and shall have successfully passed tests required by API codes for the type of work required.

Welder qualification test or retests shall be carried out on the site where the Engineer or his representative may witness them.

The Contractor shall provide necessary; labour, pipe welding, materials and equipment for performing welder qualification tests on site.

Arrangements for laboratory tests of components, if required, shall be made and paid for by the Contractor.

The Contractor shall maintain a list of approved welders agreed with Engineer and no other person shall perform welding operations on the permanent works.

8.6.3 Welding Procedure

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 piecework 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.

Pipe ends shall be swabbed with a leather or canvas belt disc to remove dirt, loose mill scale, rust, oil, grease, and other matter, which may be injurious to the weld.

Cleaning of pipe ends shall be done by power wire brushing or grinding, pipe ends damaged such that they no longer meet joint specifications shall be re-chamfered by a suitable machine. Stinger beads on transmission pipelines shall be applied by at least two welders welding in opposite quadrants.

The numbers of filler and finish beads shall be in accordance with the approved procedures. Completed welds shall have a substantially uniform cross section around the entire circumference of the pipe. At no point shall the crown surface be below the outside surface of the pipe or proud of the parent metal by more than 1-1/2mm.

No welding shall be done when the shade temperature is below 5 °C and falling unless approved by the Engineer who may require preheating of the pipe.

All joints on which welding has started shall be completed before the end of each day's work. At night or when work is not in progress, the open ends of the pipeline shall be securely

capped with suitable covers to prevent the entrance of dirt, small animals, water, and foreign matter into the pipeline.

Tie-ins shall be carefully aligned to limit residual and/or reaction stresses after completion of the weld. Tie-ins shall be made within the temperature range of 10 °C to 30 °C. In very hot weather, fully welded lengths between restraints shall be protected from excessive heat to avoid buckling.

The use of welding machines with two outlets will not be permitted; every welder shall work with his own machine

8.6.4 Quality Control of Welding

All production welds shall be subject to visual inspection by the Engineer. Visual inspections may be carried out at any stage of the welding of a joint.

Each weld shall be clearly marked adjacent to the weld indicating the identification of the welder. Steel diestamping will not be permitted.

Non destructive testing (radiography) will be carried out by an approved independent organization during the course of the work as required by the Engineer. The Contractor shall pay for the testing by the independent organization without any compensation from the Employer.

The Engineer retains the right to have cut out, removed and replaced one weld only per 5 kilometers of pipeline for each welder at no cost to the Employer.

Welds rejected by the Engineer shall be cut out and replaced by the Contractor.

8.6.5 Electrodes

Electrodes used on welding work shall have a diameter of 4mm and 3.25mm and shall approximately meet the requirements of *PS 117,PS 119*. In any event, the electrodes proposed by the Contractor shall be subject to the Engineer's approval prior to their use.

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.

8.6.6 Cleaning of Pipes

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.

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.

8.6.7 Welding Positions

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.

8.6.8 Weather Conditions

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.

8.6.9 Cutting and Preparing Pipes for Welding

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, all in addition to the required protective coating according to manufacturers' instructions. When the cut pipe is to be inserted in a "Tyton" type joint it shall be beveled for 10 mm at 30^{o} to pipe axis to remove sharp or rough edges.

The Contractor shall be solely responsible for the provision of all equipment necessary for cutting and preparing pipes.

Spare cut lengths shall as far practicable be used elsewhere in the pipeline.

8.6.10 Welding of Joints

The number of beads in each weld seam shall not be less than two and their thickness shall not exceed 3.0mm or as required by the manufacturers' instructions.

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.

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.

8.6.11 Jointing of Line Sections

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.

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 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.

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

8.6.12 Repair of Weld Defects

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.

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.

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 rewelded.

The Contractor shall clearly mark with oil paint on top of the pipe any defect that may be discovered in the pipe or weld.

8.6.13 Radiographic Tests

Radiographic tests shall be performed at locations specified by the Engineer of weld seams. If these primary tests should not give satisfactory results, the Engineer will conduct additional radiographic tests to ascertain the quality of the welding work. All weld defects discovered by the tests shall be repaired as directed by the Engineer and all repaired welds shall be retested.

The routine radiographic tests will be carried out at the Contractor expense. Should, however, the Engineer assess it necessary to conduct additional tests because of the defective quality of the welds, the cost of all such additional tests will be charged to the Contractor's account. The Contractor shall also bear the cost of repair of all welds found defective under test as well as the cost of resetting such repaired welds.

8.7 Above Ground Pipe Laying

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.

8.8 Flanged Joints

8.8.1 General

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.

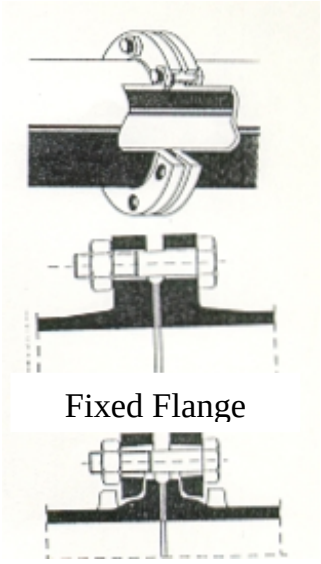
The protective coating, if any, of the flange shall be made good when the joint is completed.

Flanged outlets on steel pipes can be assembled from a short piece of pipe using a steel ring flange, or a hub flange of the slip-on type. If the main line slopes, the flange should be rotated with reference to this slope to bring the attachment vertical. Outlet piece or nozzle should be as short as possible to reduce the dominance of any bending force applied to the outlet. In general, every outlet should have a valve firmly attached to the mainline and a flexible connection to the pipe downstream from this valve. For ductile iron pipes, a Tee with flanged branch should be installed during the installation of the pipeline to provide for a flanged joint connection.

8.9 Ductile Iron Pipes (DIP) - Flanged Joints

This joint consists of flanges connected together by bolts and a gasket is inserted in between, see Figure 8.2 here below. The pipes must be carefully aligned before the bolts are inserted and the flanges pulled together. The rubber ring and flanges must be very clean. No grease, bitumastic paint, oil, dirt, grit, or water should be permitted on the flanges or gasket faces. The only permissible material to use in vertical alignment to keep rubber ring flat is the rubber solution. Any other material especially greasy material will make the joint liable to leak. Tension on the main during bolt tightening shall be avoided. The order of bolt tightening and torque as recommended by the manufactures shall be respected. This type of joint is useful in above ground lines and in connection with pumps, valves reservoirs and others because it is easy to be dismantled. Underground use of the flanged joint is generally not recommended because of the rigidity of the joint.

Figure 8.2
Flanged Joint Detail for Ductile Iron Pipes



Fixed Flange

Rotatable Flange

Two types of flanges are possible; fixed for diameter less than 600mm, and rotatable flanges for larger diameter to facilitate bolt insertion. The number of bolts used to connect the flanges depends on the pressure of the pipe.

8.10 Black Steel Pipes (BSP) - Flanged Joints

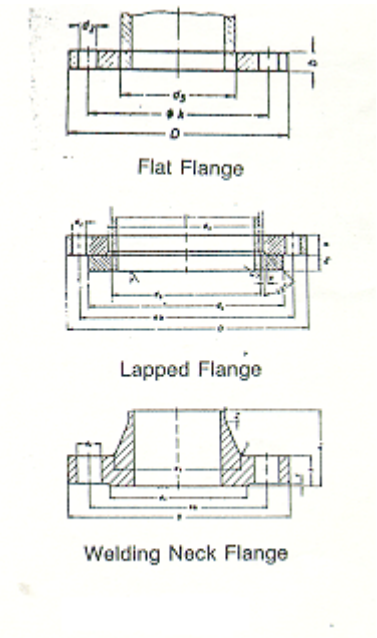
Flanges commonly used for steel water pipe are of the slip-on type raised faces welded to the pipe (See Figure 8-3). Flanges may be of two classes, as follows:

- Hub slip-on welding neck flanges shall conform to the materials requirements for the forged carbon steel flanges as specified in ISO 7005-1.
- Forged steel, made of a low hub, or with a welding neck, by rolling or forging the process.

The more costly welding–neck type of flange ordinarily is not justified for the comparatively low pressures usually found in network Services.

O-ring gasket (rubber or asbestos) should cover the raised face of the flanges to provide water tightness. The flanges are then bolted together.

Figure 8.3
Flanged Joints Detail for Steel Water Pipes



Flanges are necessary to connect pipes with pumps, valves, and other appurtenances having flanged ends. Test pressures of flanged fittings should never exceed 1.25 times the flange pressure rating, or flange may be damaged.

8.11 Mechanical Joints

8.11.1 General

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 200mm from the edge.

Joint rings shall slide freely into the pipes. Forcing on of rings by hammer blows will not be permitted.

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.

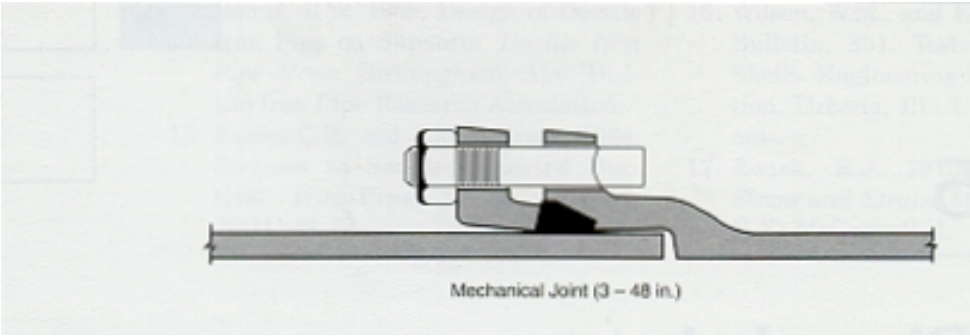
Where shown on the Drawings or required by the Engineer, dresser couplings shall be fitted with anchors. The shape and method of installation of these anchors shall be as shown on the drawings.

Every Dresser coupling shall be bridged for cathodic protection as shown on the drawings.

8.11.2 DIP Mechanical Joints

The mechanical joint works on the principle of forcing a rubber ring into an annular space formed between the socket and the plain spigot of the other pipe, see Figure 8.4. The rubber ring is forced into the annular space by a cast iron pressure gland, which is drawn by bolts or screwed into the socket. The pipe barrel, the socket and the rubber ring must all be clean before erection and the pressure gland must be tightened up uniformly. This type of joints are principally used for gas mains are being superseded by the push-in type for water pipelines in small diameters. Some deflection is permitted with this type of joint which can be up to 5^{o} for small diameter equal or less than 150mm 4^{o} for sizes 200-300mm, 3^{o} for sizes 350-600mm, and 1^{o} 30' for sizes 900-1800mm diameter.

Figure 8.4
Mechanical Joint Detail



The required torque for bolts tightening depending on the diameter of the pipe and its pressure which shall be as recommended by the manufacturer.

Care should be exercised when attempting to connect fittings with mechanical joints to cast-iron pipe in old systems. The outside diameter of pipe in old systems should be measured before cutting because some pipe made in past years was manufactured with larger diameters than are presently specified in the current standards. Special mechanical joint sleeves and/or bell-and-spigot sleeves are available to provide transition from these larger diameters to the present diameters.

8.12 Viking Johnson Couplings

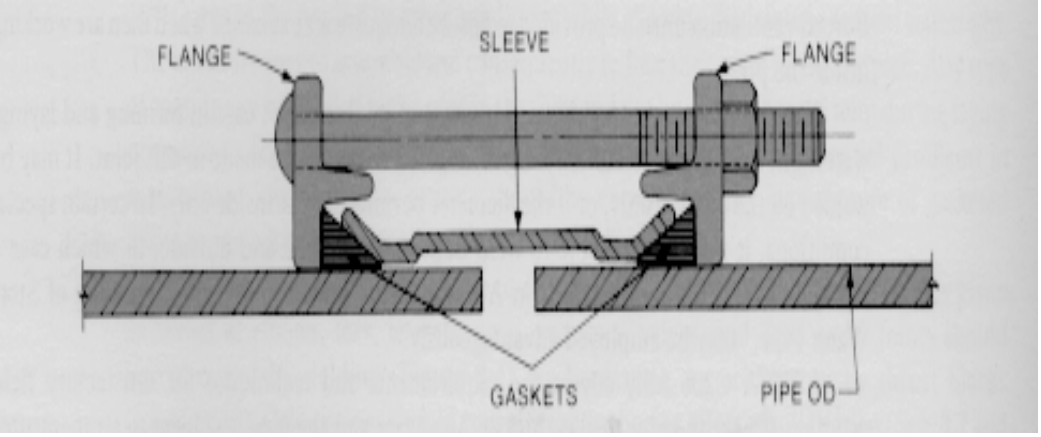
Plain-ended pipes shall be jointed using "Viking Johnson Coupling" (See Figure 8.5). The Contractor shall assemble and fix the couplings so as to be equally spaced over the adjacent spigot ends in accordance with the manufacturer's instructions.

The bolts shall be evenly tightened in diametrically opposed positions using the manufacturer's standard spanners.

It is a patent rubber ring joint used for connecting plain-ended pipes. This type is suitable for all sizes especially for lined pipes too small for a person to enter for internal lining repair. They provide tightness with flexibility. Angular and longitudinal movement is permitted with this type of joint, so there is no need for expansion joints if the displacement is small which can be taken by shear displacement of the rubber gasket rather than sliding on the surface of

the pipe. The completely enclosed rubber gaskets are protected from damage and decay. The couplings are very useful near pumps, valves water meters, and other fittings, which make it easy to disconnect them for repair or replacement. Sleeve couplings transmit only minor tension or shear stresses across pipe joints, and they do not permit differential settlement at the joints when used alone. The pipe must have a true diameter.

Figure 8.5
Viking Johnson Coupling Detail



Viking Johnson couplings are suitable for jointing buried and exposed anchored pipes that are laid on curves established by the use of the maximum permitted deflections at the couplings. Its use near fittings such as bends and tees requires the use of other means (i.e. thrust blocks) to take the unbalanced thrust forces.

8.13 Express Locking Joints

Where expressly specified on the Drawings the Contractor shall supply and install on the lines express 2GS locking joints and this would be mainly at places where thrust or anchor blocks could not be constructed and at stream crossings or where in the opinion of the Engineer the use of such joints in necessary.

8.14 Clamps

Where the thrust on the valves installed on ductile pipes with “Tyton” type joints, is to be taken by the pipes, the “Tyton” joints shall be provided with clamps for a length of 50 diameters at each side of the valve.

These clamps shall be in accordance with the Detailed Drawings and shall not be measured for direct payment and their cost shall be deemed to be included in the Unit Price of the relative pipeline.

8.15 Thrust and Anchor Blocks and Restrains

Underground pressure pipelines shall be provided with thrust and anchor blocks as shown on the Drawings or instructed by the Engineer. Thrust blocks will normally be required at bends,

tee branches, angle branches, tapers, stop ends and similar fittings; anchor blocks will normally be required on pipelines laid to gradients steeper than 1:20 as follows:

- up to 1:15 anchor block every third pipe;
- up to 1:10 anchor block every second pipe;
- greater than 1:10 anchor block every pipe.

Concrete shall extend to undisturbed ground on thrust faces of thrust blocks and on both side faces of anchor blocks; any additional costs arising from over excavation shall be borne entirely by the Contractor.

Additional requirements for both location and details of thrust and anchor blocks may be instructed as work proceeds to suit the actual Site conditions encountered.

Anchor bolts should be used in the following locations:

- Bends
- Tees
- Tapers
- Blank flanges
- Valves

8.16 Future Connections

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.

8.17 Connections to Existing Mains

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 responsibility under the close supervision of the Engineer. The cost of such work will be according to Contract BOQ.

8.18 House Connections

House connection should be constructed as indicated on the Tender Documents' Drawings or as directed by the Engineer. The house connection should be extended to the floor level of the premises exactly below the water-meter assembly location unless otherwise instructed by the Engineer.

House connection shall be extended inside the property of the customer at a distance of 1m height inside the lot, up to the nearest house facade to the network the satisfaction of the Engineer. The pipe should be sleeved with a suitable sleeve material where it passes through the boundary wall and as indicated on the Drawings.

Wherever possible, meters should be installed near the street boundary of the premises and as near as possible to the point of entry into buildings.

In case of rehabilitation the work may include the disconnecting of the old existing water meter. The same water meter of the one approved by the Employer shall be installed.

Pipe work on both sides of the meter assembly shall be firmly fixed to prevent movement of any flexible joints within the meter assembly. Such anchorage shall leave sufficient room for connecting and disconnecting of the meter, making use of the adapters provided.

A stop valve shall be installed adjacent to the meter on the entry side as indicated on the Drawings, to work as an isolating valve for maintenance purposes.

The Engineer will issue instructions regarding size, location and fittings for each service connection.

All service connections shall be subjected to a hydrostatic pressure test in the presence of the Engineer's Representative. Sterilization of the service connection will be carried out at the same time as the main to which it is connected.

8.19 Protection of Joints

All buried steel and ductile iron flange joints; flange adapters and couplings shall be protected by wrapping with "Denso Tap" or similar approved material.

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.

8.20 Backfilling and Compaction

8.20.1 General

No backfilling shall be carried out until all debris and other objectionable materials have been removed from the trench and until the Engineer has inspected and approved the pipe installation and bedding.

Backfilling shall be carried out in layers as defined below and in such a way that it does not disturb alignment, grades, or stability of pipe. Backfilling shall be carried out only with approved materials.

8.20.2 Backfill Material

Refer to DIVISION 2-EARTHWORK of these Specifications.

8.20.3 Imported Backfill

Where the excavated material does not confirm to the specification for backfill, and cannot be made to conform by sieving or other treatment, the Contractor may import material from sources approved by the Engineer at the Contractor expense.

8.20.4 Shortage of Backfill

If, after the use of all suitable, approved, excavated materials from the various locations on the site, there is a shortage of material to fill the excavations to the required levels, suitable borrow material as directed by the Engineer shall be brought to the site and used to complete the backfill.

8.20.5 Placing of Backfill

Refer to DIVISION 2- EARTHWORK of these Specifications.

8.20.6 Compaction

In these Specifications, degrees of compaction are expressed in percentages, and in all cases refer to the dry density at a percentage of the optimum density obtained by the Modified proctor method as described under method D of ASTM 1557. Water shall be added to the fill material if and as required to obtain the desired compaction.

8.20.6.1 Testing of Backfill Material

For each class of backfill material to be used, representative samples selected by the Engineer, shall be provided for testing purposes, test be carried out in accordance with *PS 687 part2*, and *PS 421* to determine the grading of the material.

Such tests shall be repeated each time the source of material changes, if there is an apparent change in the characteristics of the material or at such other times as the Engineer may require at the Contractor expenses.

Backfilling shall not be commenced until tests of the proposed backfill material indicate that it is in accordance with the requirements of the Specifications.

8.20.6.2 Compaction Testing

Representative samples of each class of backfill material to be used, selected by the Engineer, shall be taken for testing to determine the optimum moisture content and optimum density in accordance with the modified proctor method, ASTM 1557, Method D.

These tests shall be repeated each time the source of material changes or if there is and apparent change in the characteristic of the material or at such other times as the Engineer may require.

During backfilling operations tests shall be taken as and when required by the Engineer to determine the density of the compacted backfill.

If the density of the compacted backfill is less than the specified density, additional compaction shall be provided and no further backfill material shall be placed until satisfactory compaction of the material previously placed is achieved. If further compaction is unsuccessful, the backfilled material of the additional layer shall be removed.

The cost of providing delivering and testing samples shall be paid by the Contractor.

8.20.7 Maintenance of Backfilled Surfaces

The Contractor shall maintain the backfill at the specified levels and ensure that the surfaces after backfilling are kept in a satisfactory condition during the period of maintenance. Any normal settlement after backfilling shall be topped with the same class of material and kept to the required level for the Contract where such settlement shall constitute a hazard to life, property or traffic. The work shall be carried out on the same day that the settlement is noticed by or reported to the Contractor. If such settlements are substantial and indicate poor backfilling, the Contractor shall re-excavate to the trench again to the required standards.

8.21 Night Caps

The ends of joining sections of pipeline shall be securely closed by the use of suitable nightcaps to prevent the placing of any material inside the pipeline and the ingress of small animals or any other unwanted matter. Night caps shall be used at all ends left unattended at the close of a days work. If the trench is liable to become flooded appropriate action should be taken to prevent flotation of the pipeline.

8.22 Pipe Deflection

Deflection of installed steel pipe shall not exceed 2% of the diameter at any time during or after installation. If at any stage of the installation and backfilling process or during the maintenance period, excessive deflection is discovered the Contractor shall carry out remedial measures to the Engineer's approval, which may include:

(i) Reworking of existing backfill in pipe trench.

(ii) Removal of pipe trench backfill and replacement with granular or non-cohesive material.

(iii) Provision of lateral support by concrete cradle or encasement or gravel embedment.

(iv) Repair or replacement of damaged pipe or fittings.

8.23 Completion of External Coating

After welding the joints, the weld joint and end of pipes shall be wrapped with layers of anti corrosion bandages and polyethylene. PE tapes either by hot or cold process, to give the same insulation as the coating with adhesive film to form the bonding between steel surface and coating material. All the material (anti corrosion bandages and PE tapes and adhesive) must be of the types recommended by the pipe manufacturer and the Engineer.

Testing of external coating shall be according to AWWA C 216 and AWWA C209.

8.24 Reinstatement

The Contractor shall restore the ground surface after backfilling to condition at least equal to that obtaining before excavation, as recorded in the pre-excavation survey and videotape. In the case of asphalted road, reinstatement is to be made in accordance with Ministry of Public Work specification and municipality specification, materials shall comply with *PS 84*, *PS166 part1-part3*, and *PS 171* and Division-2 of these Specifications or as mentioned in the BOQ.

If any footpath, yards, pavement, kerb, garden, corps, fence, tree, wall, pole existing underground pipelines and other facilities or any other property has been damaged, removed or disturbed, it shall be replaced at the Contractor own expense to a standard equivalent to that which existed before.

8.25 Cleaning Up

The Contractor shall clear the site and shall dispose of all waste material and debris using the brush car or an approved tip, and remove all unused new materials to the satisfaction of the Engineer.

8.26 Maintenance

The Contractor shall maintain the pipelines, trenches and reinstated surfaces during the period of Maintenance.

8.27 Measurements and Payments

8.27.1 Supply of Pipes and Fittings

The supply of all materials such as pipes, valves, tees, bends, water meters, dressers, records, nipples, reducers, cast iron cover for manholes, C.I. hand holes, shrinkable tapes and all other incidental materials shall in accordance with the Tender Drawings and the Bill of Quantities. The payment shall be according to the actually installed quantities multiplied by the inserted unit price for each item.

The unit prices inserted in the Bill of Quantities shall be deemed to include the material price, transportation, loading and unloading the required materials from the trucks in the site stores or stringing the pipes along the route of the pipelines, as the Employer wishes.

8.27.2 Pipe Laying

The construction of water mains and the pipelines of the water distribution systems shall be measured and paid for by the meter run respectively for every kind of pipe and diameter of the completed and accepted works in accordance with the Drawings and the Bill of Quantities to the satisfaction of the Engineer, and the unit price for each shall include for but shall not be limited to the following:

All labour and use of equipment, supply of all electrodes, temporary supports and all other ancillary materials, as well as cleaning pipe ends and preparation for jointing, whether by welding or otherwise.

Laying and\or collection and hauling from the Employer's stores to site of works, and proper jointing of the respective pipeline including fittings and specials such as tees, records, bends, reducers, couplings, threaded valves and all other incidental required for the proper laying and completion of the relative pipeline in accordance with the Drawings, Specifications and BOQ.

Fabrication of pipe reducers and elbows(not including 90° and 45° elbows). Fabricating a pipe reducer shall include cutting the pipe to the required length, cutting out of wedges in the pipe wall, tapering the reducer to the correct shape and welding the longitudinal seams. Fabrication of elbows can be in one or more pieces as shown on the Drawings and shall include cutting, shaping, beveling and welding to achieve the required angle.

Wrapping of the welded places or other damaged outside coating by using the materials and following the procedures required by the producer.

Lowering of pipes and placing them on supports (sandbags) 150mm each 10m length inside the trenches.

All ancillary works relating to the construction of the water supply and the distribution systems which are not explicitly mentioned in the contract but could be inferred therefrom or which are customarily performed or evidently necessary to carry out the intent of the Drawings and specifications and all other liabilities and obligations setforth in the tender documents.

8.27.3 Installation of Valve

The collection and hauling from the site stores to the site of works and the installation on the respective pipeline of all kinds of valves and hydrants.

Valves shall be paid for each complete installed piece according to the diameter, as described in the Bill of Quantities.

The unit price for each shall be deemed to include cleaning, fitting-up and installation the valve in its correct position relative to the pipes, setting it true to spirit level and making the flanged connection including inserting the gaskets inserting and lighting the bolts including the installation of all fittings, specials, adapters, dressers and all incidentals required for the proper installation and the proper function of the relative valves in accordance with the Drawings and Specifications.

8.27.4 Installation of the Cast in (CI) Handholes

The collection and handling from the site stores to the site of works and the installation of the CI handholes in accordance with the Drawings and Specifications.

The payment shall be made for each installed handhole. The unit price shall be deemed to include the needed excavation, cleaning, supplying and placing the concrete needed to fix the

handhole, backfilling and compacting around the area of the handhole in accordance with the Tender Drawings and BOQ.

8.27.5 House Connections

The supply of all materials such as pipes, valves, tees, bends, plugs, water meters, cover boxes, and all other incidental materials and the installation of each house connection from the distribution main to the location of the water meter in accordance with the Drawings and the Bill of Quantities. The payment will be made for the supplied materials, and for the installation of the house connections under separate payment items. The payment for each item to be supplied as mentioned in the Bill of Quantities and for the execution of the work, will be for each executed house connection including: the installation of all pipes, fittings, water meters, excavation, and backfilling, anchoring, reinstatement and all other necessary work from the distribution mains to the location of the water meters.

DIVISION 9: PIPELINE TESTING

9.1 Work Included

This Chapter governs the pressure and leakage testing of pressure pipelines including provision of test bulkheads, temporary air valves, and pressure and temperature recorders.

9.2 Submittals

The Contractor shall submit the following data for the approval of the Engineer:

(i) Source of potable water.

(ii) Pump (if needed).

(iii) Program and method of testing.

(iv) Water disposal sites.

9.3 Reporting

For each test section: Report of pressure test including list of attendees, pressure records, duration of test, water quantity necessary to restore or reduce pressure, temperature, pressure correction calculations, repairs made, test pipeline length, date and time, and any other related information.

9.4 Pressure Recorder

The Contractor shall furnish at least one 24-hour continuous adequate pressure recorder and install it at the low point of the test section in such a manner as to permit calibration in situ. The unit shall be calibrated before the start of the test, at the mid point of the test, at the end of the test (and at other times as instructed by the Engineer), with a dead weight tester.

9.5 Temperature Recorder

The Contractor shall furnish at least one 48-hour continuous temperature recorder and install it in any tested section. The unit shall be calibrated before the test in a laboratory and during the test by comparison with mercury in situ thermometers at the same time as the calibrations of the pressure recorder.

9.6 Testing Pipelines

The Contractor shall carry out hydraulic pressure test two times: the first one by himself and he should be confident of the test results before calling the Engineer for performing the official hydraulic pressure test.

Pipelines shall be tested in the presence of the Engineer in lengths between valve chambers or in such shorter lengths (required not more than 1-2km) or as directed by the Engineer. All

pipelines and fittings shall be installed and laid in accordance with requirements mentioned in Division 8-PIPE LAYING.

The Contractor shall at his own expense provide all water required for filling, testing, and retesting pipelines (if necessary) and any pumps, pipe work fittings, pressure gauges, pressure recorder, temperature recorder, air release valve and personnel required for the purpose.

Fittings required for temporarily closing the openings in pipelines to be tested, shall be properly deigned for this purpose and shall be adequately strutted to withstand the test pressure specified.

Permanent valves may be included in the tested length but shall be open throughout the tests and shall not be used to isolate the test section.

The arrangement for testing a pipeline shall include provision for the purging of air from the pipeline prior to a water test.

The Contractor shall keep a record of all tests on forms and reports, which shall be available for inspection and handed over to the Engineer on demand.

The pipeline shall be tested after completion with the exception of any backfilling not necessary for the stability and safety of the work.

9.6.1 Hydrostatic Pressure Test for Steel and Ductile Iron Pipes

9.6.1.1 Method 1

General:

To prevent pipe movement, sufficient backfill shall be placed prior to filling the pipe with water and field testing. When local conditions require that the trenches should be backfilled immediately after the pipe has been laid, the testing may be carried out after backfilling has been completed but before placement of permanent surfacing. The Contractor shall ensure that thrust blocking or other types of restraining systems will provide adequate restraint prior to pressurizing the pipeline.

After pipelaying, 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.

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 at the lowest point of the tested section.

Preparations for Pressure Test:

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 bulkheaded and securely anchored. The testing installation and the working of the pump shall also be examined.

Filling the Line with Water:

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.

At the commencement of filling, all valves shall be opened, and each valve shall be closed after the water has flushed all dirt that may have accumulated in the pipes.

After the filling has been completed, but before the pressure is raised, all valves shall be inspected for water-tightness 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.

Pressure Test Process:

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 9.1 below:

Table 9.1
Test Pressure Factors

Working Pressure Range (atm)	Factor*
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 (required length not more than 1-2km or directed by the Engineer).

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.

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.

Acceptance:

The pipeline shall be maintained under the test pressure for a period of 24 hours:

- If during this period the pressure dropped below 75% of the test pressure, the test pressure will be not accepted and the Contractor shall proceed to locate immediately and rectify the defects and leaks, after which he shall re-test until a satisfactory test result can be secured.
- If the pressure dropped within the accepted range 25% of the test pressure), the pressure shall be restored to the full test pressure by such pumping as may be necessary.
- The test shall be deemed to be satisfactory if the pipeline holds after the initial 24 hours the specified pressure (restored pressure) for a final period of not less than two hours 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.

The test pressure shall be calculated as indicated in Table 9.1, and should be conducted at the lowest point in the section to be tested.

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.

In case of any result discrepancies from the Engineer point of view, the Engineer has the right to instruct the Contractor to proceed the pressure test according to method two described in section 9.5.1.2 below. No separate payment will be paid to Contractor for implementing the pressure test in accordance with direction of method two what so ever it costs.

9.6.1.2 Method 2

General:

Second method for hydrostatic pressure test in these specifications based on ANSI/AWWA C600.

To prevent pipe movement, sufficient backfill shall be placed prior to filling the pipe with water and field testing. When local conditions require that the trenches be backfilled immediately after the pipe has been laid, the testing may be carried out after backfilling has been completed but before placement of permanent surfacing. The constructor shall ensure that thrust blocking or other types of restraining systems will provide adequate restraint prior to pressurizing the pipeline.

After pipelaying, 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.

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 at the lowest point of the tested section.

Preparations for Pressure Test:

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 bulkheaded and securely anchored. The testing installation and the working of the pump shall also be examined.

Filling the Line with Water:

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.

At the commencement of filling, all blow-out valves shall be opened, and each valve shall be closed after the water has flushed all dirt that may have accumulated in the pipes.

After the filling has been completed, but before the pressure is raised, all valves shall be inspected for water-tightness 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.

Test Restrictions:

- Test pressure shall not be less than 1.25 times the working pressure at the highest point along the test section.
- Test pressure shall not exceed pipe or thrust-restraint design pressures.
- Hydrostatic test duration shall be at least for 2-hours.
- Test pressure shall not vary by more ± 5 psi (34.5 kPa = 0.34 Bar) for the duration of the test.
- Valves shall not be operated in either direction at a differential pressure exceeding the rated valve working pressure. A test pressure greater than the rated valve pressure can result in trapped test pressure between the gates of a double-disc gate valve. For the tests at these pressures, the test setup should include a provision, independent of valve, to reduce the line pressure to the rated valve pressure on completion of the test. The valve can then be opened enough to equalize the trapped pressure with the line pressure, or the valve can be fully opened if desired.
- The test pressure shall not exceed the rated pressure of the valves when the pressure boundary of the test section include closed, resilient-seated gate valves or butterfly valves.

Pressurization:

After the pipe has been laid, all newly laid pipe or any valved section thereof shall be subjected a hydrostatic pressure of at least 1.5 times working pressure at the point of testing (lowest point in the section to be tested).

Each valved section of pipe shall be slowly filled with water, and the specified test pressure (based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge) shall be applied using a pump connected to the pipe. Valves shall not be operated in either the opened or closed direction at differential pressure above the rated pressure. The system should be allowed to stabilize at the test pressure before conducting the hydrostatic pressure.

Air Removal:

Before applying the specified test pressure, air shall be expelled completely from the section of piping under test. If perminant air vents expel the air are not located at all high points, corporation cocks shall be installed at these points to expel the air as the line is filled with water. After the air has been expelled, the corporation cocks shall be closed and the test pressure applied. At the conclusion of the pressure test, the corporation cocks shall be removed and the pipe plugged or left in place as required by the Specifications.

Examination:

Any exposed pipe, fittings, valves, hydrants and joints shall be examined carefully during the test. Any damage or defective pipe, fittings, valves, hydrants, or joints that are discovered following the pressure test shall be repaired or replaced with reliable material, and the test shall be repeated until satisfactory results are obtained.

Testing Allowance Defined:

Testing allowance shall be defined as the quantity of makeup water that must be supplied into the newly laid pipe or any valved section thereof to maintain pressure within 5 psi (34.5 kPa) of the specified test pressure after the pipe has been filled with water and the air has been expelled. Testing allowance shall not be measured by a drop in pressure in a test section over a period of time.

Testing Allowance:

No pipe installation will be accepted if the amount of makeup water is greater than that determined by the following formula:

$$L = \frac{SD\sqrt{P}}{715317}$$

Where:

L = testing allowance (makeup water), in liters per hour
S = length of pipe tested, in meters
D = nominal diameter of the pipe, in millimeters
P = average test pressure during the hydrostatic test, in kPa

These formulas are based on a testing allowance of (1.079 L/d/km/mm) of nominal diameter at a pressure 150 psi (1034) kPa.

Testing allowance at various pressures is shown in Table 9.2.

When testing against closed-seated valves, an additional testing allowance per closed valve of (1.2mL/h/mm) of nominal valve size shall be allowed.

When hydrants are in the test section, the test shall be made against the main valve in the hydrant.

All visible leaks are to be repaired regardless of the allowance used for testing.

Acceptance of Installation:

Acceptance shall be determined on the basis of testing allowance. If any test of laid pipe, discloses a testing allowance greater than that specified in Section 9.6.1.2 (Testing Allowance), repairs or replacements shall be accomplished in accordance with the technical specifications.

Table 9.2
Hydrostatic Testing Allowance Per 300m of Pipe Length L/h*

Avg. Test Pressure kPa **	Nominal Pipe Diameter-mm																	
	76	102	152	203	254	305	356	406	457	508	610	762	914	1,067	1,219	1,400	1,500	1,600
3,000	1.84	2.30	3.45	4.59	5.74	6.89	8.04	9.19	10.34	11.49	13.78	17.23	20.67	22.97	27.57	32.16	34.46	36.75
2,800	1.76	2.22	3.33	4.44	5.55	6.66	7.77	8.88	9.99	11.1	13.32	16.64	19.97	22.19	26.63	31.07	33.29	35.51
2,600	1.71	2.14	3.21	4.28	5.35	6.42	7.48	8.55	9.62	10.69	12.83	16.04	19.25	21.39	25.66	29.94	32.08	34.22
2,400	1.64	2.05	3.08	4.11	5.14	6.16	7.19	8.22	9.25	10.27	12.33	15.41	18.49	20.55	24.66	28.76	30.82	32.87
2,200	1.57	1.97	2.95	3.93	4.92	5.9	6.88	7.87	8.85	9.84	11.8	14.75	17.70	19.67	23.61	27.54	29.51	31.47
2,000	1.50	1.88	2.81	3.75	4.69	5.63	6.56	7.50	8.44	9.38	11.25	14.07	16.88	18.76	22.51	26.26	28.13	30.01
1,800	1.42	1.78	2.67	3.56	4.45	5.34	6.23	7.12	8.01	8.90	10.68	13.35	16.01	17.79	21.35	24.91	26.69	28.47
1,600	1.34	1.68	2.52	3.36	4.19	5.03	5.87	6.71	7.55	8.39	10.07	12.58	15.10	16.78	20.13	23.49	25.16	26.84
1,400	1.26	1.57	2.35	3.14	3.92	4.71	5.49	6.28	7.06	7.85	9.42	11.77	14.12	15.69	18.83	21.97	23.54	25.11
1,200	1.16	1.45	2.18	2.91	3.63	4.36	5.08	5.81	6.54	7.26	8.72	10.90	13.08	14.53	17.43	20.34	21.79	23.25
1,000	1.06	1.33	1.99	2.65	3.32	3.98	4.64	5.30	5.97	6.63	7.96	9.95	11.94	13.26	15.91	18.57	19.89	21.22
8,00	0.95	1.19	1.78	2.37	2.97	3.56	4.15	7.74	5.34	5.93	7.12	8.90	10.68	11.86	14.23	16.61	17.79	18.98
6,00	0.82	1.03	1.54	2.05	2.57	3.08	3.6	4.11	4.62	5.14	6.16	7.70	9.25	10.27	12.33	14.38	15.41	16.44

* if the pipe line under test contains sections of various diameters, the testing allowance will be the sum of the testing allowance for each size
* 100 kPa=1 Bar

9.6.2 Hydrostatic Pressure Test for UPVC Pipes

General:

To prevent pipe movement, sufficient backfill shall be placed prior to filling the pipe with water and field testing. When local conditions require that the trenches be backfilled immediately after the pipe has been laid, the testing may be carried out after backfilling has been completed but before placement of permanent surfacing. The Contractor shall ensure that thrust blocking or other types of restraining systems will provide adequate restraint prior to pressurizing the pipeline. Refer to Division 2 Section 2.8.2 for backfilling requirements.

Hydrostatic pressure test for UPVC pipes is based on ANSI/AWWA C605.

Cross-Connection Control:

When existing water mains are used to supply test water, they should be protected from backflow contamination by temporarily installing a double check-valve assembly between the test and supply main or by other means approved by the Engineer. Prior to pressure and leakage testing, the temporary backflow protection should be removed and the main under test isolated from the supply main.

Procedure:

The following procedure is based on the assumption that the pressure and leakage tests will be performed at the same time. Separate tests may be made if desired. If separate tests are made, the pressure test shall be performed first. Tests shall be performed only after the pipeline has been properly filled, flushed, and purged of all air. The specified test pressure shall be applied by means of an approved pumping assembly connected to the pipe in a manner satisfactory to the Engineer. The test pressure shall not exceed pipe or thrust-restraint design pressures. If necessary, the test pressure shall be maintained by additional pumping for the specified time during which the system and all exposed pipe, fittings, valves, and hydrants shall be carefully examined for leakage. All visible leaks shall be stopped. All defective elements shall be repaired or removed and replaced and the test repeated until the allowable leakage requirements have been met.

Test Method:

The Contractor may perform simultaneous pressure and leakage tests or perform separate pressure and leakage tests on the installed system at test duration and pressures specified in Table 9.3. Tests shall be witnessed by the Engineer or the Engineer's representative, and the equipment used for the test shall be subject to the approval of the Engineer or the Engineer's representative.

Allowable Leakage:

The Contractor shall furnish the gauges and measuring device for the leakage test, pump, pipe, connections, and all other necessary apparatus, unless otherwise specified, and shall furnish the necessary assistance to conduct the test. The duration of each leakage test shall be 2 hours, unless otherwise specified. During the test, the pipeline shall be subjected to the pressure listed in Table 9.4. Leakage shall be defined as the quantity of water that must be supplied into the pipe section being tested to maintain a pressure within 5 psi (34 kPa=0.34 bar) of the specified leakage-test pressure after the pipe has been filled with water and the air in the pipeline has been expelled. No installation will be accepted if the leakage is greater that that determined by the formula:

$$L_m = \frac{ND\sqrt{P}}{130400}$$

Where:

L_m = allowable leakage, in liters per hour
N = number of joints in the length of pipeline tested

D = nominal diameter of the pipe, in millimeters
P = average test pressure during the hydrostatic test, in kPa

Table 9.3
System Test Methods

Procedure	Pressure	Duration of Test
Simultaneous Pressure and Leakage Tests	150% of working pressure* at point of test, but not less than 125% of normal working pressure at highest elevation †	2 Hours
Separate Pressure Test	150% of working pressure* at point of test, but not less than 125% of normal working pressure at highest elevation †	1 Hour
Separate Leakage Test	150% of working pressure* of segment tested †	2 Hours

* Working pressure is defined as maximum anticipated sustained operating pressure
† In no case shall the rest pressure be allowed to exceed the design pressure for pipe, appurtenances, or thrust restraints

Table 9.4
Allowable Leakage Per 50 Joints of PVC Pipe* (pH)

Aver. Test Pressure,		Nominal Pipe Diameter, in. (mm)											
		4	6	8	10	12	14	16	18	20	24	30	36
Psi	(kPa)	(100)	(150)	(200)	(250)	(300)	(350)	(400)	(450)	(500)	(610)	(760)	(915)
300	(2,070)	1.75	2.60	3.50	4.35	5.21	6.10	6.96	7.85	8.70	10.45	13.06	15.66
275	(1,900)	1.67	2.49	3.35	4.17	4.98	5.84	6.66	7.51	8.33	10.01	12.50	14.99
250	(1,720)	1.60	2.38	3.16	3.98	4.76	5.58	6.36	7.14	7.96	9.52	11.94	14.32
225	(1,550)	1.53	2.27	3.01	3.76	4.54	5.28	6.03	6.77	7.55	9.04	11.31	13.58
200	(1,380)	1.41	2.12	2.83	3.57	4.28	4.98	5.69	6.40	7.11	8.52	10.68	12.80
175	(1,210)	1.34	2.01	2.68	3.31	3.98	4.65	5.32	5.99	6.66	8.00	9.97	11.98
150	(1,030)	1.23	1.86	2.46	3.09	3.68	4.32	4.91	5.54	6.18	7.40	9.23	11.09
125	(860)	1.12	1.67	2.23	2.83	3.39	3.94	4.50	5.06	5.62	6.73	8.44	10.12
100	(690)	1.00	1.53	2.01	2.53	3.01	3.53	4.02	4.54	5.02	6.03	7.55	9.04
75	(520)	0.86	1.30	1.75	2.19	2.60	3.05	3.50	3.91	4.35	5.21	6.55	7.85
50	(340)	0.71	1.08	1.41	1.79	2.12	2.49	2.83	3.20	3.57	4.28	5.32	6.40

*100 kPa = 1 bar
* If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size

These formulas are based on an allowable leakage of (0.978 L/day/km/mm) of normal diameter at a pressure of 150 psi (1030 kPa).

Leakage values determined by the above formulas are presented in Table 9.4.

When testing against closed metal-seated valves, an additional leakage per closed valve of (0.0012 L/h/mm) of nominal valve size shall be allowed.

When hydrants are in the test section, the test shall be made against closed hydrant valves.

All visible leaks shall be repaired, regardless of the amount of leakage.

Alternative allowable-leakage criteria may be used if specified by the Engineer.

9.6.3 Hydrostatic Pressure Test for PE Pipes

Pressure Testing Precautions:

The piping section under test and any closures in the test section should be restrained or otherwise restrained against sudden uncontrolled movement in the event of ruptue. Expansion joints and expansion compensators should be temporarily restrained, isolated or removed during the pressure test.

Testing may be conducted on the system, or in sections. The limiting test section size is determined by test equipment capability. If the pressurizing equipment is too small, it may not be possible to complete the test within allowable testing time limits. If so, higher capacity test equipment, or a smaller test section may be necessary.

If possible, test medium and test section temperatures should be less 38^0C. At temperatures above 38^0C, reduced test pressure is required. Before applying test pressure, time may be required for the test medium and the test sections to temperature equalize. The contractor shall follow the Engineer and the pipe manufacturer instructions for elevated temperature pressure testing or as specified in the Tender Documents.

Test Pressure:

Valves or other devices may limit test pressure, or lower pressure rated component. Such components shall be able to withstand the required test pressure, and should be either removed from, or isolated from the section being tested to avoid possible damage to, or failure of these devices. Isolated equipment should be vented.

- For continuous pressure systems where test pressure limiting components or devices have been isolated, or removed, or are not present in the test section, the maximum allowable test pressure is 1.5 times the system design pressure at the lowest elevation in the section under test.
- If the test pressure limiting device or component cannot be removed or isolated, then the limiting section or system test pressure is the maximum allowable test pressure for that device or component.
- For non-pressure, low pressure, or gravity flow systems, the contractor shall follow the Engineer and pipe manufacturer instructions or as specified in the Tender Documents.

Test Duration:

For any test pressure from 1.0 to 1.5 times the system design pressure the total test time including initial pressurization, initial expansion, and the time at test pressure, must not exceed eight (8) hours. If pressure test is not completed due to leakage, equipment failure, etc, the test section should be de-pressurized, and allowed to be “Relax” for at least eight (8) hours before bringing the test section up to test pressure again.

Pre-Test Inspection:

Test equipment and the pipeline should be examined before pressure is applied to ensure that connections are tight, necessary restraints are in place and secure, and components that should be isolated or disconnected are isolated and disconnected. All low pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.

Hydrostatic pressue testing is preferred and is strongly recommended. The preffered testing medium is clean water. The test section should be completely filled with the test medium, taking care to bleed off trapped air, venting at high points may be required to purge air pockets while the test section is filling. Venting may be provided by loosening flanges, or by using equipment vents. Re-tighten any loosened flanges before applying test pressure.

Monitored Make-Up Water Test:

The test procedure consists of Initial expansion, and Test Phases. During the initial expansion phase, the test section is pressurized to the test pressure (1.5 working pressure) for four hours, and then sufficient make-up water is added each hour for three (3) hours to return to test pressure.

After the initial expansion phase, about four hours after pressurization, the test phase begins. The test phase may be one (1), two (2), or three (3) hours, after which a measured amount of make-up water is added to return to test pressure. If the amount of water added does not exceed table (9.5) values, leakage is not indicated

Table 9.5
Additional Water Amounts Allowed for PE Pipes
Expansion for (30.5) m Pipe Selection

Nominal Diam.		Make-Up Water Allowance per 100 ft (30.50 m)					
		1 Hour Test		2 Hour Test		3 Hour Test	
in	mm	US Gallons	Liters	US Gallons	Liters	US Gallons	Liters
1-1/4	31.8	0.06	0.23	0.10	0.38	0.16	0.60
1-1/2	38.1	0.07	0.26	0.10	0.38	0.17	0.64
2	50.8	0.07	0.26	0.11	0.42	0.19	0.72
3	76.2	0.10	0.38	0.15	0.57	0.25	0.95
4	101.6	0.13	0.49	0.25	0.95	0.40	1.51
5	127.0	0.19	0.72	0.38	1.44	0.58	2.19
5-3/8	136.7	0.21	0.79	0.41	1.55	0.62	2.34
6	152.4	0.30	1.13	0.60	2.27	0.90	3.40
7-1/8	181.0	0.40	1.51	0.70	2.65	1.00	3.78
8	203.2	0.50	1.89	1.00	3.78	1.50	5.67
10	254.0	0.80	3.02	1.30	4.91	2.10	7.94
12	304.8	1.10	4.16	2.30	8.69	3.40	12.85
13-3/8	339.9	1.20	4.54	2.50	9.45	3.70	13.99
14	355.6	1.40	5.29	2.80	10.58	4.20	15.88
16	406.4	1.70	6.43	3.30	12.47	5.00	18.90
18	457.2	2.00	7.56	4.30	16.25	6.50	24.57

Nominal Diam.		Make-Up Water Allowance per 100 ft (30.50 m)					
		1 Hour Test		2 Hour Test		3 Hour Test	
in	mm	US Gallons	Liters	US Gallons	Liters	US Gallons	Liters
20	508.0	2.80	10.58	5.50	20.79	8.00	30.24
22	558.8	3.50	13.23	7.00	26.46	10.50	39.69
24	609.6	4.50	17.01	8.90	33.64	13.30	50.27
26	660.4	5.00	18.90	10.00	37.80	15.00	56.70
28	711.2	5.50	20.79	11.10	41.96	16.80	63.50
30	762.0	6.30	23.81	12.70	48.01	19.20	72.58
32	812.8	7.00	26.46	14.30	54.05	21.50	81.27
34	863.6	8.00	30.24	16.20	61.24	24.30	91.85
36	914.4	9.00	34.02	18.00	68.04	27.00	102.06
42	1066.8	12.00	45.36	23.10	87.32	35.30	133.43
48	1219.2	15.00	56.70	27.00	102.06	43.00	162.54
54	1371.6	18.50	69.93	31.40	118.69	51.70	195.43

Non-monitored Make-Up Water Test:

The test procedure consists of initial expansion, and test phases. For the initial expansion phase, make-up water is added as required to maintain the test pressure for four (4) hours. For the test phase, the test pressure is reduced by 10 psi (0.7 bar, 68.95 kPa). If the pressure remains steady (within 5% of the target value) for an hour, no leakage is indicated.

9.7 Measurements and Payment

The payment will be made on a lump sum basis for the testing of the whole project distribution system or as specified in the Contract Tender Documents.

DIVISION 10: PIPELINE DISINFECTION AND FLUSHING

10.1 General

Work Included in this Section**:**

The work of this section includes requirements for disinfection of new and repaired water mains, fittings, appurtenances and connections by chlorination.

10.2 Product Certificates

Chlorine products should be certified as suitable for contact with or treatment of potable drinking water by an accredited certification organization in accordance with ANSI/NSF Standard 60. The Contractor should obtain the Engineer approval before any order for material.

10.3 Inspection

All containers, cylinders shall be carefully examined by the supplier including proper holding of filled containers/ cylinders to check for leaks before filling. Any containers and cylinders, valves, valve threads, shall be in good mechanical order and shall operate normally with wrench that is not longer than 20cm. Routine inspection and cleaning of the chlorine cylinders and containers shall be performed by the supplier to prevent the buildup of contaminants when chlorine is removed as a gas.

The Contractor shall submit manufacturer certificate to ensure material suitability and validity for the specified use.

10.4 Disinfection

10.4.1 General

The Contractor with a certified qualified staff or persons should carry out disinfection at his own expense.

10.4.2 Products

10.4.2.1 Liquid Chlorine Cl2 (Gas)

General:

Liquid chlorine shall contain 100 % available chlorine packaged in steel cylinders in net weights of usually 68kg (150lb) or according to manufacturer compatible products. Liquid chlorine shall be used with appropriate gas-flow chlorinators, heaters, and injectors to provide a controlled high concentration solution feed to the water. The chlorinators and injectors shall be vacuum operated type. The liquid chlorine supplied shall be 99.5% pure by volume.

10.4.2.2 Physical Characteristics

In it's liquid state, chlorine is amber colored and about 1.5 times as dense as water. It exerts a vapor pressure that varies with its temperature. At atmospheric pressure, liquid chlorine boils at $-35C^0$ and freezes at approximately $-100C^0$. At normal room temperature, liquid chlorine exerts a vapor pressure of about 600 KPa (gauge), but at $37.8C^0$, the chlorine vapor pressure increases to about 1 MPa (gauge). When the pressure is released, liquid chlorine vaporized into a greenish-yellow gas about 2.5 times as dense as air. One volume of liquid chlorine when vaporized will yield about 460 volumes of gas. At 15.6 C^0 under atmospheric pressure, about 8kg of chlorine is soluble in 1000kg of water. The chlorine shall be free of moisture.

10.4.2.3 Reactivity

Neither gaseous nor liquid is explosive or flammable, but both react chemically with many substances. Although dry chlorine does not react with corrode many metals, it is very reactive (strongly corrosive) when moisture is present. It will react spontaneously with iron or steel at 251 C^0, and similar reaction has been reported with copper at elevated temperature .Dry chlorine will react spontaneously with titanium metal.

10.4.2.4 Impurities

The liquid chlorine should contain no soluble mineral or organic substances in quantities capable of producing deleterious or injurious effects on the health of consumers:

- Mercury shall not exceed 1ppm (0.0001 %).
- Arsenic shall not exceed 3 ppm (0.0003 %).
- Moisture shall not exceed 150 ppm by weight.
- Heavy metals: The sum of heavy metals shall not exceed 30 ppm.
- Lead shall not exceed 10 ppm.
- Nonvolatile residue: The total residue shall not exceed 50 ppm by weight as loaded by the manufacturer in tank cars and chlorine tank trucks, or 150 ppm by weight in liquid chlorine as packaged in cylinders or ton containers.
- Carbon tetrachloride: It shall not exceed 100 ppm. Testing for carbon tetrachloride is not required until unless a carbon tetrachloride tail-gas scrubbing system is used in chlorine production unit. Consult manufacturer, packager or supplier.
- Trihalomethanes: It shall not exceed 300 ppm.

10.4.3 Sampling

If the Engineer request testing, the samples shall be taken prior to shipment according to ASTM E410, ASTM E412, ASTM E806.

10.4.3.1 Sodium Hypo Chlorite NaOCl (Liquid)

Sodium Hypo Chlorite is a powerful oxidizing agent (Ph=12, specific gravity = 1.10-1.12 at 20^0 C, soluble in cold water, decomposes in hot water) contained in glass, PVC, reinforced fiberglass, polyethylene or any other anti-corrosion containers. This liquid solution contains approximately 10%-15% chlorine. Other common names are bleach, liquor, chlorine water, Javelle water. When available as liquid can lose one and half of its strength in 100 days, or 2%

to 4% available chlorine per month at room temperature. Therefore a limit of one week of storage is advisable.

Sodium hypo-chlorite is miscible in any proportion with water. It should be stored in a dark area where the temperature does not exceed 30 C^0 . A 10%- 15% solution is still liquid at 17.8 C^0 but is a slush at -28.9 C^0.

Sodium Hypo Chlorite to be used for pipeline disinfection shall be tested for consistently of strength.

Sodium hypo chlorite solution a clear light-yellow liquid containing up to 160 g/L available chlorine (16 trade percent). Passing chlorine into a caustic soda solution or into a caustic soda-soda ash mix is one method of manufacturing.

Sodium Hypochlorite solution shall be a clear liquid containing not more than 0.15% insoluble matter by weight.

10.4.3.2 Calcium Hypo Chlorite Ca(OCl)2

Calcium Hypo chlorite is a white or yellowish-white granular powder, granule, or tablet of sizes not larger than 6.35mm (1/4") that contains 65% to 70% chlorine by weight, dissolves easily in water.

The bulk density of the granular powder is about 0.51 g/cc to 0.80 g/cc and the bulk density of the granules is approximately 1.1 g/cc to 1.3 g/cc. It is manufactured by adding chlorine to a milk of lime slurry, which may be prepared by mixing hydrated lime with water or by slaking quicklime with water.

Calcium Hypo Chlorite granular powder or granules shall be substantially free of lumps, not more than 10% of the powder shall pass a 100-mesh screen. It shall not contain any dirt or other foreign material, and shall be of uniformed shape. The weight of the tablets shall not vary by more than 5% from the average value stated on the label. Not than more 2% of the tablets shall be broken.

Calcium Hypo Chlorite may be dissolved in a mixing/ holding containers and injected in the same manner as Sodium Hypo Chlorite. Alternatively, where the pressure can be lowered to atmospheric such as at storage tanks, tablets of Calcium Hypo Chlorite can be directly dissolved in the free flowing water.

10.4.3.3 Hypo Chlorites Available Chlorine

Available chlorine is a term used to express the oxidizing power of the chlorine and can be expressed in one of the following three ways:

- Volume of trade percent = grams available chlorine per liter/ 10.
- Percent available chlorine by weight = trade percent/ specific gravity of solution.
- Percent available of chlorine by weight = grams per liter/ 10* specific gravity of solution.

10.4.3.4 Hypo Chlorites Impurities

The Hypo Chlorites supplied according to these specifications shall contain no soluble material or organic substances in quantities capable of producing deleterious or injurious effects on the health of consumers.

10.4.3.5 Hypo Chlorites Sampling

Samples shall be taken at the point of destination. Not less than 5% of the packages or containers shall be sampled. No sample shall be taken from a broken container. The powdered and granule forms of hypo chlorite shall be sampled by means of a sampling tube that at least 20mm in diameter. Tablets shall be selected at random from each container sampled.

10.4.4 Execution

10.4.4.1 General

All water mains, fittings, appurtenances, and connections if any shall be disinfected in accordance with ANSI/AWWA C651 except as modified herein.

All new, repaired water mains and temporary high lines shall be disinfected, flushed, sampled and pass bacteriological testing before they are connected to the existing system.

All water mains and appurtenances taken out of service for inspection, repairs or other activities that might lead to contamination shall be disinfected, flushed, sampled and pass bacteriological testing before they are returned to service.

The Contractor shall be responsible for documenting all disinfection practices performed in making pipeline connections, repairs or for other reasons that the Engineer may require.

Water mains and appurtenances shall be maintained clean and dry during the installation process to ensure effective disinfections process.

Pipe, valve and fitting materials which, in the opinion of the Engineer, becomes overly contaminated shall be cleaned by mechanical means and then swabbed with a 1-5 % Hypo Chlorite disinfecting solution prior to installation or replaced if directed by the Engineer.

Water mains under construction flooded by storm water, run off, sewage or ground water, shall be cleaned of the floodwater by draining and flushing with potable water. The section exposed to the floodwater shall be filled with chlorinated potable water that, at the end of a 24-hour holding period, will have a minimum free chlorine residual of 25mg/l. After construction is completed, the entire main shall be disinfected using the liquid chlorine (gas) method.

Disinfection of pipelines shall not proceed until authorized by PWA.

Disinfection of pipelines shall not proceed until all appurtenances have been installed.

Disinfection shall result in an initial minimum total chlorine concentration of 50mg/l. This concentration shall be evenly distributed throughout the system to be disinfected from a certain injection point. The chlorinated water shall be retained in the system for a minimum of

24 hours. The system shall contain a free chlorine residual of not less than 25mg/l at the end of the 24-hour retention period.

Before the disinfection process, all valves shall be operated. Appurtenances shall be flushed with the treated water a sufficient length of time to insure a chlorine concentration of 50mg/l in each appurtenance.

10.4.4.2 Methods

Liquid Chlorine:

Liquid Chlorine (gas) shall be used to disinfect all potable water pipelines and temporary high lines, regardless of size or material composition unless the Engineer approves the use of hypochlorite solution upon Contractor request.

Only vacuum type equipment shall be used. Direct-feed chlorinators which operate solely from gas pressure in the chlorine cylinder shall not be permitted.

The chlorinating agent shall be applied at the beginning of the system a certified qualified staff to be chlorinated and shall be injected through a corporation stop, a hydrant or other approved connection to ensure treatment of the entire system being disinfected.

All regulations, local laws, ordinances, orders, etc., shall be strictly adhered to.

Sodium/Calcium Hypo Chlorite Solutions:

Sodium/Calcium Hypo Chlorite solutions shall be used for cleaning and swabbing materials immediately prior to installation.

Sodium/Calcium Hypo Chlorite solutions shall be used, only as directed by the Engineer.

Disinfection shall result in an initial minimum total chlorine concentration of 50mg/l. This concentration shall be evenly distributed throughout the system to be disinfected from a certain injection point. The chlorinated water shall be retained in the system for a minimum of 24 hours. The system shall contain a free chlorine residual of not less than 25mg/l at the end of the 24-hour retention period.

Sodium/Calcium Hypo Chlorite shall be added to the system in the amount and in the places as directed by the Engineer.

The pump equipment to be used for the injection of Sodium/Calcium Hypo Chlorite solutions shall be approved by the Engineer according to the Specifications

Concurrent Testing:

Disinfection the mains and appurtenances, hydrostatic testing, and the retention time may run concurrently for the required 24-hour period. In the event repairs are necessary, additional disinfection may be required by the Engineer. This disinfection shall be made by either the liquid chlorine (gas) method, or the sodium/calcium hypochlorite method, as directly by the Engineer.

10.5 Flushing

Flushing of pipeline systems shall be according to the requirements of ANSI/AWWA C651.

In order to obtain sufficient scouring and cleaning of the pipeline system, proper water velocity during the flushing operation is necessary. The minimum water velocity during flushing shall be 0.75m/s, but 1.0m/s is recommended.

The Contractor shall be responsible for the installation of appropriate temporary piping and connections necessary to attain the prescribed flushing velocity.

After the 24-hour retention period, and upon approval from the Engineer, the chlorinated water shall be flushed from the system, at its extremities and at each appurtenance. Flushing shall continue until the replacement water in the new and repaired systems is equal chemically and bacteriologically to the permanent source of water supply (obtain free chlorine residual = 0.2-0.8mg/l at consumer taps). This shall be accomplished by completely draining the pipeline and refilling it with potable water, or by a combination of additional holding time and blending with potable water.

The environment to which the chlorinated water is to be distributed shall be inspected. If there is any likelihood that the discharged water would cause damage, a reducing agent shall be added to the chlorinated water. Local environmental regulations may require special provisions or permits for the discharge of highly chlorinated water. The Contractor shall contact the proper authorities and get a written permission prior to the disposal of highly chlorinated water. The Contractor shall drain the pipeline at a rate, which does not overload the downstream drainage system. The drainage rate shall be controlled to prevent erosion of natural ditches downstream from the point of discharge. Chlorinated water shall not be discharged to any watercourse or drainage way until it has been reduced or diluted to a level, which will result in no damage to aquatic life and only after obtaining the Engineer's approval the written permission.

When required by the local authority, the Contractor shall be responsible for recovering flushed water containing free chlorine residual according to local authorities regulations.

Under no circumstances shall the client be responsible for loss or damage resulting from such disposal.

10.6 Bacteriological Testing

PWA shall approve bacteriological sampling and testing of all new and repaired systems which should be performed directly after disinfection and flushing processes.

Testing requirements are as set forth in PWA Quality and Monitoring Regulations.

Analyze the samples for the presence of coliform bacteria and heterotrophic type bacteria (heterotrophic plate count). The evaluation criteria employed by the PWA for a passing test sample is currently as follows:

- Total and fecal coliform bacteria: no positive sample, and

- Heterotrophic plate count (HPC): less than 1000 colony forming units/ml.

Failure to pass said examination shall require the Contractor to take remedial steps as deemed necessary by the PWA, and as detailed herein.

10.7 Redisinfection

If the initial disinfection fails to produce satisfactory bacteriological results, the pipeline system shall be reflushed and shall be resampled.

If the second set of samples does not produce satisfactory results, the pipeline system shall be re-chlorinated by the liquid chlorine (or gas) methods, flushed, and resampled. This chlorination, flushing, and sampling, procedure shall continue until satisfactory results are obtained.

Re-disinfection and re-testing shall be at the Contractor's own expense.

10.8 Measurements and Payments

Pipelines disinfection, flushing and bacteriological testing shall not be measured for direct payments. But shall be considered as subsidiary works, the cost of which will be deemed to have been included in the contract prices for concrete. Unless otherwise indicated in the Bill of Quantities.

DIVISION 11: WATER TIGHTNESS TEST FOR CONCRETE WATER TANKS

11.1 General

Water tanks testing shall be done according to the method specified below.

The testing of tanks or water containment structures shall confirm to the following standards, as applicable to the project and as modified herein:

1. Reinforced concrete water retaining structures-ACI 350 IR and as specified herein.
2. Wire wound pre-stressed concrete tanks AWWA D110 or ACI 344 R-W.
3. Pre-stressed tendon tanks- ACI 344 R-T.
4. Steel tanks AWWA D100.

If water tanks are not above ground, perform water tightness tests prior to placing backfill around the water tank in order to permit observations and detection of leakage points. Walls may be backfilled prior to testing only when approved in writing by the Engineer. The request to backfill prior to testing shall include a description of the method proposed to detect leakage points after the backfill is in place. Approval place backfill prior testing shall not relive the Contractor of the responsibility for conducting water tightness tests.

Inspection:

Inspect the water tank for potential leakage paths such as cracks, voids, etc and repair such paths in compliance with the provisions specified herein.

Preparation:

Thoroughly clean the water tank to be tested of dirt, mud and construction debris prior to initiating water tightness tests. The walls, floors and sumps shall be flushed with water to provide a clean surface, ready for testing.

Inlet and outlet pipes not required being operational for the tests might be temporarily sealed or bullheaded prior to testing.

Confirm adequacy of seals around gates and valves and reset or seal as approved by the Engineer. Estimates of gate or valve leakage will not be allowed as adjustments to the measured tank or structure leakage.

Conditions for Testing-Concrete Water Tanks:

Do not begin initial filling of concrete water tank until all concrete elements of the water tank have attained the designed compressive strength of the concrete (28 days), nor less than 14 days after all concrete walls or base slabs have been placed.

Reports:

Submit to the Engineer water tightness test results for the water tank tested. The report should include the test date, the operating level, level records, test duration, temperature, attendees, and other related information.

Notify the Engineer of the scheduling of tests three working days prior to the tests. The Engineer should attend and monitor any water tightness testing performed on the water tank.

11.2 Water Tightness Test

Water tightness test shall be carried out before any internal painting or external isolation of water tank walls.

11.2.1 Filling the Water Tanks with Water

The water tank shall be slowly filled with potable water keeping the level in the tank at a maximum height rate of 1.2 meter per 24 hours till reaching the maximum operating level.

If the water tank is divided into two compartments, the water tank shall be slowly filled with potable water keeping the level in both sections of the water tank at the same height. Filling water tank shall be done at a maximum rate of 1.2 meter per 24 hours up to the maximum operating level.

If there is any leakage during the test period (24 hours), the tank shall be emptied and the leakage shall be repaired before continuing.

11.2.2 Procedure

1. Filling of reinforced concrete water tanks shall not exceed a rate of 1.2m in 24 hours.
2. Fill unlined (Fair face) or partially lined (plastered) concrete water tanks to the maximum operating water surface level and maintain the water at that level for 24 hours.
3. Measure the drop in water level over the next 72 hours to determine the water volume loss for comparison with the allowable leakage limits (72 hours to minimize water absorption by the concrete during testing process).
4. Measure and record loss of water volume should be at 24 hours intervals.

   The loss of volume is usually determined by measuring the drop in water surface elevation, and computing the change volume of the contained water. Measure water surface level at not less than locations at 180 degrees apart and preferably at four locations 90 degrees apart

   Record water temperature 457mm below the water surface when taking the first and last sets of measurements.
5. If all records for the loss of water volume over the 72 hours does not exceed the allowable leakage limits, the leakage should be considered acceptable.
6. If the leakage (loss of waster volume) in any of the three days exceeds the maximum allowable leakage limits, the leakage test should be extended to a total of five days.

7. If at the end of the five days the average daily leakage (average loss of volume) does not exceed the maximum allowable limits, the test should be considered acceptable.
8. If the leakage of the water volume exceeds the maximum allowable leakage limits, leakage should be considered excessive and the tank should be emptied and repaired.

11.2.3 Acceptance

The following conditions shall be considered as NOT meeting the criteria for acceptance regardless of the actual loss of water volume from the water tank.

1. Ground water leakage into the water tank through floors, walls, or wall-floor joints.
2. Water tank which exhibit flowing water from joints, cracks or from beneath the foundation (except for under-drain systems).
3. Lined concrete water tanks or pre-stressed concrete water tanks on which moisture can be picked up by a dry hand from the exterior surface of the walls.
4. Damp spots on the exterior wall surfaces of the water tank appears.

The water tightness of concrete tanks should be considered acceptable when loss of water volume is within the allowable leakage limits listed bellow:

1. For unlined (fair face) tanks with a sidewater depth of 7.6m or less, loss of volume not exceeding 0.1 percent in 24 hours.
2. For tanks with lined (plastered) walls and a sidewater depth 9.1m or less, loss of volume not exceeding 0.06 percent in 24 hours. Steel diaphragms in concrete walls shall be considered the same as a wall liner.
3. For completely lined tanks (walls and ceiling), loss of volume not exceeding 0.025 percent in 24 hours.

11.2.4 For Open Water Tanks

During the test period, the ambient evaporation of water shall be measured at a location near the water tank in an evaporation pan or by other approved means. Evaporation for local areas measured shall be considered. Table 11.1 shows the average pan evaporation for main areas in Palestine.

If the drop in the tank water surface in a 24 hours period exceeds the normal evaporation of water by 1/10 of 1% or the filled total volume, the leakage shall be considered excessive and shall be repaired before continuing.

Table 11.1
Variation of the Mean Daily Evaporation
Rates (mm) at Different Stations in the West Bank

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Hebron	2.1	2.9	3.0	4.6	5.3	6.7	7.1	7.3	5.2	3.6	2.9	2.0	1606.1
Jericho	2.5	2.7	4.2	6.3	8.4	9.6	9.6	8.6	7.6	5.0	3.1	1.9	2120.9
Jerusalem	3.5	3.7	3.1	6.5	7.7	7.7	8.1	7.4	5.7	4.1	2.1	1.8	1874.0
Nablus	1.6	2.4	3.2	5.0	6.5	7.5	7.7	7.0	5.9	4.2	2.5	1.6	1681.5

11.2.5 Repairs and Re-Testing

Water tank failing the water tightness test and not exhibiting visible leakage may be retested after an additional stabilization period of 7 days. Tanks failing this second test shall be repaired prior to further testing.

Repair water tanks, which fail the water tightness test, and water tanks showing visible leakage in compliance with the provisions specified herein.

Repairs and retesting of tanks shall be accomplished at no additional cost to the Owner.

Repair:

The Contractor shall make all necessary repairs if the tank fails the water tightness test or is otherwise defective. The method of repair shall be subject to acceptance by the Engineer.

Concrete Repair: The most common repair method for small areas of honeycombed concrete (rock pockets) and other defective concrete is removal and replacement with non-shrink aggregate grout (which may include pea gravel aggregate) bonded to the concrete with an epoxy bonding agent. The minimum strength of material used in the repair shall equal or exceed that specified for the concrete.

Defective tie hole patches shall be removed and the holes repacked or epoxy injected.

Epoxy Injection Grouting: Wall Repair: Damp or wet spots resulting from leakage through the wall shall be repaired with a high-pressure epoxy injection grouting system or other method acceptable to the Engineer. When epoxy grouting is to be performed, a low-viscosity, two-component, water-insensitive, nontoxic epoxy-resin system with an in-line metering and mixing system shall be used. The pumps shall be capable of producing minimum injection pressure of 100 psi (680 kPa). Injection pressure shall be limited to 300 psi (2.1 Mpa) to ensure complete penetration of the defect without damaging the structure. Epoxy shall reach a minimum compressive strength of 6,000 psi (40 MPa in 24 hours in accordance with the requirements of ASTM D695). An applicator with successful past experience in water structures shall be present on the job at all times while repairs are being made. Work shall be guaranteed against failure of the epoxy bond in the repair areas for a minimum period of one year.

Any exposed defect receiving epoxy repair shall first be cleaned of dirt, laitance, and other material that might prevent proper bonding. A suitable temporary seal shall then be applied to

the surface of the defect to prevent the escape of the epoxy. Entry ports shall be spaced along the seal at intervals not grater than the thickness of the cracked element. The epoxy shall be injected into the crack at the lowest port first, with sufficient pressure to advance the epoxy to an adjacent port, using a small nozzle held tightly against the port. The operation shall continue until epoxy material begins to extrude from the adjacent port. The original port shall be sealed and the injection shall be repeated in one continuous operation until the crack has been injected with epoxy for its entire length. All ports, including adjacent locations where epoxy seepage occurs, shall be sealed as necessary to prevent drips and runouts. On completion of the injection of the crack, the grout shall be allowed to cure for sufficient time to allow the removal of the temporary seal without any draining or running out of the adhesive epoxy material from the crack. The surface of the crack shall then be finished with the adjacent surfaces and shall show no indentations or evidence of port filling.

Floor, Piping, and Valves: Generally the loss of water through the tank floor, piping, and valves is difficult to determine separately. The total water loss shall not exceed the criteria set forth in Section 11.2.3. If the loss of water exceeds the criteria, the tank floor shall be inspected for point sources of leakage with the tank full or empty.

Water loss through floor joints or shrinkage cracks shall be located and the defective sections removed and replaced, or repaired by epoxy injection grouting as specified earlier or by other means acceptable to the Engineer. Any potential point sources of leakage found shall be repaired and the water tightness test repeated.

11.3 Measurements

Water tank testing shall not be measured for direct payments. But shall be considered as subsidiary works, the cost of which will be deemed to have been included in the contract prices for concrete. Unless otherwise indicated in the BOQ.

DIVISION 12: WATER TANK DISINFECTION

12.1 General

After construction and repairs have been effected and painting has been completed including recommended curing, and cleaning the tank shall be disinfected by one or a combination of the following procedures as specified in ANSI/AWWA C652 which is summurized below.

Water tank Disinfection should be carried out by a certified qualified Contractor staff or persons.

The environment to which the chlorinated water is to be wasted and distributed shall be inspected. If there is any likelihood that the discharged water would cause damage, a reducing agent shall be added to the chlorinated water. Local environmental regulations may require special provisions or permits for the discharge of highly chlorinated water. The Contractor shall inform the Engineer and contact the concerned authorities and get a written permission prior to the disposal of highly chlorinated water. The Contractor shall drain the tank at a rate, which does not overload the downstream drainage system. The drainage rate shall be controlled to prevent erosion of natural ditches downstream from the point of discharge. Chlorinated water shall not be discharged to any water course or drainage way until it has been reduced or diluted to a level, which will result in no damage to aquatic life.

12.2 Product Certificates

Chlorine products should be certified as suitable for contact with or treatment of potable drinking water by an accredited certification organization in accordance with ANSI/NSF Standard 60. The Contractor should obtain the Engineer approval before any material order.

12.3 Inspection

All containers, cylinders shall be carefully examined by the supplier including proper holding of filled containers/ cylinders to check for leaks before filling. Any containers and cylinders, valves, valve threads, shall be in good mechanical order and shall operate normally with wrench that is not longer than 20cm. Routine inspection and cleaning of the chlorine cylinders and containers shall be performed by the supplier to prevent the buildup of contaminants when chlorine is removed as a gas.

The Contractor shall submit manufacturer certificate to ensure material suitability and validity for the specified use.

12.4 Water Tank Disinfection Methods

12.4.1 Method One

Liquid Chlorine Use: Liquid chlorine shall be introduced into the water filling the tank, in such a way as to produce a uniform chlorine concentration during the entire filling operation. Portable chlorination equipment shall be carefully operated and include-chlorine gas-flow

chlorinator, chlorine injector, safety equipment, and an appropriate solution tube to inject the high-concentration chlorine solution into the filling water. The solution tube shall be installed through a valve located on the inlet pipe and near the storage facility such that the chlorine will mix readily with the in-flowing water.

Sodium Hypo Chlorite Use: Sodium Hypo Chlorite shall be added to the water filling the tank by means of chemical-feed pump, or shall be hand poured into the tank which allow the in-flowing water to provide the mixing. When the chemical-feed pump is used, the concentrated chlorine solution shall be pumped through an appropriate solution tube at a rate that will provide a uniform chlorine concentration in the filling water. The solution tube shall be installed through a valve located on the inlet pipe and near the storage facility, or through an appropriate valve on the storage facility such that the chlorine will mix readily with the in-flowing water. When the Sodium Hypo Chlorite is hand poured into the tank, the filling of the tank shall begin immediately thereafter. The Sodium Hypo Chlorite may be poured into the tank through the cleanout or inspection manhole or through the roof manhole. Sodium hypochlorite is to be added when the water level in the tank is not more than 915mm and not less than 305mm in depth or, as close to these depths as the manhole locations will permit.

Calcium Hypo Chlorite Use: Calcium Hypo Chlorite granules or tablets crushed to sizes not larger than 6.35mm (¼ inch) maximum dimension may be poured or carried into the tank through the cleanout, inspection manhole, or roof manhole. The Calcium Hypo Chlorite shall be put in the tank before any water is added. The granules or tablets shall be located so the in-flowing water will ensure a current of water circulating through the Calcium Hypo Chlorite, dissolving it during the filling operation. Calcium Hypo Chlorite shall be placed only on dry surfaces unless proper precautions for adequate ventilation and protective breathing equipment are taken.

The tank shall be filled to the overflow level with potable water to which enough chlorine has been added to provide an initial total chlorine concentration in the full tank of not less than 50 mg/l. The full tank should stand for 24 hours. The chlorine shall be added either as calcium hypochlorite, sodium hypochlorite, or liquid chlorine as described hereafter.

After the tank has been filled with the disinfecting solution, a retention period is of not less than 24 hours is required. At the end of the holding period a minimum free chlorine residual of 25mg/l should be achieved, the highly chlorinated water shall be drained to waste according to the instructions specified later in this Division and the tank refilled with potable water and tested for bacteriological quality.

The handling of the disinfection water shall be as follows:

After the holding period, the free chlorine residual shall be reduced from 25mg/l to not more than 2mg/l to ensure a free chlorine residual of 0.2-0.8mg/l at consumer tap. This shall be accomplished by completely draining the storage facility and refilling it with potable water, or by a combination of additional holding time and blending with potable water. When appropriate chlorine residual is obtained, bacteriological testing shall be performed. If satisfactory results are obtained from testing, the water may be delivered to the distribution system.

12.4.2 Method Two

A solution of 200mg/l total chlorine residual shall be applied to the surfaces of all parts of the storage facility that would be in contact with water when the storage facility is filled to the overflow elevation. The solution shall thoroughly coat all surfaces to be disinfected, including the inlet and outlet piping, and shall be applied to any separate drain piping such that it will have available free chlorine residual of not less than 10mg/l after 30 minutes of contact period when filled with water. Overflow piping does not need to be disinfected. The chlorine solution shall be applied with either spray equipment or brushes. Any equipment used to apply the chlorine solution shall remain in contact with the tank surfaces for at least 30 minutes, after which potable water shall be admitted, and the drain piping purged of the 10mg/l chlorinated water. The tank shall then be filled with potable water to the overflow level and tested for bacteriological quality. If satisfactory results are obtained from testing, the water may be delivered to the distribution system.

The free chlorine residual shall be reduced to insure a free residual of 0.2-.08mg/l at consumer taps.

12.4.3 Method Three

Water and chlorine shall be added to the tank in amounts such that the solution will initially contain 50mg/l total chlorine concentration and will fill approximately 5 percent of the total storage volume. The solution containing 50mg/l of total chlorine concentration shall stand in the tank for not less than 6 hours. The tank shall then be filled with potable water to the overflow level and allowed to stand for not less than 24 hours. At the end of the 24-hour period, the chlorine free residual in the tank shall be at least 2mg/l. Drain lines shall be flushed of all remaining high strength chlorine. The tank shall then be tested for bacteriological quality. If satisfactory results obtained from testing, the water may be delivered to the distribution system.

The free chlorine residual shall be reduced to insure a free residual of 0.2-0.8mg/l at consumer taps.

12.5 Bacteriological Testing

PWA shall approve bacteriological sampling and testing of all new and repaired systems which should be performed directly after disinfection and flushing processes.

Testing requirements are as set forth in PWA Quality and Monitoring Regulations.

Two or more successive samples taken at 24 hour intervals shall be required and shall indicate bacteriologically satisfactory water before the facility is released for use. If initial disinfection fails to produce satisfactory results as shown below, disinfection shall be repeated until satisfactory samples have been obtained.

- Total and fecal coliform bacteria: no positive sample, and
- Heterotrophic plate count (HPC): less than 1000 colony forming units/ml

12.6 Redisinfection

If the initial disinfection fails to produce satisfactory bacteriological results, the tank system shall be reflushed and shall be resampled.

If the second set of samples does not produce satisfactory results, the tank system shall be re-chlorinated by the liquid chlorine (or gas) methods, flushed, and resampled. This chlorination, flushing, and sampling, procedure shall continue until satisfactory results are obtained.

Re-disinfection and re-testing shall be at the Contractor's own expense.

12.7 Measurements

Tank disinfecting and bacteriological testing shall not be measured for direct payments. But shall be considered as subsidiary works, the cost of which will be deemed to have been included in the contract prices for concrete. Unless otherwise indicated in the Bill of Quantities.

DIVISION 13: ELECTRICAL WORKS

13.1 General Conditions and Standards

13.1.1 General

The electrical installation shall be carried out in accordance with the following codes of practice and standard specifications.

a. Palestinian Standards.
b. IEE Wiring Regulations, 16th Edition.
c. The By-Laws of the local Electrical Power Company.
d. General regulations for electrical installation issued by Palestine Energy Authority.
e. This Specifications.
f. The Contract Drawings.
g. The Working Drawings produce by the Contractor and approved by the Engineer.
h. The Engineer's instructions.

The Contractor shall undertake all modifications demanded by the authorities in order to comply with the regulations, and produce certificates, if any, from the authorities without extra charge.

The work shall be carried out promptly in a neat workmanlike and efficient manner to fulfill the true meaning and intent of these Specifications.

All materials used shall be of the best of their respective kinds. In full conformity with Palestinian Standards, otherwise shall comply with the following clauses of these Specifications and any relevant British Standard or the latest relevant recommendations of the International Electro-Technical Commission (I.E.C).

Low voltage materials and equipment shall comply in all respects as a minimum to the following standards.

- Palestinian Standards.
- National Fire Protection Association (NFPA): code for all small signal systems.
- British Standards BS 5839 part 1 for fire detection and alarm system in buildings.
- The latest Specification for internal and external telephone networks issued by T.C.C.

Drawings with Specifications show the approximate location of all electrical apparatus. The exact locations shall be subject to the approval of the Engineer.

The Contractor shall provide suitable means of identification for all equipment supplied and installed, all label text shall be written either in Arabic or in English and approved by the Engineer, labels shall be anodized aluminum sheet, thickness 1.5mm, or strong plastic plates.

The Electric Power Company will supply: 6.6-11 kV/415-240 V, 50Hz, 4 Wire, 3 phase and neutral having the following tolerances: voltage ±4% frequency ±4%.

All components shall be designed and rated for continuous and trouble free service under the climatic conditions of the country.

Electrical Contractor should obtain approval of the Engineer before commencing any work.

Design of the Electrical and Control Systems should take into consideration the possibility of adopting the existing system to a central Remote Control System.

13.1.2 Submittals

a. The Contractor shall submit samples of materials to the Engineer for his approval before placing an order and the Engineer has the right to refuse fully or partially any component not meeting the requirements of these Specifications.
b. No orders shall be placed by the Contractor for any material unless the written approval of the Engineer has been obtained.
c. With each submittal, the Contractor should provide a comparison sheet showing where the proposed submittal complies with the Specifications and the deviated items from specifications.

13.1.3 As Built Drawings

Upon completion of the electrical work the Contractor should supply to the Engineer one original As built drawings and five blue print copies for the electrical installations and all the low voltage systems in addition to one digital copy.

Moreover the Contractor should provide the following as per system and equipment:

a. Manufacturer's technical catalogues, dimensional drawings and wiring diagrams for each piece of equipment.
b. Operating instructions.
c. Maintenance manuals.

13.1.4 Electrical Contractor

1. The Contractor must have during the entire duration of the Contract a qualified electrical engineer and an electrical supervisor for ensuring proper supervision of the work.
2. The electrical engineer should be registered with Palestine Engineers Association, qualifications and experience should be submitted for approval.
3. The electrical supervisor should be available at site during all working hours.

13.1.5 Climatic Conditions

All equipment and materials used in the electrical installation work shall be so designed and constructed to withstand 40 C^o if installed within buildings having good heat insulating properties and adequate ventilation.

13.1.6 Drawings

a. The electrical drawings are intended to show the general arrangement of work and the approximate location of equipment.

b. Refer to all other architectural, structural and mechanical drawings to verify all spaces and conditions effecting the electrical work and to ascertain the location and routes of all gas and water services, AC ducts, piping etc., so as to maintain adequate clearance between electrical and other services.

c. Shop Drawings:

1. Prepare and submit for approval, before commencing any portion of the work, complete Shop Drawings which shall show:

   a. Exact routing of cables and ducts including sizes and details of installation.

   b. Cable trays and ladders including routing, sizes and details of supports and hangers.

   c. Exact runs of conduits and trunking including sizes, draw boxes and junction boxes and the number and sizes of wires in each run.

   d. Main boards and distribution boards and control panels including location, layout, dimensions, fixing details, cabling and final connection arrangement.

   e. Proposed supports and hangers for cable trays, trunking, conduits, cables, light fittings etc., including details of materials, finish, sizes and method of fixing to structure.

2. Shop Drawings shall be drawn to a scale not less than 1/100 or as required by the Engineer. Throughout the duration of the Contract, a detailed record shall be kept by the Contractor of all service distribution routes and installation work and such records shall be used at the end of work as a basis for production of final "Record Drawings".

13.1.7 Equipment and Materials

1. All equipment and materials used in the electrical installation work shall be new, of the highest quality and suitable for the installation as shown on the Drawings.
2. All equipment and materials shall comply as a minimum with the latest relevant recommendations of Palestinian Standard, the International Electrotechnical Commission (IEC), British Standards Code of practice, and IEE wiring regulation 16th edition.
3. All materials and equipment shall be approved in writing by the supervising Engineer before commencing any work.

4. The details of equipment & materials shall include full technical specifications and data & manufacturer's catalogues.
5. Submit, at the request of the Engineer, a sample of any equipment or material for further study before approval.
6. The Contractor shall submit the manufacturer's names & catalogues during the pricing period.

13.1.8 Workmanship

A. Whether or not shown on Drawings, equipment shall be installed in such a manner that equipment, operating and control devices etc., are readily accessible for service and adequate access spaces are maintained.

B. Obtain detailed information from the manufacturers of equipments as to proper method of installation and connection of these equipments.

13.1.9 Identification and Labeling

A. The components of all L.T. and main boards, all distribution boards, switches, isolators and other items of plant shall be clearly identified by means of labels secured to the external surfaces of the units designating the function of these units.

B. Each distribution board shall also be provided with circuit schedules fixes rigidly inside the door of the board and indicating the number, rating, type of load and location of each circuit in the board.

C. Manufacturer nameplates shall include manufacturer's name model or type number, serial number and all applicable ratings clearly marked thereon. The nameplates shall be placed in a conspicuous location on the equipment.

13.1.10 Work Programme and Progress

A. Prepare and submit for approval, detailed time programme chart for the complete work coordinated with other trades to ensure that all information, equipment and materials are available in due time and the Contract date for completion is met in all respects.

B. The time programme shall show all the work broken down into component parts and indicate various essential phases of work from time of commencement of Contract to the final completion and shall give dates of submitting Shop Drawings, ordering and delivery dates for equipment and materials and details of the labor force and equipment intended to be used for erection.

13.1.11 Testing & Commissioning

The inspection of the Contract work shall be carried out in the presence of the Engineer and shall be comprised of:

1. Verification of polarity.
2. Effectiveness of earthing.
3. Insulation resistance test.

4. Test of ring circuit continuity.
5. Phase rotation.
6. Operation test of relays, interlock and any other protective and control devices to ensure correct functioning.
7. The results & readings obtained shall be equal or better than the requirements of the IEE and local codes, and these shall be recorded on forms similar to the ones described in the IEE regulations.
8. Supply all instruments & tools required for carrying out the test.
9. All testing instruments & tools shall be calibrated & a certificate shall be presented to the supervising Engineer.
10. After the connection of the supply to the installation, commission all parts of the electrical installations covered by this Specification and demonstrate to the Engineer that the entire electrical installations are in perfect working order.
11. When equipment or service of a specialized nature are involved, and if it was found necessary, provide the services of the specialist from the manufacturer who shall be present at the time of testing & commissioning of these equipment.

    The Contractor shall not claim for any additional expense if a specialist was found to be necessary to attend the commissioning.

13.1.12 Operation and Maintenance Manuals

Submit to the Engineer three properly printed and bound copies of service manuals for the electrical installations to describe the various systems in the fullest details, these shall include the following:

1. Manufacturer's technical catalogue, dimensional drawings and wiring diagrams for each every type of equipment installed.
2. Operating instructions for various equipment and systems included the installation work.
3. Maintenance manuals for all equipment and systems included in the installation work which need regular and specialized maintenance.
4. Spare parts lists with part numbers of various component of all equipment used in the installation work.

13.1.13 Guarantee Period

During the maintenance period, replace and repair, as directed by the Engineer, all materials, equipment and accessories, other than lamps and other components which have failed before their normal life, which have been found defective and rectify any workmanship which has been determined by the Engineer as of sub-standard quality. The duration of the Guarantee should be as indicated in the Contractor Documents (Bid Data Sheet)

13.2 General Conditions and Standards

13.2.1 Main Distribution Board

13.2.1.1 General

1. The main low-tension switchboards shall be of indoor construction form four, multi cubicle type, free standing, dust and vermin protects & from operated.
2. The switchboards shall be constructed in accordance with *PS 451 part 1*-part *3*.
3. The switchboards shall be made of folded steel construction, minimum 2mm thickness, fully rust proofed and store enameled, foreign made cubicles (Himel) or equivalent.
4. All external bolts or screw heads shall be chrome.
5. All doors and removable covers or plates shall be provided with suitable PVC or neoprene gaskets to prevent the ingress of dust, vermin and insects.
6. The switchboards shall be of IP 53 construction in accordance with PS 121 and IEC 144.
7. Each unit of the switch board shall be housed in its own cell fitted with a hinged door mechanically interlocked in such a manner that the cell door can only be opened when the switch is in the "OFF" position.
8. Switch units shall be arranged in separate compartments or sections to protect against accidental contact with adjacent equipment when handling the elements in the section and to present the spreading of faults from one section to the other.
9. The switch boards shall contain the air circuit breakers, busbars, bus couplers, MCCBs, instruments, earth bus, etc., as specified hereunder with ratings and arrangement as shown on Drawings and shall be complete with all internal wiring & connections.
10. The switchboards shall be tested at the manufacturer's premises as well as after installation in accordance with tests stipulated in IEC 60439-1.
11. MCCB's and main MCCB should be connected to the buses by plug-in and no cable connection permitted, for larger sizes suitable busbar connections shall be provided.
12. Approved nameplates, permanently mounted for identification and all major and control equipment shall be supplied with each unit of assembly.
13. Each MDB shall be provided with suitable cable glands to suit the type, size and number of medium voltage cables as indicated on Drawings, the glands shall be so fixed inside the board that ample clearance exists between the various feeders.
14. Construction of switches shall prevent damages caused by electro magnetic force during short circuits in the closed position.

13.2.1.2 Busbars

1. Busbars shall be of electrolytic hard drawn copper to B.S.159 with rating as indicated on Drawings.

2. Busbars shall extend through the length of the board with same cross section throughout.
3. Busbars shall be housed in separate adequately ventilated compartment, which shall not contain any wiring or apparatus other than that required for connection to busbars. Access to busbars and busbar connections shall be gained only by removal of covers secured by bolts or suds. Busbars shall be covered with colored PVC sleeves for phase identification.
4. Busbars should be completely insulated against direct contact, insulation material should be insulating up to 1000V, Raychem or equivalent.

13.2.1.3 Air Circuit Breakers

1. The air circuit breakers shall be 500V, 50HZ, triple pole with neutral link of ratings as shown on Drawings.

   They shall be air break, trip free, drawout type with mechanical and electrical ON/OFF indicators.
2. The withdrawable part of the circuit breaker shall be effectively connected to earth through scraping contacts that shall make before and break after the main and auxiliary contacts.
3. The circuit breakers shall have sufficient number of auxiliary contacts for interlocking with two spare sets of normally open and normally closed contacts.
4. The circuit breakers shall be equipped with over current and earth leakage protection by means of inverse definite minimum time relays to *PS 192*. The over current elements shall have current plug-in setting between 50 and 200 percent in steps of 25 percent. The time multiplier setting shall be variable from zero to unity corresponding to an operating time of 3 seconds at 10 times the current plug setting, with definite minimum time of 2.2 seconds.

13.2.1.4 Instruments

1. The measuring instruments shall include ammeters, voltmeters, KwHM (kilowatt-Hour Meter), maximum demand indicators, selector switches and Power Factor Meter.
2. The instrument shall have anti-glare glass fronts, anti-parallax scales and white faces with black numerals and makings. The instrument cases shall be semi-flush mounted and shall be approximately 100 X 100mm square, accuracy shall be one percent of full scale values.

   Moving elements shall be provided with zero adjustments external to the cases.
3. Ammeters shall be moving iron type, to BS 89 scaled 0-2000 A for main incoming supply.
4. Voltmeters shall be moving iron type to BS 90 scaled 0-500 V and provided with 6-position selector switches allowing reading of line to line and line to neutral voltages.
5. Maximum demand indicators shall be of the thermal type with a 20- minute time delay.

13.2.1.5 Moulded Case Circuit Breakers (MCCBs)

1. They shall be air break deion type, quick make quick break, having free toggle mechanism ensuring full contact pressure until time of opening, whether actuated automatically or manually.
2. Circuit breakers shall have inverse time tripping characteristics with automatic release secured through action of a combination thermal magnetic element which shall trip free of the handle and operate in response to an overload or short circuit.
3. Breaker contacts shall be non-welding and non-corrodible silver tungsten composition. Circuit breaker handle shall have three positions, “OFF”, “TRIP”, thus indicating clearly abnormal conditions of the circuit.
4. Breakers shall have ratings as indicated on Drawings and breaking capacity or 20 KA symmetrical for 1 second at 415 V if the breaking is not indicated on drawings.
5. Breakers with earth leakage relay protection shall be provided with shunt trips.
6. All circuit breakers shall be ambient temperature compensated, allowing the breaker to carry full rate current with uniform tripping characteristics under all conditions.

13.2.1.6 Earth Bus

The earth bus shall be made out of copper extending throughout the length of the switchboard. The earth bus shall be extended at the ends for connection to the earth electrodes and shall have provision for terminating earth continuity conductors.

13.2.1.7 Circuits and Connections

1. All outgoing circuits shall have separate compartment and/or be screened so that equipment for any one circuit can be maintained without risk of contact with live connections on any other circuit.
2. They shall comprise main incoming isolator, busbars, moulded case circuit breakers, earth leakage relays, earth bus etc., with ratings and arrangement as shown on the drawings and all housed in a sheet steel panel fully rustproof and stove enameled equipped with a hinged door.
3. The main isolator shall be a triple pole and neutral moulded case circuit breaker without a tripping element.
4. The busbars shall be high conductivity copper to BS 159 with ratings as indicated on drawings for the three phases and neutral.
5. The earth bus shall have adequate rating and length for connecting the incoming and outgoing earth wires.
6. The distribution boards shall be complete with all necessary internal wiring and connections.
7. Adequate clearance shall be maintained between phases and non-current carrying metal and terminals shall be so located that in the final connected positions there shall be no crowding of wires in close proximity of metal.
8. The boards shall be complete with cable glands for convenient termination of incoming and outgoing cables.

13.2.2 Submain Distribution Boards

A. The submain distribution boards shall be totally enclosed, dust protected and factory fabricated suitable for operation on 415/240v, 3 phase, 4 wire, 50 Hz supply.

B. Submain distribution boards shall comprise main incoming isolator, busbars, moulded case circuit breakers, earth leakage relays, earth bus etc., with ratings and arrangement and all housed in a sheet steel panel fully rustproof and stove enameled equipped with a hinged door with approved locking device.

C. The main isolator shall be a triple pole and neutral moulded case circuit breaker without tripping element.

D. The busbars shall be high conductivity copper bars to BS 159 with ratings for the three phases and neutral. The busbars shall be arranged and marked to the approval of the Engineer, busbars should be completely insulated against direst Contact same as stated before in MLT busbars insulation.

E. The earth bus shall have adequate rating and length for connecting the incoming and outgoing earth wires or tapes.

F. The earth bus shall have an adequate rating and length for connecting the incoming and outgoing earth wires or tapes.

G. The distribution boards shall be complete with all necessary internal wiring and connections.

H. High conductivity copper bars or rods covered by colored PVC sleeving for phase identification shall be employed for all connections of 200A and higher. For smaller connections PVC insulated cable to BS 6231 shall be used with colored insulation for phase identification.

I. The arrangement of the boards shall be such that the main isolator and MCCBs, cabling and termination a second cover should be removed. There shall be ample clearance and ample space available inside the boards for cabling and termination. Adequate clearance shall be maintained between phases and non-current carrying metal and terminals shall be so located that in the final connected positions there shall be on crowding of wires in close proximity of metal.

J. All electrical Boards shall have spare space of at least 25% of their area.

K. The boards shall be complete with cable glands for convenient termination of incoming and outgoing cables.

L. Earth Bus: The earth bus shall be of copper extending throughout the length of the panel and fixed to brass nuts brazed to the steel members of the panel. The earth bus shall be extended at the ends for connection to the earth electrodes and shall have provision for terminating earth continuity conductors.

M. Circuits and Connections:

   a. All outgoing circuits shall have separate compartment and/or be screened so that equipment for any one circuit can be maintained without risk of contact with live connections on any other circuit.

   b. Provide all feeders with cable lugs and brass cable glands.

   c. Provide removable gland plates suitable for the glands required for the specified cables.

d. All small wiring shall be of stranded copper, not less than $2.5mm^2$ with PVC insulation to *PS 354 Part 1- Part 7*. Small wiring shall be neatly bunched and cleated in harness form, or shall be enclosed in purpose made plastic trunking or troughing. Wiring cleated to metal surfaces shall be insulated from the metal.

e. Each connection shall separate incoming and outgoing terminals and no more than two wires shall be connected to any terminal.

f. All wiring shall be identified using plastic ferrules at both ends.

13.2.3 Isolators

A. Isolators where mounted individually shall be of sheet steel construction with doors and from operated handles. They shall be of the quick make, quick break type with removable shields over the fixed contacts, door interlocks and "ON/OFF" indicators.

B. Isolators shall be single or triple pole with neutral, or ratings and provided with earth terminals. They shall be in accordance with IEC 60947-3.

13.2.4 Distribution Panel Boards

A. Panel boards for light and power shall be of the general purpose type, flush wall mounted consisting of box of trim, according to *PS 451 Part1- Part3*. Dust and vermin proof.

B. Box shall be fabricated form galvanized sheet steel not lighter than 2mm.

C. Trim shall have concealed hinged flush cover with a catch.

D. Panel boards interiors shall not be installed in cabinets until all conduits connections to the cabinet have been completed.

E. The interior of panel boards shall be mounted on buses of a back panel and shall be assembled as a complete unit to fit its cabinet.

F. Buses shall be rigidly supported and completely PVC insulated, in such a way that no contact with life parts can be occurred, it should be so designed that branch circuits can be removed without disturbing adjacent units or changed without additional drilling or tapping.

G. Necessary spare circuit breakers shall be provided for installation of future circuits as per panels drawings.

H. Neutral and earthing busbar shall be insulated and incorporate one terminal for the neutral and earth wires of each branch circuit and should be arrange in the same manner of phases arrangement and one for the main incoming neutral wire.

I. All panel boards shall be provided with a ground connector welded to the cabinet.

J. All panel boards shall have an identifying nameplates mounted on the inside of the door.

K. For all dB's, which are located externally, they should be enclosed in weatherproof enclosure.

L. All electrical Boards shall have spare space of at least 25% of their area.

13.2.5 Miniature Circuit Breakers

A. The circuit breaker shall be thermal-magnetic of the manually operated type and shall have rating engraved on rocker dolly layer.

B. The miniature circuit breakers (MCB) shall comply with EN 60989 part 1 and the following requirements:

   a. On the triple pole double pole, or triple pole plus neutral MCB's each pole shall have a separate thermal-magnetic time delay tripping mechanism, the toggle assemblies of all poles shall be internally mechanically interlinked for simultaneous isolation of all poles under fault conditions, and so arranged that the overload tripping characteristics and calibrations of each pole shall be completely unaffected by the loading of its neighboring pole or poles.

   b. The MCB shall either be of the plug-in or bolt on-type; screw cap type of breakers shall not be permitted.

   c. The instantaneous early tip values shall conform to type 2 & 3 characteristics as per BS 3871 part 1.

   d. The time delay tripping mechanism and calibration shall be unaffected by fluctuation of high ambient temperature.

   e. The MCB's shall have a certified short circuit breaking capacity of 5000 A at 400 V and 0.8 power factor lagging according to EN 60989 or 10 KA according to IEC 60947-2 or 15 KA according to NEMA AB-1.

   f. No MCB's over 63 A will be permitted.

C. Current Operated Earth Leakage Circuit Breakers (C.O.E.L.C.B):

   a. Current operated earth leakage circuit breakers shall provide accident protection by interrupting dangerous contact voltages, which may be present in faulty electrical appliances as a result of frame faults, insufficient insulation or misuse. It shall also provide a high degree of protection against earth faults, fires and electric shock.

   b. The breakers shall generally comply with the recommended specification IEC 60479 of the international Electrotechnical Commission Rules for the approval of Electrical Equipment and/or National or other relevant specification at least equivalent to IEC 60479.

   c. The breaker shall consist of a current transformer, a tripping coil with contact assembly, main supply contacts ON/OFF switch, a test button and a trip free mechanism, all mounted on a robust body all of insulated material.

   d. The breaker shall give trouble free services in the severe climatic conditions.

   e. The breaker terminals shall be suitable for the conductor size specified, also the breaking capacity and trip rating and other details shall be as indicated below:

Number of poles:	2 or 4
Rated current (in amps):	25/30/40/60/80
Trip current (sensitivity) (in mA):	30/300/500
Breaking capacity minimum (in Amps):	5000
Terminal size suitable for (mm^2):	10/16/25

   f. The tripping mechanism shall interrupt the incoming electricity supply within a maximum period of 200 milliseconds under earth fault conditions and also ensure

that the circuit breaker cannot be held closed against earth fault. The tripping mechanism shall not be affected by the ambient temperatures mentioned. The winding of the current transformer and trip coil shall preferably be of class "B" insulation. All contacts shall be of robust construction made from suitable alloy and shall be of the non-welding self wiping type, designed for a minimum of 10,000 operations.

13.2.6 Contactors

Contactors shall be block type, equipped with auxiliary contacts for all necessary indication, local and remote control requirements together with a means of mechanical indication to show when it is energized. Those used for switching squirrel cage induction motors shall have the following characteristics:

a. Utilization category AC3.

b. Minimum intermittent duty class 12.

c. Mechanical endurance $1x10^6$ operating cycles.

d. Co-ordination with an associated short circuit protection device protection according to *PS 120.*

Rating of contactor shall be strictly according to manufacturer's instructions.

13.2.7 Current Transformers (CTs)

CTs shall be of an appropriate class and accuracy for the application, with outputs such that the combined relay, instrument and internal burden is not greater than 60% of the rated output of the CT. They shall be securely fixed but have provision for easy removal and replacement.

13.2.8 Overload Relays

Overload relays shall be of the thermal type, with inherent ambient temperature compensation and single phasing protection. This shall be of manual reset type, having visual mechanical indication of the tripped condition, resettable without opening the compartment door. Calibration shall be adjustable between 80 and 150% of motor full load current. On motor drives, of 100 kW and above, over current relays shall be definite minimum and inverse time limit pattern.

13.2.9 Phase Failure Relays

Phase failure relays shall be connected to all phases and neutral and shall de-energize at below 80% of rated voltage on any one or more phases. The relays shall be separately fused with contacts wired down to outgoing terminals or connected to telemetry equipment.

13.2.10 Earthing System

A. All metallic equipment enclosures, steel conduit system, cable trays, trunkings, lighting fixtures, earthing pins of sockets, all non-current carrying metal parts of the

electrical systems and any other equipment or system components required by PS, MEW and I.E.E. regulations shall be earthed in an approved manner.

B. All earth connections shall terminate finally at the main low tension switch board earth bus and extended from there to earth electrodes as specified hereinafter.

C. The earthing system of the building shall be an independent system connected to the earth bus on the main low-tension switchboard.

D. The earth wires shall be covered with PVC and distinguished by Green color.

E. All distribution boards, switch fuses and isolators shall be provided with an earth bus or earth terminal and these shall be connected to the earth bus in the main switch board by earth conductors included with the feeders.

F. On cable trays and in electrical riser shafts an earthing copper tape of 25 x 3mm shall be provided for earthing all distribution boards, isolators and equipment.

G. A main earth electrode shall be supplied and installed near electrical supply intake and shall consist of copper rods driven in the ground in the 3 angles of a triangle in a cubic hole with a depth not less than 1m and interconnected by a grounding cable and as may be required to obtain the ground resistance specified. These electrodes must be installed in checking manhole of at least 60cm depth.

H. The top of the main earth electrode shall be protected from damage, but to be available for inspection by being enclosed in a concrete or brick lines pit and fitted with an inspection cover and the pit should be with a dimensions not less than 0.45mm.

I. The principal earth continuity shall be connected to the main earth electrode by heavy-duty metal clamps.

J. Galvanized steel bars (30x3.5)mm will be welded to the foundation beams and connected to the ground bus bars in main panel.

K. Connection between earth bars and equipment frames and stranded copper cables shall be made with appropriate compression lugs, bolts nuts and lock washers. Contact surfaces shall be thoroughly cleaned and tinned.

L. The maximum earth resistance shall not exceed 2 (ohm) as measured at the earth pit with main earth electrode disconnected to the earth pit. If this resistance cannot be obtained with two earth rods, additional earth rods or sectional earth rods shall be used to obtain the required resistance. Parallel-connected earth rods shall be spaced at a distance of not less than the rod lengths and connected by 25 x 3mm cooper tape copper tape. If approved by the Engineer, earth plates or other earthing means may be used instead of the additional earth rods.

M. Earth rods shall be steel copper of not less than 16mm diameter, three meters long, driven full length into the earth.

N. The connection between, earth conductors and earth rods shall be made by means of high strength corrosion resistant copper alloy connector clamps.

O. The tops of the electrodes shall be protected from any damage and shall be easily accessible. With a view of this, they shall be enclosed in pies equipped with covers.

P. A drawing shall be prepared showing the principal connections in the earthing system.

Q. Where a plant's location necessitates the fitting of a lightning conductor, a separate electrode for the conductor shall be placed at a suitable distance from the electrode for the low voltage installations.

13.3 Distribution and Wiring

13.3.1 General

A. Distribution and wiring shall include all bus ducts, cables and conductors, flexible cords and cables, cable ladders and trays, cable trunking and conduits with all associated accessories, supports and fixings used for the distribution of electric power in the building.

B. Trunking and conduits shall be either steel or PVC. In general trunking and conduits installed exposed in vertical risers or where heavy protection against mechanical damage is required shall be rigid steel. All other conduits shall be, unless specifically indicated otherwise, of PVC according to PS 132, PS 76, PS 70.

C. All conduit systems shall be installed in such a manner that electrical conductors can be installed after the conduit system is completed and that the conductors can be removed and replaced at any time.

13.3.2 Cable Trays and Ladders

A. Cable trays shall be heavy duty, return flange, perforated type formed from sheet steel to PS 354 and hot-dip galvanized after manufacture in accordance with PS 442.

B. Cable trays shall have a minimum thickness of 1.6mm for trays up to 300mm and 2 mm for wider trays.

C. Cable trays shall be assembled complete with couplers, bends, tees, risers, reducers and all other accessories as required and these accessories shall be of the same material, thickness and finish as the trays. Manufacturer's standard accessories shall be used and site fabrication shall only be allowed where special sections are required subject to the approval of the Engineer.

D. Cable trays shall be cut only along a line of plain metal and not through perforations. All cut edges of trays shall be prepared with burrs and sharp edges removed prior to installation and treated with zinc epoxy paint.

E. Cable trays shall be fixed by support channels and hanger rods or by cantilever brackets fixed to walls or columns.

F. Cable ladders shall be H-type made from 2mm mild steel with 3mm coupling plates. Slide channels shall be strengthened by reinforcing insets or other means to increase torsional rigidity. Rungs shall be slotted type. Cable ladders shall be hot-dip galvanized and shall be complete with coupling pieces, bends, tees, reducers, risers, drop-outs, intersection and all other accessories as required and these shall be of the same material, thickness and finish as the ladders.

13.3.3 Conduits

A. Steel conduits shall be heavy gauge to PS 286, PS 354, hot-dip galvanized inside and outside with screwed ends. Conduit fittings shall be malleable iron, galvanized, with threaded spouts suitable for the number and arrangement of conduits connecting to them.

B. No conduit used should have a diameter less than ¾ ". The conductors area within the conduit should not exceed 40% of the conduit area.

C. Couplers, unions, saddles, hangers, straps, etc., shall be employed for connection and fixings of conduits in a permanent and rigid manner and these shall be all of galvanized steel.

D. Inspection type elbows, bends, tees and manufactured bends shall not be allowed.

E. Steel conduits shall be continuous from outlet to distribution boards, junction or pull boxes and secured to all boxes so that each system is electrically continuous from service to outlet. Conduits shall be screwed tightly into couplings and fittings and connected to unspouted accessories such as distribution boards, switch and socket boxes by couplers and male brass bushes to ensure earth continuity.

F. PVC conduit shall be high impact, rigid PVC unthreaded push type. Conduits and conduit fittings shall be in accordance with PS 132, PS 70, PS 76 BS 4607 – part 1.

G. PVC conduits and fittings shall be joined by using sealing cement to ensure a watertight joint. When PVC conduits are embedded in concrete slabs, they shall be securely held in place by fixing to shuttering and reinforcing bars. In walls they shall be run in cut chases and fixed by saddles or crampets.

H. Chases shall be deep enough to allow full thickness of plaster cover to be applied. Bends in PVC conduits shall be neatly made with proper size bending spring.

I. Empty conduits when left with ends exposed for some time shall be closed with suitable plugs to prevent entry of dirt and foreign matter.

J. No wire is to be drawn inside conduits until they are completely erected and approved by the Engineer. The conduits shall be swabbed through to remove any dirt or loose matter before drawing of wires.

K. The sizes of conduits shall be in accordance with the number and size of wires to be drawn inside them as indicated in PS 286, PS 354 regulations but no conduit smaller than 20mm shall be used. A pull wire or tape shall be provided in all empty conduits with no less than 200mm of slack left at each end.

L. Flexible conduits shall be used for connection of motors, HVAC Equipment, recessed light fittings, etc. Fixed conduits shall be terminated in a conduit box and flexible conduit shall then connect to the equipment.

13.3.4 Cables

13.3.4.1 General

A. All wires and cables shall have multi-stranded copper conductors insulated with poly vinyl-chloride (P.V.C). Cables are to have poly vinyl-chloride sheaths; all internal wiring shall be carried out with single core wires.

B. Cables shall be installed on cable trays or on building structure as indicated on Drawings. They shall be neatly fixed in straight lines. On cable trays, cables shall be fixed by cable clips or ties while on building structure cable cleats shall be used. The spacing of cable supports shall PS 354 be as indicated in. The minimum radius of bends for cables shall be in accordance with PS 354 of the regulations with bends made neatly and uniformly.

C. Proper cable glands shall be used for cable entries into distribution boards and equipment.

D. Each end of each cable shall be provided with identification label lettered with feeder or circuit designation to the Engineer's instructions. The labels shall be permanently fixed in distribution boards, terminal boxes, isolators, etc., and shall be made of durable material ensuring permanent legibility.

E. Cables shall be of the following types with type and size as indicated on Drawings:
   1. PVC Insulated/PVC Sheathed Cables: The shall be 600/1000V, single or multi-core conforming to PS 354 with high conductivity plain annealed stranded copper conductors to PS 354, PVC insulated with an extruded layer of PVC bedding and a final outer extruded PVC sheath. The insulation and sheath shall be to PS 354 with insulation colored to identify phases and neutral.
   2. Cross Linked Polyethylene Cables: These shall be single core or multi-core cables, 600/1000V conforming to BS 5467 with high conductivity plain annealed stranded copper conductors to BS 6360, linked polyethylene (XLPE) to BS 5468. Armoured cables shall have a single layer of galvanized steel wires for multi-core cables and aluminum wire or tape for single core cables.

13.3.4.2 PVC Insulated Single Core Wires

This type of cable shall be 450/750 Volt grade, PVC insulated and comply with and PS 354, 354 part 1 – part 4 and shall have conductors of plain annealed copper, the conductors shall be insulated with type 5 PVC.

13.3.4.3 PVC Insulated Cable

Each cable shall comprise stranded conductors of plain annealed copper wires having high conductivity. The conductors shall be insulated by PVC and the core insulation shall be colored according to the Palestinian Standard. The bedding shall consist of an extruded layer of PVC over which a single layer of galvanized steel wires shall be provided as armour. The cable shall have a final serving over the armour comprising of a black extruded PVC sheath. The PVC used for the core insulation, bedding and sheath shall be type 5 and comply with *PS 354*.

The cable shall be 600/1000 Volt grade and shall comply with BS 6346 in every respect.

13.3.4.4 PVC Insulated Non-Cable

This type of cable shall be 600/1000 Volt grade, complying with *PS 354* and shall have stranded conductors of plain annealed copper wires of high conductivity. The conductor shall be insulated with PVC and core insulation shall be colored according to British standard. The bedding shall consist of an extruded layer of PVC over which a black extruded PVC sheath

shall be provided. The PVC used for core insulation, bedding and sheath shall comply with *PS 354*.

13.3.4.5 E.L.P.E Insulated (X.L.P.ES.W.AP.V.C) Cable

600/1000 Volts X.L.P.E/S.W.A/P.V.C cables shall comply with:

PS 354 I.E.C. Standard 60502-1: 1975; and BS Standard 5467: 1977 V.D.E 0271.
The cable shall have stranded conductor comprising of plain annealed copper wires of high conductivity to BS 6360: 1969.

The conductors shall be insulated by cross-linked polyethylene, nitrogen cured, homogeneous and suitably colored for phase identification. The four cores of a cable shall be identified by RED, YELLOW, BLUE AND BLACK colors. The bedding shall consist of a layer of extruded P.V.C over which round galvanized steel wire shall be provided as armour. The cable shall have final serving over the armour comprising of an extruded black P.V.C.

Cable shall not be sent during installation to a radius smaller than eight times the overall diameter.

13.3.4.6 Single Core X.L.P.E. Insulated (X.L.P.E/A.W.A/P.V.C) Cables

600/1000 Volts X.L.P.E/P.V.C cables shall be similar to X.L.P.E/S.W.A/P.V.C cable described above regarding conductors, core insulation, colour identification, bedding and sheathing. Additionally the non-magnetic armour will be solidly bonded at both ends of the cable run.

Cable lugs for power cables of suitable and adequate size shall be provided. Compression type cable gland shall be fitted in all cases to prevent stress on conductor or terminals and to prevent dust and moisture entering the terminal box, switch board, distribution board, etc. where required the glands must also be provided with suitable means for binding the cable to the metal frame or to earth.

13.3.4.7 Armoured Cables

This type of cable shall be 600/1000 volt grad complying to *PS 354* and shall have stranded conductors of plain annealed copper wires of high conductivity the conductors shall be insulated by heat resistive PVC to *PS 354* rated 70 c for continuous operation and core insulation shall be colored according to PS 164 phases colors.

The armour shall be round galvanized steel wires with opposite lay of galvanized steel tape, the bedding shall consist of an extruded layer of PVC over which a black extruded PVC sheath shall be provided, bedding and sheath shall be type 5 PVC and comply to *PS 354*.

The Contractor shall comply with the following color code: The phases shall be indicated by red, yellow and blue, black for the neutral and green (green/yellow) for the earth. Color coding shall be maintained throughout the entire installation.

13.3.5 Wires

A. Wires shall be plain annealed copper conductor to BS 6360, insulated with PVC to BS 6746, 600/1000V grade conforming to PS 354, BS 6004, single core for drawing inside conduits and trunking.

B. Wires shall be continuous from outlet and no splice shall be made except within outlet and junction boxes. A separate neutral wire shall be provided for each circuit. Wires shall be left sufficiently long to permit making final connections. The color of insulation shall be as specified in IEE regulations for different phases, neutral and earth wires.

C. Telephone System Cables: Two pair and multi-pair cables indoor cabling are to be polyethylene insulated, tinned solid copper conductors, twisted into pairs, color coded with wrapping of aluminum polyester tape and gray PVC sheath, minimum diameter of conductor is to be 0.5mm, 0.5mm diameter for 1 to 10 pair cables and 0.6mm diameter for cables with more than 10 pairs.

D. All wires and cables, except where otherwise stated are to have soft copper core, refined and tinned, with electric conductivity of not less than 98% the core be insulated with rubber with braid for 600 Volt service.

E. Samples of cabling and wiring proposed the Contractor are to be submitted prior to commencement of the work. These must comply with the requirement of the I.E.E and local standards to ensure constant voltage in every part of the building.

F. All wires should run in conduits and shall be continuous between outlets and boxes. At least 20 cm of the wire shall be left at outlets for fixture connections.

G. All wires are to be standard (1.5mm2 for lighting, 2.5mm2 for power) or as otherwise specified.

H. Wiring inside panel shall be neat and well arranged, using appropriate lugs for termination and connection of conductors.

I. Joints in the cables or wires are not allowed to be made inside conduits.

J. Wires are to be fixed to panel with appliance ensuring perfect electrical contact, to the approval of Electrical Engineer.

K. All boxes and distribution boards have to be carefully cleaned from plaster and other foreign material before drawing cables and wires.

13.3.6 Flexible Cords

Flexible cords shall be circular silicon rubber insulated glass fiber braided, three core, 300/500 volts and shall comply with PS 354 part 9 – part 11. The conductors, shall be tinned, annealed copper and the core shall be colored brown, blue, green/yellow for identification.

13.3.7 Accessories

13.3.7.1 Sockets

1. Sockets shall be 250V, three pin, 13A switched type *PS 161*. Safety shutters shall cover pin holes to prevent accidental contact. Contact arrangement shall be such that contact is made on two sides of the tangular pins of plugs.

2. Sockets shall be fixed inside galvanized stamped steel or rigid PVC boxes, which shall be flush mounted in walls. PVC boxes shall have tapped brass inserts for fixing screws.
3. Sockets shall have white moulded cover plates. The mounting heights for wall sockets shall be 400mm above finished floor level for offices; spare parts and shows, 1.5m for Garage unless otherwise indicated on Drawings.
4. Sockets connected on emergency or UPS systems shall be identified connected on emergency or UPS systems shall be identified by engraved lettering on the plates as directed by the Engineer.
5. 3 phase industrial socket outlets should be 5 pins, (3p+N+E) with rating complying with EN 60309, IEC 60309, splash proof IP44.

13.3.7.2 Switches

1. Switches used on light branch circuits shall be quick made, quick-break, with silver alloy contacts, with insulated dollies, rated at 10 Amp, 250 volt AC, according to *PS 137* - part 2. The switch shall be ivory finish and should be provided with suitable earthing terminal.
2. All switches shall be mounted on 1.2m above the finished floor level.
3. Switches for out door use shall be waterproof; the switch shall comply with PS *137*.
4. All switches shall be mounted inside the room on the side of the door where the catch or lock is situated, the nearest switch being approximately 200mm from the door frame.
5. All signal pole switches shall be so connected that they control the phase lead to the light or other consuming device and the switch should be designed so that the position has been moved to still unchangeable even in case of high vibrations.

13.3.8 Electrical Work

A. The electrical work included in this section of the Specifications shall commence from the supply and installation of the main air-conditioning control panel as shown on the Drawings and specified herein. The main supply cables feeding these control panels are included in the "Electrical Specification" section but the jointing of this cable on to the control panel shall form part of the work included in this section.

B. The entire electrical work associated with the heating, ventilating and air-conditioning services shall conform strictly to the latest "Rules and Regulations for Electrical Installation Works" issued by the Ministry of Electricity and Water. Where no specific mention is made in the above Rules and Regulations, for any particular type of work, then that portion of the works shall be executed in accordance with the latest "Regulations for Electrical Equipment in Buildings" issued by the Institution of Electrical Engineers, London. The execution of all electrical work shall, in addition to the above, be subject in all respects to the approval of the Engineer and shall be carried out to his entire satisfaction.

C. Identification of Units and Circuits: All isolating switches, shall have engraved labels showing the services fed from them. The inscription shall be in black 3mm high letters on white Traffolyte sheets and shall be fixed to the lids of the apparatus by screws or rivets. All equipment where two or more phases are present shall have engraved

CAUTION 415 labels in red 6mm high letters on white. A "Treatment for Electric Shock" instruction sheet shall be wall mounted adjacent to the main control panel.

D. Identification:

(i) The core or multi-core PVC insulated armoured and unarmoured cable shall be identified by the following colors according to PS 164:

Type	**Color**
Three Core	(A) Red, Yellow, Blue or (B) Red, black (neutral) and Green or Green/Yellow (Earth)
Four Core	Red, Yellow, Blue & Black

(ii) The core of single core PVC insulated non-armoured cable shall be identified by the following colors:

Phase Conductor	-	Red, Yellow, Blue
Neutral Conductor	-	Black
Earth Conductor	-	Green, or Green/Yellow

13.4 Lighting

13.4.1 General

A. Lighting installations shall include electrical wiring for lighting, lighting control and luminaries all as specified and indicated on Drawings.

B. Wiring shall be by means of PVC wires drawn inside PVC conduits concealed in ceiling slabs, in walls or above suspended ceiling with all accessories. Lighting outlets shall be provided through PVC circular boxes with connector blocks. Each terminal of the connector block shall be suitable to take three 2.5mm^2 cables. Final connections between outlets boxes and luminaries shall be by means of silicon rubber flexible cords of not less than 1mm^2. For luminaries recessed in suspended ceilings, the cords shall be drawn inside flexible conduits.

13.4.2 Light Fittings

13.4.2.1 General

1. All fittings and associated equipment shall be new; of the proven best quality and grade; and current models, for which replacement parts and lamps are and will be available for the normal expected useful life of the fittings and associated equipment.
2. All fittings shall be designed to be compatible with the appropriate ceiling system.
   a. Each fluorescent shall be mounted at no fewer than two points on each side for fittings 180cm long or shorter, and four points on each side for fittings over 180 cm long.
   b. The weight of each fitting shall rest only on the ceiling support channels in the case of plaster or acoustical tile ceilings.

3. All fittings shall be installed true and level and shall be free of light leaks, wraps, dents and all other irregularities.
4. Lamp wattages and sizes shall be as designated on the accepted manufacturer Shop Drawings. Where lamp wattages are not designated lamps shall be supplied and installed by the Contractor, as directed by the Engineer.

13.4.2.2 Fittings

1. The electrical description must be conformed to lighting performance.
2. The fittings shall be constructed of material sufficient for the specific application.
   a. If steel is used, the equivalent of United States 20 gauge sheet shall be minimum thickness. All steel shall be degreased and phosphate or zinc coated to prevent corrosion.
   b. If sheet or extruded aluminum is used, the fitting parts (except reflector) shall be clear, anodized aluminum to prevent corrosion.
   c. Exposed parts, regardless of material, shall be finished as directed by the Engineer.
   d. All reflectors shall be spun of high purity (99.85%) aluminum. Aluminum gauge shall be sufficient to be independently rigid and resistant to dents. The finishing shall consist of chemical brightening, color anodizing and appropriate cleaning steps. Surface texture, specular reflectivity, total reflectivity, image clarity and color shall match Engineer's sample. Reflector samples shall be submitted before installation. If acceptable, these samples shall indicate finish range.
3. Control Gear
   a. Control gear may be:
      (i) Separate Choke/Capacitor/Starter/Fuse units factory assembled and wired with terminal block on a "Control Gear Tray" for ease of maintenance; or
      (ii) An integral self-contained ballast type.
   b. Gear may be switch start or quick start provided the electrical characteristics are satisfied.
   c. Control gear shall have the following minimum characteristics:
      (i) Power factor – high (0.90 minimum).
      (ii) Harmonics – 20% maximum per phase.
      (iii)Control gear power consumption – 13 watts maximum.
   d. All control gears shall be fused with 1-ampere fuses (maximum current a.6A).

13.4.2.2.1 Lamps and Lamp Holders

- Tungsten Filament Lamps: Tungsten filament lamps shall comply with PS 322.
- Tubular Fluorescent Lamps: Tubular fluorescent lamps shall comply with PS 209, PS 177 & IEC 60081. Standard Tubular fluorescent lamps of 20, 40, and 65 W with a tube diameter of approx. 38mm shall be used. However, the low-energy type for 18, 36 and 58 W with a tube diameter of approximately 26mm is preferred and shall be provided.

13.4.2.2.2 Lamp Holders

- Lamp holders shall be of the all insulated patter, shall have a substantial cord and grip with the flexible wire so connected that no pull due to the weight of the holder can be transmitted to the connection of the conductors to the terminal.
- All lamp holders for screw cap lamps shall be so connected that the contact formed by the screwed cap is connected to the neutral conductor.
- Lamp holders for Tungsten Filament Lamps: Lamp holders for tungsten filament lamps shall comply with PS 320 part 1. Lamp holders shall consist of hear-resistant plastic or porcelain Edison screw. Type E 14, E 27 and E 40 are preferred.
- Lamp holders for Tubular Fluorescent Lamps: Lamp holders for tubular fluorescent lamps shall comply with IEC 60400. The locking angle shall be approximately 30 degrees to both sides.

  Lamp holders shall be of heat-resistant plastic, and in such a design as to ensure proper contact for the tube pins, and preferably made of polycarbonate material.

13.4.2.2.3 Ceiling Roses

- All flexible cords of cable not connected to the supply by plug and sockets shall be connected by means of insulated ceiling roses.
- Where the flexible cord or cable contains an earth continuity conductor, the ceiling rose shall be of the three-plate type and the connection shall be clearly marked to indicate the phases, neutral and earth conductors.

13.4.2.2.4 Ballast and Accessories

- **Ballast:**
  - ***Ballast for Fluorescent Lamps:***

    Ballast for fluorescent lamps shall comply with *PS 177-1*.

    Ballast shall be sheet metal enclosed with a protection code IP 20 according to PS 121 and the coil shall be cast-resin impregnated.

    The temperature rating shall be at least 130/55/125, which means:
    130 = 130 Cº Maximum coil temperature, 55 = 55 Cº temperature rise of coil at normal operating conditions, 125 = 125 Cº temperature rise of coil at abnormal operating conditions.
  - ***Ballast for High-Pressure Discharge Lamps:***

    Ballast for HP discharge lamps shall comply with IEC 60188. Integrated ballast shall be used for discharge lamps, which include the ballast coil and the power factor correcting capacitor in a sheet metal enclosure with a protection code IP 53 according to PS 121. The coil shall be cast-resin impregnated. The ballast shall have two or three tamps for voltage adjustment.
- **Starters:**

  Starters for fluorescent lamps shall comply with PS 209.

  Starters shall be provided in a plastic enclosure and shall be rated for an ignition temperature range from –20 degrees to +80 degrees C.

The universal type shall be provided to allow for start of lams in the range of 20 W to 65 W.

- **Capacitors:**

  Capacitors for lighting fixtures shall comply with PS 207.

  Capacitors shall be installed for fluorescent lamp for power factor correction of approximately 0.95 to 1.0.

13.4.2.2.5 Lighting Fixtures

- **Fluorescent Lighting Fixtures**

  - ***Recess-Mounted Lighting Fixtures:***

    – *Housing:* The housing of recess-mounted lighting fixtures shall be suitable for various ceiling systems by only modifying the fastening devices. Fixture housing shall be constructed from heavy gauge, cold rolled steel with solid top. The steel shall be formed and braced for maximum rigidity. Seams shall be constructed to prevent light leakage. Frames and socket plates shall be heavy-gauge steel formed and braced to hold lamp sockets rigidly in place during relamping.

    – *Painting:* The housing shall be coated with electrostatic powder coat of baked white enamel not less than 70 micron thickness and a test certificate must be submitted by the Contractor for one sample have been chosen by the Engineer. The finish coat shall have a reflectivity of not less than 85%.

    – *Reflector and Control Gear Housing:* The reflector shall be of high polished aluminum completely enclosing the control gear and wiring extending the full length of fixture, and forming a wire wary for circuits through the fixture. Reflector shall be securely connected to the fixture body, but shall be removable for access to the control gear and wiring without the use of tools other than a screwdriver. Suitable ventilation must provide for heat transfer from the control gear to the outside so as not to overhear the lightening fixture.

    – *Louvers:* The louvers shall be constructed of regress-extruded aluminum or of baked white enamel sheet metal, and shall be of precision fit or gasket to prevent light leakage. Louvers shall be hinged from either side, shall be easily removable without the use of tools and shall be held in the closed position without external project.

    – *Diffusers:* Diffusers shall be of a 100% virgin prismatic or Plexiglas lens, as completely framed into the fixture housing to prevent light leakage. All diffusers shall be formed from one piece with rigid corners and to be fixed on housing by means of plastic hangers.

    – *Earthing*: An earthing screw shall be provided at the fixture housing close to the power connection terminals. All metal parts of the fixture including the louver must be incorporated into the earthing protection system by proper means of connectors and hinges.

    – *Protection Code:* Lighting fixtures with open louvers shall have a protection code of at least IP 20 according to PS 121, and fixtures with diffusers shall have a protection code of at least IP 40 according to PS 121.

- ***Surface-Mounted Lighting Fixtures:***

  – *Housing:* The housing of surface-mounted lighting fixtures shall be wither of sheet metal as described above or of rigid reinforced glass fiber plastic made from one piece, and solid along its entire length. The housing shall have sufficient knockouts for convenient mounting by normal methods and diffusers fixing methods as described above.

  – *Painting, Reflector and Control Gear Housing, Louvers, Diffusers and Earthing:* These shall be the same as for recess-mounted lighting fixtures.

  – *Protection Code:* Lighting fixtures for interior installation in dry locations shall have a protection code of at least IP 40 according to PS 121, and lighting fixtures for installation in wet or outside location shall have a protection code of at least IP 54, class II according to PS 121.

  – *Open-Type Lighting Fixtures:* Open-type fixtures shall generally comply with above-listed requirements. The housing shall form a channel to enclose the control gear and the wiring. If a reflector shall be designed for direct attachment to the channel cover with suitable threaded fittings and shall be constructed of heavy gauge aluminum or steel white enamel. The reflector shall be for a symmetric or symmetric distribution as specified. Fixtures shall be for continuous rows or for individual mounting for chain, pipe, or messenger cable hangers. The fixture shall be provided with tube retention devices to prevent lamp dropout due to shock or vibration.

- ***Incandescent Lighting Fixtures:***

  – Recess-mounted Fixtures (Down Lights) Recessed low-brightness 450 degrees lamp shielding, open reflector down light. The housing shall be made of steel, ventilated, with baked-on matt black finish.

    The fixture shall be produced with an auxiliary junction box attached to the side mounting frame and pre-wired to the fixture protection medium base socket.

  – *Wall or Ceiling-Mounted Fixtures:* Bracket, watertight, die-cast aluminum with screw-in white opal enclosing globe and heat-proof neoprene gasket. The fixture shall be finished in satin chrome. A cast aluminum wire guard shall be produced with the fixture when it is required.

    Light control shall be provided by a louver guard of integral cast aluminum with 45 degrees louvers providing horizontal cut-off that is backed with clear, tempered glass.

    All recessed units shall be equipped with hinge-retained face plates easily removable for cleaning, which are secured by stainless steel head screws. Gaskets shall be provided for weather tight operation. The housing finish shall be anodized aluminum for maximum resistance to corrosion. The faceplate finish shall be satin anodized aluminum.

  – *Walkway Lighting Fixtures*: The spherical walkway fixture shall have a cast-aluminum base. It shall have a white globe constructed of impact-resistant virgin acrylic. The fixture shall have an integrally mounted heat shield reflector. The luminary shall be suitable for wet locations. The fixtures shall be suitable for mounting on a pole and secured by at least three corrosion-resistant screws. The

fixture shall be designed for use with 150 W incandescent lamp or if specified in the Project Documents for 250 W mercury vapor high-pressure lamp.

- ***Lighting Fixtures for Discharge Lamps:***

– Protection code for lighting fixtures for discharge lamps should be IP 54, Class II according to PS 121.

Discharge lighting units should be consist of a refined aluminum reflector, treated against corrosion by vacuum metallization and injection moulded polypropylene opening canopy, lamp holder should be with a size not less than E40 with safety lock and porcelain skirt and removable prewired control gear tray, separate from reflector, polycarbonate refractor with silicon elastoumer gasket, embrassed steel fixing strap, galvanized, bichromated, control gear, ignator and ballast should suitable for such lamp as per manufacturer recommendation.

– *Floodlight Fixtures:* High-intensity floodlights shall have one discharge lamp. The housing construction shall be heavy-gauge cast aluminum designed for maximum heat dissipation. The fixture shall be adjustable horizontally up to 360 deg. And vertically up to 180 deg. The fixture reflector shall be textured aluminum and shall be adjustable.

The socket shall be made of high-temperature, metal encased, spring-loaded porcelain with protection code IP 54 according to PS 121, class II.

– *Industrial Type Fixtures:* Industrial type fixtures shall have a porcelain enameled seamless steel dome-like reflector having a ventilated hood and a wiring terminal outlet. Pendant and wall-mounted fixtures shall have connectors for rigid steel conduit. Connectors shall contain a setscrew or other approved method to prevent the fixture from turning on the conduit. Pendant-mounted fixtures shall be provided with a swivel suspension. Reflector and socket shall be easily detachable as a unit without the use of tools, but shall be so arranged that the socket and reflector cannot come loose because of vibration. Ventilation openings in the neck of the fixture shall be in accordance with the manufacture's published standards. Fixtures shall be wired with not smaller than $1.5mm^2$ conductor and as specified in the relevant drawings having a minimum temperature rating of 150 C^o.

– *Aircraft Warning Light:* The flashing red light unit shall be controlled by the control panel, which is located in the pumps' room. The control panel shall have a 3-hr. backup battery. The unit shall have a running lifetime of at least 16000 hrs and IP 567 according to PS 121, protection degree.

– *Switch Light Exterior Photocell:* Photocell control units shall switch a lighting load on at dusk and off at dawn. It shall consist a photocell, socket and mounting bracket. The photocell shall fit NEMA socket with 70-75 lux switch-on level.

- ***Lighting Fixture Poles:***

– *General:* The complete assembly of the lighting fixtures consisting of a pole luminaries and bracket arms shall be designed for deal loads imposed and theoretical dynamic loads of pressures development by wind velocities.

High, shaft tube shape, and dimensions shall be as indicated by the Engineer. Poles shall be galvanized or painted (one coat primer and two finishing coats) steel or aluminum.

Poles with a length of 15m and more above F.F.L (finished floor or ground level) shall be provided with climbing irons starting 2m above ground and extending to the position of the fixture floodlight poles carrying more than two lighting fixtures shall be provided with a suitable service platform including a safety basket.

Each pole shall be equipped with a cable connection box protection code IP 55, for two incoming armoured cables up to 4 x 25mm^2, equipped with two fuse sockets for fuses up to 63 Amp. The cable box shall be installed inside the pole behind a lockable handhole opening which shall be located approximately 600mm above F.F.L.

Each pole shall have an earthing lug above F.F.L for the connection of a separate earthing conductor.

– *Poles with Flange Plate:* The base assembly of these poles shall consist of a base plate, of suitable dimension, welded to the shaft tube. A minimum of four hot-dipped galvanized high-tensile steel anchor bolts, with square leveling nuts, hexagonal hold-down bolts, flat and lock washers shall be capable of withstanding full bending moment of the shaft at its yield strength stress. The base plate shall have a 100mm wide opening for cable penetration from the concrete foundation.

– *Bracket Arms:* Brackets shall be normally formed as one part of the pole and not separately bolted to the pole. Bracket shape shall be straight (with an angle of 10-20 deg.), elliptical or parabolic. Only poles for floodlights or for special purposes shall be equipped with separately bolted or welded bracket arms to suit the type and quantity of fixtures.

13.5 Lighting Production System

13.5.1 General

13.5.1.1 Description

A. Provide and install a complete lighting protection system as indicated on the Drawings and as specified.

B.The system shall comprise as air terminals, air termination network, down conductors, test clamps, and earth termination.

13.5.1.2 Applicable Codes and Standards

A. The following codes and standards are a guide to the minimum quality acceptable for materials, products and workmanship.

B.The Contractor may propose alternative codes and standards, providing the Contractor can demonstrate that the minimum quality for materials, products and workmanship will not be reduced and they are submitted to the Supervision Officer for his review and approval in advance of their use.

(1) Palestinian Standards.

(2) British Standard Code of Practice. CP 326: 1995 “protection of structures against lighting”.

13.5.1.3 Submittals

A. Submit manufacturer’s product data, technical literature and wiring diagrams.

B. Submit shop drawings, which shall include catalogue pages of each component and each material utilized in the installation of the system.

13.5.2 Products

13.5.2.1 Air Termination

A. Air terminals shall be taper pointed air copper air rods supplied with lock nuts, and the length is 1000mm and the diameter is 10mm. They shall be provided with air terminals base for flat structures supplied with M10 nut and bolt.

B. Conductors of earth terminal networks shall be of 32 x 3mm copper, unless otherwise specified or required by code, and fastened by means of single fixing polypropylene clamps.

13.5.2.2 Down Conductors

The function of a down conductor is to provide a low impedance path from the air termination network to the earth termination network, to allow the lighting current to be safety conducted to earth.

A. The down conductor shall be of PVC covered tinned red copper strip, 32mm wide x 3mm thick. If it is impossible to attach the copper strip, a copper cable with a minimum cross section of 70mm sq. mm, or tinned copper flexible braid 30 x 3mm can be utilized. Utilizing a copper strip under lead sheath or PVC must be reserved for down leads installed in particularly corrosive atmosphere. Annealed or zinc plated round steel bars must not be utilized, because of their poor resistance to corrosion in time, and also because of the large cross section required to obtain an identical conductivity.

B. Joints in down conductors should not be permitted.

C. Where down conductors are installed in common ducts, all metal works within the duct shall be bonded to the lighting protection system at the top and the bottom of the runs.

D. All fasteners shall be secured to concrete blockwork by means of brass wool screws and white metal rawlplugs.

E. A combination of strip and rod conductors, reinforcing bars, structural steel stanchions, etc. can be used as all or part of the down conductor system providing that they are appropriately connected to the air and earth termination networks, and are known to offer good electrical conductivity. Using ‘shielded’ coaxial cables as down conductors is not permitted because of potentials up to hundreds of kilo-volts can occur between the inner and outer conductor (shield) at the top of the down conductor so triggering a side flash.

F. Down conductor system should, where possible, take the most direct route from the air termination network to the earth termination network. Ideally they should be symmetrically installed around the outside walls of the structure staring from the comers. Routing to avoid side-flashing should always be given particular attention in designing any installation.

G. Down conductors should be positioned no more than 20m apart around the perimeter at roof or ground level, whichever is the greater. If the structure is over 20m height, then the spacing is reduced to every 10m or part thereof.

H. Re-entrant loops in a conductor can produce high inductive voltage drops, which could lead to the lighting discharge jumping across the side of the loop. To minimize this problem the length of the conductor forming the loop should not exceed eight times the width of the open side of the loop.

13.5.2.3 Earthing

Types of earth termination networks:

(1) **Deep Driven Earth Electrodes:** A soil resistivity survey indicating lower resistivity at greater depths will make the deep driven earth electrode a logical choice. Deep driven earth electrodes are more likely to reach permanent moisture unaffected by seasonal changes.

To obtain low overall resistance a very large dimension electrode (rod or strip electrode) in comparison with other dimensions can be used.

(2) **Parallel Earth Rod Electrodes:** Where ground conditions make deep driving of earth rods impossible, a matrix arrangement of rods coupled to one another by conductors can be used. If possible, the earth rods must be spaced at least equal to their driven depth. No significant decrease in resistance will be obtained by spacing greater than twice their driven depth.

(3) **Radial Strip Electrodes:** Ground that has one-meter depth of soil before encountering bedrock will best be suited to a buried radial electrode, provided the system is installed below the frost line and below the area that is subject to seasonal weather changes.

Testing Earthing System:

There are two stages in testing an earth network for satisfactory resistance:

A. An earth electrode should be connected to each down conductor with a test like incorporated into every down conductor path.

With the test link removed and without any bonding to other services, etc. the earth resistance of each individual earth electrode should be measured. The resistance, in ohms, should not exceed ten times the number of down conductors on the structure. For example, if there are fifteen down conductors equally spaced around building, and then the resistance of each electrode with the test link removed should not exceed 10 x 15 = 150 ohms.

B. With the test links replaced the resistance to earth of the complete lighting protection system is measured at any point on the system. The reading from this rest should not exceed ten ohms. This is still without any bonding to other services.

13.5.2.4 Bonding

All exposed metal work on or around a structure must be bonded to the lighting protection system if side-flashing is to be avoided.

Aluminum and copper, the two metals most commonly used in lightning protection systems are not compatible, so great care must be taken when both are used in a system particularly where they come into contact with each other.

13.5.3 Installation

A. The routing of the down conductors must be as straight as possible avoiding all sharp bends or potential backup. The curve radius of a section of the lead running around an obstacle shall not be less than 200mm.

B. The external metal mass located less than one meter from the down conductor must be electrically connected to these leads (connection by riveting and welding) with conductors of the same cross section as the strip itself.

C. The lighting down conductors must include a control junction box or a cut-off bar, in order to allow measurement of the earthing system resistance and of the down conductor electrical continuity. The control junction is located 2 meters above ground level, in order to be accessible only when measurements are made.

D. The liaisons between the down conductor and the earthing system, and the control junction, must be made by riveting and welding. After any check of the installation, it is necessary to verify that the connections are correct.

E. The strip is protected between the control junction and the ground by a protection pipe made of flat galvanized metal sheet, this pipe is two meter high and attached by three sealing clamps supplied with the pipe.

F. When installing the earthing system, care should be exercised to make sure that it is directed towards the outside of the building, and as distant as possible from the building. The earthing system should be at least 3 meters away from any buried electrical conduit.

13.5.4 Testing and Commissioning

A. All tests required by the local Regulations and BS shall be carried out by the Contractor.

B. Tests on earth continuity as mentioned in the above rules and regulations shall be carried out by the Contractor on completed installation.

C. The expenses for the above tests shall be carried out by the Contractor.

D. All tests must be carried out in the present of the Engineer or such a person appointed for this purpose, but the Contractor alone will be responsible to the authorities as to the installation's compliance with rules and regulations.

E. The Contractor shall provide precise instruments and all labor for the testing. Test results shall be submitted to the Engineer within 14 days of the test, and the Contractor shall issue the Certificate upon completion, as required under the above mentioned regulations.

F. Any defects, faults or omissions of the installations made apparent by such test, shall be corrected by the Contractor at his own expense.

G. Final tests to be carried out in the presence of the Engineer and to start upon the completion of the works and the Contractor must submit to the Engineer a detailed test procedure and time schedule for the test.

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Num	Division	Standard	Document Num	Description	Year
1	Division 2	ASTM	D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))	2000
2	Division 2	ASTM	C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	2003
3	Division 2	PS	48	Mineral aggregates from natural resourses	1997
4	Division 2	ASTM	A90	Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings	2001
5	Division 2	ASTM	A239	Standard Practice for Locating the Thinnest Spot in a Zinc (Galvanized) Coating on Iron or Steel Articles	1999
6	Division 2	ASTM	A641	Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire	1998
7	Division 2	ASTM	A764	Standard Specification for Metallic Coated Carbon Steel Wire, Coated at Size and Drawn to Size for Mechanical Springs	2001
8	Division 2	ASTM	B6	Standard Specification for Zinc	2000
9	Division 2	ASTM	B117	Standard Practice for Operating Salt Spray (Fog) Apparatus	2002
10	Division 2	FS	QQ-W 461	Wire, Steel, (Carbon), Bare and Coated	1953
11	Division 3	PS	40	Ready mixed concrete	1997
12	Division 3	PS	54	Portland cement	1997
13	Division 3	ASTM	C150	Standard Specification for Portland Cement	2002
14	Division 3	PS	48	Mineral aggregates from natural resourses	1997
15	Division 3	PS	687	Paving test methods - Tests of aggregates	2001
16	Division 3	PS	41	Drinking water	1997
17	Division 3	PS	50	Rolled plain steel bars for concrete reinforcement	1997
18	Division 3	PS	52	Steel for the reinforcement of concrete: Ribbed bars	1997
19	Division 3	PS	125	Chemical admixture for concrete	1997
20	Division 3	ACI	201.2R -92	Specification for the performance of prestressing anchorages for post-tensioned construction	1973
21	Division 3	PS	55 (1-6)	Method of testing concrete	1997
22	Division 3	Arab Code	Sec 4-2-3-1	تحديد المقاومات الميكانيكيه المميزه للخرسانه بالاختبار	1977
23	Division 3	ACI	318 PART6-CH20	Building Code Requirements for Structural Concrete and Commentary	2002
24	Division 3	BS	CP110 PART1 SEC9.6	Testing Concrete - Part 110: Method for Making Test Cylinders from Fresh Concrete	1983
25	Division 3	PS	51	Steel for reinforcement of concrete - Welded fabric	1997
26	Division 3	ACI	117-90	Standard Tolerances for Concrete Construction and Materials (ACI 117-90) and Commentary (ACI 117R-90)	1990

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Num	Division	Standard	Document Num	Description	Year
27	Division 3	ACI	304 /68-33	Placing concrete by pumping methods	1996
28	Division 3	ASTM	C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete	1998
29	Division 3	ACI	517	Accelerated Curing of Concrete at Atmospheric Pressure	1987
30	Division 3	ACI	516		
31	Division 3	PS	125	Chemical admixture for concrete	1997
32	Division 3	ASTM	C494	Standard Specification for Chemical Admixtures for Concrete	1999
33	Division 3	ACI	305	Hot Weather Concreting	1999
34	Division 3	ACI	207 /67-17	Cooling & Insulating Systems for Mass Concrete	1988
35	Division 3	PS	45	Concrete for constructional use	1997
36	Division 3	BS	4254	Specification for two-part polysulphide-based sealants	1983
37	Division 3	BS	882	Specification for Aggregates from Natural Sources for concrete	1992
38	Division 3	PS	136	Quicklime for building purposes	1997
39	Division 3	ASTM	A421	Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete	1998
40	Division 3	BS	5896	Specification for High Tensile Steel Wire & Strand for the Prestressing of Concrete	1980
41	Division 3	ASTM	A416	Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete	2002
42	Division 3	ASTM	A722	Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete	1998
43	Division 3	BS	4486	Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete	1980
44	Division 3	BS	4757	Specification for the performance of prestressing anchorages for post-tensioned construction	1973
45	Division 3	ASTM	C490	Standard Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concret	2000
46	Division 3	ASTM	E11	Standard Specification for Wire Cloth and Sieves for Testing Purposes	2001
47	Division 3	BS	4447	Specification for the performance of prestressing anchorages for post-tensioned construction	1973
48	Division 4	PS	442	Primer, zinc chromate synthetic (alkyd) for general use	2001
49	Division 4	PS	107	Seamless steel pipes	2001
50	Division 4	PS	141	Steel pipes suitable for screw threading	1999
51	Division 4	ISO	7900	Zinc-coated steel wire for fencing	1988
52	Division 4	ISO	7989	Zinc coatings for steel wire	1988

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Num	Division	Standard	Document Num	Description	Year
53	Division 4	EN	10223-1	Steel Wire & Wire Products for Fences - Zinc & Zinc Alloy Coated Steel Barbed Wire	1998
54	Division 4	ISO	630	Structural steels - Plates, wide flats, bars, sections and profiles	1995
55	Division 4	EN	10056-1	Structural Steel Equal and Unequal Leg Angles-Dimensions	1999
56	Division 4	EN	10056-2	Specification for Structural Steel Equal and Unequal Angles - Part 2: Tolerances on Shape and dimensions	1993
57	Division 4	ISO	4014	Hexagon head bolts - Product grades A and B (ISO 4014:1999); German version EN ISO 4014:2000	2001
58	Division 4	EN	4014	Hexagon head bolts - Product grades A and B (ISO 4014:1999); German version EN ISO 4014:2000	2001
59	Division 4	ISO	4016	Hexagon head bolts - Product grade C (ISO 4016:1999); German version EN ISO	2001
60	Division 4	EN	4016	Hexagon head bolts - Product grade C (ISO 4016:1999); German version EN ISO	2001
61	Division 4	ISO	4032	Hexagon nuts, style 1 - Product grades A and B (EN)	2001
62	Division 4	EN	4032	Hexagon nuts, style 1 - Product grades A and B (EN)	2001
63	Division 4	ISO	4034	Hexagon nuts - Product grade C (EN)	2001
64	Division 4	EN	4034	Hexagon nuts - Product grade C (EN)	2001
65	Division 4	ISO	8992	Fasteners; general requirements for bolts, screws, studs and nuts; identical with ISO 8992:1986	1992
66	Division 4	EN	26157-1	Fasteners. Surface Discontinuities. Bolts, Screws and Studs for General Requirements	1992
67	Division 4	PS	186	Steel welded pipes for general use	1997
68	Division 4	PS	43	Washable, emulsion (water) paint for interior use	1997
69	Division 4	PS	91	Paints and varnishes - Cross-cut Test	1997
70	Division 4	PS	97(1-24)	Paints and varnishes	1999
71	Division 4	PS	97(PART 26-31)	Pudding and jelly powders	1997
72	Division 4	PS	97 part 33	Pudding and jelly powders	1997
73	Division 4	PS	114	Anodic coatings on aluminium	1997
74	Division 4	PS	154	Alkyd Based Undercoating Paint for General Purposes	1998
75	Division 4	PS	288	Primer oil paints	1999
76	Division 4	PS	461	Coating by powder organic coatings on aluminum (BS 6496)	1999
77	Division 4	PS	471	Emulsion Ceiling Paint for interior use "Synthetic Lime Wash"	1999
78	Division 4	PS	480	Paints and varnishes - Definition of terms A	1999
79	Division 4	PS	528	Priming Bitumen Paint	1999
80	Division 5	ISO	2531	Ductile iron pipes, fittings, accessories and their joints for water or gas applications	1998

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Num	Division	Standard	Document Num	Description	Year
81	Division 5	EN	545	Ductile Iron Pipes, Fittings, Accessories and their Joints for Water Pipelines - Requirements and Test Methods	2002
82	Division 5	ISO	4179	Ductile iron pipes for pressure and non-pressure pipelines -- Centrifugal cement mortar lining -- General requirements	1985
83	Division 5	AWWA	C104/A21.4	Cement Mortar Lining For Ductile-Iron Pipe And Fittings For Water	1995
84	Division 5	ISO	8179-1	Ductile iron pipes -- External zinc coating -- Part 1: Metallic zinc with finishing layer	1995
85	Division 5	ISO	8179-2	Ductile iron pipes -- External zinc coating -- Part 2: Zinc rich paint with finishing layer	1995
86	Division 5	ISO	4633	Rubber seals - Joint rings for water supply, drainage and sewerage pipelines - Specification for materials	2002
87	Division 5	ISO	2230	Rubber products - Guidelines for storage	2002
88	Division 5	EN	681-1	Elastomeric seals - Materials requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber; German version EN 681-1:1996 + A1:1998 + A2:2002 + AC:2002	2003
89	Division 5	EN	12560	Flanges and Their Jonts	2001
90	Division 5	ISO	8180	Ductile iron pipes -- Polyethylene sleeving -	1985
91	Division 5	ISO	10804-1	Restrained joint systems for ductile iron pipelines - Part 1: Design rules and type testing	1996
92	Division 5	ISO	7005-2	Metallic flanges - Part 2: Cast iron flanges -	1988
93	Division 5	EN	1092-2	Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 2: Cast iron flanges; German version EN 1092-2:1997	1997
94	Division 5	ISO	4014	Hexagon head bolts - Product grades A and B (ISO 4014:1999); German version EN ISO 4014:2000	2001
95	Division 5	ISO	4016	Hexagon head bolts - Product grade C (ISO 4016:1999); German version EN ISO	2001
96	Division 5	ISO	4032	Hexagon nuts, style 1 - Product grades A and B (EN)	2001
97	Division 5	ISO	4034	Hexagon nuts - Product grade C (EN)	2001
98	Division 5	ISO	10221	Ductile iron Pipes Rubber sealing rings for pipeline carrying potable water	1993
99	Division 5	PS	107	Seamless steel pipes	2001
100	Division 5	PS	141	Steel pipes suitable for screw threading	1999
101	Division 5	PS	186	Steel welded pipes for general use	1997
102	Division 5	PS	325	Steel pipes with protective Coatings: General	1998
103	Division 5	PS	325-1	Steel pipes with protective Coatings - Internal coating by cement mortar	1998

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Num	Division	Standard	Document Num	Description	Year
104	Division 5	PS	325-4	Steel pipes with protective coatings - External coating by cement mortar	1999
105	Division 5	ISO	3419	Non-alloy and alloy steel butt-welding fittings	1981
106	Division 5	EN	10224(Draft)	Non-alloy steel tubes and fittings for the conveyance of aqueous liquids including water for human consumption - Technical delivery conditions; German version EN 10224:2002 Product	2003
107	Division 5	EN	10253-1	Butt-welding pipe fittings - Part 1: Wrought carbon steel for general use and without specific inspection requirements; German version EN 10253-1:1999	1999
108	Division 5	EN	10253-2 DRAFT	Draft Document - Butt welding pipe fittings - Part 2: Wrought carbon and ferritic alloy steel with specific inspection requirements; German version prEN 10253-2:1999	1999
109	Division 5	ISO	7005-1	Metallic flanges - Part 1: Steel flanges	1992
110	Division 5	EN	1092-1	Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories - Part 1: Steel flanges, PN designated; German version EN 1092-1:2001	2002
111	Division 5	ISO	4097	Rubber, ethylene-propylene-diene (EPDM) -- Evaluation procedure	2000
112	Division 5	ISO	2322	Styrene-butadiene rubber (SBR) - Emulsion- and solution-polymerized types - Evaluation procedures	1996
113	Division 5	PS	54	Portland cement	1997
114	Division 5	PS	421	Sand incasing pipes and Cables in trenches	1999
115	Division 5	PS	325-1 to 6	Steel pipes with protective Coatings	1998
116	Division 5	ISO	7483	Dimensions of gaskets for use with flanges to ISO 7005	1991
117	Division 5	EN	1515-1	Flanges and their joints - Bolting - Part 1: Selection of bolting; German version EN 1515-1:1999	2000
118	Division 5	EN	1515-2	Flanges and their joints - Bolting - Part 2: Classification of bolt materials for steel flanges, PN designated; German version EN 1515-2:2001	2002
119	Division 5	ISO	4422-1,2,3,5	Pipes and fittings made of unplasticized poly(vinyl chloride) (PVC-U) for water supply - Specifications -General,Pipes,Fittings, Fitness for purpose of the system	1997

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Num	Division	Standard	Document Num	Description	Year
120	Division 5	ISO	727	Fittings of unplasticized polyvinyl chloride (PVC-U), chlorinated polyvinyl chloride (PVC-C) or acrylonitrile/butadiene/styrene (ABS) with plain sockets for pipes under pressure -- Dimensions of sockets -- Metric series	1985
121	Division 5	EN	1452-1	Plastics piping systems for water supply - Unplasticized poly(vinyl chloride) (PVC-U) - Part 1: General; German version EN 1452-1:1999	1999
122	Division 5	EN	1452-2	Plastics piping systems for water supply - Unplasticized poly(vinyl chloride) (PVC-U) - Part 2: Pipes; German version EN 1452-2:1999	1999
123	Division 5	EN	1452-3	Plastics piping systems for water supply - Unplasticized poly(vinyl chloride) (PVC-U) - Part 3: Fittings; German version EN 1452-3:1999	1999
124	Division 5	EN	1452-5	Plastics piping systems for water supply - Unplasticized poly(vinyl chloride) (PVC-U) - Part 5: Fitness for purpose of the system; German version EN 1452-5:1999	1999
125	Division 5	ISO	264	Unplasticized polyvinyl chloride (PVC) fittings with plain sockets for pipes under pressure -- Laying lengths	1976
126	Division 5	ISO	2536	Unplasticized polyvinyl chloride (PVC) pressure pipes and fittings, metric series - Dimensions of flanges	1974
127	Division 5	ISO	3460	Unplasticized polyvinyl chloride (PVC) pressures pipes - Metric series - Dimensions of adapter for backing flange	1975
128	Division 5	ISO	11647	Fusion compatibility of Plyethylene pipes & Fittings	1996
129	Division 5	ISO	10508	Thermoplastics pipes and fittings for hot and cold water systems	1995
130	Division 5	ISO	12162	Thermoplastics materials for pipes and fittings for pressure applications - classifications and design- overall service (design) coefficient.	1996
131	Division 5	EN	12201-1,2,3,5	Plastic piping systems for water supply Polyethylene (PE)-General, Pipes, Fittings, Fitness for purposes of the system.	2003
132	Division 5	ISO	4427	Polyethylene (PE) pipes for water supply - Specifications	1996
133	Division 5	EN	13244-1,2,3	Plastics piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage - Polyethylene (PE) - General; Pipes,Fittings-German version EN 13244-:2002	2003

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Num	Division	Standard	Document Num	Description	Year
134	Division 5	EN	14236	Plastics pipes and fittings - Mechanical-joint compression fittings for use with polyethylene pressure pipes in water supply systems - International	2000
135	Division 5	ISO	7370	Glass-reinforced thermosetting plastics (GRP) pipes and fittings - Specifications for nominal sizes, diameter series, nominal pipe lengths and tolerances (Revision of ISO 7370:1983) - DRAFT	1996
136	Division 6	PS	24	Concrete blocks for ribbed slabs	1997
137	Division 6	PS	6	Blocks - Concrete blocks for walls (Superseded by PS 6 - 1 - 2001)	1997
138	Division 6	PS	40	Ready mixed concrete	1997
139	Division 6	PS	54	Portland cement	1997
140	Division 6	PS	44 (1-2)	Aluminium sections - Unfinished sections-1-1997, Finishing of sections 2-1999	Part1-97, Part2-99
141	Division 6	PS	114	Anodic coatings on aluminium	1997
142	Division 6	PS	461	Coating by powder organic coatings on aluminum (BS 6496)	1999
143	Division 6	ISO	6362 Parts 1- 5	Wrought aluminium and aluminium alloy	
144	Division 6	ISO	6363 Parts 1- 5	Wrought aluminium and aluminium alloy cold-drawn rods/bars and tubes	
145	Division 6	ISO	11600	Building construction - Jointing products - Classification and requirements for sealants	2002
146	Division 6	EN	3624 DRAFT	Draft Document - Aerospace series - Polysulphide sealants, two component - Technical specification	1996
147	Division 6	PS	136	Building Lime	
148	Division 6	PS	125	Chemical admixture for concrete	1997
149	Division 6	PS	240	Finished plaster in buildings - Interior plaster - Requirements and test methods	1997
150					
151	Division 6	PS	13	Terrazzo floor tiles	2001
152	Division 6	PS	47	Terrazo aggregates	1997
153	Division 6	PS	60	In situ installation of floor tiles of terrazzo or marble chips	1998
154	Division 6	PS	225	Slabs of terrazzo or slabs of concrete covered with terrazzo or with marble segments for stair surfacing	1997
155	Division 6	PS	53	Ceramic wall and floor tiles	1997
156	Division 6	PS	178	Mosaic tiles of ceramic or glass	1997
157	Division 6	ISO	630	Structural steels - Plates, wide flats, bars, sections and profiles	1995
158	Division 6	EN	10056-1	Structural Steel Equal and Unequal Leg Angles-Dimensions	1999
159	Division 6	BS	1391	Adhesives for Leather & Footwear Materials - A Method for Evaluating the Bondability of Materials - Minimum Requirements & Material Classification	1998
160	Division 6	ISO	12543	Glass in Buildings	1998
161	Division 6	EN	12543	Glass in Buildings	1998

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Num	Division	Standard	Document Num	Description	Year
162	Division 6	ISO	9051	Glass in building - Fire-resistant glazed assemblies containing transparent or translucent glass, for use in building	2001
163	Division 6	EN	357	Glass in building - Fire resistant glazed elements with transparent or translucent glass products - Classification of fire resistance; German version EN 357:2000	2000
164	Division 6	EN	1036	Glass in building - Mirrors from silver-coated float glass for internal use; German version EN 1036:1999	1999
165	Division 6	PS	97 sec1-33	Paints and varnishes - Determination of volume of dry coating (non-volatile matter) obtained from a given volume of liquid coating (ISO 3233-1984) A	1999
166	Division 6	PS	471	Emulsion Ceiling Paint for interior use "Synthetic Lime Wash"	1999
167	Division 6	PS	91	Paints and varnishes - Cross-cut Test	1997
168	Division 6	PS	480	Paints and varnishes - Definition of terms A	1999
169	Division 6	PS	12	Gloss synthetic paint	1997
170	Division 6	PS	43	Washable, emulsion (water) paint for interior use	1997
171	Division 6	PS	442	Primer, zinc chromate synthetic (alkyd) for general use	2001
172	Division 6	PS	528	Priming Bitumen Paint	1999
173	Division 6	PS	288	Primer oil paints	1999
174	Division 6	PS	154	Alkyd Based Undercoating Paint for General Purposes	1998
175	Division 6	PS	641	Coating by powder organic coatings on aluminum (BS 6496)	1999
176	Division 6	BS	1186 Part 2	Timber for and Workmanship in Joinery. Specification for Workmanship	1988
177	Division 6	BS	455-1975	Specification for locks and latches for doors in buildings	1980
178	Division 6	BS	7352	Specification for strength and durability performance of metal hinges for side hanging applications and dimensional requirements for template drilled hinges	1990
179	Division 6	BS	1228-1945	Iron and steel Bolts…	
180	Division 7	ISO	4014	Hexagon head bolts - Product grades A and B (ISO 4014:1999); German version EN ISO 4014:2000	2001
181	Division 7	ISO	4016	Hexagon head bolts - Product grade C (ISO 4016:1999); German version EN ISO	2001
182	Division 7	ISO	4032	Hexagon nuts, style 1 - Product grades A and B (EN)	2001
183	Division 7	ISO	4034	Hexagon nuts - Product grade C (EN)	2001
184	Division 7	EN	4014	Hexagon head bolts - Product grades A and B (ISO 4014:1999); German version EN ISO 4014:2000	2001
185	Division 7	EN	4016	Hexagon head bolts - Product grade C (ISO 4016:1999); German version EN ISO	2001

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Num	Division	Standard	Document Num	Description	Year
186	Division 7	EN	4032	Hexagon nuts, style 1 - Product grades A and B (EN)	2001
187	Division 7	EN	4034	Hexagon nuts - Product grade C (EN)	2001
188	Division 7	ISO	2531	Ductile iron pipes, fittings, accessories and their joints for water or gas applications	1998
189	Division 7	ISO	7005-1	Metallic flanges - Part 1: Steel flanges	1992
190	Division 7	ISO	7005-2	Metallic flanges - Part 2: Cast iron flanges -	1988
191	Division 7	EN	1092-2	Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 2: Cast iron flanges; German version EN 1092-2:1997	1997
192	Division 7	EN	1092-1	Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories - Part 1: Steel flanges, PN designated; German version EN 1092-1:2001	2001
193	Division 7	ISO	5208	Industrial valves -- Pressure testing of valves	1993
194	Division 7	ISO	7259	Predominantly key-operated cast iron gate valves for underground use	1988
195	Division 7	ISO	5996	Cast iron gate valves	1984
196	Division 7	EN	1171	Industrial valves - Cast iron gate valves	2002
197	Division 7	ISO	6002	Bolted bonnet steel gate valves	1992
198	Division 7	EN	1984	Industrial valves - Steel gate valves	2000
199	Division 7	ISO	4633	Rubber seals - Joint rings for water supply, drainage and sewerage pipelines - Specification for materials	2002
200	Division 7	EN	12560	Flanges and Their Joints	2001
201	Division 7	ISO	5752	Metal valves for use in flanged pipe systems - - Face-to-face and centre-to-face dimensions	1982
202	Division 7	EN	558-1	Industrial valves - Face-to-face and centre-to-face dimensions of metal valves for use in flanges pipe systems - Part 1:PN-designated valves	1995
203	Division 7	EN	558-2	Industrial valves - Face-to-face and centre-to-face dimensions of metal valves for use in flanged pipe systems - Part 2: Class-designated valves	1995
204	Division 7	ISO	7121	Flanged steel ball valves	1986
205	Division 7	ISO	5781	Hydraulic fluid power -- Pressure-reducing valves, sequence valves, unloading valves, throttle valves and check valves -- Mounting surfaces	2000
206	Division 7	EN	1074-3	Valves for water supply - Fitness for purpose requirements and appropriate verification tests - Part 3: Check valves	2000
207	Division 7	EN	13709	Industrial valves - Steel globe and globe stop and check valves	2002
208	Division 7	EN	12334	Industrial valves - Cast iron check valves	2001

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Num	Division	Standard	Document Num	Description	Year
209	Division 7	ISO	10631	Metallic butterfly valves for general purposes	1994
210	Division 7	EN	593	Industrial valves - Metallic butterfly valves	1998
211	Division 7	EN	1503-1	Valves - Materials for bodies, bonnets and covers - Part 1: Steels specified in European Standards	2000
212	Division 7	EN	1503-2	Valves. Materials for bodies, bonnets and covers. Steels other than those specified in European Standards	2000
213	Division 7	EN	1503-3	Valves - Materials for bodies, bonnets and covers - Part 3: Cast irons specified in European Standards	2000
214	Division 7	ISO	6264	Hydraulic fluid power - Pressure-relief valves - Mounting surfaces	1998
215	Division 7	EN	1074-5	Valves for water supply - Fitness for purpose requirements and appropriate verification tests - Part 5: Control valves	2001
216	Division 7	ISO	6150	Pneumatic fluid power - Cylindrical quick-action couplings for maximum working pressures of 10 bar, 16 bar and 25 bar (1 MPa, 1,6 Mpa, and 2,5 MPa) - Plug connecting dimensions, specifications, application guidelines and testin	1988
217	Division 7	ISO	2861	Vacuum technology -- Quick release couplings -- Dimensions -- Part 2 : Screwed type	1980
218	Division 7	ISO	7241-1	Hydraulic fluid power - Quick-action couplings - Part 1 : Dimensions and requirement	1987
219	Division 7	ISO	16028	Hydraulic fluid power -- Flush-face type, quick-action couplings for use at pressures of 20 MPa (200 bar) to 31,5 MPa (315 bar) -- Specifications	1999
220	Division 7	ISO	2230	Rubber products - Guidelines for storage	2002
221	Division 7	EN	681-1,2,3	Elastomeric seals - Materials requirements for pipe joint seals used in water and drainage applications	2003
222	Division 7	ISO	10221	Ductile iron Pipes Rubber sealing rings for pipeline carrying potable water	1993
223	Division 7	ISO	5171	Pressure gauges used in welding, cutting and allied processes	1995
224	Division 7	EN	837	Pressure gauges	1997
225	Division 7	EN	1074-4	Valves for water supply. Fitness for purpose requirements and appropriate verification tests - Part 4: Air Valves	2000
226	Division 7	ISO	6263	Hydraulic fluid power - Compensated flow-control valves - Mounting surfaces	1997
227	Division 7	ISO	12149	Bolted bonnet steel globe valves for general-purpose applications	1999
228	Division 7	EN	13789	Industrial valves - Cast iron globe valves; German version EN 13789:2002	2003

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List of Standards used in Technical Specifications for the Construction of Water Tanks

Num	Division	Standard	Document Num	Description	Year
229	Division 7	EN	1567	Building valves - Water pressure reducing valves and combination water pressure reducing valves - Requirements and tests	1999
230	Division 7	PS	402	Velocity Type Cold Water Meters	1999
231	Division 7	PS	447	Hot Water Meters	1999
232	Division 8	ISO	2230	Rubber products - Guidelines for storage	2002
233	Division 8	AWWA	C209	Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines	2000
234	Division 8	AWWA	C216	Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines	2000
235	Division 8	ISO	10465-1	Underground installation of flexible glass-reinforced thermosetting resin (GRP) pipes -- Part 1: Installation procedures	1993
236	Division 8	ISO	8572	Pipes and fittings made of glass-reinforced thermosetting plastics (GRP) -- Definitions of terms relating to pressure, including relationships between them, and terms for installation and jointing -	1991
237	Division 8	API	1104	Welding of Pipelines and Related Facilities - 19th Edition - Includes errata dated October 31, 2001	1999
238	Division 8	AWS	D10.12	Guide for Welding Mild Steel Pipe	2000
239	Division 8	API	5L	Specification for Line Pipe	2000
240	Division 8	PS	117	Covered electrodes for arc welding of carbon steel E	1997
241	Division 8	PS	119	Rods and Covered electrodes for welding cast iron B	1999
242	Division 8	ISO	7005-1	Metallic flanges - Part 1: Steel flanges	1992
243	Division 8	ISO	7005-2	Metallic flanges - Part 2: Cast iron flanges -	1988
244	Division 8	ASTM	1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³(2,700 kN-m/m³)	2002
245	Division 8	PS	687 Part 2	Paving test methods - Tests of aggregates	2001
246	Division 8	PS	421	Sand incasing pipes and Cables in trenches A	1999
247	Division 8	PS	84	Paints and varnishes - Determination of flow time by use of flow Cups - Testing methods of viscosity	1997
248	Division 8	PS	166-1	Bitumen for road purposes - Asphaltic bitumen (Asphalt Cement)	1997
249	Division 8	PS	166-2	Bitumen for road purposes - Bitumen emulsions	1998
250	Division 8	PS	166-3	Bitumen for road purposes - Cut-back bitumen	1998

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Num	Division	Standard	Document Num	Description	Year
251	Division 8	PS	171	Hot Asphalt Mixtures- Composition, production, transport, laying and compaction	1998
252	Division 9	AWWA	C600	Standard for Installation of Ductile-Iron Water Mains and their Appurtances	2000
253	Division 9	AWWA	C605	Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water	1994
254	Division 10	AWWA	C651	Disinfecting Water Mains	1999
255	Division 10	ANSI /NSF	60	Drinking Water Treatment Chemicals - Health Effects	2002
256	Division 10	ASTM	E410	Standard Test Method for Moisture and Residue in Liquid Chlorine	1998
257	Division 10	ASTM	E412	Standard Test Method for Assay of Liquid Chlorine (Sinc Amalgam Method)	1993
258	Division 10	ASTM	E806	Standard Test Method for Carbon Tetrachloride and Chloroform in Liquid Chlorine by Direct Injection (Gas Chromatographic Procedure)	1999
259	Division 11	ACI	350 IR	Tightness Testing of Environmental Engineering Concrete Structures and Commentary	2001
260	Division 11	AWWA	D110	Wire-Wound Circular Prestressed Concrete Water Tanks (includes addendum D110a-96 and 2001 erratum)	1995
261	Division 11	ACI	344 R-W	Design & Construction of Circular Wire & Strand Wrapped Prestressed Concrete Structures - RENUMBERED AS ACI 372R-97	1988
262	Division 11	ACI	344 R-T	Design & Construction of Circular Prestressed Concrete Structures w/ Circumferential Tendons	1988
263	Division 11	AWWA	D100	Welded Steel Tanks for Water Storage	1996
264	Division 11	ASTM	D695	Standard Test Method for Compressive Properties of Rigid Plastics	2002
265	Division 12	AWWA	C652	Disinfection of Water-Storage Facilities	1992
266	Division 13	BS	5839	Fire detection and alarm systems for buildings. Code of practice for system design, installation, commissioning and maintenance	2002
267	Division 13	PS	451-1	Low-voltage switchgear and controlgear assemblies: Requirements for Prefabricated assemblies (IEC 439-1)	1999
268	Division 13	PS	451-2	Low-voltage switchgear and controlgear assemblies: Particular requirements for busbar trunking systems (busways) (IEC 439-2)	1999
269	Division 13	PS	451-3	Low voltage switchgear and controlgear assemblies - Particular requirements for low voltage assemblies intended to be installed in places were unskilled persons have access for their use - Distribution boards	2001

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Num	Division	Standard	Document Num	Description	Year
270	Division 13	PS	121	Classification of degrees of protection,provided by enclosures of electric equipment	1997
271	Division 13	IEC	60439-1	Low-voltage switchgear and controlgear assemblies - Part 1: Type-tested and partially type-tested assemblies (test switch boards)	1999
272	Division 13	BS	159	Specification for High-Voltage Busbars and Busbar Connections Product	1992
273	Division 13	PS	192	Safety of household and similar electric appliances - General requirements (IEC 335)I	1997
274	Division 13	BS	89	Direct acting indicating analogue electrical measuring instruments and their accessories. Specification for special requirements for ammeters and voltmeters	1990
275	Division 13	BS	90	Specification for direct-acting electrical recording instruments and their accessories	1975
276	Division 13	PS	354 Part 1-7	Cables, cords and insulated conductors for nominal voltage up to 1000 volts - General requirments	1997
277	Division 13	IEC	60947-3	Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units	1990
278	Division 13	PS	451 Parts 1-3	Control Panels	
279	Division 13	EN	60898	Miniature Air-break Circuit-breakers for A. C. Circuits	
280	Division 13	IEC	60947-2	Low-voltage switchgear and controlgear - Part 2: Circuit-breakers	1989
281	Division 13	NEMA	AB-1	Molded-Case circuit Breakers, Molded Case Swithes, and Circuit-breakers Enclosures	2002
282	Division 13	IEC	60479-1	Effects of current on human beings and livestock - Part 1: General aspects	1994
283	Division 13	IEC	60479-2	Effects of current passing through the human body. Part 2: Special aspects - Chapter 4: Effects of alternating current with frequencies above 100 Hz - Chapter 5: Effects of special waveforms of current - Chapter 6: Effects of unidirectional single impulse	1987
284	Division 13	IEC	60479-3	Effects of current on human beings and livestock - Part 3: Effects of currents passing through the body of livestock	1998
285	Division 13	PS	120	Contactors	1998
286	Division 13	PS	132	Plastic ducts for electrical and telecommunication installation and electronic application	1997
287	Division 13	PS	76	Connection boxes for electrical installations - Plastic boxes	1997

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Num	Division	Standard	Document Num	Description	Year
288	Division 13	PS	70	Plastics pipes for electric and communication installations in buildings	1997
289	Division 13	PS	442	Primer, zinc chromate synthetic (alkyd) for general use	2001
290	Division 13	PS	286	Conductors of insulated cables	1998
291	Division 13	PS	354		
292	Division 13	BS	5467	Specification for Cables with Themosetting Insulation for Electricity Supply for Rated Voltages of up to and Including 600/1000 V and up to and Including 1900/3300 V	1989
293	Division 13	BS	6360	Specification for conductors in insulated cables and cords	1991
294	Division 13	BS	5468	Specification for cross-linked polyethylene insulation of electric cables	1977
295	Division 13	BS	6346	Specification for 600/1000 V & 1900/3300 V Armoured Electric Cables Having PVC Insulation	1997
296	Division 13	PS	164	Flexible cords for supply of electric protable appliances colours of the cores	1997
297	Division 13	BS	6746	Specification for PVC insulation and sheath of electric cables	1990
298	Division 13	PS	161	Plugs and outlets for household and similar purposes not exceeding 16 ampere	1997
299	Division 13	EN	60309-1	Plugs, Socket-Outlets and Couplers for Industrial Purposes - General Requirements	1998
300	Division 13	EN	60309-2	Plugs, Socket-Outlets and Couplers for Industrial Purposes. Dimensional Interchangeability Requirements for Pin and Contact-Tube Accessories of Harmonized Configurations	1992
301	Division 13	IEC	60309-1	Plugs, socket-outlets and couplers for industrial purposes - Part 1: General requirements	1999
302	Division 13	IEC	60309-2	Plugs, socket-outlets and couplers for industrial purposes - Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories	1999
303	Division 13	PS	137	Switches for household and similar fixed electrical installations	1997
304	Division 13	PS	322	Tungsten filament incandescent lamps - General Quality requirements	1999
305	Division 13	PS	209	Fluorescent lamp auxiliaries - Starters (IEC 155)	1997
306	Division 13	PS	177	Flourescent lamps - Auxiliaries-ballasts, excluding resistance type (IEC 82)	1997

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Num	Division	Standard	Document Num	Description	Year
307	Division 13	IEC	60502-1	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)	1998
308	Division 13	IEC	60502-2	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)	1998
309	Division 13	IEC	60502-4	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 4: Test requirements on accessories for cables with rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV	1997
310	Division 13	IEC	60081	Double-capped fluorescent lamps - Performance specifications	2002
311	Division 13	PS	320	Lampholders - screw lampholders. Edison type	1998
312	Division 13	IEC	60400	Lampholders for tubular fluorescent lamps and starterholders	2002
313	Division 13	IEC	60188	High-pressure mercury vapour lamps - Performance specifications	2001
314	Division 13	PS	207	Auxiliaries for discharge lamps - capacitors	1998
315	Division 13	BS	6231	Specification for PVC-insulated cables for switchgear and controlgear wiring	1998

Technical Specifications

Booster Pump Specifications

January, 2021

Contents

1. BOOSTING PUMP STATION

1.1 Scope of Work

The Contractor shall include in his Bid for the complete supply, installation, testing and commissioning of the pump stations as detailed on the Bid drawings and in this specification. The Contractor shall include for all labor, materials, tools and tackle, complete with all supports and fixings. The Contractor shall include for preparation of all necessary drawings and other required information, checking all dimensions and location of other services, and the correct setting out of the installation.

1.2 Description

The work under this specification shall include the following: -

- A pump station intended to deliver water towards existing water tank at village. The station consists of two Vertical in Line pumps on the transmission pipe line, identical, centrifugal multistage pumps, with the General Technical Specifications and standard construction as the following:

1.2.1 pump

- Flow capacity Q = 100m^3/hr.
- Rated Total Dynamic Head = 130 m.
- Motor cap. not less than 75 kw
- Shutoff Head not less than 125% of the total dynamic head and not more than 150% of TDH.
- Mechanical Efficiency not less than 70%.
- Motor eff. Not less than 92%
- Speed (n) r. p.m. = 2960 rpm.
- The impellers manufactured must be Zinc free – Bronze type, (G-CU-Sn 10) with S.S shaft (416L).

One pump of the station will operate as duty pump while the other pump will serve as stand by.

- Motor Control Centre
- All pipe work, valves and instruments.
- All electrical work connected and required for the operation and control of the pumps.
- Water measuring devices.
- Testing and operation of the pumps.

1.3 General Requirements

- All pumps and their drivers shall be mounted on a reinforced concrete foundation of an adequate construction and dimensions including an anti-vibration floating base.
- All pumps shall be located in accessible locations for ease of repair and maintenance.
- All pumps shall be provided from the factory with plugged connections for casing vent, drain and suction and discharge pressure.
- Each pump shall be tested at the factory to provide detailed performance data and to demonstrate its compliance with the specification.
- Each pump shall be hydrostatically tested by the manufacturer for a pressure not less than 25 bars.
- Piping shall be supported independently of pumps nozzles to prevent piping weight or stresses from bearing on or being transmitted to the pump nozzles
- Drain from base plate, pump, relief valves, etc. shall be piped to the floor drain located in pump shed.
- All valves, strainers, flexible connections shall be of the same size as the pipe on which they are installed.
- All pipes, fittings, valves and instrumentation shall have a pressure rating not less than 16 bars.
- Other requirements of pipe work and valves shall be as called for in these specifications.
- All conduit for electrical work shall be heavy gauge galvanized steel.

1.4 Shop Drawings

Shop drawings of the pumping unit shall be submitted to the Project Manager for approval, prior to shipment from the factory.

The shop drawing shall include the following requirements: -

Certified performance curves showing job number, customer, customer order number, date of manufacture, model number, pump size, impeller diameter, impeller type, rpm, flow-head characteristic curve, consumed horsepower curve and pump efficiency curve.

- Pump cross- sectional drawing showing major components with parts numbers and parts list.
- Pumps and controllers outline dimensional drawing showing overall dimensions of all pumps and controller's enclosure, location of foundations bolts holes and size, location and rating of suction and discharge nozzles of pumps.
- Detailed wiring diagrams of pumps controllers, and any other electrical devices or accessories.
- Recommended list of spare parts for two years operation.
- Installation, operation and maintenance instruction manuals.

1.5 Foundation and Setting

The booster pumps and the electrical motor drivers shall be mounted vertically on a main concrete foundation adequately reinforced against deflection and provided with drip rim and bolt holes.

The pump shall be directly connected to the driver through a suitable flexible coupling easy to be removed and adjusted without disturbing the pump or the electrical motor and shall have a steel protecting cover as required. . The pumping units shall be supported on the foundation in such a way that proper pump and driver shaft alignment will be assured.

The foundation of the pumps shall be made of reinforced concrete designed to carry the weight of the pumps. The foundation shall be extended 100 mm at each side of pump base plate, and 250 mm from F.F.L. The foundation shall be provided with anti-vibration floating base pad as shown on the drawings.

1.6 Vertical inline centrifugal pump construction

The pump shall be direct closed coupled, vertical in line centrifugal pump fitted with closed radial impellers and as indicated on the pumps schedule. Enclosure shall be not less than IP 56.

The impellers manufactured must be Zinc free – Bronze type (G-CU-Sn 10). The impeller shall be dynamically balanced at the factory. The impellers shall be interchangeable. Pump base, casing, suction body, delivery body, diffusers, bearing housing, bushing, and sleeve shall be made of cast iron –EN 1561. Protecting/pushing sleeve, disc shall be constructed of stainless steel– EN 10088.

The shaft shall be of stainless steel AISI 416 amply sized to carry all axial and
radial thrust. Tungsten Carbide sleeves including innovative axial load compensation system to reduce axial thrusts shall protect the shaft.

Standard mechanical shaft seals and elastomers shall be balanced according to EN 12765 and ISO 3069.

The pump-rotating element shall be supported with mechanical seal water lubricated ball bearings mounted in heavy iron housing. The bearing shall be lubricated by screw type grease cups.

The pump shall be provided from the factory with in-line standard flanges (EN 1092-2, ISO 9906 class 2) for suction and discharge connections. The pump shall be provided with welded steel nameplates and all documentation as per CE requirements (catalogues, dimension tables, assembly installation manuals, operating manuals, performance curves). Approved manufacturers: KSB-Germany origin, ITT Vogel or equally approved and should have a local agent/representative in Palestine.

1.7 OPERATING CHARACTERISTICS

The pumps shall have an efficiency not less than 70%, at the specified flow and head. The impeller size shall not exceed 85% of the maximum pump casing size. The pump curve shall provide the shutoff head of the pump not more than 20% greater than the required rated dynamic head. The rated design point shall be located right to the best efficiency point on the characteristic head.

1.8 Motors

The motors of all electric driven pumps shall be of squirrel cage induction type, 2 pole, 2960 rpm and rated for continuous operation at ambient temperature 50-55 Deg. C with finned aluminum casing and enclosed construction with external ventilation.

The motors shall be totally enclosed fan cooled type with insulation class F and IP 55 protection. The motor shall be rated for 380/220 phase and 50 cycle. The motor shall be designed for PLC.

The locked rotor current of the motor shall not exceed approximately six times the full load current. The motor shall be sized so that the full load ampere rating will not be exceeded.

All motor terminals shall be marked in accordance with NEMA Standard MG1-part 2.

Motor performance shall be according to EN 60034-1.

All motors shall be provided with nameplates in accordance with NFPA 70.

The power supply feeder of the pump shall be sized at 125 percent of full load current of the pump.

Motor power factor shall not be less than 0.9.

The service factor shall not be less than 1.15

The horsepower rating of the motor driving the pump shall be of such magnitude as to ensure non-overloading of the motor throughout the capacity range of the pump for the impeller size selected.

The motor pump to be suitable to install variable frequency drive inside MCC panel

2- VALVES

2.1 General

All valves and accessories are recommended to be furnished by a single manufacturer and should be subjected to the Engineers approval before ordering the valves. Valves shall be compatible with pipes and fittings specified in Division 5 of these Specifications. Compatibility should be the Contractor's responsibility at his own expense, and should be approved by a third party accredited by PSI certified Testing Laboratory.

Two copies of manufacturing and installation manuals shall be provided at time of materials delivering.

All valves shall be supplied according to the latest editions of standards and references specified in these Specifications. Valves shall be fabricated according to Standards and References specified in these specifications or shall be equivalent and compatible to these standards and references subjected to third party accredited testing laboratory.

The type and size of valve to be used at any location shall be as indicated on the Contract Documents or specified herein and shall be rated to at least the same pressure as the pipeline in which they are to be installed. All valves shall be designed to avoid cavitations and vibration in all positions, to minimize head loss in the open positions and to seal the water passage when completely shut.

All operating spindles and gears shall be provided with adequate points for lubrication. Unless otherwise specified, all valves shall be closed in a clockwise direction. Head loss curves through the valves for throttled flow conditions shall be provided for all valve sizes.

Bolts, nuts, rubber seals (joint rings), gaskets, and flanges shall be in accordance with standards specified in Division 5.

Valves of different types in general can be listed as follows:

1. Gate valves and appurtenances for yard piping.
2. Gate valves for inside service.
3. Ball valves.
4. Check valves (None Return Valve).
5. Pressure gauges.
6. Air release and vacuum valves.
7. Dismantling joints and dressers.
8. Strainers.

2.2 Submittals

The contractor shall submit the following:

- Assembly drawings.
- Manufacturer Valid quality certifications ISO or equivalent.
- Certified copies of Manufacturer quality control Test results and reports.
- Assembly shop drawings.
- Instruction manuals.
- Catalogues.
- With every consignment of valves, accessories and specials delivered under this Contract, the Contractor shall furnish a certificate worded as follows:

"This is to certify that the valves, accessories and specials delivered in this consignment comply with the required specifications and Standards".

2.3 Marking of Valves

The valves and water meters shall be clearly labelled and marked with the following information:

2.4 Valves:

- Class or Pressure rating.
- Nminal Diameter

- Arrow showing the flow directions (for valves designed for one way flow only).
- Name or trade mark of the manufacturer.
- Date of manufacturing.

2.5 Valve Coatings

Unless otherwise indicated in the Tender Documents for an alternative coating system, the internal and external surfaces of valves shall be prepared and coated with epoxy paint. The final coat shall be applied to external surfaces after installing the valves.

2.6 Works Tests

All valves shall be hydrostatically tested at the place of manufacture. The Contractor shall supply a certificate stating that the valves supplied have satisfactorily passed the specified tests and comply in all respects with these Specifications or BOQ.

All valves shall be subjected to pressure test in accordance with ISO 5208 and shall be drop tight.

2.7 Packing

All valves shall be securely packed in crates or boxes for protection against damage during transit, and shall be accompanied by the materials necessary to secure all flanges to adjacent pipe work. These materials shall also be suitably packed and shall be stored away from sunlight at all times.

Material, Pressure Rating and Equipment

1. All valves and appurtenances shall be of the size shown on the Drawings and as far as possible all equipment of the same type shall be from one manufacturer.

2. All valves and appurtenances shall have the name of the maker, flow directional arrows, and the working pressure for which they are designed cast in raised letters upon some appropriate part of the body.

3. All buried valves shall open left (counter clockwise). Insofar as possible, all valves shall open counter clockwise.
4. All valves installed at booster pumps discharge shall have a minimum working pressure of 16 bars.
5. All valves installed at well pump discharge and booster suction side shall have a minimum working pressure of 16 bars.

2.8 Gate Valves and Appurtenances

2.8.1 GATE VALVES AND APPURTENANCES FOR BURIED SERVICE

Ductile Iron Gate valves for water shall meet the requirements of ISO 7259, ISO 5996 or EN 1171. Steel gate valves should comply with ISO 6002 or EN 1984.
Valves shall be steel body, or ductile bronze-mounted, double disc, parallel seat; non-rising stem type fitted with "O-Ring" seals. The operating nuts shall be 50mm (2in) square. All valves shall open left, or counter clockwise. Stuffing boxes shall be the "O-Ring" type.

Valves shall be equipped either with hand-wheel or the spindle as specified in the Drawings or BOQ.

Tapping sleeves shall have cadmium-plated low alloy steel nuts and bolts. Sleeves shall be of cast iron, designated for working pressures not less than 30 bars (435 psi). Lead gaskets shall be provided for the full area of the sleeve flanges.

Tapping valves shall conform to the requirements specified above for gate valves except that one end shall be flanged and one mechanical. Tapping valves shall be provided with an oversized opening to permit the use of full sized cutters.

Valve boxes shall be provided for each buried valve. They shall be cast iron, of heavy pattern, adjustable type and provided with cast iron cover. The upper section of each box shall have a bottom flange of sufficient bearing area to prevent settling. The bottom of the lower section shall enclose the stuffing box and operating nut of the valve. Boxes shall have barrels of not

less than 130mm (5in) in diameter and be of length adapted to pipe cover.

Valve boxes shall be adjustable, with a lap of at least 150mm (6in) when in the most extended position. Covers shall have lettering indicating the type of service.

Four tee-handled gate wrenches of suitable length shall be furnished to operate all valves with valve boxes. Valves greeter than 300mm in diameter supposed to be actuator operated or fixed in a horizontal position should be fitted with mechanical gear on the wedge working in machined gunmetal channel in the body.

2.8.2 GATE VALVES FOR NON-BURIED SERVICE

Gate valves, shall have flanged, screwed, or solder ends as required; and shall be bronze, solid wedge, rising-stem-type gate valves or none rising-stem type as specified in the Tender Documents.

Gate valves, shall be iron body, steel or as specified in the Tender Documents, bronze mounted, solid wedge gate valves with flanged ends. Ductile Iron Gate valves for water shall meet the requirements of ISO 7259, ISO 5996 or EN 1171. Steel gate valves should comply with ISO 6002 or EN 1984.

A. Valves shall be outside screw and yoke type with rising stem.

B. Face to face metal valves dimension shall conform to ISO 5752 or EN 558-1,2.

C. Bronze gate rings shall be fitted into grooves of dovetail or similar shape in the gates. For grooves or other shapes, the rings shall be firmly attached to the gates with bronze rivets.

D. Hand wheels shall turn counter clockwise to open the valves. Hand wheels shall be of ample size and shall have an arrow and the word OPEN cast thereon to indicate the direction of opening.

E. Stuffing box follower bolts shall be of steel and the nuts shall be of bronze.

F. The design of the valves shall permit packing the valves without undue leakage while they are wide open and in service.

G. O-ring stuffing boxes may be used.

2.9 Check Valves (Non-Return Valves):

A. Materials

a. Check valves shall be swing type and shall meet the material requirements of AWWA C508. The valves shall be iron body, bronze mounted, single disc.

b. When there is no flow through the line the disc shall hang lightly against its seat in practically a vertical position. When open, the disc shall swing clear of the waterway.

c. Check valves shall have bronze seat and body rings, extended bronze hinge pins and bronze nuts on the bolts of bolted covers.

d. Valves shall be so constructed that disc and body seat may easily be removed and replaced without removing the valve from the line. Valves shall be fitted with an extended hinge arm with outside lever and spring. Springs with various tensions shall be provided and springs approved by the Engineer shall be installed.

B. Applicable Standards:

1- Valve Design API 594

2- Flange Design: ASA 300

3- Testing API 598

C. Body: Cast iron, ASTM A126, Class B for 16 bar working pressure. Carbon steel, ASTM A216-WCB for 25 bar and 40 bar working pressure.

D. Cap: Cast iron, ASTM A126, Class B for 16 bar working pressure. Carbon steel, ASTM A216-WCB for 25 bar and 40 bar working pressure.

E. Disc: Cast iron, ASTM A126, Class B for 16 bar working pressure. Carbon steel, ASTM A216-WCB or 316 Stainless Steel for 25 bar and 40 bar working pressure.

F. Gasket: Spiral Wound AISI 316 and Graphite.

G. Manufacturers and Products: Velan, Crane or equivalent products subjected to the Engineer approval.

2.10 Pressure Gauges

Pressure gauges shall be manufactured in accordance with ISO 5171 or EN 837-1,2,3 and shall be furnished and installed in each pump suction and discharge nozzle in accordance with Tender Documents requirements. Where gauge taps are not available in the pump's suction or discharge nozzle, the necessary taps in the adjacent piping shall be made for installation of gauge connections. Pressure range up to 16 bars. Each pressure gauge should be equipped with a stop valve of the same pressure rating.

2.11 Air Relief Valves

Air relief valves shall be of the double orifice pattern with ductile cast iron bodies, the inlet flange shall be fitted and drilled in accordance with EN 1074-4.

The valves shall be adequately sized for the release of air from the pipeline (or other container) without restriction of rate of filling or flow due to backpressure. Air shall be allowed to enter at a rate sufficient to prevent excessive reduction of pressure in the pipe during pipeline emptying. The "aero kinetic" type shall be provided; air valves with internal operating linkages shall be avoided.

Valves shall be designed to prevent the operating elements being in contact with the pipeline liquid by approved means such as the provision of an auxiliary float and chamber sufficiently large to isolate the orifice valves and seats throughout the rated operational range.

Air valves shall be fitted with a separate isolating sluice valve and gearing shall be provided, where necessary, to facilitate operation.

In applications where the pipeline characteristics may lead to liquid column separation with consequent possibility of surge conditions, a vented non-return valve shall be provided which allows air to enter freely on separation but controls expulsion of air as the liquid column rejoins.

All air relief valves and associated isolating valves shall be works tested and capable of withstanding the same test pressure as the pipeline or vessel on which they operate. All materials used in the manufacture of the valve shall conform to EN 1074-4.

2.12 Strainers

Strainers will be made of ductile iron or cast iron. Strainer body will be coated with an epoxy powder minimum thickness 120 microns. Screen shall be made of stainless steel.

For maintenance purposes, covers shall be provided to allow ample access to inspection, cleaning and servicing. A drain bend at the bottom of the body, fitted with a stopcock shall be incorporated.

Due to particularly hard conditions of service – high speed, high-pressure, presence of solid elements in the network – bidders are requested to pay particular attention to the quality of the protection provided by the strainers to the regulation valves and meters placed downstream.
Head loss shall not be more than 0.1 bars, when clean, at the nominal flow rate of the control valve or water meter protected by the strainer box.

2.13 Surge Anticipating Control Valve

Surge valves shall be in accordance with ISO 6264 and shall be installed on the plant water lines as shown on the Drawings .The surge valve shall be heavily constructed cast iron valve body, with integral end flanges and full unobstructed flow through area. The disc shall be cast iron having a replaceable resilient seat for tight shut-off. The Pivot shaft shall be stainless steel and be a single unit (not stubs), extending through the valve body with a weight and lever mounted on one or both ends.
The surge valve shall be adjusted at the factory to hold closed against the normal operating system pressure. When the system pressure exceeds this setting, the surge relief
Valve shall open immediately to relieve the pressure rise, but closes slowly at an adjustable rate as the system pressure returns to normal.
A heavy-duty oil dashpot system and stainless steel oil reservoir shall be externally mounted on the valve to control the rate of closure, in such a manner, to positively prevent any slam.
The closing rate shall be externally and infinitely adjustable thru a color-coded flow control valve having a locking device to prevent tampering, once the close rate is set.
Prior to shipment of the valves the manufacturer shall factory test the valves under the pressure and flow conditions specified above. The manufacturer shall submit to the Engineer with certified copies of the factory test results.
Surge valves shall be installed where indicated on the Drawings. Valves shall be rated 40 bars (600 psi) working pressure or as specified in the Contract Tender Documents

2.14ACCESSORIES OF EQUIPMENT

Each vessel will be equipped by the accessories below:

- Secured access to high part by metallic deck.
- Secured access to and through the manhole by metallic foot-racks.
- Inlet and outlet branches with connecting companion flange.
- Adjustable bases with fixing system on site in stainless steel. o Manhole with full plate.
- Gauge glass with isolating valves in upper and lower parts and bleeder valve.
- Manometer mounted with two needles and three ways valve and an isolating valve.
- ND 60 branch of evacuation welded on the shell of the vessel in lower part with isolating valve and full plate.
- Solenoid valve of air evacuation.
- Poppet valve tarred to maximum pressure in transient operation.
- Name plate in stainless steel with the mark of the vessel, the volume, the date of manufacture.
- Acceptance stamp of the Regional Direction of Industry, Research and Environment.
- The evacuation of air will be fulfilled by a solenoid valve mounted with an isolating valve and controlled by the level "Excess of air" (see characteristics data sheet). Time of evacuation will be adjustable from 1 to 10 mn. The solenoid valve will be mounted on the air pipe at the inlet on the vessel.
- The reading of the manometer will be possible by an operator (man height).
- The manhole will be installed at man height from an access metallic foot-rack. It will be installed on the side. The full plate will be equipped with a hinge and a removable support beam.

2.15 Flange-Mounted Pressure Sensing Level Transmitters.

{Level transmitters shall be of the differential pressure sensing type that connects to the process by a 3-inch [50 mm], ANSI/ASME B16.5, Class 150, flat faced, carbon steel mounting flange. Each transmitter shall have a 1/2-inch [132.7 mm] NPT threaded low-pressure connection for the process or atmospheric reference. [Where indicated on the Drawings or in the Instrument Device Schedule, the transmitter shall have a process flushing port connection on the process side of the mounting flange.]The transmitter shall be an all solid state electronic two-wire device that does not require a direct power connection to the transmitter. Process fluid shall be isolated from the sensing elements by AISI Type 316 stainless steel, Hastelloy-C, ceramic, or cobalt-chromium-nickel alloy diaphragms, and the transducer may use a silicone oil fluid fill. Transmitters shall have self-diagnostics and electronically adjustable span, zero, and damping. Transmitters shall be enclosed in a NEMA Type 4X housing and shall be suitable for operation at temperatures from 0° to 180°F [-17° to +82°C] and a relative humidity of 5 to 100 percent. All wetted parts shall be cadmium-plated carbon steel, stainless steel, or other corrosion-resistant materials. Transmitters shall have over-range protection to a maximum line pressure. Accuracy of the transmitter shall be 0.075 percent of span and the transmitter output shall be 4-20 mA dc without the need for external load adjustment. Transmitters shall not be damaged by reverse

polarity. Transmitters shall have an elevated or suppressed zero.

Transmitters shall be factory calibrated to the required range and provided with the manufacturer's standard hand-held communications/calibration device. One device shall be furnished for all transmitters provided by a single manufacturer.

Transmitters tagged on the Drawings or specified to be the indicating type shall be furnished with LCD type digital indicators.

Transmitters shall be ABB “Model 264DC”, Endress+Hauser “Deltabar S Series”, Foxboro "Model IDP10 with Remote Seal", Rosemount “Model 2051LT”, or Siemens SITRANS P DS III, or approved equal.

2.16 Target-Type Flow Switches.

Target-type flow switches shall utilize a vane or paddle type target to actuate the switch. For pipe sizes greater than or equal to 50 mm, switches shall have a treaded connection for insertion into the process piping. For pipe sizes less than 50 mm, the flow switch shall be factory installed in a spool piece, suitable for flange or thread mounting in the process
piping. Switch wetted components shall be Type 316 Stainless Steel. Switches shall contain at least one non-mercury SPDT contact, rated 2 amp [A] at 230 volts ac. The switch enclosure shall be a minimum NEMA Type 4/IP66 housing. Switches shall be factory calibrated to actuate at the specified flow rates for the given pipe size. All flow switches shall be installed in horizontal piping. switches shall be Magnetrol or approved equal.

2.17Flow meter

A. Magnetic flow meter systems shall be the low frequency electromagnetic induction type which produces a DC pulsed signal directly proportional to and linear with the liquid flow rate. Complete zero stability shall be an inherent characteristic of the flow meter system. Each magnetic flow metering system shall include the installation and furnishing a metering tube, signal cable, transmitter, flow meter grounding rings, transmitter enclosures, antennas, external batteries and all related items. The meter shall be compatible to the approved control and SCADA systems according to drawings and specifications

1. The metering tube shall have:
   a. Pressure ratings as indicated and in accordance with the requirements of piping specifications.
   b. Polyurethane or Butyl Rubber Liner, conforming to the manufacturer's recommendation for the intended service.
   c. Electrodes shall be 316 stainless steel or Higher grade
   d. Metering tube housing rated for IP66 or better. Metering tube housing rated for IP 68, suitable for continuous submergence in up to 3 meters of water, if installed in a below grade vault or any other area with reasonable potential for submergence.
   e. Epoxy protective coating.
   f. Grounding rings shall be 316 stainless steel. Grounding rings shall be designed to protect and shield the liner’s edge interface from abrasion at the meter end.

2. The microprocessor-based signal converter/transmitter shall have:
    a. DC pulse technique to drive flux-producing coils.
    b. Six digit LCD displays for flow rate, percent of span, and totalization.
    c. An operator interface with keypad which responds to English text entry.
    d. Automatic range change.
    e. Capable of measuring flow in both directions.
    f. Programmable parameters including meter size, full scale Q, magnetic field frequency, primary constant, time constant.
    g. Data retention for a minimum of 5 years without auxiliary power from main source or battery.
    h. Self-diagnostics and automatic data checking.
    i. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
    j. Ambient temperature operating limits of -29 to 60 degrees C.
    k. Remote transmitter enclosure rated for IP65.

B. Calibration and Performance

1. Calibration: Each flow metering system shall be hydraulically calibrated at a facility that is traceable to the National Institute of Standards and Technologies. The calibration procedure shall conform to the requirements of ANSI/NCSL Z 540-1 Calibration.

C. The flow metering system shall conform to the following:
1. Accuracy: ± 0.25% of flow rate from 10 to 100% full scale.
2. Repeatability: ± 0.05 at ± 0.0008 ft/s.
3. Environmental Limits: - 10 to +60º C.
4. Power requirements: external battery with 8 years life.

D. The flow meter shall be furnished with the following accessories:
1. Furnish remote mount flow transmitter with a sufficient cable.
2. Provide stainless steel stanchions for mounting of remote transmitter no less than 4 feet above grade.
3. Provide manufacturer digital calibration verification unit with necessary accessories to interface with the furnished magnetic flow meter.

E. GSM/GPRS Communications:
    1. Where indicated on the drawings or the Instrument Device Schedule, the magnetic flow meter shall be a battery operated, stand-alone water meter capable of GSM/GPRS communications using commercially available cellular data service. An external battery shall be supplied with the meter to extend service life to at least 7 years.
    2. The magnetic flow meter shall also be capable of operating on 230 or 24 volts ac, 50 Hz.
    3. The meter shall be equipped with EEPROM memory to prevent data loss.
    4. GSM/GPRS communications hardware shall allow the meter to transmit real-time flow rate, totalized flow, and time-stamped stored process data over a third-party cellular network to the Client's facilities identified on the drawings. The communications hardware shall be integral to either the flow meter or signal converter.
    5. A high gain remote antenna shall be supplied with the meter that will allow data to be transmitted via GSM/GPRS technology. Additional requirements for the

GSM/GPRS communications are shown on the drawings and specified in Section …. Network Systems.

6. Installation of GSM/GPRS-capable magnetic flow meters shall be coordinated with the cellular service provider as specified.

F. GSM/GPRS Coordination.

Where GSM/GPRS communications are employed, the System Supplier shall coordinate with the GSM/GPRS cellular service provider for the following:

- Coverage of GSM/GPRS service acceptable to the Engineer at all designated locations.
- Antenna, transmitting requirements, and any other requirements.
- Setting up the instrument for signal/data transmission over the cellular network.

G. PRODUCTS:

GENERALLY, the following paragraphs provide minimum device requirements. The Drawings and Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

I. Interconnecting Cable.

1. For instruments where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided.
2. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter.
3. Length of cable shall be a minimum of three meters or as indicated on the Drawings or in the Instrument Device Schedule.
4. The interconnecting cable shall be provided in the length necessary for installation.
5. Splices shall not be allowed in the installed cable.

II. Programming Device.

1. For instruments that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Client facility (quantity required shall be as indicated in the Instrumentation and Control System section).
2. The programming device shall include appropriate operation manuals and shall be inacluded in the training requirements.
3. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

III. Configuration Software/Serial Interface.

1. Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link.
2. As a minimum, an appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer.

3. One licensed copy of the diagnostic/interface software shall be provided for each Client facility (quantity required shall be as indicated in the Instrumentation and Control System section).
4. Software shall be capable of running under the Windows XP operating system.
5. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

H. Field Services:

Manufacturer's field services shall be provided for installation, programming, commissioning, field calibration, start-up, and training as specified in the Instrumentation and Control System section