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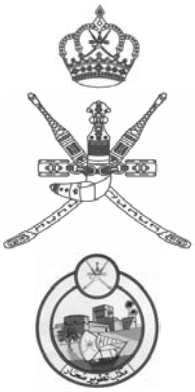
Sohar Water Network (Phase 1)
Volume 2 – Specifications
(PRS/05/033)

Sultanate of Oman



Diwan of Royal Court
Sohar Development Office

SOHAR WATER NETWORK (PHASE 1)

TENDER DOCUMENTS
VOLUME 2 - SPECIFICATIONS

MAY 2005

AL ABRAJ
Consulting Engineers
and Architects

NJS Consultants
(Nippon Jogesuido Sekkei Co., Ltd)
International Consulting Engineers

WATER DISTRIBUTION SYSTEM

VOLUME 2: SPECIFICATIONS

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PARTICULAR SPECIFICATIONS

This Particular Specification is specific to this Contract only and supplements the Technical Specification contained in this Volume.

1.1 GENERAL OBLIGATIONS

1.1.1 Definitions

Add the following new definitions:

a) "Contract Rates" means the rates and prices entered by the Contractor in the Bill of Quantities.

b) "Agent" means the person for the time being or from time to time appointed by the Contractor pursuant to the provisions of Clause 15 of the Conditions of Contract

c) "Daywork" means extra or substituted work ordered by the Engineer which is to be performed at the rates provided for in the Contract.

d) The term "sub-letting" is deemed to have the same meaning as sub-contracting.

1.1.2 Units

All units of weight and measurement shall be based on the metric (SI) system unless otherwise specified.

1.1.3 Data and Information

a) The Contractor shall obtain all related information/data required for the execution of different components of the project from the Sohar Development Office and all other concerned Ministries/Departments.

b) Any geotechnical information included in the Specification or Drawings is to assist the Contractor at the time of tendering only. Such information shall not relieve the Contractor from any of his obligations under the Contract.

c) Interpretations and analysis of the geotechnical investigations are a matter of opinion of the Engineer. The Employer gives no warranty as to any of the data or information either as to the accuracy or sufficiency or as to how the same should be interpreted and the Contractor shall make use of and interpret the same entirely on his own responsibility provided always the Contractor shall not be precluded from referring to such data or information in connection with the determination of any such question as aforesaid.

1.1.4 Orders Deemed to be in Writing

If the Contractor shall within seven days confirm in writing to the Engineer any verbal order of the Engineer and such confirmation shall not be contradicted in writing by the Engineer within a further fourteen days it shall be deemed to be an order in writing by the Engineer.

1.1.5 Payment Failing Provisions of Daywork Schedule

Failing the provisions of the Daywork Schedule the Contractor shall be paid at the rates and prices to be agreed between the Engineer and the Contractor.

1.1.6 Assignment and Benefit of Agreement

The Contractor shall before the expiration of the notice referred to in Sub-Clause l of Clause 63 of the Conditions of Contract, assign to the Employer without the payment the benefit of any agreement which the Contractor has entered into for the supply of any materials or for the execution of any works for the purposes of the Contract if so required by the Employer and/or the Engineer. A supplier or Sub-Contractor shall be entitled to make any reasonable objection to any further assignment thereof by the Employer and the Employer may pay the Supplier or Sub-Contractor for any such materials supplied and delivered to the Site or Works executed under such agreement (whether the same be assigned as aforesaid or not) before or after the giving of the said notice the amount due by such agreement in so far as it has not already been paid by the Contractor to the Supplier or Sub-contractors or by the Employer to the Contractor. The Employer's rights under this sub-clause are in addition to his rights to pay Nominated Sub-Contractor's as provided in Sub-Clause 59(2) and payments under Sub-Clause 59(2) or under this sub-clause may be made out of any retention monies in the hands of the Employer.

1.1.7 Remedy on Default of Contractor

If the Contractor fails duly to observe or perform any requirement, instruction, direction or order of the Engineer or the Engineer's Representative duly made or given in accordance with the Contract or otherwise fails to fulfil any of his obligations under the Contract, the Employer may without prejudice to any other rights or remedies he may have himself, or through his servants or agents have remedy such default, and all expenses consequent thereon or incidental thereto shall be borne by the Contractor and shall be recoverable from him or may be deducted by the Employer from any monies due to the Contractor.

1.1.8 Explosives

Except as may be provided in the Specification or ordered by the Engineer, the Contractor shall not use any explosives.

Where explosives are used, the Contractor shall comply with all laws and security regulations in force relating to the acquisition, movement, storage and use of explosives including the provision of magazines at locations approved by the appropriate authorities. The magazines shall conform in all respects to all laws in force regarding the erection, maintenance and guarding of magazines. The Contractor shall obtain all necessary licenses as may be necessary for the acquisition, movement, storage and use of explosives and do all things

necessary to ensure compliance with the laws in force relating to dangerous goods.

1.1.9 Cooperation Between Contractors

The Contractor is hereby notified that the Employer may award contracts for work in adjacent areas. In addition, the work for the Sohar Water Transmission Project that will be implemented by the DG Water, Ministry of Housing, Electricity & Water (MHEW) may be ongoing at the same time as this contract.

Where two or more contractors are employed on related or adjacent work, each shall conduct his operations in such a manner as not to cause unnecessary delay or hindrance to the other. Each contractor shall be responsible to the other for all damage to work, person or property, or for loss caused by failure to finish within the time specified for completion. Each contractor shall coordinate his activities with adjacent contractors.

The Contractor must allow for this and for coordinating work as necessary to cause minimum disruption.

1.1.10 Scope of Work

This contract for the construction of a major expansion of Sohar's existing water system to provide potable piped water supply to the residents of northern and central parts of al Tarayf; al Multaqa south and north, al Jafrah, Falaj al Qaba'il and al Khuwayah; al Ghushbah and Falaj al Oahi; coastal part of Majz al Kubra, al Uwaynat and Khor Siyabi; and the highway part of Uwaynat and Khor Siyabi. The source of water will be a new Service Reservoir on a hill opposite Magan Village that will be built by others for the DG Water, MHEW. The work under this Contract will connect the 900 mm diameter primary distribution pipeline to the outlet of the new MHEW Service Reservoir at the boundary of the reservoir. In addition, the Scope of Work includes items associated with the expanded water system.

This Contract includes the following works as indicated on the Drawings and as specified herein:

- Supply and installation of about 44 km of primary distribution pipelines of asbestos cement (AC) pipes with cast iron (CI) fittings with diameters ranging from 400 mm to 900 mm nominal internal diameter, except that road and wadi crossings will be of ductile iron pipes and fittings.

- Supply and installation of about 312 km of secondary water distribution pipelines ranging from 100 mm to 300 mm nominal internal diameter in the project area. The total length comprises about 15 km of 300 mm nominal internal diameter of AC pipes and CI fittings, except that road and wadi crossings will be of ductile iron pipes and fittings, and about 297 km of 100 mm to 200 mm nominal internal diameter HDPE pipes and fittings including road and wadi crossings.

- Supply and installation of two pressure reducing valve chambers to control the pressure of the primary distribution system that will feed the northern area and the central and southern areas.

- Supply and installation of waste meters in the network.
- Connection of the new pipeline to the proposed Sohar Ground Reservoir that will be built be others under a design/build contract for the MHEW under the Sohar Water Transmission Project.
- Connections of new pipelines to existing pipelines and facilities.
- Construction of tanker filling stations at specified locations in the project area.
- Supply and installation of consumer service connections.
- Construction of buildings to serve the expanded water supply system:
  - Laboratory for testing water quality
  - Workshop for mechanical and electrical repairs
  - Office building for water operations, including hot line emergency repairs room
  - Store for materials with computerized storing system
- Supply and installation of facilities to serve the expanded water supply system:
  - Laboratory equipment for testing water quality
  - Equipment for workshop
  - Equipment for store
  - Safety equipment.
- Construction of all other related works to make the Works complete.
- Testing and commissioning of the completed works.
- Maintenance of the works for a period of 365 days.

Some portions of any components of the Works may not be carried out and, if so, the Contractor will not be entitled to any claim for additional payment whatsoever. This may include, but is not limited to, pipelines that are to be located within 1 km of the coast, which would include all of Bill Nos. 8 and 16 and part of Bill Nos. 5, 9A, 13 and 17A.

The Contractor shall comply with all requirements, codes and regulations of all concerned Omani authorities and agencies whether contained in these tender documents or not including, but not limited to, SDO, MHEW, MRME&WR, MOTC, ROP, MOD, OGC, PDO and Omantel, and provide all necessary works complete in order to comply with the above and the Contractor will not be entitled to any claim for extra payment whatsoever.

1.1.11 Drawings

The Drawings forming part of the Contract Document are listed in Volume 4, Drawings.

Upon acceptance of the Contractor's Tender by the Employer, the Contractor will be furnished free of charge, two sets of Contract Drawings and Specification from the Engineer. The Engineer's printing fee shall be R.O. 5.000, per A1-size sheet, for additional Contract Drawings in excess of that amount provided free of charge to the Contractor.

1.1.12 Work in the Urban Area

The site of the work is within the urban areas of Sohar Town. The Contractor is required to organize his operations in such a way that disruption of access to contiguous properties and interference with existing services and improvements is minimized.

The Contractor shall ensure that roads and thoroughfares used by him for the transportation of Construction Plant, labour, materials and excavated materials are not dirtied because of his operations. If, in the opinion of the Engineer, the Contractor's operations result in dirty conditions, the Contractor, upon notification by the Engineer, shall take all necessary steps to clean roads and thoroughfares so dirtied, at no extra cost to the Employer.

1.1.13 Water Supply for Testing and Disinfection

Water Supply for testing and disinfection of pipelines and water retaining structures shall be potable water provided by the Contractor at his expense.

The Employer will designate, except as described below, a location from where the Contractor may draw water for use in testing and disinfecting pipelines and water retaining structures. The Contractor shall, under the direction of the Employer, provide all labour, equipment and materials required for making the connection and constructing the pipeline and service connections including, but not limited to, tapping sleeve and valve, meter, pumps (including all appurtenances, structures and services), including the pipes, fittings, specials, valves and structures required for his use.

The Employer will provide, except as described below, water for the Contractor's use for the testing and disinfection of pipelines and water retaining structures at the rate of RO 3.000 per 1000 imperial gallons.

The Employer does not guarantee that water will be provided for the Contractor's use, should Sohar Development Office at any time and for any reason, be unable to supply water, the Contractor shall make his own arrangements for water supply at no extra cost, notwithstanding any designation by Sohar Development Office of a point of connection or the installation of a connection and pipeline by the Contractor.

For each reservoir testing or disinfection event, the Employer will provide, at the above rates, sufficient water to fill one chamber of the reservoir. The Contractor shall use this volume of water for testing or disinfecting both chambers, and shall transfer water from one chamber to the other at no additional cost to the Employer.

The Contractor shall make his own arrangements for the supply of water for his use for all other purposes.

The Contractor shall make his own arrangements for discharge to waste of all water used for testing of the reservoir.

1.1.14 Environmental Requirements

The Contractor shall comply with the environmental requirements of the Ministry of Regional Municipalities, Environment & Water Resources which include, but are not limited to, the following:

- Any environmental pollution resulting from the Contractor's activities is set right by the Contractor at his own cost.
- Care should be taken during construction to minimize disturbance and damage to surrounding areas. All reasonable measures should be taken to control dust.
- Noise levels should not be such as to cause harm or disturbance to inhabitants in the vicinity of the Contractor's operations. The Contractor shall abide by the controlling rules and regulations of noise pollution issued by Ministerial Decrees 79/94 and 80/94 regarding noise pollution control.
- Septic and holding tanks should comply in all respects with the Sultanate of Oman's Regulations for Septic Tanks and Holding Tanks, issued by Ministerial Decision 421/98 (supersedes MD 5/86).
- Percolation tests shall be submitted to the MRME&WR by the Contractor upon commencement of the Project.
- The approval of the local Municipality is obtained for disposal of any solid wastes.
- Cutting of trees and natural plants should be avoided. If it is necessary to cut trees, it should be done without using excavators. Cutting should be level with the ground level and roots should remain in ground to avoid soil damage. A minimum distance of 5 m from trees which are in the location of the excavation should be maintained.
- The site should be reinstated following the cessation of activities by the Contractor. Spoil tips are to be removed and excavation sites are to be levelled.
- The approvals of other concerned Ministries and Authorities are obtained by the Contractor prior to commencement of Work.
- The Contractor shall abide by the regulations for air pollution control from stationary resources (Ministerial Decree No. 5/86)
- The Contractor shall abide by the rules regarding management, treatment, and disposal of non-hazardous and hazardous waste according to Ministerial Decrees 17/93 and 18/93, respectively.

The Employer will hold the Contractor responsible for compliance with the above-listed requirements and all other obligations imposed by the MRME&WR to the

extent that the Contractor's fulfilment of his obligations under the Contract may result in conditions requiring actions to comply with the above-listed requirements and all other obligations imposed by the MRME&WR. The Contractor shall carryout the necessary actions at no additional cost to the Employer .

The requirements and obligations imposed by the MRME&WR shall be deemed to be additional to obligations otherwise imposed under the Contract, and no extra payment whatsoever shall be paid for full compliance with these requirements and obligations.

1.1.15 Contractor's Access to the Site

The Contractor shall arrange his own access routes to the site, obtain all necessary permissions and shall carry out such improvements and maintenance works he deems necessary for the fulfilment of his obligations under the Contract. Existing routes may be used by other Contractors as access to their working areas. All matters relating to the joint use of access routes shall be resolved by mutual agreement among the contractors jointly using the access route. No Contractor shall be deemed to have priority right to the use of the access route. Access routes shall be restored to a condition with respect to use and safety not less than its original condition, to the approval of the Engineer.

1.1.16 Security Fence for Construction

Temporary security fencing to isolate site areas from the public are to be provided by the Contractor and shall be provided at the Contractors own expense. It shall be the Contractor's responsibility to obtain all necessary approvals and permits, and no claim for extra payment or extension of time will be considered for delays resulting from the Contractor's failure to obtain the same.

1.1.17 Contractor's Working Area

The Contractor shall be responsible for the security of his property located throughout the Contractor's working area and shall make his own arrangements, at no additional cost to the Employer, for any additional working and lay-down area he may require.

1.1.18 Location of Contract Offices and Other Facilities

Within two weeks of the notice of acceptance of the Tender, the Contractor shall submit a plan(s) showing his proposed locations for:

- Offices for the Engineer
- Contractor's Site Offices
- Contractor's Stores, Plant and Maintenance Yard, Concrete Batching and Materials Stockpiling Facilities
- Principal routes for heavy plant and trucks
- Areas for the temporary storage and permanent dumping of excavated material

Note that the offices of the Contractor's Agent will normally be adjacent to or close to those of the Engineer for ease of access and communication. However, the Engineer's site office shall be completely detached from the Contractor's own office.

The plan(s) shall be submitted to the Engineer in six copies for approval. Any reasonable changes or modifications suggested by the Engineer shall be incorporated.

Departures from the approved details shall not be permitted unless written consent is obtained from the Engineer.

1.1.19 Overtime Work

Whenever working outside the normal hours is proposed, the Contractor shall request approval from the Engineer giving not less than two working days notice.

The Engineer’s inspection staff are to be compensated for the additional time at a negotiated rate, mutually agreed, for the overtime work which will be deducted from the next or following payment due the Contractor.

1.2 EARTHWORK AND SITE WORK

1.2.1 Permits

The Contractor shall be fully responsible for obtaining all necessary excavation permits and permissions, except those normally obtained by the Employer or Engineer, prior to commencement of the Works.

These shall include but shall not be limited to the following:

- excavation permits from Petroleum Development Oman (PDO)
- general excavation permits
- specific excavation permits relating to road crossings, etc.
- provisions of all necessary bonds required by the permits
- permissions in respect of erection of site offices, labor camps, stores, etc.
- permissions in respect of use of explosives.

1.2.2 Hoarding

Unless otherwise specified, hoarding shall be provided as directed by the Engineer or other concerned Ministries/Authorities at no extra cost to the Employer.

1.2.3 Site Clearance

All areas of the Site from which material is to be excavated or upon which fill is to be deposited shall be cleared to the extent required by the Engineer of all

buildings, foundations, walls, fences and other structures and obstructions and of all vegetation. Material so cleared shall be disposed of off the Site.

The area to be cleared shall be restricted to the minimum areas necessary for construction of the Works. Site clearance beyond the limits of the Works shall not be carried out unless authorized by the Engineer in writing.

1.2.4 Excavated Material

Excavated material approved for use either as backfill or fill, or imported fill material shall be stored on the site at locations approved by the Engineer; such materials shall be stored so as not to impede the natural flow of surface runoff in wadis or drains and so as not to constrain the activities of other parties. The Contractor shall transport such materials to a temporary storage area, and subsequently reload and haul materials to the place of subsequent reuse; no claim for extra payment will be considered for handling of excavated material.

Surplus excavated material not approved for use either as backfill or fill shall not be stored on the Site, but shall be directly removed from the Site. The Contractor shall make his own arrangements for the transport and disposal of surplus excavated material.

1.2.5 Shoring and Bracing

The Contractor's attention is drawn to Clauses 2.1.6 and 2.2.6 of Section 2 of the Specification regarding shoring and bracing excavations. It is the Contractor's responsibility to provide sheeting, shoring, etc., or to justify that open excavation is feasible and safe. The Contractor's justification of feasibility and safety shall take into consideration the close proximity to the Works of previous excavations for other utilities and all other factors affecting the safety of the works and the security of adjacent structures, improvements and services. In accordance with Clauses 2.1.6 and 2.2.6, the Contractor shall be deemed to have made his own allowance for shoring and bracing and the Contractor is required to obtain the prior written approval of the Engineer to execute trench excavations with battered sides instead of providing shoring and bracing. The Contractor shall submit individual requests for approval for each section of pipeline and for each structure for which excavations with battered sides are proposed. In the event that the Engineer approves excavations with battered sides, the Contractor shall not fail to proceed in accordance with the Contractor's proposed methods and to comply with all of the conditions of the Engineer's approval.

Any necessary permits for the widths required by the Contractor to accommodate his excavation shall be obtained by the Contractor. The concerned authority shall have the right to stop the work at any site, if, in their opinion, it is considered that the Contractor is not adopting a safe method of working.

Requests for approval for trench excavations with battered sides will not be considered in or near areas paved with concrete, asphalt, interlocking brick or precast concrete tiles or near underground utilities.

Cuts in existing concrete or asphalt paved surfaces shall be made with a pavement sawing device approved by the Engineer and saw cuts shall be even and truly aligned. The Contractor shall conduct his operations so as not to disturb the retained saw-cut edge.

The Contractor may be required to work in the vicinity of high and low voltage cables, telecommunication cables, water pipelines, sewers, pumping mains and petrochemical industry pipelines in certain locations under this Contract. The Contractor shall ascertain and confirm these locations on site with the appropriate utilities agencies. Work in these areas will not be permitted with mechanical excavating plant. All electrical and telephone utilities shall be provided with service protection ducts.

1.2.6 PDO/OGC Gas and Oil Pipelines

The Contractor shall obtain excavation permits from PDO/OGC for all excavation within 25m of any PDO/OGC pipeline, and shall comply with all requirements of the permit.

At all PDO/OGC pipeline crossings, any pipelines of metal materials shall have double wrapping of PVC tape with bitumen rubber adhesive or similar of total thickness 1000 microns giving a zero cathodic effect.

The Contractor shall duly notify PDO/OGC of all pipeline testing to be carried out under the Contract in the vicinity of PDO/OGC pipelines sufficiently beforehand so that a PDO representative can be present during the testing. Only hand excavation methods are to be used for PDO/OGC pipeline crossings.

All technical details of water pipeline i.e., material of construction, coating, cathodic protection (CP), etc shall be provided to PDO/OGC O&M Section for detail analysis. Specific recommendations and approval will be provided by PDO/OGC on case to case basis. The Contractor shall obtain written permission from PDO/OGC and strictly follow PDO/OGC procedures and technical requirements.

Heavy vehicle traffic is prohibited on PDO/OGC pipeline ROW and the ROW shall not be used for construction purposes. All heavy equipment shall cross the PDO/OGC pipeline only at the approved crossings.

The construction of the water pipelines shall adhere to all the legal requirements of ROW Royal Decree (Usage & Obstructions).

The Contractor shall submit CP system design report to PDO/OGC for review and approval, in case of using metallic water pipeline and the new water pipeline shall have an independent CP system from PDO/OGC pipeline CP system.

All pipeline crossings shall be carried out as per OGC specification, PIM-2-4108-002. The water pipeline shall cross the ROW at a 90° angle.

Prior to any construction activity for crossing, the PDO/OGC pipelines shall be located by a trial pit (hand excavation only) after removing the windrow.

Water pipeline shall cross underneath the PDO/OGC pipeline. The minimum spacing between the water pipeline and the PDO/OGC pipeline shall be 1 m. This depth shall be maintained for the full distance of 25 m on either side of the PDO/OGC pipeline.

All crossings of water pipeline with PDO/OGC pipeline shall be accurately located and marker plates installed as per PDO/OGC standards.

The Contractor shall adhere to PDO/OGC HSE rules and regulations and their personnel are required to attend the mandatory HSE courses prior to working near high pressure PDO/OGC pipelines.

PDO/OGC O&M Section will provide parallel supervision on site while the Contractor's personnel are working within 25 m of PDO/OGC pipelines.

The excavation spoils and construction waste shall not be left in the PDO/OGC pipeline ROW and the PDO/OGC pipeline ROW shall be restored after completion of all activities.

After completion, "As built" drawings shall be submitted to PDP/OGC O&M section for record in AutoCAD/Micro station format with coordinates all to the approval of PDO/OGC.

The Contractor is required to approach OGC with all the specific drawings and technical details for final approval prior to the construction stage."

1.3 CONCRETE

1.3 .1 Sulphate Protection of Chambers, Thrust Blocks and Concrete Encasement

Surface of reinforced concrete chambers, thrust blocks and concrete encasement shall be provided with sulphate protection by application of three coats of bituminous protection to:

- upper surface of blinding concrete
- external faces of walls in contact with ground.

The method of application shall be as detailed in Section 5 of the Specification.

1.3.2 Water Tightness of Concrete Structures

All concrete structures designed to retain or convey liquids, or having floor slabs below outside grade, shall be tested for water tightness by the Contractor before backfilling. Structures shall be free from leakage of external or internal water, wet patches or sweating. Units shall be filled to maximum operating level as shown on the Drawings. Tests shall be conducted under the direction of the Engineer and any noticeable leaks shall be repaired by the Contractor in an approved manner and if necessary, the tests shall be repeated until water tightness is assured. Additional tests for water tightness, if any, are detailed in the appropriate section of the Specifications. The costs of any replacement of any part of the work, shall be borne by the Contractor.

The external faces of water retaining structures shall be examined during testing for indications of leaks, wet patches and sweating, and leakage shall be corrected before any material or backfilling is placed against the concrete surface.

All leaks shall be repaired within one month of their detection.

1.3.3 Blinding Concrete

Blinding concrete, minimum 75 mm thick, whether or not shown on the Drawings shall be placed on the underside of all concrete surfaces in contact with soil.

Underneath of the blinding shall be provided with 2 layers of gauge 1000 polythene sheet directly in contact with soil. The upper surface of blinding shall be provided with tanking membrane with protection board for water retaining structures complying with Section 8 of the Technical Specification, while 3 coats of bituminous paint shall be used for all other structures.

1.4 PAINT AND PROTECTIVE COATINGS

1.4.1 Painting Schedule

Except as provided for in this Sub-Clause, paint and protective coatings shall be provided as specified in Section 7 of the Specification.

Internal and External Surfaces and precast concrete block wall and ceiling surfaces shall be painted as indicated on the Drawings.

1.5 LININGS AND PROTECTIVE COATINGS FOR CONCRETE

1.5.1 General

Except as provided for in Sub-Clause 1.3.1, linings and protective coatings for all concrete surfaces shall be as specified in Sections 5 and 8 of the Specification.

1.6 SPECIAL CONSTRUCTION

1.6.1 Ductile Iron Yard Piping

Self-restrained type ductile iron pipes and fittings shall be provided for all buried pipes that are used in yard piping.

Self-restrained type ductile iron pipes and fittings may also be used on all buried pipe in lieu of thrust blocks in accordance with Clause 3.2.2 of Section 3 of the Specification.

The Contractor must satisfy himself that the pipe suppliers can deliver the pipes and fittings to suit the Contractor's proposed construction program. The Contractor must also satisfy himself that the proposed pipes and fittings are adequate to meet the requirements of the Specification and that the manufacturer's handling and installation specification meet the requirements of the Specification.

1.6.2 Landscaping

Areas of gravel where shown on the Drawings shall consist of 100mm depth of 20 mm single size aggregate placed over well-compacted natural ground.

1.7 LABORATORY

1.7.1 Benches and Shelves

The bench shall be a proprietary acid resistant design with double door cupboards and one drawer unit underneath. Each cupboard shall be equipped with one intermediate shelf. The bench shall be 900 mm high and 600 mm deep, not less than 9 m long. Timber work shall be hardwood.

Two sets of shelves shall consists of 5 levels, capable of adjustment.

1.7.2 Equipment and Instruments

The equipment and instruments for the laboratory shall be as specified in Section 14. The reagents for the laboratory shall be that required for the tests as stated in Section 14.

1.8 WORKSHOP

1.8.1 Shelving and Lockers

The workshop shall be provided with a metal heavy duty industrial type shelving system total length 10 m, 3 shelves (depth 1 m), total height 2.5 m.

The workshop shall have a unit of 6 lockable lockers – each locker being 450 mm wide x 750 mm high with one shelf 550 mm from top.

1.8.2 Equipment

The equipment for the workshop shall be as specified in Section 15.

1.9 STORE

1.9.1 Shelving System and Lockers

The store shall be provided with a metal heavy duty industrial type shelving system total length 30 m, 3 shelves (depth 1 m), total height 2.5 m.

The store shall have a unit of 6 lockable lockers – each locker being 450 mm wide x 750 mm high with one shelf 550 mm from top.

1.9.2 Equipment

The equipment for the workshop shall be as specified in Section 15.

The Contractor shall provide a computerized storing system for the SDO Water Department Store. The system shall be provided with one computer with the following minimum requirements: IBM Compatible PC with minimum Pentium 4 Intel processor, minimum 100GB Hard Disk, 520 MB RAM complete with telephone/fax modem, super VGA 17 inch color monitor, latest licensed Windows XP Professional operating system, latest licensed Windows Office Professional; Laserjet printer of 20 page/minute with 2 MB buffer, including all cables and accessories.

The Contractor shall employ a Specialist in the setting up and operation of computerized systems for the complete management of the stores to serve the entire wastewater system, including the wastewater treatment plant and its collection system. If the computer software is proprietary, one licensed copy of the program including manuals shall be provided. If the computer software is not proprietary, one copy of the program shall be provided and manuals if available.

The Specialist shall provide a minimum of three days on-site training to staff assigned by SDO Water Department in operation and troubleshooting of the system. The Contractor shall provide three copies of a clearly written step-by-step guide in English and Arabic on how to operate the system and for troubleshooting.

The Contractor shall provide comprehensive maintenance of the computer system including all hardware and software for 12 months, excluding any further training in the software beyond what is specified herein.

The software for the management of the stores shall meet the following minimum objectives:
Categorization of groups of items
Location of each item in the store
Inventory of existing store items
Control of each store item: Including, but not limited to, Date, Item No., Group, Description, Party received from/issued to, Purpose of Use, for both incoming and outgoing items.
Balance of each item in the store
Cost of each item.

1.10 SAFETY EQUIPMENT

The Contractor shall provide the following safety equipment:

Item	Description	Unit	Qty
1	Road hazard safety jackets of colour and material as approved by SDO Water Department	Nr	10
2	Road traffic cones of size, colour and material as approved by SDO Water Department	Nr	20
3	Road traffic warning signs to be of type, size, colour and wording as approved by SDO Water Department	Nr	50
4	Road traffic warning battery-operated lanterns to meet SDO Water Department requirements, with rechargeable batteries, plus one charger for every 5 lanterns.	Nr	50
5	First-aid kits for use in vehicles	Nr	10
6	Safety chains and ropes	Nr	2
7	Safety torches	Nr	4
8	Safety goggles	Nr	4
9	Safety boots: Size to suit SDO Water Department	Nr	4
10	Safety gloves: Size to suit SDO Water Department	Nr	4
11	Chemical resistant overalls	Nr	4

SECTION 1

GENERAL OBLIGATIONS

1.1 GENERAL

1.1.1 Requirements

The Conditions of Contract apply to all Sections of the Specification the same as if they were written herein. Unless otherwise specified all materials incorporated in the Permanent Works shall be new. Materials not otherwise designated by detailed Specification shall be of the best quality and suitable for the purpose intended and shall be to relevant British or American Standards where applicable.

Any advice, approval or instruction provided by the Engineer will not relieve the Contractor of his responsibilities or liabilities under the Contract, implied or expressed.

1.1.2 Workmanship

All workmanship shall be in conformance with the best trade practice. Particular attention shall be given to the appearance of exposed work. Any work or workmanship not conforming to the best practices shall be subject to rejection.

1.2 SCOPE OF WORK

1.2.1 Work to be Performed

The work to be performed under this Contract is delineated in the Particular Specifications which form apart of the Tender Documents and the description and extent of the work are specified in the Bill of Quantities.

1.2.2 Compliance with Drawings

All work, during its progress, and upon completion, shall conform to the lines, elevations, and grades as shown on the Drawings. The Contractor shall complete the proposed work in every detail as specified. Should any detail or details be omitted from the Drawings and Specification that are essential to its intended completeness, then it shall be the responsibility of the Contractor to furnish and install such detail, so that upon completion of the proposed work, the work will be acceptable and ready for use.

1.3 DRAWINGS

1.3.1 List

A list of drawings that accompany the Specifications is given in Volume 1.

1.3.2 Interpretation of Drawings

The Employer accepts no responsibility for any omissions or the correctness of the representation of existing features on the Drawings.

1.3.3 Further Drawings

The Engineer may issue further drawings to the Contractor as work progresses.

1.3.4 Interpretative Drawings

Any additional drawings that the Contractor requires to interpret the Drawings for the use of his employees shall be prepared by the Contractor and four copies of each shall be supplied to the Engineer if required by him.

1.3.5 Foundation Drawings

Contractor shall, within the times named in the Specifications or in accordance with the programme, provide Drawings showing the manner in which the set of pumping equipment it to be fixed together with all information relating to the Works, required for:

a) Preparing suitable foundations

b) Providing suitable access for the set of pumping equipment to the point on site where the plant is to be erected

c) Making all necessary connections to the set of pumping equipment (whether such connections are to be made by the Contractor under the Contract or not).

1.4 ABBREVIATIONS

The abbreviations used in the Drawings and Specifications are abbreviations the meanings of which are established by general usage throughout the industry. Such abbreviations include, but are not limited to, the following:

AASHTO	American Association of State Highway and Transportation Officials
AFBMA	Anti-Friction Bearing Manufacturer's Association USA
AGMA	American Gear Manufacturers Association
AISC	American Institute of Steel Construction, Inc.
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
BS	British Standards

BSEN	British Standard European Number
BSI	British Standards Institution
BSCP	British Standard Code of Practice
CMA	Crane Manufacturer's Association USA
DIN	Deutsches Institut fur Normung e.V. West Germany
FP	Federal Specification, USA
HI	Hydraulic Institute, USA
HMI	Hoist Manufacturer's Institute USA
IEE	Institution of Electrical Engineers UK
IEEE	Institute of Electrical and Electronic Engineers UK
ISO	International Standards Organization Switzerland
MMA	Monorail Manufacturer's Association USA
NEC	National Electrical Code USA
NEMA	National Electrical Manufacturer's Association USA
SMACNA	Sheet Metal and Air-Conditioning Contractors National Association USA
UBC	Uniform Building Code USA
UL	Underwriters' Laboratories, Inc. USA
UMC	Uniform Mechanical Code USA

1.5 STANDARDS AND SUPPLEMENTARY SPECIFICATION

1.5 .1 Applicable Standards

All workmanship, materials, and components throughout shall where applicable unless otherwise stated in the Contract comply with the latest edition of Oman Standards where they existing, ISO, American or British Standards and Code of Practices or other Standards and Codes of Practice subject to the following Conditions:

a) American and British Standards or Codes of Practice

The relevant American or British Standard and Code of Practice with all subsequent amendments, changes or additions or replacement as thereafter adopted and published, that are the latest edition in effect at the date for submission of tender.

b) Standard Not Specified

If no Standard is indicated, then the relevant latest edition of American or British Standard, if any, shall apply.

c) Other Standards

Other Standards or Codes of Practice (latest edition) proposed by the Contractor at the time of tendering provided that these Standards or Codes of Practice are equivalent or superior to the relevant American or British Standards or Code of Practice, and certified translations of the Standards or Codes are supplied with Tender; and

d) Data to be Supplied

The following data must be submitted with the tender and the relevant sections of these documents completed (i.e., Schedule of Deviations and Data Sheets):

- Authentic copies of latest edition of Standards or Codes of Practice proposed (including certified English translations).
- Full technical data and test results.
- List of similar projects where materials to proposed standards have been used satisfactorily.
- Confirmation that all material supplied is fully compatible and complete with all adaptors.

e) Definitions

- Where "as shown", "as indicated", as detailed", or words of similar import are used, it shall be understood that reference to the Drawings accompanying the Specifications is made unless otherwise stated.
- Where "as approved", "as reviewed", "as accepted" or words of similar import are used, it shall be understood that the approval, direction, requirement, permission" authorization, review, or acceptance of the Engineer is intended, unless otherwise stated.
- As used in the Contract Documents. "provide" shall be understood to mean "provide complete in place", that is, "furnish and install a fully operational system".

1.5.2 Engineer's Approval

The acceptance of a tender based upon a Standard or Code of Practice proposed by the Contractor shall only signify the Engineer's general approval to use of such Standard or Code of Practice, and shall not make the Engineer liable to accept a standard of workmanship subsequently found to be inferior to the corresponding American or British Standards or Codes of Practice.

1.5.3 Certificates

Where the relevant Standard provides for the furnishing of a certificate to the Employer or Engineer at their request, stating that the materials supplied comply in all respects with the Standard, the Contractor shall obtain the certificate and forward it to the Engineer.

1.5.4 Standards, Codes and Regulations

The whole of the Works shall be of such standard and quality as to be acceptable for insurance by a first class insurance company, especially in respect of fire detection and protection.

Contractor shall submit one original copy of all reference standards, codes, local and administrative orders, regulations and technical literature he will use for the Works to the Engineer at no extra cost. The original copy of each shall be bound together and submitted to the Employer on completion of the works. Copies shall be purchased by the Contractor from the authorized standard agencies.

1.6 PROGRAM OF WORK

1.6.1 Details to be Submitted

The Contractor shall submit the following details with his Tender:

a) Chart. A detailed program in the form of an activity/time related bar chart showing the order in which the Tenderer proposes to construct the various parts of the Works and the supply and installation of associated plant and equipment, the dates on which it is proposed that the several principal operations of features will be started and completed including the dates by which various items of information will be needed to achieve programme requirements.

b) Schedule. A plant schedule listing major items of plant and showing their time on site related to the operations described on the bar chart.

c) Graph. A graph showing the build-up of labour force and supervision related to the bar chart.

1.6.2 Notice to Commence Work

Programming shall take into account the period of notice to commence work in accordance with the Conditions of Contract.

1.6.3 Revised Program

Within two weeks of the notice of acceptance of tender, the Contractor shall submit a revised detailed construction program to the Employer and the Engineer based on actual date of acceptance, and six further copies on receipt of the Employer's approval of the program. Approval of the program and constructional details shall not relieve the Contractor of his responsibilities under the Contract.

The detailed construction program should take the form of a critical path network showing optimum order of work, available time for each activity and effects of delays complimenting the Bar Chart under Clause 1.6.1a) C.P.N. shall be

updated at 3-month intervals with a resource summary to indicate where extra inputs will be necessary to keep up to schedule.

If during the course of the work a program revision becomes necessary, details must be submitted to the Employer and the Engineer for approval within one week of the required revision and four copies of the revised program must be supplied as soon as approval is given.

Interim payments may be withheld until the Contractor has complied with the Engineer's request under this sub-section.

1.6.4 Rate of Work

Where progress has fallen behind the expected rate, the revised program must be accompanied by the Contractor's proposals for increasing the rate of work to meet the new program.

1.7 SETTING OUT

The Contractor shall be deemed to have ascertained before the Tender Date the extent and probable accuracy of the information and reference points likely to be available to him and shall carry out all additional survey work necessary for setting out the Works in accordance with the provisions of the Conditions of Contract. Elevations shown for the various parts of the work refer to Mean Sea Level (MSL). Where necessary the Contractor shall establish the necessary base lines at the surface of the ground and at convenient locations for the construction of the work. From the established base lines and Bench Marks the Contractor shall extend the necessary lines and grades for construction of the work and shall preserve all stakes set for lines, Bench Marks, or measurements of the work in their proper places until authorized to move them by the Engineer. Any expense incurred in replacing said stakes that the Contractor may have failed to preserve shall be borne the Contractor.

The Contractor shall undertake a survey of the routes of the pipeline prior to the commencement of construction work, and shall provide the Engineer with at least two copies of the results of the surveys including plan and profile of pipelines with ground levels, pipeline gradient and invert levels, which shall include details of air valves, washouts, bends, fire hydrants, road crossings, wadi crossings, etc., and shall conform to the following:

- The length of the route shall be accurately measured and chainage markers (12 mm steel pegs or similar approved) fixed at 50 m intervals and clearly marked with the chainage at that point. The route thus marked shall be agreed with the Engineer prior to commencement of level surveying.

- Using modern survey equipment listed in Clause 1.21.16, ground levels shall be taken at intervals agreed with the Engineer, but generally at 25 m intervals or closer along the pipeline route and at significant changes in ground levels.

- Levels shall relate to Mean Sea Level (MSL), and permanent bench marks shall be established, well clear of the proposed pipeline, at intervals along the pipeline route. At each change of direction the UTM coordinates

shall be indicated. **Surveys shall be to the Sohar Development Office's Coordinate System, which is WGS 72.**

- The results of the survey shall be presented in the form of a list of chainages corresponding to existing ground levels and final ground levels as required by the relevant concerned authority. The survey results shall also show the location, dimensions and levels of all underground existing services or obstructions along the pipeline route.

The Contractor shall survey ahead of the pipelaying and copies of the results shall be submitted to the Engineer without delay. At all times the route surveying shall be sufficiently ahead of excavation and pipelaying to enable agreement to be reached between the Engineer and the Contractor on the lines, levels and gradients:

- between high and low points on the pipeline section under construction and the next section to be opened up for construction

- for at least one further week's work.

1.8 GEOLOGICAL DATA

Details, if any, of bore holes that may have been put down on the location of the proposed Works are shown on the Drawings. Such information shall not relieve the Contractor from any of his obligations under the Contract. Contractors will be deemed to have satisfied themselves as to the form and nature of the Site before submitting their tenders.

1.9 ACCESS TO THE SITE

The Contractor shall arrange for, construct, maintain and afterwards remove and reinstate any access required for and in connection with the execution of the Works. Reinstatement shall include restoring the area of any access route to at least the degree of safety, stability and drainage that was obtained before the Contractor entered the Site.

1.10 SPOIL TIPS ON PRIVATE LAND AND ADDITIONAL SITE AREA

1.10.1 Additional Land

This clause refers to land needed by the Contractor additional to that to be provided by the Employer.

1.10.2 Responsibility for Obtaining Land

The Contractor shall make his own arrangements to dispose of excavated material to spoil tips and for possession of any additional land area he may require for working or accommodation space. He shall be responsible for obtaining the consent of the owner, tenant or occupier of private land for such use or for other temporary purpose. Before entering upon private land, the Contractor shall confirm in writing to the Engineer that he has obtained such consent. The Contractor shall pay all costs, expenses, rentals, fees, compensation or other disbursement that may be incurred by him, by the

government or in negotiations with owner, tenant or occupier and during the subsequent use by him of such private land for purposes in connection with this Contract. No reimbursement will be made to the Contractor who shall be deemed to have included the full cost thereof in the Tendered rates. The Contractor shall note that his responsibility under the relevant Clause of the Conditions of Contract relating to Damage to Persons and Property shall apply to the whole of the land occupied or used by him for the purpose of the Works.

1.10.3 Responsibility for Damage

The Contractor will be held responsible for all damage that he may do to land or property outside his necessary working space. Compensation for damage to such land or property will be assessed by the Employer for settlement by the Contractor through the Employer. The Employer will be entitled to withhold from any payments due to the Contractor sufficient sums as may appear to him to be necessary to cover the Contractor's liabilities under the Conditions of Contract until evidence is produced by the Contractor to the Engineer to show that the Contractor's liabilities in this respect have been finally settled and discharged.

1.11 DAMAGES TO PERSONS OR PROPERTY

1.11.1 Claims for Damage to Persons or Property

Any claim received by the Employer or Engineer in respect of matters in which the Contractor is required under the Contract to indemnify the Employer will be passed to the Contractor who shall likewise inform the Employer and the Engineer of any such claim which is submitted directly to him by a claimant. The Contractor shall do everything necessary including notifying the insurers of claim received, to ensure that all claims are settled properly and expeditiously and shall keep the Employer and the Engineer informed as to the progress made towards settlement, failing which the Employer shall be entitled to make direct payment to claimants of all outstanding amounts due to them in the Employer's opinion and without prejudice to any other method of recovery to deduct by way of set-off the amounts so paid from any sums due or which become due from the Employer to the Contractor.

1.11.2 Indemnified Claims

If the Contractor receives a claim that he considers to be in respect of matters in which he is indemnified by the Employer under the Contract, he shall immediately pass such claim to the Employer.

1.12 RIGHT-OF-WAY

The right-of-way, easements (if required), and land for the improvement will be provided by the Employer. The Contractor shall at his own cost obtain consent from the property owners and shall make his own arrangements and pay all expenses for the area, access, way-leaves, etc. required by him to perform the work outside of the area, access, way-leaves, etc. provided by the Employer.

1.13 WORK SITE MAINTENANCE

1.13.1 Access to Property Adjacent to Works

Convenience of abutting owners along streets shall be provided for as far as possible. Convenient access to driveways, houses and buildings adjoining the work shall be maintained and temporary approaches to intersecting streets and alleys shall be provided and kept in good condition. When a section of surfacing, pavement, or a structure has been completed, it shall be opened for use by traffic at the request of the Engineer.

1.13.2 Water Hydrants and Utility Valves

The Contractor shall not prevent the free access to water valves, water hydrants or utility valves by the relevant authorities. Access to all fire hydrants within the areas of work must be available throughout the entire period of work for the Fire Department.

The right is reserved to the Employer, to governmental agencies, and to owners of public utilities to enter upon any street, alley, right-of-way, or easement for the purpose of maintaining or of making necessary repairs or change in property made necessary by the work.

1.13.3 Rights of Access

The Contractor shall at all times provide proper facilities for access and inspection of the work by the Engineer, his assistants, inspectors, agents and representatives of public agencies having jurisdiction.

1.14 PROTECTION OF PROPERTY AND UTILITIES

1.14.1 Protection of Property

The Contractor shall conduct his operations in such a manner as to avoid injury or damage to adjacent property, improvements, or facilities. Buildings, trees, ground cover, and shrubbery that are not designated for removal, pole lines, fences, guard rail, guide posts, culvert and property markers, signs, structures, conduits, pipelines, and other improvements within or adjacent to the street or right-of-way shall be protected from injury or damage. The Contractor shall provide and install suitable safeguards to protect such objects from injury or damage, which objects if injured or damaged, by reason of the Contractor's operations, shall be replaced or restored to a condition as good as when entered upon the work, or as required by the Specification. The Contractor shall not disturb any monuments, property corners or survey markers without permission from the Engineer, and he shall bear the expense or resetting any monuments, property corners or survey markers that may be disturbed.

The Contractor shall be responsible for all damage to streets, utilities, roads, highways, ditches, embankments, bridges, culverts or other public or private property, which may be caused by transporting equipment, materials, or men to or from the work. The Contractor shall make satisfactory and acceptable

arrangements with the property owner over the damaged property concerning its repair or replacement.

1.14.2 Protection of Utilities and Substructures

The Contractor shall be responsible to check the location of utilities, if any which exist within the limits of work. The Contractor will also mark all such utilities and sub-structures on the Drawings for further reference and record.

1.14.3 Liaison with Utility Owners

It shall be the responsibility of the Contractor, before commencing any excavation, to contact all possible owners of utilities within the work area and to ascertain from records or otherwise, the existence, position and ownership of all utilities, utility structures and service connections. No error or omission regarding said utilities shall be construed to relieve the Contractor from his responsibility in protecting all such facilities.

1.14.4 Maintenance and Repair

Unless otherwise indicated on the Drawings or in this Specification, all water, gas and oil lines, lighting, power, telephone or radio cables and conduits, sewer lines, house connection lines, and other subsurface structures of any nature along the work shall be maintained by the Contractor at his own expense and shall not be disturbed, disconnected, or damaged by him during the progress of the work. Should the Contractor in the performance of the work disturb, disconnect, or damage any of the above, all expenses of whatever nature arising from such disturbance, or the replacement or repair thereof, shall be borne by the Contractor.

1.14.5 Sewers

The Contractor shall not disturb any existing sanitary facilities. Unless otherwise indicated on the Drawings, all sanitary facilities shall be maintained by the Contractor and shall not be disturbed or disconnected by him. The Contractor shall install temporary pipes of adequate size to carry off sewage from any sewer facilities cut off by construction work. Connections to temporary pipes shall be made immediately by the Contractor upon cutting of the existing facility. No sewage shall be allowed to flow from any severed facility upon the ground surface or in the trench excavation. Pipe used in temporary sewers may be clay, metal, concrete or of other composition. Upon completion of work the Contractor shall replace all severed connections and restore to operating order the existing sanitary facilities.

1.14.6 Water Service

No valve or other control of the water system shall be operated by the Contractor without approval of the Sohar Development Office Water Department and the Engineer and all customers affected by such operation shall be notified by the Contractor at least one hour before the operation and advised of the probable time when service will be restored. The Contractor shall not draw any water from a fire hydrant for use on the work, without first obtaining permission from the Sohar Development Office Water Department.

1.14.7 Temporary Maintenance or Relocation

In case it should be necessary to move or temporarily maintain the property of any public utility or other party, the cost of which for any reason must be borne by the employer, the employer will, upon proper application by the Contractor, be notified by the Engineer to move or temporarily maintain such property within a specified reasonable time, and the Contractor shall not interfere with said property until after the expiration of the time specified. The cost of permanent relocation of utilities, if required, will be borne by the Employer. However, the cost of moving services to provide working space for the Contractor shall be borne by the Contractor. The permanent relocation of all utilities will be done by the respective Owners.

1.14.8 Changes

The Employer reserves the right during the progress of the work, upon determination of the actual position of the existing utilities, and utility structures, to make changes in the grade or alignment of the pipelines, wherever by so doing, the necessity for relocation of utility or structure will be avoided. Such changes will be ordered in writing by the Engineer.

1.14.9 Lighting, Watchmen and Signposting

The Contractor shall supply free of charge all requisite plant for the proper execution of the work including scaffolding, tackle, machinery, pumps, tools, barricades, lights or other appliances and everything necessary for the use of his workmen, together with the carriage thereof to the spot where required and for their erection, operation and subsequent removal. The Contractor shall be responsible for the adequate protection of the Works and shall provide, free of charge, all necessary footways, etc., necessary for the passage of pedestrian traffic to all buildings bounding the sites of the works. The Contractor shall provide and maintain all necessary hoardings, traffic barriers, lights and all other requirements to the satisfaction of the Engineer and the Police Authorities. In the event that the Contractor fails to provide adequate watching and lighting as described above, the Engineer shall inform the Contractor as to the additional barricading, the supply of an adequate number of warning lanterns and other necessary signs that the Engineer deems necessary under the circumstances and the Contractor shall immediately provide and maintain such at his own expenses. Full-time night watchmen shall be engaged. If by neglect or omission the Contractor shall fail to provide adequate hoarding, barricading, lighting or signposting, or the services of watchmen, the Employer reserves the right to enter upon the sites of the works and to provide any or all of the services required under this Clause without prior notice to the Contractor and deduct the cost thereof together with overhead expenses, if any, from monies due to him under this Contract. At each point where work is being carried out on a roadway or in any other place open to the public, the Contractor shall provide at his own expense temporary signs in accordance with the requirements of the local authorities and the Police Authorities. Any temporary signs of sizes and to legend as approved or as directed by the Engineer shall be provided. Every sign placed on a site shall be illuminated at night by one or more lanterns as directed and the provision of such lanterns shall be deemed to be part of the illumination as required above. The Contractor should make his own arrangements for the purchase or fabrication of any signs or notices required under this Clause and the Engineer may assist the Contractor in making any such arrangements or may,

alternatively, and with the approval of the Contractor supply the Contractor with any signs necessary and deduct the cost thereof from any Payments due to the Contractor. The Contractor will not be permitted to commence work under any circumstances until the Engineer is satisfied that an adequate number of barricades, lanterns, signs and notices as described herein of this Specification have been provided and are stored, ready for use, on the site of the works.

1.15 SUPERINTENDENCY AND LABOR COMPETENCY

1.15.1 Authorized Representative

Whenever the Contractor is not present on any part of the work, orders given by the Engineer shall be received and obeyed by the superintendent or foreman as authorized representative who may be in charge of work. Any order given by the Engineer, not otherwise required to be in writing by the Specification, will on request of the Contractor, be given or confirmed in writing. An authorized representative of the Contractor shall be at the site of the work during working hours.

1.15.2 Declaration Against Waiver

The condonation by the Employer or the Engineer of any breach or breaches by the Contractor or an authorized Sub-Contractor of any of the stipulations and conditions contained in the Contract shall in no way prejudice or affect or be construed as a waiver of the Employer's rights or powers and remedies under the Contract in respect of any other breach or breaches as aforesaid.

1.16 AMENITIES TO BE PRESERVED

The Contractor shall cause the least possible interference with existing amenities, whether natural or man-made. No trees shall be felled except on the instructions of the Engineer and approval of the relevant authority. Clearance of the Site shall generally be kept to the minimum necessary for the Works and Temporary Works.

The Contractor shall during the progress of construction, take proper precautions to prevent damage to trees, plants, and shrubs. The piling of excavated material, equipment, construction materials, or anything else on top of branches or against tree trunks will not be permitted.

1.17 WORKS TO BE KEPT CLEAR OF WATER

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 as is practicable all work is carried out in the dry. 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 dewatering that may be necessary to exclude water from the Works while construction is in progress. Such temporary works shall not be removed without the approval of the Engineer. The Contractor is to take all necessary precautions to avoid flotation of any partially completed structure. Notwithstanding 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 Works safe at all times, particularly

during any floods, and for making good at his own expense any damage to the Works including any that may be attributable to floods.

1.18 DISCHARGE OF WATER INTO WATERCOURSES, ETC.

The Contractor shall make provision for the discharge or disposal from the Works and Temporary Works of all water and waste products howsoever arising, and the methods of disposal shall be to the satisfaction of the Engineer and of any Authority or person having an interest in any pond or watercourse over or in which water and waste products may be so discharged. The requirements of this Clause shall not limit any of the Contractor's obligations or liabilities, particularly as to the Clause relating to Damage to Persons and Property of the Conditions of Contract.

1.19 TEMPORARY FENCING

The Contractor shall erect, maintain, and remove suitable and approved temporary fencing to enclose such areas of the Works and all areas of land occupied by the Contractor within the Site as may be necessary to implement his obligations under Clauses of the Conditions of Contract pertaining to Care of Works and Damage to Person and Property, to the satisfaction of the Engineer. Where any temporary fencing has to be erected alongside a public road, footpath, etc., it shall be of the type required by and shall be erected to the satisfaction of the Authority concerned.

1.20 TEMPORARY WORKS

Within a reasonable time (and in any case not less than 21 days) before he intends to commence construction of any of the Temporary Works, the Contractor shall submit full particulars, including drawings, of the same for the information of the Engineer. The submission to the Engineer of any such particulars shall not relieve the Contractor of his responsibility for the sufficiency of the Temporary Works or of his other duties and responsibilities under the Contract. The Contractor shall make safe and reinstate all areas affected by Temporary Works.

1.21 CONSTRUCTION FACILITIES

1.21.1 Water Supply

All water shall be of drinking water quality. The Contractor shall provide suitable supplies of water for drinking, washing, sanitation, and general cleaning down in addition to that required for construction and testing of the Works. The Contractor shall make his own arrangements for supply of water. Where a piped supply is not available, the Contractor shall arrange for bulk supplies of water to the site and shall ensure that a sufficient quantity is available for continuous working.

1.21.2 Electricity Supplies

The Contractor shall make all arrangements for the supply, installation, operation, maintenance, and subsequent removal of temporary supplies of electricity for the heating, lighting and ventilation of all offices, stores, laboratories, housing, and other temporary buildings used by him and by the Engineer in addition to any supplies he may require in connection with the construction of the Works. The

Employer will, however, be responsible for the provision of permanent power to the sites.

1.21.3 Telephone

In addition to any telephone facilities which the Contractor may install in connection with the work, a separate line and system shall be provided for use of the Engineer or his representatives without charge, except that international call charges incurred by the Engineer shall be paid by the Engineer.

1.21.4 Storage

The Contractor shall be responsible for the storage of all materials, equipment and so on, which are used in the Work. All materials, equipment and articles at the site shall be adequately housed by the Contractor or otherwise protected by him against deterioration and damage. If any materials stored at the site or any partially completed structures are not adequately protected by the Contractor, the materials or the partially completed structures may be kept protected by the Employer at the expense of the Contractor. All costs incurred through the failure to provide protection shall be borne by the Contractor during the course of the Work.

1.21.5 Transportation Facilities

The Contractor make all arrangements necessary for the delivery of materials to be used on the work. The Contractor shall make his own investigation on the conditions of available public roads, access rights-of-way, and of restrictions, bridge load limits and other limitations affecting transportation and ingress and egress at the site of work.

1.21.6 Dust Control

The Contractor shall conduct his operations and activities in such a manner that no operation shall be conducted which will emit into the atmosphere any flying dust or dirt which might constitute a nuisance.

1.21.7 Sanitation

The Contractor shall maintain the Site and all working areas in a sanitary condition and in all matters of health and sanitation shall comply with the requirements of the local Medical Officer of Health or other competent authority.

1.21.8 Mosquitoes

No empty containers or other receptacles capable of collecting water and forming breeding places for mosquitoes are to be left in the open and the Contractor is responsible during the course of the work for all measures necessary to prevent the breeding of mosquitoes on the sites of the work.

1.21.9 Safety Measures and Public Convenience

The Contractor shall provide for the protection of all persons and property at all times. The Contractor shall comply with the recommendations for safe construction methods from the "Manual of Accident Prevention in Construction",

published by the Associated General Contractors of America, Inc., to the extent that such provisions do not conflict with the applicable local laws. Machinery and equipment shall be guarded in accordance with the requirements of the above-mentioned manual, to the extent what such provisions do not conflict with the applicable local laws. The Contractor shall take all necessary measures to protect the work and prevent accidents during the construction. He shall provide and maintain sufficient night lights, barricades, guards, temporary footpaths, temporary bridges, danger signals, watchmen and necessary appliances and safeguards to properly safeguard life and property. He shall also protect all excavations, equipment and materials with barricades and danger signals so that the public will not be endangered.

1.21.10 Inconvenience

The Contractor shall so conduct his operations as to offer the least possible obstruction and inconvenience to traffic, and he shall have under construction no greater amount of work than he can handle properly with due regard for the rights of the public. Where existing streets are not available as detours, all traffic shall be permitted to pass through the work with as little delay and inconvenience as possible, unless otherwise authorized by the Engineer.

1.21.11 Nuisance

The Contractor shall take all necessary precautions to prevent any nuisance or inconvenience to the owners, tenants or occupiers of adjacent properties and to the public generally and shall at all times keep the roads and paths contiguous to the Works in a safe and passable state.

1.21.12 Trespass

The Contractor shall be responsible for all damage or injury which may be caused on any property by trespass by Contractor or his employees in the course of their employment, whether the said trespass was committed with or without the consent or knowledge of the Contractor.

1.21.13 Representatives for Emergencies

The Contractor shall file with the Engineer, the names, addresses, and telephone numbers of representatives who can be contacted, at any time, in case of emergency. These representatives must be fully authorized and equipped to correct unsafe or excessively inconvenient conditions on short notice.

1.21.14 Contractor's Offices, etc.

The Contractor shall provide, erect, construct, maintain and subsequently remove all temporary offices, sanitary conveniences, stores, workshops, compounds, parking areas and the like necessary for the completion and maintenance of the Works and the siting and layout of these shall be made with the general approval of the Engineer. The Contractor shall pay all fees required by law to the relevant authorities. The Contractor shall also provide, maintain and subsequently remove temporary services for water supply, drainage, lighting and heating, roads, paths, parking place and refuse disposal.

1.21.15 Engineer's Office

This Clause contains a description and the Specification for the Engineer's Site Office Facilities to be provided by the Contractor for use by the Engineer and shall include, but not by way of limitation, the providing, constructing, furnishing, equipping, supplying, maintaining and removing upon completion of Contract by the Contractor of such facilities as specified herein.

The facilities shall be located on Site and in accordance with the requirements of the town planning and building regulating agencies, the Technical Specification, and as approved by the Engineer.

The facilities shall be provided with electric services of lighting and power, water service and two telephone lines for the exclusive use of the Engineer. One line shall be equipped with a facsimile machine. The facilities shall be provided with two toilet/washrooms, kitchen and shall be completely equipped with desks, chairs, drafting boards, stools, files, plan racks, storage cabinets, tables, bookshelves, bulletin boards, drinking water, lighting and other furnishings as directed by the Engineer. The facilities shall be fully air-conditioned. The Contractor shall be responsible for any site grading required for the Engineer's Site Office facilities including access to the project by means of all weather roads and for a covered parking area for at least four vehicles adjacent to the facilities. The Contractor shall provide security for the facilities during off-duty hours and such security shall be subject to the approval of the Engineer. The Contractor shall be responsible for all telephone and facsimile charges for calls within Oman.

The Contractor shall provide maintenance of the facilities which shall include, but not by way of limitation, continual maintenance of the mechanical, air conditioning, heating, electrical and plumbing systems; providing potable drinking water and toilet supplies; disposal of all waste; maintenance of interior and exterior of building, grounds and paved areas, and including any minor repairs thereto. Maintenance shall also include providing water, electricity and telephone service and any other maintenance or services as specified herein or as further directed by the Engineer.

All Engineer's Site Office facilities, furnishings, equipment, and related items, supplied by the Contractor for the Engineer and his representatives shall be considered as an integral part of the Works. All furnishing, equipment and related items shall be new.

Upon completion of all construction, the facilities shall be removed from the Site and disposed of by the Contractor.

All wastewater and sewage lines shall be connected to existing underground sewers and as approved by the Employer and the Engineer. Where existing underground sanitary sewers are not available and when approved by the Engineer, the Contractor shall provide a disposal system as approved by the Sohar Development Office and the Engineer.

The Contractor shall be responsible for and pay all charges, fees, or other expenses for providing and maintaining electric service, water service, telephone service in accordance with Omantel billing practices or other utilities until the completion of Contract.

The Engineer's Site Office Facilities shall be new and shall provide a minimum of 50 sq m of working area. The space shall be subdivided with full height permanent walls and doors as directed by the Engineer.

The building shall be provided with all weather access and connected to suitably covered and paved vehicular parking space for not less than four vehicles.

The Contractor shall furnish and install the following new furniture in the Engineer's Site Office Facilities:

Item	Quantity
• Desk, double pedestal 800 mm x 2000 mm	3
• Chairs, swivel	3
• Chairs, with arms	4
• Inclined plan table for drawings	2
• Magnetic white board	1
• Digital camera, minimum 3.2 megapixels, true optical zoom 3x, autofocus with 30-140 range lens and date imprint facility	1
• Table, conference with chairs 1200 mm x 1800 mm	1
• Table, reference with chairs 900 mm x 2400 mm	1
• File cabinet, 4 drawer, legal size with lock	2
• Steel drawing file cabinets capable of storing a minimum of 1,000 A1 size drawings in a hanging position	1
• Storage cabinet 600 mm deep by 900 mm by 2000 mm high with lock	1
• Bulletin board 1200 mm x 2000 mm	1
• Shelving	15 m
• Bookcase, 6 shelved with glass hinged double doors	1
• Fire extinguishers to ROP approval, powder type 1 kg capacity	2
• Plastic waste baskets	3
• First Aid Kit	2
• Refrigerator minimum 0.28 cu m	1
• Photocopier up to A3 size having a minimum speed of 23 copies/min (A4) and facilities for duplexing dual copying, quadruple zooming, page by page copying, image shift, frame and punch hole erase, built in editing and 20 Bin sorter.	1
• Calculator with paper printout	1
• Combination binding machine	1
• Facsimile Machine (Plain paper)	1
• IBM Compatible PC with minimum Pentium 4 Intel processor, minimum 40GB Hard Disk, 520 MB RAM complete with telephone/fax modem, super VGA 17 inch color monitor, Latest licensed Windows XP Professional operating system, Latest licensed Windows Office Professional, Latest licensed MS Project, and licensed Autocad 2004; Laser printer of 20 page/minute with 2 MB buffer, including all accessories and integral Scanner.	1
• Any other item reasonably necessary to the use of the facilities.	As needed

The Contractor shall provide protective clothing as required for the use of the Engineer and his staff and visitors to the Site.

The Engineer's site office shall be completely detached from the Contractor's own office. The offices, including furniture and equipment will be returned to the Contractor upon the satisfactory completion of the work.

1.21.16 Survey Equipment

The Contractor shall provide and maintain in good condition at all times, the following new survey equipment and materials during the continuance of the contract. The Engineer and his staff shall be permitted to use this equipment when required:

Item	Quantity
• Electronic distance meter Wild D14, or approved equal, with 1 second theodolite, 3 target reflectors with a minimum range of 1 km, plumbing poles and tripods, carrying case tribacks, and all necessary accessories	1
• Self-level, Zeiss No.II or approved equal, with upright image and with tripod, carrying case and all necessary accessories	2
• Levelling staff, engine divided 4 m long folding, including staff level	3
• Staff leveling plate	3
• Steel tape, 50 m length non-corrosive	4
• Steel tape, 25 m length non-corrosive	4
• Steel tape, 5 m length non-corrosive	6
• Ranging rod, 3 m length	10
• Conical plummet	1
• Steel straight edge, 1 m length	1
• Spirit level, 1 m length	1
• Spirit level 400 m length	1
• Mason string line, 50 m length	3
• Concrete thermometer	2
• Hammer, 3 kg, weight	2
• Shovel	1
• Flask, with thermal insulation, 1 litre capacity	2
• Water containers, 5 litre capacity	2
• Thermometer, wet and dry bulbs, graduated in degrees C and degrees F	1
• Sand replacement soil density equipment comprising:	
- Standard equipment for in situ dry density testing of compacted fill materials.	1
- Approved rapid moisture content apparatus and	1
- Equipment for determination of optimum moisture content	1
• Optical square	1
• Cloth tape, 30 m length with case	1
• Survey stakes, metal pins	As required

On the satisfactory completion of the work, all survey equipment will revert to the Contractor.

1.21.17 Engineer's Accommodation and Vehicles

The Contractor shall provide, maintain and provide any minor repairs for fully air-

conditioned, fully furnished accommodation to best European standards to the approval of the Engineer and for the sole use of his staff and their families. The accommodation shall be a minimum of one 4-Bedroom Villa, one 3-Bedroom Villa and one 2-Bedroom Villa. Fully furnished accommodation includes all furnishings, linen, household equipment and all related items. The accommodation shall be at a location to the approval of the Engineer. Each accommodation shall be not more than five years old. All furnishings, linen, equipment and related items shall be new. Each accommodation shall have covered parking area for at least three vehicles adjacent to the facilities for sole use of the facilities. The Contractor shall be responsible for all fixed and mobile telephone and facsimile installation and rental charges and for all calls within Oman, and for all charges for other utilities and services including piped water, electricity, drinking water, and toilet supplies. Six new mobile phones shall be provided.

The Contractor shall provide, maintain and provide any repairs for three vehicles for sole use of the Engineer's staff. At a minimum, one vehicle shall be a sedan (at least 2000 cc) and the others shall be two 4-wheel drive vehicles (at least 2000 cc). All vehicles shall be new. The Contractor shall pay for all operating costs of the vehicles.

The accommodation and the vehicles shall revert to the Contractor at the end of the maintenance period.

1.21.18 Assistance to be Provided

The Contractor shall provide every assistance to the Engineer and his staff in carrying out their duties and shall provide soils testing equipment and a sufficient supply of pegs, poles, paint, lines, spirit levels and other materials and small tools for checking the setting out and for measurement of work.

The Contractor shall also provide for the Engineer and his staff such waterproof clothing, safety helmets, rubber boots, torches and the like as may reasonably be required by them. These articles shall remain the property of the Contractor.

1.22 MATERIALS GENERALLY

1.22.1 Definition

The terms "materials" and "goods" shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.

1.22.2 New Materials

All materials shall be suitable for climatic and environmental conditions prevailing on site, new and of the kinds and qualities described in the Contract. It shall be to the satisfaction of the Engineer that the material offered is equal or superior to the material specified for the use to which it is to be put and the Contractor has obtained from the Engineer approval in writing to its use. Where materials to be used for any component have not been laid down in the Specification, the Contractor shall use only those materials in such compositions as have been proved in actual service to be the most suitable for the particular purpose.

All materials shall be imported in the name of the Employer and originals of all test certificates including the guarantees and warranties with the Employer named as the beneficiary shall be submitted to the Engineer at the time of delivery of all such materials to site.

1.22.3 Schedule of Manufacturers and Suppliers

The Contractor shall submit to the Engineer with his Tender a schedule of proposed manufacturers and suppliers of materials and items to be used in the Contract. The acceptance of the tender does not necessarily imply approval by the Engineer of the manufacturers and suppliers submitted by the Contractor. In the event of the Engineer not approving during the contract any manufacturer or supplier submitted by the successful Contractor in his Tender, the Contractor shall be responsible for submitting alternatives for the Engineer's approval. No extra cost or extension of time will be permitted in the event of the alternative being approved.

1.22.4 Approval

The Contractor shall not place any order for materials without the approval of the Engineer, which maybe withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Engineer informed of orders for and delivery date of all materials.

1.22.5 Brand Names

Brand names where used herein are merely to describe the nature of the desired equipment and not used to endorse or indicate a preference for a particular product or manufacturer. Goods that have similar characteristics and provide performance and quality equal or superior to those of the specified brands are acceptable; however, they still require the approval of the Engineer.

1.23 EQUIPMENT

1.23.1 Standardizing of Equipment

To the extent possible, equipment to be supplied and installed by the Contractor under this contract is to be standardized both as to type and to supplier.

1.23.2 Spare Parts

The Contractor is to supply as a part of the Contract all spares listed in the Contract Documents. In addition to any spares which, in accordance with the Specification are to be supplied, the Contractor shall submit with his tender a list of spares as recommended by the respective manufacturers which would be required for operating the equipment for a period of 2 years. Each item in the list shall be priced and the Employer retains the option of purchasing a part or all or none of the spares thus recommended by the Contractor.

1.24 TESTING AND REJECTION

For testing of materials, etc., the Contractor shall have the following options:

a) The Contractor may set up a laboratory on site. It shall be staffed by the Contractor and supervised by the Engineer. The Engineer will check and approve the laboratory prior to any testing being carried out. The Contractor shall supply an Operations Manual for the laboratory for approval, prior to commencing testing. The Engineer may carry out random, unannounced spot checks on the laboratory to check quality

assurance. The Contractor shall arrange for any re-tests required due to failures during quality assurance checks.

b) The Contractor may use the services of an approved independent laboratory.

The following is the schedule of minimum requirements governing tests of materials which shall be carried out during the execution of the Works:

• Granular Gradation	AASHTO T88
• Field density	AASHTO T191
• Field C.B.R. with a speedy estimate for moisture content and dry unit weight	ASTM D 4429
• One set of at least 6 cubes (or 4 cylinders) shall be obtained from each 75 m^3 or fraction thereof placed in each day or class of concrete.	BS 1881
• Slump tests and compaction factor tests shall be carried out at the site of the actual placing of concrete as directed by the Engineer	
• Preparation of concrete specimens & curing of specimens	BS 1881 ASTM C192 AASHTO T126

Should the Engineer deem it necessary to increase or reduce the number of the above mentioned tests, he will issue his written instructions to the Contractor as and when required.

1.24.1 Operational and Field Testing

After all construction is complete and before acceptance, the Contractor shall perform field tests as called for in the Specification. The Contractor shall demonstrate to the Engineer the operation of the facilities for proper sequence of operation and satisfactory performance of the individual components. Any improper operation of the system or any improper, neglected or faulty construction shall be repaired or corrected to the satisfaction of the Engineer. The Contractor shall make such changes, adjustments or replacement of equipment as may be required to make same comply with the Specification, or replace any defective parts or material.

1.24.2 Tests and Samples

Pursuant to the Conditions of Contract the Contractor shall submit samples of such materials as may be required by the Engineer and shall carry out the specified tests directed by the Engineer at the Site, at the supplier's premises or

at a laboratory approved by the Engineer. The cost of transportation of personnel and test samples shall be borne by the Contractor. Test results may only be collected by a representative of the Engineer or by an approved representative of the Contractor.

Materials requiring testing shall be furnished in sufficient time before intended use so as to allow for testing. No materials represented by tests may be used prior to receipt of written approval of said materials. Samples that are of value after testing shall remain the property of the Contractor.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer from material to be used in the project and all tests will be under the supervision of, and directly by, and at such points as may be convenient to the Engineer.

The Contractor shall give the Engineer at least 14 days notice in writing of the date on which any of the materials will be ready for testing or inspection at the supplier's premises or at a laboratory approved by the Engineer and unless the Engineer shall attend at the appointed place within said 14 days the test may proceed in his absence. Provided that the Contractor shall in any case submit to the Engineer within seven days of every test such number of certified copies (not exceeding six) of the test readings as the Engineer may required.

Approval by the Engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer's powers under the Contract.

The provision of this Clause shall also apply to materials supplied under any subcontract.

1.24.3 Defective Work or Materials

The inspection of the work shall not relieve the Contractor of any of his obligations to fulfil his contract, and defective or damaged work shall be made good, and unsuitable materials may be rejected, notwithstanding that such work and materials have been previously overlooked by the Engineer and accepted. If the work, or any part thereof, shall be found defective at any time before the final acceptance of the whole work, the Contractor shall forthwith make good such defect, without additional compensation, in a manner satisfactory to the Engineer. Should it be considered necessary or advisable for the Engineer at any time before final acceptance of the work to make an examination of work already completed by removing or exposing the work, the Contractor shall on request promptly furnish all necessary facilities, labour and materials. If such work is found to be defective in any respect due to fault of the Contractor or any of his subcontractors, he shall defray all the expenses of such examinations and of satisfactory reconstruction. If however, such work is found to meet the requirements of this Contract, the additional cost of labour and material necessarily involved in the examination and replacement shall be allowed the Contractor. All costs for re-testing and re-inspection which are necessary by defective materials and/or workmanship shall be at the sole expense of the Contractor.

1.24.4 Equipment Performance

At the time of testing, failure of the equipment to perform at the specified level will be the responsibility of the Contractor. The Employer reserves the right to not accept such equipment and to withhold retention money and to make claims on the Performance Bond in the event of failure of equipment to meet the specified performance.

1.25 DRAWINGS AND DATA TO BE FURNISHED BY THE CONTRACTOR

1.25.1 General

From the set of reproducible Contract Drawings provided under the Contract, the Contractor shall print and distribute the following minimum number of prints of full size and A3 Drawings at the commencement of the contract:

	Full Size	A3 Size
Employer	3 sets	3 sets
Engineer	3 sets	3 sets

The Contractor shall submit to the Engineer for his review and approval all drawings and data as called for in the Specifications, including but not limited to, reinforcing steel placement and bending diagrams, shop drawings for structural steel and miscellaneous iron work, architectural items, shop drawings for mechanical, electrical, instrumentation and control work, samples, materials lists, equipment data, instruction manuals, record documents, manufacturer's equipment manuals and other submittals required by the Specifications, or subsequently as covered by variations. Those covering the several related items of equipment in an integrated system, shall be submitted concurrently in order that the system can be reviewed by the Engineer. Submittals and their contents shall be properly prepared, identified, and transmitted as provided in the Specification or as the Engineer may otherwise direct. Except for record documents and instructional manuals for operation and maintenance, submittals shall be approved by the Engineer before the materials or equipment covered by the submittals are shipped out in the case of foreign supplies and delivered to site in the case of local supplies.

The Contractor shall be responsible for and shall pay the extra cost, if any, occasioned by any discrepancies, errors or omissions in the drawings and other particulars supplied by him, whether they have been approved by the Engineer or not.

1.25.2 Schedule of Submittals

The Contractor shall submit a list of all submittals showing the forecast date for submission of each item at the commencement of the Contract.

Drawings and data shall be submitted to meet the time schedules stipulated in these Specifications and where such time schedules are not specified, to meet the requirements of the approved program. Unless specified otherwise, the Contractor shall allow not less than 15 days for the review of submittals by the Engineer, not including the time necessary for delivery or mailing. Extension of time will not be granted because of the Contractor's failure to make timely and

correctly prepared and presented submittals with allowance for the checking and review periods.

1.25.3 Method of Submittals

The Contractor shall deliver submittals by means of dated, signed, and sequence numbered transmittals on the Contractor's letterhead, identifying as to initial or resubmittal status, and fully describing the submittal contents. Submittals are not acceptable directly from Sub-Contractors, suppliers, or manufacturers. In each transmittal the Contractor shall state the Drawing numbers and Specification Clauses, Articles, and paragraphs to which the submittal pertains; accompanying data sheets, appropriate standards and codes of practice, catalogues, and brochures shall be identified in the same manner, and where several types or models are contained the Contractor shall delete non-applicable portions or specifically indicate which portions are intended and applicable.

1.25.4 Contractor's Review and Approval

Every submittal of shop drawings, samples, materials lists, equipment data, instruction manuals, and other submittals upon which the proper execution of the Work is dependent shall bear the Contractor's review and approval stamp certifying that the Contractor:

a) has reviewed, checked, and approved the submittal and has coordinated the contents with the requirements of the Work and the Contract Documents including related Work,

b) has determined and verified all quantities, field measurements, field construction criteria, materials, equipment, catalogue numbers, and similar data, or will do so, and

c) states the Work covered by the submittal is recommended by the Contractor and the Contractor's guarantee will fully apply thereto.

The Contractor's stamp shall be dated and signed by the Contractor in every case. It is expected that the Contractor will prepare his submittals in such a manner that he is able to obtain a submittal approval by not more than the second submission. **The Employer reserves the right to deduct monies from the amounts due to the Contractor to cover the cost of the Engineer's review time beyond the first re-submission.**

1.25.5 Corrections and Resubmittals

The Contractor shall make all required corrections and shall resubmit the required number of corrected submittals until approved. The Contractor shall direct specific attention in writing to revisions other than the corrections called for on previous submittals. He shall identify each resubmittal with number of the original submittal followed by consecutive letters starting with "A" for first resubmittal, "B" for second resubmittal, etc.

1.25.6 Check of Returned Submittals

The Contractor shall check submittals returned to him for correction and ascertain if the corrections result in extra cost to him above that included under the

Contract Documents, and shall give written notice to the Engineer within five days if, in his opinion, such extra cost results from corrections. By failing to so notify the Engineer or by starting any Work covered by a submittal, the Contractor waives all claims for extra costs resulting from required corrections.

1.25.7 Review and Approval

Submittals will be reviewed only for conformance with the design concept of the Project and with information given in the Contract Documents. The approval of a separate item as such will not indicate approval of the assembly in which the item functions. The approval of submittals shall not relieve the Contractor of his responsibility for any deviation from the requirements of the Contract Documents or for any revision in resubmittals unless the Contractor has given notice in writing of the deviation or revision at the time of submission or resubmission and written approval has been given to the specific deviation or revision, nor shall any approval by the Engineer relieve the responsibility of Contractor for errors or omissions in the submittals or for the accuracy of dimensions and quantities, the adequacy of connections, and the proper and acceptable fitting, execution, and completion of the work.

All expenses resulting from any error or omission in or from delay resulting in returned submittal or resubmittal shall be borne by the Contractor.

1.25.8 Incomplete Submittals

Submittals which are incomplete, including those not correctly transmitted, not correctly titled and identified, or not bearing the Contractor's review and approval stamp, may be returned to the Contractor without review.

1.25.9 Conformance

No Work represented by required submittals shall be purchased or commenced until the applicable submittal has been approved. Work shall conform to the approved submittals and all other requirements of the Contract Documents unless subsequently revised by an appropriate variation order, in which case the Contractor shall prepare and submit revised submittals as may be required. The Contractor shall not proceed with any related Work which may be affected by the Work covered under submittals until the applicable submittals have been approved, particularly where piping, machinery, and equipment and the required arrangements and clearances are involved.

1.25.10 Interrelated Submittals

Except where the preparation of a submittal is dependent upon the approval of a prior submittal, all submittals pertaining to the same class or portion of the Work shall be submitted simultaneously.

1.25.11 Shop Drawings

Each submittal shall be complete with respect to dimensions, design criteria, materials, connections, bases, foundations, anchors, and the like, and shall be accompanied by technical and performance data as necessary to fully illustrate the information in the shop drawings. Unless otherwise specified, each submittal

shall include six sets of copies. Three sets of copies will be returned to the Contractor marked to show the required corrections or approval.

1.25.12 Samples

Unless otherwise specified, each submittal shall include two sets of samples. One set of approved samples and all disapproved samples will be returned to the Contractor. Samples of value retained by the Employer will be returned to the Contractor after completion of the Work if the Contractor's first transmittal for the sample requests its return. Approved samples of manufacture items returned to the Contractor may be installed in the Work if the locations are recorded and the samples bear temporary identification as such.

1.25.13 Material Lists

Submittal copies shall be neatly bound and shall have an index listing the contents. For each item listed, the Contractor shall include the manufacturer's name and address, trade or brand name, local supplier's name and address, appropriate standards and codes of practice, catalogue numbers and cuts, brochures, terms and conditions of manufacturer's guarantee and warranty, other information to fully describe the item, and supplementary information as may be required for approval. Cuts, brochures, and data shall be marked to indicate the items proposed and the intended use. Unless otherwise specified, each submittal shall include six bound copies, three of which will be returned to the Contractor marked to show the required corrections or approval.

1.25.14 Equipment Data

The Contractor shall submit complete technical and catalogue data for every item of mechanical and electrical equipment and machinery to be incorporated in the Work, including components as specified under sections dealing with mechanical and electric equipment.

1.25.15 Instruction Manuals

The Contractor shall submit four sets of operation, maintenance and instruction manuals covering all mechanical and electrical equipment and machinery installed in the Work as specified under sections dealing with mechanical and electrical work.

1.25.16 Record Drawings and Specifications

The Contractor shall maintain one record copy of all Drawings, Specifications, Addenda, variations, approved submittals, correspondence, and transmittals at the site in good order and readily available to the Employer and the Engineer. The Record Drawings shall be clearly and correctly marked and the Record Specification annotated by the Contractor to show all changes made during the construction process at the time the changed Work is installed. No such changes shall be made in the Work unless previously authorized by a variation order or by specific approval of deviations or revisions in submittals.

The Contractor shall prepare and furnish to the Engineer accurate "As-Built" record drawings in digitized format (DWG, DGN, or DXF), as directed by the Engineer. The drawings shall be compatible with the GIS system adopted by

Sohar Development Office and shall be supplemented as necessary by schedules and data sheets indicating quantity and types of materials installed, and the manufacturers of valves, meters and hydrants. The Contractor shall coordinate with the GIS Section of the Sohar Development Office and submit sample digitized "As-Built" record drawings to the GIS Section of the Sohar Development Office for written approval, prior to preparing all of the "As-Built" record drawings. In addition, draft "As-Built" record drawings shall be submitted to the Engineer for his approval, and then finalized in accordance with any amendments required by him.

No release of retention monies will be made until all "As-Built" record drawings have been received and approved by the Engineer. The Works shall not be considered to be completed for the purposes of Clause 48 of the Conditions of Contract until all approved "As-Built" record drawings have been supplied to the Employer.

Computer files containing AutoCAD drawings shall be maintained as seamless drawings.

The record drawings shall show the works as executed complete with existing and finished levels, dimensions, reinforcing details, details of supports left in place and locations of all services encountered. For mechanical and electrical equipment the details shall include the whole plant as erected and described in the Specifications. For other works the drawings shall include, but not be limited to:

- Existing and finished levels
- UTM coordinates
- Profiles of all pipelines
- Dimensions
- Reinforcing steel details
- Details of supports left in place
- Locations of all services and underground utilities encountered
- Locations of all structures including tanks, buildings, chambers and appurtenances
- Invert and cover levels of all chambers
- Connection details and locations
- Details of pipe materials and bedding
- Sizes and grades of manhole covers
- Any other information requested by the Engineer.

Record drawing submissions shall include:

- Four bound sets of “As-Built” record drawings and abandoned distribution main drawings
- One set of first copy negatives
- One set of CDs.

At the end of the project, and for the purposes of archiving, the Contractor shall provide all project documents and records in digital format recorded on to a CD-R disc. Three copies of the disc shall be submitted to the Client. The Contractor shall ensure that the files are readable using programs available to the Client. In the event files are not readable, the Contractor shall provide the appropriate installable reader with the files. The documents and records shall include, but not be limited to, the following:

1. Clear and detailed index of contents of the disc, properly clustered and ordered.
2. The project specification and BOQ
3. The design drawings
4. The shop and as built drawings
5. Construction reports
6. Scanned copies of signed original correspondence
7. Scanned copies of signed original permits and permissions
8. Scanned copies of submissions
9. Scanned copies of signed site instructions
10. Scanned copies of signed minutes of site meetings
11. (Where the original copy is in colour the scan shall be performed in colour mode.)

The Contractor shall not be entitled to any extra payment or extension of time for the preparation or changes thereto of the Final “As-Built” Record drawings.

1.25.17 Revision of Submittals

Whenever a variation order causes a change to the information contained in previously approved submittals, the Contractor shall submit information and data corresponding to the changed requirements for approval. Revision submittals shall be submitted following the procedures required for previously approved submittals.

1.26 UNITS OF MEASUREMENT

All units shown in this Specification are metric and these shall form the basis of the Contract.

1.27 FIRE HAZARD (NAKED LIGHTS)

No naked light shall be used by the Contractor on or about the Site otherwise than in the open air without the permission in writing of the Engineer. If in the Engineer's opinion the use of naked lights may constitute a fire hazard, the Contractor shall at no extra cost to the Employer take such additional precautions and provide such additional fire fighting equipment (including breathing apparatus) as the Engineer considers necessary. The term "naked light" shall be deemed to include electric arcs and oxyacetylene or other flames used in welding or cutting metals. Compliance with the requirements of this Clause shall not relieve the Contractor of any of his liabilities and obligations under the Contract.

1.28 SITE TO BE KEPT TIDY

Throughout the progress of his work, the Contractor shall keep the Site and all working areas in tidy and workman-like condition and free from rubbish and waste materials. Any Temporary Works, Constructional Plant, materials or other things which for the time being are not required for use by the Contractor may with the consent of the Engineer be removed from the Site, but otherwise shall be dispersed about the Site in an orderly fashion and shall be properly and securely stored thereon. The requirements of this Clause shall not limit the Contractor's obligations under the Conditions of Contract.

1.29 FINAL CONDITIONS OF WORK

Before application is made for the Employer to accept the work, all items of work shall be complete, ready to operate and in a clean condition. All trash, debris, unused building material and temporary structures shall have been removed from the site of the work. Tools and construction machinery not needed for repair and adjustment consequent to operational tests shall not be on the site. The walkways, parking areas, roadways, streets and lanes pertaining to the works shall be completely cleaned.

1.30 SUPERVISION AND INSPECTION

The Employer shall provide inspection for all work to be performed under the Contract. All materials and work shall be performed only in the presence of the Engineer or his authorized inspector and any work done in the absence of the said Engineer or authorized inspector shall be subject to rejection. The Contractor shall notify the Employer and Engineer two working days in advance of any work to be done, in order that inspection services may be provided.

1.31 SIGN BOARD

The Contractor shall provide and maintain and remove, when directed by the Engineer, construction identification signs for the Site. These signs shall be constructed of a timber framed, blackboard panel, size 2440 mm wide by 3700 mm high, all painted with two coats of white oil paint back and front and supported 400 mm above the ground with steel angle framing and struts painted mat black and set into the ground and fixed in concrete foundations for adequate support.

The board shall be lettered in both Arabic and English by a skilled sign-writer to include the information as approved by the Engineer.

A large-scale layout shall be submitted for approval before manufacture. No advertising material, other than the above, will be permitted. The temporary construction identification signs shall be maintained in good condition, repainted as directed by the Engineer and removed from the Site when directed by the Engineer. The siting and layout of subcontractors' and/or manufacturers' signs shall be to the approval of the Engineer.

1.32 CLIMATE AND OPERATING CONDITIONS

The Contractor shall take account of the climatic conditions at the Site of the Works for the construction of the Works.

1.33 PUBLIC NOTICE OF STARTING WORK

The Contractor shall provide and distribute to all occupants along the streets or other alignments affected by the Works, a full A4 page size printed notice, with wording approved by the Engineer, indicating the nature of the proposed works the inconveniences likely to be caused thereby and the name, designation and address of the Contractor's Agent or Representative who should be contacted in an emergency. The notice shall be in Arabic and English.

1.34 PROJECT MEETINGS

1.34.1 Attendees

Unless otherwise specified or required by the Employer, the meetings shall be attended by the Employer, the Engineer, the Contractor and his Site Agent. Subcontractors may attend when involved in the matters to be discussed or resolved, but only when requested by the Employer or Engineer.

1.34.2 Meeting Records

The Employer or the Engineer will record minutes of each meeting and will furnish copies to the Contractor within 5 working days thereafter. If the Contractor does not submit written objection to the contents of such minutes within 7 days after presentation to him, it shall be understood and agreed that the Contractor accepts the minutes as a true and complete record of the meeting.

1 1.34.3 Meeting Schedule

The dates, times and locations for the various meetings shall be agreed upon and recorded at the preconstruction conference. Thereafter, changes to the schedule shall be by agreement between the Employer and Contractor, with appropriate written notice to all parties involved.

1.34.4 Pre-construction Conference

Prior to commencement of the work, a pre-construction conference shall be held at the location date, and time designated by the Employer. In addition to the attendees named herein, the meeting shall be attended by the representatives of regulatory agencies having jurisdiction over the Project, if required, and such other persons the Employer may designate.

a) Execution and Submittal of Documents

At the pre-construction conference, unless otherwise specified or agreed by the Employer and Contractor, the Tender Agreement shall be executed by the parties thereto and the Contractor shall present to the Employer the guarantees, certificates of insurance, progress schedule, written safety program if required, and all other preconstruction documents required of him by the Contract Documents.

b) Agenda

In general, the matters to be discussed or resolved and the instructions and information to be furnished to or given by the Contractor at the pre-construction conference will include, but not be limited to:

- Project meeting schedule
- Progress schedule submitted by Contractor.
- Communications procedures between the parties.
- The names and titles of all persons authorized by the Contractor to represent and execute documents for him, with samples of all authorized signatures.

- The names, addresses, and telephone numbers of all those authorized by the Contractor to act for him in emergencies.
- Construction permit requirements, procedures, and posting.
- Public notice of starting work.
- Procedures concerning the installation of Work on public or private property not owned by the Employer.
- Access and rights-of-way furnished by the Employer.
- Forms and procedures for Contractor's submittals.
- Variation Order forms and procedures.
- Payment application forms and procedures and the revised progress schedule reports to accompany the applications.
- Contractor's safety program.
- Contractor's provisions for barricades, traffic control, utilities, sanitary facilities, and other temporary facilities and controls.
- Project Sign Board for Employer if required by the Specification.
- Inspector and his duties.
- Construction surveyor and initiation of surveying services.
- Testing laboratory or agency, and testing procedures.
- Construction equipment and methods proposed by the Contractors.
- Procedures for payroll and labour cost by the Contractor.
- Other administrative and general matters as needed.

1.34.5 Progress Meetings

Progress Meetings shall be held on a basis in accordance with the agreed schedule. All matters bearing on the progress and performance of the Work since the preceding progress meeting shall be discussed and resolved, including without limit any previously unresolved matters, deficiencies, in the work or the methods being employed for the Work, and problems, difficulties, or delays which may be encountered.

1.34.6 Special Meetings

Upon appropriate notice to the other parties, special meetings may be called by the Employer, Engineer, or Contractor. Special meetings will be held where and when designated by the Employer for the following purposes unless the matters are resolved at the pre-construction conference.

a) Separate Contract

After award of any separate contract by the Employer, a meeting attended by those specified herein and the separate contractor shall be held to discuss and resolve the involved portions of the Project, time constraints, and the procedures to coordinate the operations of the Contractor and the separate contractor. If required by the Employer, the Contractor shall revise and resubmit his progress schedule to conform to the decisions agreed upon at this meeting.

b) Work by Others

A meeting, attended by those specified herein and representatives of those to provide such other work, shall be held to discuss and resolve all

matters bearing on the coordination and cooperation required between the parties involved.

1.34.7 Regulatory Agencies

When requested, the Contractor shall attend meetings held or required by the government regulatory agencies having jurisdiction over the Project.

1.34.8 Post-construction Conference

A post-construction conference shall be held prior to final inspection of the Work to discuss and resolve all unsettled matters. The Guarantees and insurance to remain in force, and the other documents required to be submitted by the Contractor will be reviewed and any deficiencies determined. Schedules and procedures for the final inspection process, and for the correction of defects and deficiencies, shall be discussed and agreed.

1.35 PROGRESS PHOTOGRAPHS

The Contractor shall obtain a photographic record of the execution of the Works by taking photographs at regular agreed intervals, or more frequently if the Engineer shall so direct, from various points as the Engineer shall specify from time to time. A commercial photographer, hired by the Contractor, shall be available upon one day's notice to take photographs as directed. The number of such photographs required will not normally exceed 30 per month. The first series of photographs shall be taken prior to commencement of work and the objective shall be to fully record details of existing conditions. The first set of photographs for pipelaying contracts will not exceed 300 and for other specified contracts will not exceed 100. The Contractor shall supply six 250 mm x 200 mm prints of each photograph and shall forward these, together with the negative, to the Engineer for his approval. After approval, two prints shall be signed and dated by the Engineer and the Contractor and one print shall be retained by the Contractor. All photographs shall be in colour, unless otherwise directed by the Engineer. All photographs shall be properly referenced to the approval of the Engineer; the back of each print shall be inscribed with the date of the photograph, the direction in which the camera was facing, and brief description of the subject and a reference number.

The Contractor shall supply two sets of albums, mount two sets of prints and title the prints and albums all to the approval of the Engineer. Any photograph which is not clear and distinct, double exposed, over exposed, etc., shall be retaken at the Contractor's expense until approved by the Engineer. The negatives and prints shall not be retouched.

Photographs taken under the provision of this Clause shall not be utilized by the Contractor for commercial advertisement either of his organization or of any materials or equipment used on the works, without the written approval of the Engineer. No prints shall be supplied to any other person without written permission of the Engineer.

1.36 PERMITS AND LICENCES

Unless otherwise explicitly provided for in these Specifications, all permits and licenses required for the proper execution of the work shall be obtained by the Contractor prior to commencement of the Works at no extra cost to the Employer.

The Employer shall hold the Contractor responsible for compliance with the obligations imposed in the permits and licenses to the extent that the Contractor's fulfilment of his obligations under the Contract may result in conditions requiring actions to comply with these permits and licenses. The Contractor shall carry out the necessary actions at no additional cost to the Employer.

1.37 DAILY REPORTS

The format of the daily reports shall be agreed with the Engineer.

1.37.1 Daily Program

The Contractor shall furnish a daily program for the following working day before the close of site on each working day.

The program shall include amongst others the following:

a) Work to be executed during:

- Normal working hours only, or
- Overtime or shift system is necessary.

b) Location of the area of site where work will be carried out.

c) Proposed labour, Contractor's equipment and supervision to be provided by the Contractor.

1.37.2 Daily Construction Reports

The Contractor shall furnish a daily progress report before the close of site on each working day. The Progress Report shall include amongst others the following:

a) Work activities.

b) Labour force, supervision and its allocation.

c) Material and equipment utilized.

d) Work progress during the day.

e) Temperature and weather conditions.

f) Description of any occurrence that may affect the progress of the Works.

1.38 REPRESENTATIVES FROM PLANT AND EQUIPMENT MANUFACTURER'S WORKS

The representatives from the principal Plant and Equipment Manufacturer's Works shall be required to visit the Site to supervise and ensure that the Plant and Equipment are erected, tested and satisfactorily operated in accordance with the manufacturer's instruction during:

a) Commencement of erection
b) Testing and commissioning
c) 3 months trial operating period
d) Defects Liability period.

1.39 CONTRACTOR'S SUPERVISORY AND OFFICE STAFF

a) It shall be clearly understood that:

   I. The key Supervisory staff as detailed herein shall be the minimum requirements and shall be made available for the execution of the Work under this Contract.

   2. Only suitably qualified personnel with adequate relevant experience are to be employed on the Works.

b) The Contractor shall propose and submit for approval, additional positions which complement and supplement the above positions. The names and details of experience, qualifications and previous appointments for the proposed staff including those of the Sub-Contractors shall be submitted for approval of the Engineer.

c) For each candidate, for each position, the Contractor shall submit authenticated copies of all technical degrees and/or licenses required.

   I. In addition, for each candidate the Contractor shall submit a CV or Resume which includes the bio-data of the candidate along with the candidate's work history for at least the periods of experience required for the respective position.

   2. The work history shall include as a minimum for each engagement: beginning and ending dates of employment; employer name, address and phone number (or fax numbers); location, description and value of project; responsibilities; duties and authority of the candidate.

d) The Contractor shall be required to present any or all of the listed supervisory and office staff for individual interviews by the Engineer prior to award, or in the case of award, after award of the Contract.

e) Each person listed herein is subject to final approval by the Engineer.

f) Approval of the Contractor's supervisory and office staff does not waive the right of the Engineer to withdraw that approval at any time thereafter as provided for by Clause 15 of the Conditions of Contract.

g) It is pointed out that the provision of the key supervisory and office staff as detailed herein, does not relieve the Contractor in any way of his liability under the Contract to provide all the staff necessary for the satisfactory completion and maintenance of Works.

The minimum requirements of the key supervisory staff shall be as follows:

I. Project Manager

a. Responsibilities and Duties:

i) Provide necessary superintendence during the execution of the Works and as long thereafter as the Engineer may consider necessary in accordance with the Conditions of Contract for the proper fulfilment of the Contractor's obligations under the Contract.

ii) Act as the Contractor's agent for all dealings with the Employer and the Engineer, with the authority to make final decisions and executions on behalf of the Contractor.

iii) Permanently available on site during working hours.

iv) Shall have the ultimate authority over all the work required in completing the requirements of this Contract.

v) Contractor's other supervisory and office personnel and all sub-contractors shall report directly to the Project Manager.

b. Technical Requirements:

i) Project Manager shall have a degree in civil engineering from a university that is specifically recognized by the engineering profession as a minimum level of qualification for a practicing Engineer.

ii) Project Manager shall have a minimum of 15 years experience of increasingly responsible positions in the direct supervision of water supply and utility construction, of which a minimum 5 years, must have dealt directly with construction of underground utilities and associated structures and similar in nature and size to those of this Contract.

iii) Past experience shall include successfully completing a previous position as Project Manager as above described on a project of similar type and scope of work as this Contract.

2. Project Engineer

a. Responsibilities and Duties:

i) To assist the Project Manager in managing the administration and overall coordination of the Works.

ii) Project Engineer is responsible for overall coordination with governmental agencies and other contractors, and for obtaining NOC's, etc., for expediting the work.

b. Technical Requirements:

i) Project Engineer shall have a degree in civil engineering from a university that is specifically recognized by the engineering profession as a minimum level of qualification for a practicing civil engineer.

ii) Project Engineer shall have a minimum of 10 years experience of increasing responsibility with engineering or construction companies, at least 2 years of which was spent working in Oman in a position having responsibilities and duties similar to those described above.

3. Site Civil Engineer

a. Responsibilities and Duties:

i) The Site Civil Engineer shall be responsible for the engineering details of the work.

b. Technical Requirements

i) The Site Civil Engineer shall have a degree in civil engineering from a university that is specifically recognized by the engineering profession as a minimum level of qualification for a practicing civil engineer.

ii) The Site Civil Engineer shall have a minimum of 10 years experience of increasing responsibility with engineering or construction companies with at least 2 years in the field of potable water supply pipelines/utility construction projects.

4. Quantity Surveyor

a. Responsibilities and Duties:

i) To measure, calculate and/or estimate construction quantities and cost, both for planning and for payment purposes.

ii) Continuously monitor and maintain the Contractor's detailed construction scheduling program.

b. Technical Requirements:

i) Quantity Surveyor shall have a relevant degree from a University or an equivalent qualification from a professional body which is specifically recognized by the engineering profession as a minimum level of qualification for a practicing quantity surveyor in engineering contracts.

ii) Quantity Surveyor must have a minimum of 4 years experience in increasingly responsible positions in the field of engineering and/or construction, at least 3 years of which shall have been involved in the duties of Quantity Surveyor on water supply and utility projects.

5. Land Surveyor

a. Responsibilities and Duties

i) A minimum of two Land Surveyors shall re responsible for carrying out surveying of the Work.

b. Technical Requirements

ii) Each Land Surveyor shall have at least 10 years experience.

END OF SECTION 1

SECTION 2

EARTHWORK AND SITE WORK

2.1 EXCAVATION

2.1.1 General

The entire area within the limits of earthwork as indicated shall be constructed to the lines, grades, elevations, slopes, and cross sections indicated on the Drawings with added allowance for the thickness of any lining and riprap if required. Slopes shall present a neat uniform appearance upon completion of the work and shall be approved by the Engineer. Excavated materials meeting the requirement of fill materials may be conserved for subsequent use or placed as earth fill immediately after excavation upon approval of the Engineer. If not immediately re-used, the storage in streets of excavated material to be subsequently used as fill will not be permitted. Large rocks unacceptable as earth fill material may be stockpiled for use as a riprap, if required in the works, subject to all requirements specified for riprap in the Specification. The suitability of all excavation materials shall be determined by testing and approved by the Engineer. The Contractor shall not waste or otherwise dispose of suitable excavated materials. All excavation shall be performed under the limitations and requirements set out in the sections of this Specification pertaining to control of water.

The following terms shall have the meanings hereby assigned to them:

"Topsoil or Sweet Sand"	Means any surface materials suitable for use in areas to be grassed or cultivated.
"Bulk Excavation"	Means excavation in open cut (excluding Trench and Structure Excavation) down to levels specified in the Drawings or otherwise as being the general levels after completion of excavation other than Industrial Excavation.
"Trench Excavation"	Means excavation of trenches into which pipes or cables are to be laid to levels and limits specified in the Drawings or otherwise.
"Structure Excavation"	Means excavation for the construction of pump stations, tanks, structure and building footings and other structures to levels and limits specified in the Drawings or otherwise.
"Incidental Excavation"	Means excavation (generally in small quantities) below or outside the limits of Bulk Excavation, Trench and Structure Excavation, but excluding Excess Excavation.
"Excess Excavation"	Means excavation outside the limit specified for Bulk, Trench, Structure or Incidental Excavation.

2.1.2 Earthwork

Shall include all site preparation, excavation of all materials of whatever nature encountered, handling, hauling and compaction of required fill materials, disposal of all excess excavated material, shoring and protection work, preparation of subgrade, dewatering as necessary, protection of adjacent property, backfill, surface reinstatement, and forming embankment to the lines and grades indicated in the Drawings.

2.1.3 Site Investigation

The Contractor shall assume all responsibility for deductions and conclusions made by him regarding the nature of the materials to be excavated, the difficulties involved, dewatering, maintaining the required excavations and of doing the work affected by the subsurface conditions at the site of the works. Neither the Employer nor the Engineer shall be liable for any loss sustained, indicated by or deduced from any borings, samples, tests, and/or reports and the actual conditions encountered during progress of the work.

The Contractor shall conduct soil investigations when necessary to support his calculations. When required to do so he shall follow the recommendations stated in BS 5930: Code of practice for site investigations and any local orders.

2.1.4 Levels to be Recorded

Before the surface of any part of the Site is disturbed or the works thereon are begun, the Contractor shall take a complete topographic survey of the site and record levels of such part, in the manner specified or as agreed with the Engineer. Two working days notice is to be given the Engineer so that the recording of levels can be performed in the presence of the Engineer.

2.1.5 Explosives and Blasting

Blasting is not generally permitted, unless authorized by the appropriate authority.

2.1.6 Bracing and Shoring

Bracing and shoring shall be carried out in accordance with the recommendations stated in BS 6031: Code of practice for earthworks and any local orders. Excavated surfaces shall be supported as necessary in the opinion of the Contractor or of the Engineer to safeguard the work and workmen, to prevent sliding or settling of the adjacent ground, and to avoid interruptions in existing services and damage to existing improvements and utilities infrastructure. The width of the excavation shall be increased if necessary to provide space for sheeting, backing, shoring, and other supporting installations. The Contractor shall also obtain the permission of the relevant authorities for the surface width of the excavation required. The Contractor shall furnish, place and subsequently remove such supporting installations at no extra cost to the Employer.

If the depth of the excavation exceeds 1.5 m, perform one of the following: a) batter the sides of the excavation to the soils natural angle of repose or to a lesser angle, b) support the sides with a system of sheet piling, trench sheeting or shoring.

The Contractor shall furnish before commencement of excavation for any structure, three copies of drawings showing details of the backing and shoring he proposes to use, together with all relevant calculations prepared by an approved qualified engineer. One copy of the drawings indicating modifications which in the Engineer's opinion are required for the safety of the personnel and/or works will be returned to the Contractor who proposes to excavate with battered side slopes instead of providing sheeting, shoring, etc., as aforementioned the Contractor shall furnish three copies of a report by an approved competent soils engineer, together with all relevant calculations, demonstrating the sufficiency of the proposals.

No excavation work shall commence until the Engineer's consent has been obtained. Provided, however, that such consent shall in no way relieve the Contractor from any of his contractual obligations and responsibilities.

Erection, maintenance and removal of the excavation supports shall be performed by competent personnel and in their absence by an approved qualified Contractor.

Items supporting the excavation shall not be removed until the Engineer opines that the permanent work is sufficiently advanced to permit removal of the supporting items.

Remove any unsound soil and soft areas in the excavation and restore with approved materials utilising acceptable workmanship.

2.1.7 Borrow Excavation

When the quantities of suitable materials obtained from specified excavations are insufficient to construct the specified fills, additional materials shall be obtained from approved borrow areas. Borrow pits shall be excavated and finally dressed in a manner to eliminate steep or unstable side slopes or other hazardous or unsightly conditions. The extent and depth of borrow pits within the limits of the designated borrow areas shall be approved by the Engineer. The Contractor shall be responsible for the arrangement and payment for all borrow material and the material selected shall meet the approval of the Engineer.

2.1.8 Disposal of Materials from Excavations

All requirements herein relating to the disposal by the Contractor of materials arising from Site clearance or from excavations are subject to applicable provisions of the Conditions of Contract. Subject to any specific requirements of the Contract, the Contractor shall make his own arrangements for the temporary storage of any excavated material that is required for use in refilling trench or structure excavations, including any necessary double handling. The storage in streets of excavated material not to be immediately reused in the backfill of trenches will not be permitted. In this connection the Contractor shall have regard to the working areas available to him for the construction of the pipelines particularly where this is located in roads or in other places to which the public has free access. Any temporary tips alongside the trench excavation shall be to stable slopes and heights. Where the nature of the excavated material is suitable, the Contractor's temporary storage as aforesaid shall include for separate storage as the Engineer may direct of any of the various grades of

materials hereinafter specified for the refilling and surface reinstatement of trench or structure excavation, namely, soft material, coarse material, hard material and topsoil. Any excavated material not required for or not suitable for use as refilling as aforesaid or use elsewhere in the works shall become the property of the Contractor and he shall be entirely responsible for its removal from the Site and for its ultimate disposal.

Excavated stockpiles shall be clearly and appropriately labeled with prominent signage to indicate whether they are suitable for re-use or not.

2.1.9 Excess Excavation to be Made Good

The Contractor at his own expense shall remove from the Site all material resulting from excess excavations below that required for the foundation, lining or bedding and shall make good the same with concrete as may be required by the Engineer. Where, due to site conditions, an alternative method for supporting the foundations, linings or beddings, may be possible the Contractor shall provide three copies of a design report by an approved competent engineer together with all calculations demonstrating the sufficiency of the proposals. No alternative proposals shall be undertaken except with the Engineer's consent. Provided, however that such consent shall in no way relieve the Contractor from any of his contractual obligations and responsibilities.

2.1.10 Control of Water

The Contractor shall furnish, install and operate all necessary machinery, appliances, and equipment to keep excavations free from water during construction and shall remove water so as not to cause damage to private property, or to cause a nuisance or menace to the public as specified herein. Spare dewatering equipment shall be maintained at the site and that will automatically come into operation upon the failure of a machine in operational mode. Berms shall be provided to prevent surface water from drainage into structural excavations. Earth banks shall be suitably protected from damage by erosion during construction. The Contractor shall ensure that, at all times, during construction no groundwater shall come into contact with any concrete surface or reinforcement and that any structure shall be capable of withstanding any hydrostatic pressure to which it may be subjected during construction and until completed.

a) Drainage Provision

Drainage ditches, diversions, and temporary pipes shall be constructed as required to maintain drainage of the work areas and shall be constructed with cross-sectional area at least equal to that of the intercepted watercourses, as approved by the Engineer.

b) Dewatering

The Contractor shall perform dewatering as required so that all work of the Contract is installed on dry areas and excavations, including without limitation the construction of all structures and underground piping. The Contractor shall ensure that dewatering is carried out only to a depth sufficient for the required excavation.

c) Qualified Personnel

The Contractor shall, where extensive dewatering is required, be fully qualified to perform the dewatering operations or shall furnish the services of an experienced, qualified, and equipped Dewatering Subcontractor to design and operate the dewatering and groundwater recharging systems required for the work, all subject to the Engineer's approval.

d) Monitoring

Where required to do so by the Engineer, the Contractor shall establish a specified number of groundwater level monitoring stations at each site that will be observed during the work. These shall be located as directed by the Engineer and consist of acceptable open tube piezometers. As directed settlement gauges will be provided to the approval of, and designated by, the Engineer at each site, time and location to monitor settlement of new and existing facilities.

e) Submittal

Shop drawings and data shall be submitted for review and approval showing the intended plan for dewatering and recharging operations. The Engineer’s approval shall in no way whatsoever relieve the Contractor from any of his contractual obligations and responsibilities. Details of locations and capacities of dewatering wells, well points, pumps, sumps, collection and discharge lines, standby units, water recharge system, water disposal methods, monitoring and settlement measuring equipment, and data collection and dissemination shall be included. These shall be submitted not less than 30 days before start of dewatering operations.

f) Operation

The Contractor shall furnish, install and operate all necessary pumping, well-point dewatering appliances and equipment to keep excavations free from water during construction, and shall dewater and dispose of water so as not to cause injury to public or private property, or to cause a nuisance or a menace to the public. He shall at all times have on hand sufficient pumping equipment and machinery in good working condition for all ordinary emergencies, including power outage, and shall have available at all times competent workmen for the operation of the pumping equipment. During excavation, construction of chambers, etc., installation of pipelines, placing of structure and trench backfill and the placing and setting of concrete, excavations shall be kept free of water. The Contractor shall control surface runoff so as to prevent entry or collection of water in excavations. The static water level shall be drawn down a minimum of 300 mm below the bottom of the excavation so as to maintain the undisturbed state of the foundation soils and allow the placement of any fill or backfill to the required density .The dewatering system shall be installed and operated so that the groundwater level outside the excavation is not reduced to the extent that would damage or endanger adjacent structures or property.

g) Maintenance of Existing Water Table Level

All required operations shall continuously maintain the level of the water table outside the dewatered areas to prevent damage to structure, pipelines, etc., adjacent to the excavations. A water injection recharging system shall be maintained to replenish the groundwater supply as required to maintain the water table, including pumps, piping, well points, standby units, other required equipment, and a source of water sufficient to meet the recharge requirements should supply of water from dewatering operations be interrupted or become inadequate.

h) Protection of Existing Facilities

Excavations shall not interfere with the 45 degree bearing splay of existing structures. Where any sloped excavation infringes on, or potentially endangers, any existing facilities or structures, shoring, sheeting, and bracing shall be provided according to plans and calculations made by a qualified Engineer. A copy of such plans and calculations shall be given to the Engineer for record purposes. At his expense, the Contractor shall repair and make good all damage or resettlement to the foundation or other portion of any existing facilities or structures) and for damage to existing works caused by permanent or temporary failure or operation of the dewatering or recharging systems or by failure to maintain the existing groundwater level outside the dewatered areas.

i) Disposal of Water

Water not injected back into the ground shall be disposed of lawfully without damage to new and existing facilities or adjoining properties. Water pumped from excavations shall not be directed into the sewerage system or on to ground, roads or footpaths such that it causes erosion or a public nuisance.

j) Removal

The release of groundwater to its static level shall be performed so as to maintain the undisturbed state of the natural foundation soils, prevent disturbance of compacted fill or backfill and prevent flotation or movement of structures, pipelines and sewers.

Equipment shall be removed when no longer required, but monitoring and settlement measurement systems shall be maintained in operation until removal is approved by the Engineer. To the extent approved by the Engineer, well-points and like items may be abandoned in place.

2.1.11 Standard Earthwork Compaction Test Procedure

a) Test Methods

All compacted earth fill dry density shall equal or exceed the specified percentage as determined by ASTM D1557, Method C. This method will be used to determine the maximum dry density of each type of soil used

in compacted fills, backfills, and embankments, and to measure the relative compaction at optimum moisture content of compacted fills, backfills, embankments, and subgrades. Alternatively, Part 4, Method 3.5/3.6 of BS 1377 may be used in lieu of ASTM D1557.

b) Compaction Tests

During the course of the work, the Contractor, under supervision of the Engineer, will perform such tests as are required to identify materials, to determine compaction characteristics, to determine moisture content, and to determine density of fill in place. These tests performed by the Contractor will be used to verify that the fills conform to the requirements of the Specification.

2.1.12 Testing

Testing shall be performed at an approved testing laboratory.

Test methods that are applicable to soil testing include ASTM D 698, D 1556, D 1557, D 2167, D 1557, D 2487, D 2922, D 3017, AASHTO T 180 and all parts of BS 1377. Alternate equivalent test methods may be used if equivalence can be proved by actual test data provided by the approved test laboratory.

All samples of soil shall be taken in a sound double polyethylene bag provided by the approved testing laboratory and sealed immediately to preserve the moisture status of the sample as sampled. The soil sample shall be immediately labeled with the relevant data required. The sampled shall be stored away from direct sunlight at all times.

A detailed sampling certificate shall be generated for each sample taken and witnessed by the Engineer.

A 1 kg of each soil sample sent for testing shall be packed in a sealed air tight clear PET or glass jar and submitted to the Engineer for his retention.

Labels must be securely affixed to the sample container. Labels written with water insensitive ink shall be inserted into the sample bag.

Each sample shall be clearly print labeled with the following data:

a) Project reference number
b) Name of the contractor
c) Sample number
d) Map reference of sampling point
e) Type of soil
f) Sampling certificate reference number
g) Date of sampling
h) Time of sampling
i) Ambient temperature, humidity and weather conditions at time of sampling
j) List of tests to be conducted at approved laboratory

The costs of all compaction testing and other tests as stated above will be borne by the Contractor. The Contractor shall adjust his operations so as to permit time to make tests, and shall excavate and fill such holes as may be required for

sampling and testing. The Contractor shall maintain, with a copy to the Engineer, a daily log of tests carried out.

Tests to determine the optimum dry density of the backfill material shall be carried out as directed on site, the frequency depending on consistency of material and test results.

Unless directed otherwise on site testing for density and moisture content of in-situ soils shall be at the rate of:

a) One test per backfill layer of 200 mm thickness for each structure.
b) One test per backfill layer for every 30 linear metres of pipeline trench.

2.1.13 Inspection by Engineer

When the specified levels of trench or structure excavation are reached, the Engineer will inspect the ground exposed, and if he considers that any part of the ground is by its nature unsuitable, he may direct, the Contractor to excavate further and to refill the further excavation with such materials as he may direct, and such further excavation will not be held to be excess excavation. Should the bottom of any trench or structure excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. In this case the cost of the extra excavation and of the additional foundation materials required will be the Contractor's responsibility if necessitated by his negligence.

2.1.14 Rock

Before commencement of any excavation in rock, the Contractor shall demonstrate to the satisfaction of the Engineer his inability to excavate without resorting to heavy percussion tools.

Before beginning to excavate any material that the Contractor considers to be rock, the Contractor shall advise the Engineer of the presence of such material, and the said material shall not be classified as rock unless the Engineer has agreed to such classification beforehand. The Engineer's agreement shall be subject to reservations on the extent of rock so classified and the extent of the rock excavation shall be determined after examination of the excavated faces. Excavations where rock has been encountered and classified as such shall not be backfilled before examination of the excavated faces by the Engineer to enable the extent of the rock excavation to be determined.

Individual masses less than 0.2 cu m in size or agglomerated soil decomposed rock and laterite shall not be considered as rock. Where reasonable progress can be made with the aid of tracked ripping tools as recommended by the plant manufacturer for the material encountered or where power tools or heavy percussion tools are used for the Contractor's convenience the material will not be considered as rock.

The Engineer's decision as to whether or not the material of the excavation is to be classified as rock shall be final.

2.1.15 No Voids

If any of the existing pipes or chambers is made redundant, they shall either be removed from the excavation and disposed off or if left in place, filled completely with Grade 20 concrete. Voids of any sort shall not be created in earth fills under any circumstances.

2.2 TRENCH EXCAVATION

2.2.1 Pipe Trenches

Trench excavation means excavation in all materials of whatever nature encountered for trenches into which pipes, ducts or cables are to be laid, or appurtenances constructed, and the term pipe shall mean pipe of all kinds and for whatever purposes. The requirements of Clause 2.1 also apply.

The line and level of trenches shall be as shown on the Drawings or as may be directed by the Engineer. Before commencing trench excavations, the route of the trench shall be pegged out accurately and the natural ground level shall be agreed with the Engineer. Strong sight rails shall then be fixed and maintained at each change of gradient, and at as many intermediate points as may be necessary. On these rails shall be marked the centre line and the level to which the excavation is to be carried out, such rails being not more than 230 m apart. Alternative methods to maintain line and level of pipelines shall be to the approval of the Engineer.

2.2.2 Trench Excavation Generally

a) General

Trench excavation shall be carried out by such methods and to such lines, dimension and depths as shall allow for the proper construction of the works, provided always that, unless the Engineer permits otherwise, no trench excavation shall be less than 600 mm in width. Excavation shall be carried out by hand methods where required to ensure the stability of utilities encountered during excavation work. Notwithstanding the foregoing, any rock in trench excavation shall be so excavated that the clearance between the pipe, when laid, and the rock sides and bottom of the trench is kept to the minimum limits necessary to provide for the specified thickness of bedding and concrete protection of the pipe. The bottom of the trenches shall be properly trimmed off and a compacted granular bed of thickness as shown on the Drawings shall be placed and prepared to provide a firm and uniform bearing throughout the length of the pipe. The bedding shall be lightly raked prior to placing the pipes on it. Bell holes and holes and depressions for couplings, valves and the like shall be excavated the same distance below these installations. The materials excavated shall be used in the backfill or removed and disposed of by the Contractor, as required by the Engineer and as specified. The trench shall be dug only so far in advance of pipelaying as the Engineer shall permit. Trenches shall have vertical sides unless otherwise authorized by the Engineer. No length of trench excavation shall be started until the pipes and fittings to be laid in that length are available on the Site.

If obstructions not shown on the Drawings are encountered during the progress of the work and these will require alterations to the Drawings, the Engineer will change the plans and order the necessary deviation from the line and/or grade. The Contractor shall not make any deviation from the specified line and/or grade without approval by the Engineer. Should any deviations in line and/or grade be permitted by the Engineer for convenience to the Contractor, any additional costs for the thrust blocks, valves, air and vacuum assemblies, and washout assemblies shall be borne by the Contractor. Should the pipeline be constructed in a manner that the points are not located at the Stations shown on the plans or in a manner that additional high or low points are caused in the profile for the convenience of the Contractor, the Contractor shall relocate or add additional installations and assemblies at his own expense and as directed by the Engineer.

Trenches shall be excavated to depth of 150 mm to 300 mm below the underside of the pipe depending on the pipe diameter in accordance with Clause 4.2.4 and the Drawings.

Unless otherwise specified or instructed, the minimum trench width shall be as required to meet the design requirements and for the proper assembly and joint inspection, but in no case less than the outside pipe diameter plus 300 mm. The trench widths are given below for rigid and flexible pipes.

Any permanent works, pipe laying or concrete placement shall not commence until the Engineer has inspected the excavation and given his approval.

b) Rigid Pipes

Unless otherwise specified or instructed, the maximum trench width at 300 mm above top of pipe for rigid pipe shall be as follows.

i) For AC, Concrete and VC pipes:
Maximum trench width shall be 1.5 x (nominal internal diameter of pipe) plus 300 mm. The maximum width for 100 mm and 150 mm pipes shall be 600 mm.

ii) For DI and CI pipes:
Maximum trench width shall be nominal internal diameter of pipe plus 600 mm, except that the maximum trench width for 100 mm and 150 mm pipes shall be 600 mm.

If these widths are exceeded, the Contractor shall, at his own expense, provide concrete surround to the full trench width as directed by the Engineer.

c) Flexible Pipes

Unless otherwise specified or instructed, the minimum trench width at 300 mm above top of pipe for flexible pipe shall be as follows:

i) For uPVC pipes:
Where the soil is classed as "stable", for uPVC pipe less than or equal to 500 mm diameter, minimum trench width shall be the outside diameter of pipe plus 300 mm, except that the minimum trench width for 100 mm through 250 mm pipes shall be 600 mm.

Where the soil is classed as "unstable", for uPVC pipe less than or equal to 500 mm diameter, minimum trench width shall be 5.0 times the outside diameter of pipe.

ii) For HDPE pipes:
Where the soil is classed as "Fully Stable":
- Minimum trench width shall be 1.6 x outside diameter of pipe except that the minimum trench width for pipes up to 400 mm outside diameter shall be 700 mm.

Where the soil is classed as "Unstable":
- For HDPE pipe less than or equal to 350 mm outside diameter, minimum trench width shall be 3.5 x outside diameter of pipe.

iii) For GRP pipes:
Where the soil is classed as "Fully Stable":
- For pipes less than or equal to 400 mm diameter, minimum trench width shall be nominal internal diameter of pipe plus 600 mm.
- For pipes more than 400 mm diameter and less than or equal to 1400 mm diameter, minimum trench width shall be 2.5 times the nominal internal diameter of pipe.

Where the soil is classed as "Unstable":
- For pipes less than or equal to 400 mm diameter, minimum trench width shall be 2000 mm.
- For pipes more than 400 mm diameter and less than or equal to 1400 mm diameter, minimum trench width shall be 5.0 times the nominal internal diameter of pipe.

For the flexible pipes referred to above, the terms "Fully Stable" and "Unstable" used to define the native soil refer to the degree of side support provided by the native soil to the bedding material.

"Fully Stable" soil means native soils such as rock and some granular materials that provide a high degree of side support.

"Unstable" soil means native soils of a cohesive nature and in cases where a very weak native soil offers little or no side support.

Where the side support provided by the native soil offers some degree of side support but less than that offered by a "Fully Stable" native soil where directed by the Engineer intermediate minimum trench widths may be adopted. The Engineer may require tests to be carried out at pipe formation level to assist in determining whether the native soil is "Stable". The costs for all of these tests shall be deemed to be included in the rates for excavation. Where directed by the Engineer the trench shall be over excavated and

backfilled with either concrete or suitable granular material if exceptionally poor ground conditions are encountered at formation level.

d) Minimum Levels of Fill Above the Crown of the Pipe

i) Rigid pipe-Concrete, VC or AC pipe on granular bed: 300 mm.
ii) GRP or thermoplastic pipe on granular bed: 500 mm.
iii) GRP or thermoplastic pipe on non-granular bed and in heading: 600 mm.
iv) Minimum level above crown of pipe with soil or granular fill under public roadway shall be 2m.
v) Minimum level above crown of pipe with concrete fill under public roadway shall be 1 m.

2.2.3 Trial Holes

Trial holes shall be excavated well ahead of the trench excavation to such depths as necessary to determine and confirm the alignment for the trench and the soil condition. The Contractor shall arrange for the refilling and reinstatement of trial holes to be carried out immediately after the required information is obtained. The reinstatement of trial holes shall be carried out to the approval of the Engineer.

2.2.4 Trench Excavation in Roads

Normally the crossing of paved roads and buried utilities shall be carried out using non-disruptive construction techniques as specified in Clause 2.5.

Battered excavations shall not be made in public highways or within 30 metres from any building or structure unless approved by the Engineer.

If, exceptionally, open excavation is allowed by the concerned authorities, all trench excavation and other work carried out within the limits of any existing road or highway shall be completed as rapidly as possible and, in the case of roads capable of carrying two or more lanes of traffic, not more than half of the width of the carriageway shall be obstructed at anyone time. In single-lane roads, the Contractor shall program his work in such a manner that the minimum inconvenience is caused to those persons who have reasonable grounds for using the road and, in the case of private or restricted roads, who have authority to use them.

If in the opinion or the Engineer, the amount of traffic using a road that is completely or partly obstructed by the works is sufficiently great to make it necessary, the Contractor shall operate a system of traffic control to the approval of the Engineer. For any such system of control, the Contractor shall prepare a plan for the maintenance and protection of traffic in accordance with the Sohar Development Office (SDO) and the Ministry of Transport & Communications (MOTC) requirements showing details of detours, locations of different types of signs and flashing signals, flagmen, barricades, lanterns, etc., and obtain approval for the plan from the R.O.P. and the SDO, and shall provide, erect and maintain all the facilities in accordance with the approved plan. The Contractor shall remove all the above temporary facilities after they are no longer required, subject to the approval from the Engineer and the concerned authorities at no

additional cost. The Engineer's approval shall not relieve the Contractor from his responsibility in obtaining permits from the R.O.P., the SDO, and Directorate of Roads of MOTC. Such permission will not, in general, be granted for roads that have more than one traffic lane or for those sections or roads for which satisfactory alternative routes exist. The costs incurred by the Contractor in respect of all aspects of work in roads, including full compensation for detours, handling of traffic during construction, for the provision and maintenance of barricades, signs, flares, lanterns, flagmen, flashing signals and all other items necessary for proper completion of the works to the satisfaction of the concerned authorities, shall be included in rates for excavation and pipelaying. The Employer will not be liable to pay any compensation to the Contractor should permission to close any road to traffic not be granted for any reason.

Road drains and channels shall be kept free from obstruction at all times.

Normally trench excavation along roads will be located in the service reserves or verges adjacent to the road rather than in the carriageway itself. Trench excavation shall wherever practicable be carried out in such a way that every part of the excavation is at least 1 m clear of the existing edge of the carriageway. In such event the Contractor shall take special precautions, which shall include the continuous support of the sides of the excavation, from the time when excavation is begun until the refilling of the trench is placed, to ensure that there is no disturbance of the adjacent road or road foundation.

Where open excavation is carried out in paved or unpaved roads, the pipes shall be encased in concrete as shown on the Drawings and or directed by the Engineer and shall be saw cut along the edges of the trench prior to excavation.

The Engineer may direct the trench excavation to be realigned from that shown on the Drawings in order to avoid interference with existing utilities and structures or to facilitate smooth traffic flow.

Where trench excavation or any other part of the works obstructs any footpath or right-of-way, the Contractor shall provide, at his own cost, a temporary footpath around the obstruction to the satisfaction of the Engineer. Where applicable, this temporary footpath shall include stout bridges of wooden planks or other approved construction across any open trenches across including handrails of the required strength and stability.

Where excavated material has temporarily been deposited on a grass margin or verge, the margin shall on completion of refill be restored entirely to its original condition and left free from loose stones.

2.2.5 Trench Excavation in Surfaces Other than Roads

Trench Excavations in surfaces other than roads shall include all surfaces except those asphalt surfaces that require road reinstatement. These surfaces include but are not limited to cultivated areas, undeveloped areas, footpaths, verges, non-asphalted roads, lanes, alley, and all private lands. Trench excavation shall if the Engineer so requires have temporary fencing erected around that length.

Temporary fencing shall not be removed without the Engineer's permission, which will not normally be given until the trench excavation has been refilled and reinstated. The Contractor shall have particular regard to the safety of animals

that may be introduced to the areas, and shall ensure that all open excavation, access routes and steep or loose slopes arising from the Contractor's operations are adequately fenced and protected.

2.2.6 Supporting Trench Excavations

The Contractor shall where necessary in the opinion of the Contractor or of the Engineer well and effectively support the sides of all trench excavation which shall include the use of timber, concrete, steel sheet piles, or such other material as may be approved by the Engineer at no extra cost to the Employer to prevent any fall or run from any portion of the ground outside the excavation into the trench and to prevent settlement of or damage to structures adjacent to the excavation.

If, when the excavations are filled in, it is necessary in the opinion of the Engineer, to leave in position any such supporting installations, the Contractor will be paid for it, provided that in the opinion of the Engineer the necessity has not arisen from carelessness or neglect of the Contractor.

When concrete encasement of pipelines, or granular or selected fill is required in pipe trenches the supporting installations shall be designed to permit gradual withdrawal during the placing of the encasement or fill and this shall be affected in such manner as to minimize the danger of collapse, and all voids formed behind the supports shall be carefully filled and compacted.

The Contractor shall be deemed to have made his own allowance for shoring up the sides of trenches, any extra excavation necessary to provide space for such support and for any other working space. If for any reason any portion of trench excavation shall give way, the Contractor shall at his own expense take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed.

Where the Contractor elects and is permitted by the Engineer to execute trench excavations with battered sides instead of providing support as aforesaid they shall be excavated to stable slopes and heights from a point of 300 mm above the top of the pipe. Drawings and data shall be provided in accordance with Clause 2.1.6.

2.2.7 Trimming Trench Excavation

When excavating to specified levels for trench excavation or to specified limits for the face of any structure therein required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing construction work except where the Engineer permits otherwise. Should the Contractor have excavated to within 150 mm above these specified levels or to within 150 mm of these specified limits before he is ready or able to commence the construction work he shall, where required by the Engineer, excavate further so as to remove not less than 150 mm of material immediately before commencing the constructional work, and any such further excavation and additional foundation material ordered by the Engineer shall be at the cost of the Contractor. Where no bedding material is specified the bottom of trench excavations shall be carefully boned in and trimmed true to grade with the aid of a straight-edge at least 6 m long so as to ensure a continuous support for the pipes. Any stones or flints either likely to cause the pipe to bed unevenly or to

damage the pipe and its coating of greater than 25 mm in size shall be picked out of the trench bottom and any holes so formed shall be filled in with soft material and trimmed to the correct level. Where bedding material is specified all shattered and loose material shall be removed from the bottom of the trench excavations so that the bedding material rests on a solid and clean foundation.

2.2.8 Trenches Not to be Left Open

Trench excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of trench excavations shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and jointed. Pipelaying shall follow closely upon the progress of trench excavation, and the Contractor shall not permit unreasonably excessively lengths of trench excavation to remain open while awaiting testing of the pipeline but not more than 200 m ahead of the pipe laying operation. The Contractor shall take precautions to prevent floatation of pipes in locations where open trench excavations may become flooded and these precautions may include the partial refilling of the trench leaving pipe joints exposed for tests of the joints. If the Engineer considers that the Contractor is not complying with any of the foregoing requirements he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trench excavation. The Contractor will not be permitted to excavate trenches in more than one location in anyone road at a given time without the Engineer's permission.

2.2.9 Control of Water

All excavation and placement of bedding and backfill shall be carried out in the dry as described in Clause 2.1.10.

2.2.10 Backfilling Trench Excavation

Trench excavation in existing or future roads or paved/tiled areas shall be backfilled with structural filling materials in accordance with the specification of the SDO. Trench excavations other than those in roads or paved/tiled areas shall normally be refilled using suitable material selected from the excavation. The material shall have a liquid limit less than 35% and plasticity index not more than 10. Unless bedding material is specified, selected suitable material (free from stones greater than 50 mm in size for pipes without coatings and 25 mm size for pipes with coatings) shall be deposited in layers of not greater than 150 mm compacted thickness and thoroughly rammed with suitably shaped rammers working alternatively on either side of the pipe except for HDPE pipes until the selected filling has been carried up at least 300 mm above the top of the pipe. For HDPE pipes the fill shall be compacted simultaneously on either side of the pipeline using hand tampers only. Tamping shall be controlled such that the pipe will not develop ovality over the tolerances permitted or cause deflections to the straight line of the pipeline. Particular care shall be taken to prevent damage to the pipe during backfilling. Coated pipes shall be wrapped tightly with a sheet of thin flexible foam or polyethylene sheet before backfilling. The remainder of the trench fill shall be as specified for selected fill material, except that boulders and clods of earth up to 150 mm in size may be allowed provided that the compacted backfill is, in the opinion of the Engineer, the required densities can be achieved. This coarse material shall be spread in layers of not greater than 200 mm compacted thickness and be thoroughly rammed by an approved mechanical

rammer mechanical rammer except for HDPE pipes where hand tampers shall be used. The coarse filling is to be carried up to the level at which (in roads and footpaths) surface reinstatement is to commence or (elsewhere) to such level as with the surface reinstatement of the whole of the topsoil will leave the finished work sufficiently "proud" to allow for future settlement to the original ground level. Hard material such as broken rock and original road metalling shall normally be used only for the surface reinstatement of roads as specified, but where it is suitable and available in sufficient quantity it may be used in place of or as well as the aforesaid coarse material.

Where necessary, the Contractor shall adjust the moisture content of the refill material either drying out or by adding water to assist the compaction of the material. During compaction, the backfill shall have a uniform moisture content equal to within the range 1% above to 2% below the optimum moisture content recorded in the Compaction Test. Backfill shall be compacted to a dry density of not less than 95 % of the maximum dry density.

Granular material for GRP pipes shall be compacted to better than 85 percent of the maximum dry density but such that the pipe deflection does not exceed the specified limits.

The maximum deflections for flexible pipes with granular bedding (measured-in-situ) shall be:

a) after completion of surround: 0 percent
b) one month after reinstatement of trench: 2 percent
c) immediately prior to issue of Final Certificate: 4 percent
d) immediately prior to commissioning: 4 percent
e) deflection of pipes installed with concrete surround shall be measured when the concrete has set and the deflection shall not exceed 2 percent.

Any pipe exhibiting a greater deflection shall be broken out. Deflections shall be considered as the maximum difference between the measured in-situ diameter and the stated non-deflected diameter on any axis divided by the non-deflected diameter and shall be measured by an approved mechanical device at any points determined by the Engineer.

Should the material being placed as backfilling, while acceptable at the time when approved, become unacceptable to the Engineer due to exposure to weather condition or due to flooding or have become puddle, soft or segregated during the progress of works, the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material.

To permit the proper consolidation of backfill into the voids behind trench sheeting and supports, trench sheeting shall be withdrawn gradually as backfill progresses in depth and along the trench. On no account shall any excavated material be dozed back when refilling trenches in roads and no backfilling shall be carried out unless in the opinion of the Engineer, sufficient mechanical rammers are in operation on that portion of the work. Where directed by the Engineer, trench excavation shall be refilled with concrete.

No extra payment will be made for concrete or special backfilling when the necessity for it arises because of the method of excavation adopted by the Contractor.

2.2.11 Suitable Refill Material -Special Measures

Where in the opinion of the Engineer sufficient supplies of the aforesaid material for trench refilling cannot reasonably be obtained from excavations the Engineer may order the Contractor to:

a) Remove Stone

Carry out such work as may be necessary to sieve out stones, or

b) Borrow

Excavate material from suitable borrow areas and transport it to the length of trench to be refilled, and the Contractor shall do any or all of these things as directed. All costs of borrow material shall be borne by the Contractor.

2.2.12 Surface Reinstatement in Asphalt Paved Roads

Temporary and permanent reinstatement of asphalt paved roadways is to be in accordance with the specification of the SDO. Final reinstatement of road surfaces affected by longitudinal cuts shall include resurfacing of the entire paved surface width using the materials and pavement thickness specified by the SDO.

At transverse crossings of asphalt paved roads, open cut or thrust boring, the Contractor shall install utilities ducts and shall reinstate the road surface and road base as specified by the SDO or to such higher standard to which the road surface and road base were constructed.

If in the course or for the purpose of the execution of the Works or any part thereof, any highway or other road or way shall have been broken into or crossed beneath then notwithstanding anything herein contained, the Contractor shall at his own cost and independently of any requirement of or notice from the Engineer be responsible for the making good of any subsidence or shrinkage or other defect, imperfection or fault in the permanent reinstatement of such highway, road or way and for the execution of any necessary repair or amendment thereof from whatever cause the necessity arises until the end of the Period of Maintenance in respect of the works beneath such highway or other road or way and shall indemnify and save harmless the Employer against and from any damage or injury to the Employer or to third parties arising out of or in consequence of any neglect or failure of the Contractor to comply with the foregoing obligations or any of them and against and from all claims, demands, proceeding damages, costs, charges and expenses whatsoever in respect thereof or in relation thereto.

2.2.13 Reinstatement of Surfaces other than Asphalt Paved Roads

All non-asphalt road and all other surfaces shall be restored to their original condition by the Contractor. All reinstatement of cultivated surfaces shall be carried out by the Contractor. This reinstatement is deemed to be entirely covered by the Contractor's rates for pipe installation.

2.2.14 Reinstatement of Other Surfaced Areas

Reinstatement of surfaced areas other than roads, such as pavements or reservations, shall be temporarily reinstated to conform to the requirements of the SDO.

Permanent reinstatement shall be carried out to conform to the requirements of the SDO using materials similar to and not inferior to those existing prior to commencement of the works.

2.2.15 Excavation and Reinstatement in Developed Reservations

The SDO will remove any trees, bushes and plants from developed reservations that they wish to preserve, prior to the commencement of work by the Contractor. The Contractor shall allow in his rates for the removal and disposal of any remaining trees, bushes and plants necessary for the execution of the works to keep sweet topsoil separate for reuse.

The reinstatement of the developed reservations shall be to backfill and compact the excavations in accordance with Clause 2.2.10 and to restore the surface in accordance with Clause 2.2.16.

2.2.16 Reinstatement of Unpaved Land

In general the reinstatement of stripped areas of unpaved land shall restore the ground to a condition not inferior to that which existed before the site was occupied.

The compacted backfill shall be taken up to a level which allows for settlement. In arable, grassed and similar areas the surface to be top-soiled shall then be loosened to a depth of 200 mm and topsoil replaced on it to the specified depth without compaction using approved topsoil of comparable quality to make up any deficiency.

Areas where grass is to be sown shall be worked with fine tilth, levelled, graded and rolled with alight roller. The seed shall be sown evenly at the specified rate of application in the proper season and in suitable weather conditions, and the area again rolled. Restoration and reseeding of any areas where the new grass is inadequate shall be carried out as instructed.

As an alternative to seeding the "dibbing in" at 200 mm centres of "Bugunda" or similar tropical grass tufts may be required.

The grass shall be well-watered four times a day and the Contractor shall keep the grass cut short until the Maintenance Certificate has been issued.

2.2.17 Appurtenant Structures in the Pipeline

The Contractor shall carry out further excavation as may be necessary to accommodate structures as such as valve chambers. Such excavation shall include for disposal of surplus material and, where appropriate, for backfilling around the structures.

2.2.18 Fill Adjacent to Structures

Fill materials adjacent to structures shall be placed in such a manner as will ensure that they can be satisfactorily compacted without damage to the structures. Compaction adjacent to all structures shall be carried out by hand or by suitable hand operated plant. No fill material shall be placed and no compaction shall be permitted adjacent to concrete for 14 days following placing of the concrete.

2.2.19 Existing Services

The Contractor shall locate all underground services and structures in the area of the Works and if necessary and as instructed by The Engineer, dig trial pits to confirm their location. Excavation around existing services structures shall be done carefully, providing support to the structure, where necessary. Adjacent trial pits shall be within 25 m of each other.

The Contractor shall submit photographs and drawings in plan and elevation of the underground, surface and overhead structures located within the work area.

Methods of work must ensure that existing service items are preserved as they are. The Contractor shall be solely responsible for the restitution of structures and assets he damages and where applicable reimbursement of costs for remedying the damage. The Contractor shall obtain a clearance certificate from the relevant authority upon satisfaction of the remedial work and submit it to the Engineer for his information.

Methods of work must be devised and managed to ensure that that existing service items are not likely to be damaged or prevented from functioning at any time. Where temporary or permanent re-routing of the existing services is required the Contractor shall obtain the required permissions from the relevant authorities together with the submissions of drawings and detailed method of construction utilising approved materials and acceptable workmanship.

2.2.20 Temporary Works

Pipelines shall be protected from damage from site traffic by adequate fill of at least 1m compacted soil or 500 mm of reinforced concrete above the crown of the pipe. Lateral protection shall be provided by means of barriers.

2.2.21 Fences and Walls

Where the trench excavation crosses barriers such as fences and walls the Contractor, as a temporary measure during construction of the pipeline, shall provide temporary fencing for any parts of such barriers as have had to be removed. After trench excavation has been reinstated, the Contractor shall carry out such work as the Engineer may order for permanent restoration of such barriers.

2.2.22 Wadi Crossings

The Contractor shall be deemed to have allowed for all the additional measures necessary for the proper construction of the pipeline crosses underneath or over

wadis, culverts and other watercourses including maintaining their full capacity to convey water.

2.2.23 Restoring Existing Improvements

All road or street improvements excavated or damaged and any damage to adjoining property caused by construction operations, shall be restored or repaired by the Contractor to a condition equal to that which existed before commencement, shall be of the same kind and work, shall conform to the same dimensions and be of quality equal to the original construction and shall conform to the requirements of the agency having jurisdiction.

2.2.24 Cleanup

Upon completion of work of this clause, all rubbish, debris, and excess or waste material shall be removed from the Site. All construction equipment and implements of service shall be removed and the entire area involved shall be left in a neat, clean and acceptable condition. The Contractor shall restore the site and the surrounding ground to the satisfaction of the Engineer.

2.3 STRUCTURE EXCAVATION

2.3.1 General

Structure excavation means excavation in all materials of whatever nature encountered for the construction of structure footings or other structures. The requirements of Clause 2.1 also apply.

The line and level of structural excavations shall be as shown on the Drawings or as may be directed by the Engineer. Before commencing excavation the structure shall be pegged out accurately and the natural ground levels shall be agreed with the Engineer. Excavations shall be of sufficient size to permit the placing of structures or structure footings of the full width and length indicated. The elevations of the bottoms of footings, as indicated on the Drawings, shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary to secure a satisfactory foundation.

Boulders, rocks, and any other objectionable material encountered during excavation shall be removed.

In the event that during the progress of the work, loose or improperly compacted soil is encountered at bottom of structure foundation levels, or adjacent thereto, such material shall be completely removed within the limits as directed by the Engineer, backfilled with approved borrow material and compacted in accordance with Clause 2.4 or backfilled as otherwise directed by the Engineer.

2.3.2 Control of Water

All excavation and construction of structures and backfill shall be carried out in the dry as described in Clause 2.1.10.

2.3.3 Supporting Structure Excavations

Suitable and practically watertight cofferdams shall be used wherever water or water-bearing strata are encountered above the elevation of the bottom of the excavation. The Contractor shall submit shop drawings showing his proposed method of cofferdam construction at least 2 weeks prior to starting of excavation.

The Contractor shall employ an engineer to prepare the shop drawings who is registered in Oman or who is acceptable to the Employer. The engineer who prepares the shop drawings shall be familiar with cofferdam construction and shall include his qualifications for the preparation of such a submittal. The shop drawings shall be complete with all details, design calculations, description of construction and include such other particulars all as directed by the Engineer.

Cofferdams or cribs for foundation construction shall, in general, be carried well below the bottoms of the footings; or when footings are to be founded on or in rock, the cofferdam construction shall be placed at least to the level of top of rock or the bottom of excavation in rock to suitably develop a stable cofferdam and shall be well braced and as nearly watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance.

When conditions are encountered which, as determined by the Engineer, render it impracticable to dewater the foundation before placing the footing, the Engineer may require the construction of a concrete foundation seal of such dimensions as he may consider necessary, and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as directed by the Engineer. The foundation shall then be dewatered and the footing placed. In the event weighted cribs are employed and the weight is utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low water level as directed by the Engineer.

2.3.4 Backfilling Structure Excavation

Excavated areas around structures shall be backfilled as specified in Clause 2.2.18 with excavated or borrow materials as approved by the Engineer. Backfill materials shall be placed in layers not exceeding 150 mm compacted thickness and compacted in accordance with Clause 2.4.3.

2.4 BACKFILL AND EMBANKMENT FILL

2.4.1 Embankment Filling and Structure Backfilling

All fills, embankments, linings, and structure backfills shall be placed in dry conditions.

a) Equipment

Equipment for construction of fills and backfill shall produce the specified compaction, type and capacities as required and approved by the Engineer.

b) Protection

All working areas shall be protected from damage by water and site drainage shall be maintained at all times. Heavy equipment shall not be operated within 1 m of any structure and vibration rollers within 1.5 m of any structure.

2.4.2 Foundation Preparation

Foundations for earth fill shall be stripped to remove all obstructions, vegetation, debris, or other unsuitable materials. Except as otherwise specified, foundation surfaces shall be graded to remove surface irregularities and shall be scarified and loosened to a minimum depth of 100 mm. The moisture content shall be controlled as specified for engineered fill and the surface materials of the foundation shall be compacted and bonded with the first layer of earth fill as specified for subsequent layers of earth fill.

a) Rock Foundations

All rock foundation and abutment surfaces shall be cleared of all loose materials by hand or other effective means and shall be free of standing water when fill is placed. Previous rock foundations shall be excavated to 150 mm below finished grade shown on the Drawings and a lining shall be placed as specified herein. Fill placed immediately adjacent to such rock foundations or where not accessible with large compaction equipment shall be compacted to the specified density by means of hand tamping or manually directed power tampers or plate vibrators.

b) Benching

Where slope of existing soils to receive fill exceeds 4:l, horizontal benches shall be cut to key the new fill material to the existing soils. At least 600 mm of existing soil normal to the original slope shall be removed and recompacted as the new fill is brought up in layers.

2.4.3 Construction

a) Materials

Structural filling is required in paved carriageways and wherever a structure is to be supported on the fill and where settlement is required to be minimal. Non-structural filling will normally be carried out to embankments and other fill areas. Embankments shall normally be overfilled and subsequently trimmed to the required profiles.

i) Structural Fill

Structural filling shall be carried out using well graded natural sands and gravel having the following minimum requirements.

Liquid limit	less than 25%
Plasticity index	less than 6%

The material shall have a smooth grading curve within, and sensibly parallel to, the following grading envelope:

Sieve Size	% by Mass Passing
75 mm	100
37.5 mm	85 - 100
10 mm	45 -100
5 mm	25 - 85
0.6 mm	8 - 45
0.075 mm	0 - 10

The material shall be laid and compacted to layers not greater than 150 mm thick (compacted thickness) to achieve a dry density of not less than 95% of the maximum dry density, determined in the vibrating hammer compaction test. The placement moisture content shall be adjusted to fall within the range 1% above to 2% below the optimum percentage.

(ii) Non-Structural fill

Cohesive soils selected as being suitable shall be placed and compacted in layers not greater than 150 mm compacted thickness to achieve an air voids content (expressed as volume of air divided by total volume of soil) of not greater than 10%. The material shall placed at its natural moisture content unless this is more than 2% below the optimum moisture content, in which case it shall be raised by approved means to a moisture content in the range of 2% above and below the optimum.

Granular soils selected as being suitable shall be placed and compacted in layers not greater than 150 mm thick (compacted thickness) to achieve a dry density of not less than 90% of the maximum dry density. The moisture content shall be adjusted by approved means to bring the moisture content within the range 3% below to 1.5% above the optimum moisture content.

(iii) Disposal on Site of Unsuitable Materials

If the Contractor is given permission to dispose of excavated materials that are designated unsuitable for filling or backfill on the site they shall be placed in regular layers without compaction as directed. If the Contractor is not given such permission they shall be classified as surplus excavated material and disposed of elsewhere upon approval of the Engineer.

b) Placement

Earth fill shall not be placed until the required excavation and foundation preparation have been completed and the foundation has been inspected and approved by the Engineer. Fill shall be placed in approximately horizontal layers of thickness that can be uniformly compacted by the equipment used but of maximum 200 mm loose thickness. Hand compacted fill, including fill compacted by manually directed power tampers, shall be of maximum 100 mm loose thickness. Fill adjacent to structures shall be placed as specified in Clause 2.2.18 and will allow structures to assume the loads from the fill gradually and uniformly. The height of the fill adjacent to a structure shall be increased at approximately the same rate on all sides of the structure. Embankments shall be placed in manner such that they meet the following additional requirements:

i) The distribution of materials throughout each layer shall be essentially uniform and the fill shall be free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material.

ii) If the surface of any layer becomes too hard and/or smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth not less than 75 mm before the next layer is placed.

iii) The top surface of all embankments shall be approximately level during construction except that a crown or cross-slope (super elevation) of not less than 2 percent shall be maintained for effective drainage. If not shown on the Drawings, all finish grade embankment top surfaces shall be finished with a 2 percent crown or cross-slope as applicable for the site drainage.

c) Compaction

All engineered fills shall be constructed to not less than 95 percent of maximum dry density including areas to receive future structures and to a line and grade at least 2 m outside the structure area. All fill shall be moistened or aerated to control the moisture content to within 2 percent of optimum and then compacted.

Uniform moisture distribution shall be obtained by discing, blading or other approved methods before the compaction of the layer. If the top surface of the preceding layer of compacted fill or foundation becomes too dry or wet to permit suitable bond it shall be scarified and moistened by sprinkling or aerated to an acceptable moisture content before the placement of the next layer.

d) Structure Backfilling

Excavated or imported material that meets the requirements for engineered fill material shall be used. Backfill shall be compacted by use of tamping sheepsfoot rollers or mechanical tampers or other approved methods. Backfill material shall be brought to within 2 percent of optimum

moisture content and compacted in layers of depths compatible with the equipment used. Flooding or jetting is not acceptable unless approved by the Engineer. Backfill shall be compacted to not less than 95 percent of maximum dry density.

2.4.4 Rock Riprap

This work shall consist of the construction of rock riprap blankets for purposes of embankment protection from erosion.

a) Material

Rock for rock riprap shall conform to the requirements:

i) Individual rock fragments shall be dense, sound, and free from cracks, seams and other defects conducive to accelerated weathering. The least dimension of an individual rock fragment shall be not less than one-third the greatest dimension of the fragment.

ii) Absorption of water shall be not more than 3 percent and the bulk specific gravity (saturated surface-dry) not less than 2.5 as determined by ASTM Method C127 or BS 1377.

iii) Weight loss in 5 cycles shall be not more than 20 percent when sodium sulphate is used or 25 percent when magnesium sulphate is used. The test for soundness shall be performed according to the procedure for ledge rock in ASTM C88.

iv) Rock that fails to meet the requirements stated above, may be accepted only if similar rock from the same source has been demonstrated to be sound after 5 years or more of service under conditions of weather, wetting and drying, and erosive forces similar to those anticipated for the rock to be installed under this Specification.

b) Subgrade Preparation

The subgrade surfaces on which the riprap is to be placed shall be cut or filled and graded and compacted to the lines and grades shown on the Drawings. The cross sections shown on the Drawings are the limits for cuts and engineered earth fills. Gravel bedding where specified or shown on Drawings shall be placed on top of cut or filled surface. Gradation of bedding material shall be as shown on Drawings. The bottom of the riprap bed shall be taken as top of the gravel bedding and where no gravel bedding is shown or specified, it shall be taken as the embankment surface line shown in the cross sections. Riprap shall not be placed until the foundation preparation is completed and the finished engineered fill surfaces have been inspected and approved by the Engineer.

c) Equipment-Placed Rock Riprap

The rock shall be placed by equipment on the surfaces and to the depths specified. The riprap shall be constructed to the full course thickness in one operation and in such a manner as to avoid serious displacement of

the underlying materials. The rock shall be delivered and placed in a manner that will ensure that the riprap, in place, shall be reasonably homogeneous with the larger rocks uniformly distributed and firmly in contact one to another with smaller rocks and spans filling the voids between the larger rocks. Riprap shall be placed in a manner to prevent damage to structures. Hand placing will be required to the extent necessary to prevent damage to the permanent works.

d) Hand-Placed Riprap

The rock shall be placed by hand on the surfaces and to the depths specified. It shall be securely bedded with the larger rocks firmly in contact one to another. Spaces between the larger rocks shall be filled with smaller rocks and spalls. Smaller rocks shall not be grouped as a substitute for larger rock.

e) Size and Depth

Riprap placed in ditches, channels, or alongside structures for erosion protection shall be about 150 mm nominal diameter, while riprap placed on embankments shall range from 150 to 350 mm. All riprap layers unless otherwise specified shall be a minimum of 375 mm in depth. The finished grade shall be reasonably homogeneous in appearance and depth and be free from moulds, dips, or windows.

f) Sources

All suitable rock obtained during job site excavation shall be conserved for riprap. Additional rock shall be obtained from sites to be located by the Contractor and approved by the Engineer. Quarries approved by the Engineer shall not relieve the burden upon the Contractor of ensuring that all rock utilized meets all requirements specified herein.

g) Slush Grouting

All riprap designated as slush grouted shall be grouted with Grade 20 concrete using 20 mm aggregate. Slush grout concrete shall be placed to fill all voids in the riprap blanket to a minimum depth of l00 mm into the blanket. It shall be placed, consolidated and finished with a shovel or it may be broom finished. Slush grout concrete exposed to air after placing shall be sprayed with an approved curing compound or shall be sprayed with an approved curing compound or shall be cured in a manner approved by the Engineer.

2.5 NON-DISRUPTIVE PIPELINE INSTALLATION (PIPE BORING AND JACKING)

2.5.1 Quality Assurance

a) Qualifications

The Contractor or Sub-Contractor who will perform the Work shall be experienced in the performance of boring and jacking work under similar conditions and shall be undertaken from within a shield equipped with

steering jacks for adjusting the alignment. Face boards shall be provided for boarding up the exposed excavation.

b) Allowable Tolerances

The Contractor shall monitor line and grade with a laser beam. Extreme care shall be exercised to maintain line and grade during jacking operations, and modifications in the manner in which the jacking operation is being conducted may be required to correct any deviation when deemed necessary by the Engineer. A maximum tolerance in the line and grade combined of 200 mm in 100 m shall be required. The Engineer shall have access to the jacking pit and such use of Contractor's facilities as are necessary to monitor and verify accuracy of conductor pipeline and grade. Monitoring of line and grade shall be carried out every 8 m of conductor pipe installed, but a minimum of once daily, during jacking operations.

2.5.2 Job Conditions

Unless otherwise specified, the methods and equipment used in jacking the conductor pipe shall be optional with the Contractor, provided that the proposed method is approved. Such approval, however, shall in no way relieve the Contractor of the responsibility for making a satisfactory installation meeting the criteria set forth herein.

It shall be understood that when a change in construction method or an increase in jacking limits as specified herein or shown on the Drawings is requested by the Contractor and authorized by the Engineer no additional payments will be made.

Once the jacking operation has commenced, it shall be continued in an expeditious manner until the conductor pipe has been jacked between the specified limits, and the requirements of the Conditions of Contract shall prevail.

2.5.3 Conductor or Casing Pipe

Pipe to be placed by jacking methods shall be of sufficient thickness and axial strength to withstand the forces to be encountered during the jacking process.

The diameter of the conductor pipe shall be as shown on the Drawings.

It shall be the Contractor's responsibility to provide stress transfer across the conductor pipe joints that is capable of resisting the jacking forces involved.

All pipe installed in the jacked conductor pipe shall have socket and spigot with rubber gasket or mechanical compression joints, except where restrained joint pipe is required.

Skids, for supporting the pipe inside the conductor pipe, and blocking, shall be construction grade redwood or, where there are high bearing stresses, Douglas Fir treated by painting with pentachlorophenol.

2.5.4 Excavation

The leading section of conductor pipe shall be equipped with a jacking head securely anchored thereto to prevent any wobble or variation in alignment during the jacking operation. Excavation shall be performed entirely within the jacking head and no excavation in advance thereof shall be permitted. Every effort shall be made to avoid any loss of earth outside the jacking head.

The excavation shall be kept to a minimum, but shall be of sufficient dimensions for satisfactory completion of the work. Where necessary in the opinion of the Contractor or of the Engineer, the Contractor shall well and effectively support the excavated surfaces which shall include the use of bracing and shoring, steel sheet piles or such other material as may be approved by the Engineer to adequately protect the workmen and to protect the roadway at no extra cost to the Employer.

Excavated material shall be removed immediately and continuously from the conductor pipe as excavation progresses. Method of removal will be at Contractor's selection. No accumulation of excavated material within the conductor pipe shall be permitted.

Ventilation shall be furnished in the conductor pipe and at the working face as necessary to protect the men and meet safety requirements.

After jacking is completed, the Contractor shall tap the conductor pipe with a hammer to locate ground loss or other voids outside the pipe. Holes shall be drilled in the conductor pipe at suspected locations and grout shall be forced in to fill voids to refusal at pressures determined by the Engineer, but not to exceed 395 kPa.

Should appreciable loss of ground occur during the jacking operation, the voids shall be backpacked promptly to the extent practicable with soil cement consisting of slightly moistened mixture of one part cement to five parts granular material. The cement mixture shall be thoroughly mixed and rammed into place as soon as possible after the loss of ground.

2.5.5 Pipelaying

After grouting, the conductor pipe shall be cleaned and the pipe installed. The pipe shall be supported on concrete blocks and timber wedge with a bearing area of one quarter of the pipe circumference with sufficient thickness to prevent the pipe sockets from touching the conductor pipe and to align the pipe to meet the line and level specified. Concrete shall then be placed to provide a minimum concrete bedding to half pipe height, care being taken to ensure the pipe does not move. After the concrete cradle is set the remaining annulus shall be filled with concrete to within 150 mm of the soffit of the conductor pipe. This void shall then be pressure grouted to refusal. All concrete bedding, filling and grouting shall be carried out between shutters and the whole annulus shall be filled completely with concrete for the whole length between shafts.

2.5.6 Alternative Method of Pipe Boring

If the Contractor proposes to use another alternative method of pipe boring, he shall submit his detailed proposal and obtain the approval of the Engineer prior to commencing any non-disruptive pipeline work.

2.6 SERVICE PROTECTION DUCTS

2.6.1 General

The Contractor shall furnish and install new protection ducts of split unplasticised polyvinylchloride (uPVC) pipes, concrete encased, to protect existing utility mains or cables where new pipelines or roads are to cross such utility mains or cables.

2.6.2 Materials

Protection ducts shall be split, uPVC pipe extruded from 100 % virgin materials. All pipes and fittings shall be new and unused. The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign materials, blisters, deleterious materials, wrinkles, and dents. Plastic pipe shall be delivered to the site in unbroken bundles or rolls, packaged in such a manner as to provide adequate protection of pipe and pipe ends, either threaded or plain, from damage or exposure to sunlight. All plastic pipe fittings to be installed to uPVC pipe shall be moulded fittings manufactured of the same material as the pipe and shall be suitable for solvent welding.

2.6.3 Construction

After the split uPVC pipe has been placed around the existing utility mains or cables, the pipe shall be wrapped twice with polyethylene film, 150 microns thick, to prevent fresh concrete from entering the duct. The protection ducts shall be supported on suitable non-corrosive spacers before placing the concrete encasement. The diameter of the split uPVC pipe shall be 150 mm as approved by the Engineer.

All concrete work shall be in accordance with the requirements of Section 5 of the Specification. Concrete encasement shall be constructed with Grade 20 concrete.

2.7 ACCESS ROAD

The specification and BOQ shall be that contained within the Sultanate of Oman, General Specifications for Roads, April 1994 and Highway Design Manual - Volume - I and II February 1994.

Tenderers are deemed to be in possession of their own copy of these documents at tender stage and to be fully aware of and to have understood the contents therein.

END OF SECTION 2

SECTION 3

PIPES AND APPURTENANCES

3.1 GENERAL

3.1.1 Scope of Work

The work included in this Section consists of the manufacture, factory testing and witnessing by the Employer and or the Engineer and supply and delivery of pipes, couplings, fittings, valves, specials and other pipeline materials as specified herein.

All pipeline materials shall be supplied by the Contractor, unless otherwise indicated in these documents or instructed by the Engineer.

All materials and equipment supplied shall be suitable for use under conditions prevailing at the site of the works.

3.1.2 Submittals

a) General Rules

Submissions shall be made during the mobilization period.

The Contractor shall submit all individual component items and materials of a composite construction or product in one single submittal. For example these may include the submitted material together with sealants, gaskets, fittings, coatings and fixings necessary to complete the construction or assembly as a whole.

The submittal will be assessed only on technical requirements, expressed or implied, specific to the project. The Contractor shall ensure that submittals are relevant to the project; that items are properly identified, indexed and clustered into logical sections with headings. The Contractor shall not submit useless and irrelevant information such as voluminous catalogues containing products that are irrelevant to the project, promotional information of the company, exaggerated or elevated claims and descriptions or statements of promises or good intentions.

Where applicable, shop drawings shall accompany the submittal.

The Engineer will retain samples for the period of the project at the end of which the Contractor will remove the samples. In certain cases, with high value samples such as pipe fittings and valves the Contractor may reclaim the sample and incorporate it in the project.

Samples of small items, e.g., screws, bolts and the like shall be mounted neatly on a board, with the specific and relevant label affixed next to it. The items must be detachable for visual inspection.

Samples that are composite in nature such that overlying items prevent visual inspection of the underlying items e.g. coating system, sealant,

concealed joint systems, the sample must be presented in such a way that all components of the system can be visually examined in relation to its fabricated position. Such samples may be presented as stepped applications or as cutaways.

b) Labeling of Samples

A label for each sample shall be neatly printed and contain the following information in the following order:

i) The contract reference number
ii) The Contractor's name
iii) The original manufacturers exact product designation
iv) Generic identification of the sample
v) The name of the local agent, if applicable
vi) The specification reference and page number
vii) The Contractor's submission reference number
viii) The date of submission.

c) Installation Engineering Details

The Contractor shall submit the following, arranged in the order stated:

i) Project relevance: Describe in brief the whole construction or assembly relevant to the submission
ii) Diagram of configuration of the entire assembly or system with its component items
iii) Submit the shop drawing(s) and specification pages relevant to the submission
iv) Pipeline calculations relevant to the needs of the project
v) Show fit by tabulation and diagram: show dimensions and tolerances of each part arranged in sequential order and the method of joining
vi) Detailed method statement for installing the entire composite structure or assembly relevant to the submission
vii) Complete list and samples of the site process inspection and quality worksheets
viii) Identification of the third party testing laboratory, if applicable, and a list of tests it will conduct.

d) Pipes, Fittings, Valves and Associated Items

The Contractor shall submit the following for each material, arranged in the order stated:

i) Pipes and Fittings
   1. For pipes, submit tabulated pipe data for each diameter in each pressure class in the following tables as appropriate
   2. Pipes selected and technical details of each pipe and fitting grade
   3. Each product identification and designation including classification and grade
   4. State the appropriate standards that the product conforms to
   5. For DI pipes and fittings identify foundry if separate from final manufacturer

6. Manufacturer's design calculations for each grade
7. Manufacturing method for each grade
8. Drawing of cross sections of the body, flange or socket-spigot parts for each pipe size and fitting including the identification of each type of material used, composition and nominal dimensions of each layer and their tolerances, gasket and sealing ring details where applicable
9. Complete and detailed manufacturer's product data sheet and specification for the pipe
10. Complete and detailed manufacturer's product data sheet and specification for each material used in the manufacturing of the fitting
11. Type test certificate (short and long term tests) for each pipe and fitting grade selected
12. Sample of the production test certificate for each pipe and fitting grade selected
13. Provide actual product markings
14. Detailed instructions for installation
15. Sample of Manufacturer's Inspection and QC sheet
16. Sample of Contractor's Inspection and QC sheet
17. Manufacturer's instruction and guidance on transportation, site storage and handling
18. Health and Safety data sheet to European Union format
19. Pipe — 30 cm wide cylindrical sample of cut pipe body
20. Flange or socket-spigot joint — submit a finished cut away sample with fitted rubber seal or gasket as appropriate
21. Fittings — submit a full sample
22. For DI pipes and fittings details of corrosion protection
23. Bolting details including bolt size, length of bolt and number of washers to be used
24. Bolt torque sequence and maximum torque pressure.

HDPE Pipe Data for Each Diameter and Class

Manufacturing details		
Product description and number		
Designation, type and class		
Enter conforming standards		
Name of Manufacturer		
Manufacturing process for pipes		
Joint type: pipe to pipe		
Joint type: pipe to HDPE fittings		
Design criteria summary		
	Unit	
Pressure class/rating	-	
Nominal internal diameter	mm	
Wall thickness	mm	
State lengths selected	m	
Minimum depth of cover	m	
Maximum designed depth of cover	m	
Maximum working pressure	bar	
Maximum test pressure	bar	

Maximum internal vacuum pressure	bar	
Tolerance for wall thickness		
Tolerance for outside diameter		
Tensile strength at yield		

HDPE Fitting Data for Each Diameter and Class

Manufacturing details		
Product description and number		
Designation, type and class		
Enter conforming standards		
Name of Manufacturer		
Manufacturing process for fittings		
Joint type: fitting to HDPE pipe		
Joint type: fitting to HDPE fittings		
Design criteria summary		
	Unit	
Pressure class/rating	-	
Nominal internal diameter	mm	
Wall thickness	mm	
Minimum depth of cover	m	
Maximum designed depth of cover	m	
Maximum working pressure	bar	
Maximum test pressure	bar	
Maximum internal vacuum pressure	bar	
Tolerance for wall thickness		
Tolerance for outside diameter		
Tensile strength at yield		

Restrained Transition Fitting for PE/Metal Connection for Each Diameter and Class

Manufacturing details		
Product description and number		
Designation, type and class		
Enter conforming standards		
Name of Manufacturer		
Manufacturing process for fittings		
Design criteria summary		
	Unit	
Pressure class/rating	-	
Minimum depth of cover	m	
Maximum designed depth of cover	m	
Maximum working pressure	bar	
Maximum test pressure	bar	
Maximum internal vacuum pressure	bar	
Method of restraining HDPE pipe		
Material to restrain HDPE pipe		
Guaranteed minimum pressure rating for no-slipping of restraint		

Ductile Iron Pipe and Fitting Data for Each Diameter and Class

Manufacturing details		
Product description and number		
Designation, type and class		
Name of Manufacturer		
Name and location of foundry for pipes		
Name and location of foundry for fittings		
Name and location of foundry for flange		
Joint type		
Design criteria summary		
	Unit	
Pressure class/rating	-	
Nominal outer diameter	mm	
Minimum wall thickness	mm	
State lengths selected	m	
Minimum depth of cover	m	
Maximum designed depth of cover	m	
Maximum working pressure	bar	
Maximum test pressure	bar	
Properties		
Internal lining		
External coating		
Polyethylene sleeving		

AC Pipe Data for Each Diameter and Class

Manufacturing details		
Product description and number		
Designation, type and class		
Enter conforming standards		
Name of Manufacturer		
Manufacturing process for pipes		
Manufacturing process for couplings		
Joint type:		
Design criteria summary		
	Unit	
Pressure class/rating	-	
Nominal internal diameter	mm	
Wall thickness	mm	
Minimum depth of cover	m	
Maximum designed depth of cover	m	
Maximum working pressure	bar	
Maximum test pressure	bar	
Crushing strength		
Sulphate Resistance Test		

Cast Iron Fittings for AC Pipe		
Product description and number		
Designation, type and class		
Name of Manufacturer		
Name and location of foundry for fittings		
Name and location of foundry for flange		
Joint type		
Design criteria summary		
	Unit	
Pressure class/rating	-	
Nominal outer diameter	mm	
Minimum wall thickness	mm	
Minimum depth of cover	m	
Maximum designed depth of cover	m	
Maximum working pressure	bar	
Maximum test pressure	bar	

ii) Polymer Data

1. Product identification and designation including grade
2. Grade and type of polymers used in the production of each identified product
3. State the appropriate standards that the product conforms to
4. Manufacturer's specification
5. Sample of Manufacturer's Inspection and QC sheet
6. Identification of conformance to the appropriate standard
7. Type test certificate
8. A sample of the production batch test certificate for each polymer used
9. Health and Safety data sheet to European Union format
10. A 100 g sample of each polymer described in the submittal, contained in a glass jar.

iii) Bolts, Nuts and Washers

1. Product identification and designation including grade, thread size and length
2. State the appropriate standards that the product conforms to
3. Name of manufacturer
4. Identification of conformance to the appropriate standard
5. Manufacturer's specification
6. Sample of Contractor's Inspection and QC sheet
7. For stainless steel, details of pickling and passivation treatment and storage after treatment
8. Bolt markings
9. For stainless steel, list of iron free tools to be used during installation
10. Sample for each type and size of bolt, nut and washer.

iv) Valves and Pumps

1. Product identification and designation including type
2. Identification of conformance to the appropriate standard
3. Technical details and sketch of each item and each pipe it is to be connected to including product identification, materials of construction, dimensions and tolerances
4. Manufacturer's specification
5. For metal castings identify foundry if separate from final manufacturer
6. Drawings in cutout format showing each component part
7. Complete and detailed manufacturer's product data sheet
8. Details of corrosion protection for each item
9. List of each item and its technical designation, description and conformance to standard
10. Structural details
11. Reliability test data
12. Transient peak and normal performance calculations
13. Bolting details including bolt size, length of bolt and number of washers to be used
14. Bolt tightening sequence and maximum torque pressure
15. Type test certificate for each item selected
16. Sample of the production test certificate for each item selected
17. Sample of Contractor's Inspection and QC sheet
18. Provide actual product markings
19. Manufacturer's instruction and guidance on transportation, site storage and handling
20. Installation manual
21. Operating manual
22. List of spare parts required at each interval for maintenance over 10 years
23. Commissioning instructions
24. Health and Safety data sheet to European Union format.

v) Gaskets and Sealing Rings

1. Name of manufacturer
2. Product identification and designation including grade
3. State the appropriate standards that the product conforms to
4. Manufacturer's specification
5. Sample of production test certificate
6. Sample of Contractor's Inspection and QC sheet
7. Product markings
8. Sample for each type and profile.

vi) Manhole Covers, Frames, Sealing Plates and Gratings

1. Submit date for each size and class in the following table
2. State the appropriate standards that the product conforms to
3. Manufacturer's specification
4. For metal castings identify foundry if separate from final manufacturer
5. Cross section drawing of the item and identification of each material used

6. Complete and detailed manufacturer's product data sheet and specification for the item
7. Details of corrosion protection including coating data sheet, approved applicator, coating system details such as thickness and curing period
8. Installation details including location, grade of concrete, and elevation drawings
9. Type test certificate for each item selected
10. Sample of the production test certificate for each item selected
11. Provide actual product markings
12. Sample of Contractor's Inspection and QC sheet for manholes and gratings and coating
13. Manufacturer's instruction and guidance on transportation, site storage and handling
14. Health and Safety data sheet to European Union format
15. A sample of the item.

Manhole Cover and Frame for Each Size and Class

Manufacturing details		
Product description and number		
Designation, type and class		
Enter conforming standards		
Name of manufacturer		
Name and location of foundry for cover		
Name and location of foundry for frames		
Design criteria summary		
	Unit	
Weight of cover	kg	
Properties		
Coating material and thickness		

e) Program

Within 4 weeks of the date of acceptance of his Tender, the Contractor shall submit for the Engineer's approval a detailed program for submission of drawings, approval, manufacture ,testing, witnessing and delivery of pipes, couplings, fittings, valves and other pipeline materials to achieve the completion of the Works within the Contract period. Any deviations from the program shall be notified to the Engineer, but will not relieve the Contractor of his obligations under the Contract.

f) Shop Drawings

Shop drawings, complete with material, grade, and class for all pipe, fittings, and couplings and for all joints and coatings shall be submitted. Detailed catalogue and engineering data sheets shall be submitted for all

components such as flexible couplings, rubber gaskets, and insulating joints.

Shop drawings for valves, and miscellaneous components shall be complete with bill-of-materials showing kind and class of materials, and catalogue and engineering data showing compliance with the specified requirements. In addition shall submit:

i) Instructions and Certificates for each type of model of valve:

- Assembly instructions and spare parts list.
- Preventative/corrective maintenance instructions.
- Certificate of seat compatibility with entailed fluid exposure.

ii) Erection Drawings including the procedures to be used in setting, supporting, and/or anchoring the valves, the fitting of line pipe to the valves for proper coupling, and for adjusting and testing all valve assemblies.

g) Protective Coatings

Protective coatings schedules shall be submitted, showing shop and field surface preparations, materials, methods of application, dry film thickness and tests for defects, all in consonance with this Section.

All exposed pipework shall be provided with a topcoat of blue colour paint compatible with the protective coating and having the colour code RAL 5015 unless otherwise directed by the Engineer.

3.1.3 Marking

Each length of pipe and fitting shall be marked with the following:

- Manufacturing standard
- Manufacturer's name
- Manufacturing date
- Nominal diameter in mm
- Pressure rating in bars
- Inspection mark
- Coupling "homeline" position on spigot ends
- Serial number.

3.1.4 Not More Than One Manufacturer

Pipes, couplings, fittings and valves for each component classification shall not be supplied by more than one manufacturer, except with the Employer's approval.

3.1.5 Test Certificates

All pipes, couplings, fittings and valves delivered to the Site shall have been tested (referred to hereinafter as "works test") in accordance with ISO standards or other approved equivalent or better standard. The Contractor shall furnish the

Engineer with the manufacturer's test certificates for each consignment before each delivery begins.

The Engineer and or the Employer reserves the right to inspect the pipes, couplings, fittings and valves to be supplied for the works at the place of manufacture and to witness works tests in accordance with Clause 11.24, Section 11. The Contractor shall provide the equipment and labour necessary for carrying out the inspection.

3.1.6 Service Conditions

All water pipes and appurtenant materials shall be suitable for carrying potable water at temperatures up to 50^{o}C. Working pressure for water pipelines is up to 16 bars except for asbestos cement pipes which is up to 9 bars.

All sanitary sewer pipes and appurtenant material shall be suitable for carrying domestic wastewater at temperatures of up to 50^{o}C with sulphide concentrations up to 50 mg/L.

All storm drains and overflow drains shall be suitable for carrying urban storm runoff.

All buried pipes and appurtenant materials shall be suitable for immersion in corrosive groundwater.

3.1.7 Materials

Acceptable materials for pipes and appurtenances are as follows:

a) Water Transmission Pipelines that are Subject to Pumping

Ductile iron pipe with DI fittings.

b) Water Distribution Pipelines (Gravity Flow)

i) Internal Diameter 250 mm and Greater:
Asbestos cement pressure pipe with cast iron fittings, except at road crossings and wadi crossings where the pipe shall be ductile iron.

ii) Internal Diameter 200 mm and less:
HDPE pressure pipe with HDPE fittings, including HDPE under road crossings and wadi crossings.

c) Consumer Service Pipelines

HDPE pressure pipe and fittings up to the transition fitting at the consumer’s valve. Brass fittings from the transition fitting to the consumer’s water meter.

3.1.8 Basis of Acceptance

The acceptability of the pipes and fittings will be based on the results of tests carried out at the manufacturer's plant and/or in the GCC at the Contractor's

expense and the result of any independent testing carried out by the Employer or his agent. The frequency and type of tests required for each pipe material are given in the following subsections and certified copies of all records of inspection and test results shall be submitted to the Engineer.

All pipeline materials and components, including their protective coatings and joint materials that will or may come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth, shall not cause taste or odour, cloudiness or discolouration of the water, and shall be approved by a recognized certifying authority as being suitable for use in potable water supply schemes.

The Engineer may at any time instruct any of the stipulated tests to be conducted on any item delivered to the site at the Contractor's cost.

3.2 PRODUCTS

3.2.1 General

a) General Requirements

All pipes, fittings, couplings, and appurtenant items shall be new, free from defects or contamination, and wherever possible, shall be the standard product of the manufacturer. They shall be furnished in pressure or thickness classes as specified. Unless otherwise indicated, the size shown shall be the nominal pipe diameter except that in the case of HDPE pipe and uPVC pipe the nominal diameter shall mean the internal diameter.

b) Length

All pipes shall be furnished in a maximum of 6 m lengths, unless indicated otherwise.

c) Joints

All buried pipes shall have mechanical or socket and spigot push-on joints, unless, flanged or other joints are specified. All exposed pipes shall be flanged unless other joints are specified. All bolts, nuts and washers for flanges, joints and couplings shall be galvanized unless specified otherwise.

3.2.2 Ductile Iron Pipes and Fittings

Ductile Iron (DI) pipes and fittings shall comply with specification MEW-W02, the coating system as amended hereinafter or superior and shall conform to the following requirements:

a) Push-On Joints

Joints shall conform with ISO 2531. Joint rings shall be of natural or synthetic rubber conforming to AWWA C111, suitable for potable water use and tropical conditions to 50^{o}C.

b) Flanged Joints

Flanges shall be integrally cast or screwed on and drilled to PN 16 in accordance with ISO 2531. All flanges shall be provided with all necessary nuts, bolts, washers and gaskets plus an extra 10% to cover wastage. All nuts, bolts and washers shall be of galvanized steel. Bolts and nuts shall be supplied with two washers per bolt. The bolt length shall be such that after the joints are made up, the bolts protrude through the nut, but not more than 3 screw threads.

Unless otherwise specified, flanged joint gaskets shall be full width EPDM to AWWA C111 with dimensions to BS EN1514. Thickness of joint gaskets shall be such that, when jointed in accordance with manufacturer's instructions, the joint shall provide a positive seal for at least 16 bar pressure under the maximum joint deflection permitted.

Unless otherwise specified, bolts, nuts and washers shall conform to the requirements of BS EN 1092. All bolts, nuts and washers shall be carbon steel which conforms to the requirements of ASTM A307-65 Grade B and shall be galvanized in accordance with BS 729.

c) Restrained Joints

Bolted type or other approved anchored joints are to be provided for ductile iron pipes and fittings adjacent to valves and on exposed pipe work bends where no thrust blocks are provided to resist lateral hydraulic thrusts. The joints shall be subjected to the pull-out force on a closed end produced by the field test pressure of 24 bar.

In case of self-restrained joint piping, the length of restrained piping required shall be determined in accordance with the manufacturer’s recommendation. The restrained length shall be in multiples of the full length of one standard pipe piece.

Pipes with anchored joints shall be able to be laid in any direction to a minimum radius equivalent to 11/2 degree deflection per joint by deflecting the joints from the in-line position. After installation at this radius the pipes should be able to be deflected by a minimum of one degree in a plane at 90 degrees to the initial plane of deflection.

d) Polyethylene Sleeving

Heavy duty black polyethylene sleeving with a thickness of 250 microns to be applied to underground installations shall be in accordance with ISO 8180. PVC or any other approved tape shall be supplied in sufficient quantity for joining of the sleeving, plus 10% extra for wastage.

e) Coatings

(Amendment to MEW-W02)

Exterior surface of exposed pipe and fittings shall be coated with polyurethane with a minimum thickness of 300 microns.

Exterior surface of buried pipe shall be sprayed with a metallic zinc coating in accordance with ISO 8179/BS ENS45 with a minimum thickness of 30 microns, the minimum coating mass per unit area to be 150 grams of zinc per sq m of pipe surface and coated with a bituminous coating of not less than 70 microns thickness to BS 3416 suitable for tropical climates.

Exterior surface of buried fittings shall be polyurethane coated with a minimum thickness of 300 microns or shall be sprayed or brushed with a zinc-rich paint coating in accordance with ISO 8179 with a minimum thickness of 30 microns, the minimum coating mass per unit area to be 150 grams of zinc per sq m of fitting surface, and coated with a bituminous coating of not less than 70 microns thickness suitable for tropical climates.

All coatings shall be factory applied.

3.2.3 Asbestos Cement Pressure Pipes and Fittings

a) General

Asbestos Cement (AC) pressure pipe shall be manufactured and tested in accordance with the requirements of these Specifications and shall conform to the applicable provisions of ASTM C128 and AWWA C400, or BS EN 512 or ISO R160.

b) Class

The class of AC pipe pipe shall be Class 18 suitable for an operating pressure of 9 bar.

c) Materials

The AC pipe shall be composed of an intimate mixture of high sulphate resisting cement conforming to BS 4027, silica and asbestos fibre, and water free from organic substances, with or without the addition of curing agents, and cured in such manner as will produce pipe meeting the requirements of these Specifications. Copies of cement mill certificates shall be submitted with each consignment of pipe delivered to site.

d) Fabrication

The pipe shall be formed under pressure and thoroughly cured. The external surface of pipe shall be provided with a shop coat of bituminous paint. The internal surface shall be given one lining coat at the works with a phenol free bituminous coating particularly suitable for concrete pipes carrying water, all to clause 2.3 of BS EN 512.

e) Dimensions

The pipe shall be furnished in the size indicated on the Drawings. The average internal diameter, measured 75 mm from the end of the pipe, shall not vary from the manufacturer's standard, as approved, by more than 1.5%. The wall thickness at the machined portions of any pipe shall

not vary more than the manufacturer's standard by 2 mm. Unless otherwise stated pipe sections shall be made in standard lengths not exceeding 4 m long.

f) Joints

The joint assemblies shall be so formed and accurately manufactured that when the pipe units are drawn together in the trenches, the pipe shall form a continuous watertight conduit with smooth and uniform interior surface and shall provide for slight movements of any pipe in the pipeline due to expansion, contraction, settlement, or lateral displacement. The rubber gasket shall be the sole element of the joint depended upon to provide water tightness. The ends of the pipe shall be planes at right angles to the longitudinal centreline of the pipe. The ends shall be finished to regular smooth surfaces.

The coupling sleeve may be fabricated of asbestos-cement and shall be equivalent to the class of pipe for which it is used. The coupling sleeve shall be accurately machined to fit over the ends of the pipe and to compress the rubber gaskets in position between the pipe and the sleeve when assembled. The sleeve shall be centred over the joint when assembled in final position.

Rubber gaskets shall conform to ASTM D1869 or AWWA C111.

All gaskets shall be stored in as cool a place as practicable, preferably at 22^{o}C or less, and in no case shall the gaskets be stored in the open, exposed to the direct rays of the sun. No gasket which shows any evidence of deterioration, such as surface checking or cracking, shall be installed in a pipe joint.

g) Hydrostatic Proof Test

Each pipe unit, each coupling, and all pipe used in fabricating bends, tapers, tees, or other fittings each withstand, without leakage, a hydrostatic proof test by the manufacturer of not less than 1.8 MPa for class 18 pipes and 2.4 MPa for class 24 pipes.

The hydrostatic proof tests shall be conducted by placing the pipe in a hydrostatic pressure testing machine with gaskets which seal the ends of the pipe. All air shall be expelled from the pipe, and the internal water pressure increased at uniform rate to the applied proof pressure stated and maintained at this test level for not less than thirty seconds.

h) Hydrostatic Bursting Strength Test

Pipe specimens 500 mm or longer, cut from unmachined portions of the pipe, shall withstand the minimum bursting stress of 22.5 MPa. A 500 mm or longer test specimen shall be cut from a standard pipe unit selected from each 300 lengths, or fraction thereof, of each size and class of pipe manufactured on each machine during each shift. The hydrostatic bursting test shall be conducted by placing the test specimen in a hydrostatic pressure testing machine with gaskets which seal against the inside of the pipe at or near the ends of the test specimen without

materially counteracting the hydrostatic test pressure. All air shall be expelled from the pipe, and the water pressure shall be increased to the minimum bursting pressure at a uniform rate. Each test specimen which passes the bursting test will be accepted for use in construction provided that such test specimens to be used shall be re-tested in accordance with the provisions of subparagraph (i) below and withstand the hydrostatic proof test without leakage.

In the event that a test specimen fails to withstand the hydrostatic bursting test, the manufacturer will be allowed to test two additional specimens of the same size and class manufactured during the same shift. If either of the two additional specimens fails to pass the test the entire lot of pipe represented by the test specimen shall be rejected.

i) Crushing Strength Test

Pipe specimens cut from unmachined portions of the pipe shall withstand the minimum crushing strength of 45.0 MPa. A 300 mm-long test specimen shall be cut from a standard pipe unit selected from each 100 lengths, or fraction thereof, of each size and class of pipe manufactured on each machine during each shift. The test shall be performed in accordance with BS EN 512.

In the event that a test specimen fails to withstand the crushing strength test, the manufacturer will be allowed to test two additional specimens of the same size and class manufactured during the same shift. If either of the two additional specimens fails to pass the test, the entire lot of pipe represented by the test specimen shall be rejected.

j) Sulphate Resistance Test

If this test is required, as provided in Subparagraph (p) below, the Contractor shall submit, at no cost to the Employer, 300 mm sections of each size and class of pipe to be used in the work. These samples shall be delivered at the Contractor's expense to the Engineer. If the manufacturer makes changes in the type of amount of cement being used in the pipe or in the methods of manufacturing or curing, the Contractor shall submit additional 300 mm sections of each size of pipe in which such changes occurred. The sulphate resistance of AC pipe shall be determined by the following test method:

Specimens taken from the section of pipe to be tested shall be saw cut into small test specimens. The test specimens shall be prisms 150 mm in length and generally square in cross-section, with width and thickness being equal to the thickness of the pipe when the thickness is 25 mm or more. Where thickness of the pipe is less than 25 mm, the width of test specimens shall be 25 mm. After the test specimens are cut, stainless steel inserts for length change measurements shall be placed and cemented in each end test specimen so that an effective gage length of 125 mm is obtained. The test specimen shall then be conditioned at 23^{o}C plus or minus one degree and 50 plus or minus five percent relative humidity for a minimum of three days prior to testing. Upon completion of this conditioning period, the initial length between inserts of each specimen shall be measured to the nearest 0.0025 mm, and the length

recorded. The test specimen shall then be subjected to a daily cycle of 16 hours soaking in 0.15 molar solution of Na_2S0_4 at room temperature, and eight hours drying in circulating air at 54^{o}C plus or minus three degrees. The test specimens shall be removed from the cycle on completion of the eight-hour drying period at 7, 14 and 28 days age, cooled to 23^{o}C plus or minus one degree, and the length of each test specimen measured and the lengths recorded.

The test specimens, after 28 days exposure under test conditions, shall meet the following limitations on linear expansion:

- 0.20 percent, maximum, for pipe having a shell thickness of 18 mm or less.
- 15 percent, maximum, for pipe having a shell thickness greater than 18 mm.

k) Uncombined Calcium Hydroxide Test

If this test is required, as provided in subparagraph (p) below the Contractor shall submit specimens of the AC pipe to be used in the work for determination of compliance with limitation on the amount of uncombined calcium hydroxide in the pipe. The specimens shall be obtained and submitted in accordance with the requirements for submission of samples for the sulphate resistance test as provided in subparagraph (j) above except that separate specimens for uncombined calcium hydroxide test will not be required if specimens from the pipe are submitted for sulphate resistance test. The percentage of uncombined calcium hydroxide shall be determined in accordance with Appendix F of Australian Standard AS 1711-1975.

The AC pipe shall not contain more than 2.0 percent uncombined calcium hydroxide when tested in accordance with the specified test method.

l) Cast Iron Fittings for Asbestos Cement Pipelines

The fittings shall be Cast Iron (CI) to BS 4622. Suppliers shall not change the source of supply of their material without written notification to the Engineer. The class shall be PN 16.

The fittings shall be internally and externally fusion bond epoxy coated with a minimum thickness of 300 microns as specified under Clause 3.4.

It shall be the responsibility of the Contractor to provide the required quantity of fittings in order to complete the pipeline installation.

Elastomeric gasket type joints shall be flexible spigot and socket joints with socket integral with the pipes and incorporating rubber rings recommended by the manufacturer and approved by the Engineer.

Fittings shall be plain-ended with a machined spigot suitable for coupling to AC pipe.

Flanged joints shall comply with the dimensions and drilling details set out in ISO 2531. Flanged gaskets shall be the metal reinforced type.

Details of CI fittings showing exact dimensions of joints and diameter of rubber gasket including tolerances, and other major dimensions shall be submitted in quadruplicate for approval of the Engineer.

All connections between AC pipe and other types of pipe shall be made with neoprene rubber gasket joints. The design of fittings to connect AC pipe to other types of pipe including valves, couplings and adaptors shall be submitted to the Engineer for approval.

m) Curves

Minor changes in alignment and grade may be made by deflecting the pipe units at joints as provided herein and pipe units shorter than standard length may be required. The maximum deflection angle between adjacent pipe units of 4 m length in place shall not exceed the values given in the following tabulation:

Pipe Diameter (mm)	Maximum Deflection (degrees)
250 and less	2.5
300	2.0
350	2.0
400	1.5
500	1.5
600 and larger	1.0

The ends of each pipe shall be laid on the theoretical centreline of the pipeline and to the grade shown on the Drawings.

For pipe units shorter than 4 m, the deflection angle shall be decreased in proportion to the ratio of the length used to 4 m.

The Contractor may submit details of other methods of providing curves in pipelines for consideration by the Engineer and, if deemed satisfactory, will be approved by the Engineer at no additional cost to the Employer.

Where no radius is given at minor points of intersection, the deflection angle shall be accomplished by making the deflection at one or two couplings as required. The pipe unit on each side of a deflected coupling shall have a minimum length of 2 m.

n) Longitudinal Bending Test

A longitudinal bending test shall be performed on each length of pipe in sizes up to and including 200 mm diameter when the length exceeds 2.9 m. The test shall be performed in accordance with AWWA C400 Class 100.

p) Basis of Acceptance

The acceptability of the pipe will be based on the results of the following tests at the frequency specified in the foregoing:

- Hydrostatic proof
- Hydrostatic bursting
- Crushing strength
- By inspection during and after manufacture
- Longitudinal bending test.

The Engineer reserves the right to perform uncombined calcium hydroxide and sulphate resistance tests on samples of the pipe as provided in subparagraphs (j) and (k) above. If he does not elect to perform uncombined calcium hydroxide and sulphate resistance tests, the Contractor shall furnish certification that the pipe being furnished is AC pipe that has been tested and meets the requirements of these Specifications.

3.2.4 HDPE Pipes and Fittings

HDPE (High Density Polyethylene) pipe and fittings shall to ISO 4427, Table 3, Pipe Grade PE 100 with SDR 11 which is rated for PN 16 at 20 °C. The outside diameters shall be in accordance with ISO R 161-1. Where diameters are stated on the Drawings the diameter shall be the nominal internal diameter of the pipe and fitting. In the Bill of Quantities the diameters stated are the nominal outside diameters.

The nominal outside diameters of the pipe and fittings shall be as follows:

Nominal Internal Diameter (mm)	Nominal Outside Diameter (mm)
80	110
100	125
150	180
200	250

The upper limit of the HDPE pipe and fittings under this Contact shall be the equivalent of 200 mm nominal internal diameter.

All jointing shall be by fully automatic butt fusion welding or by electrofusion welding or by mechanical restrained joints for use with HDPE pipe and fittings.

Special restrained transition fittings manufactured specifically for that purpose shall be provided at PE to metal connections. Fabricated fittings will not be permitted. The system shall be restrained completely, except at locations where HDPE pipes are connected to unrestrained pipe systems. The restrained transition fittings shall be in accordance with Clause 3.2.4 (b).

Fittings and bends shall be manufactured from PE 100 polymer of compatible material to that of the pipe. Pipe coils may be supplied for pipes of internal 100 mm diameter and less.

No HDPE pipe and fitting shall be ordered until all tests and Engineer's approvals have been obtained.

a) Pipes

i) Requirements

Pipes shall be extruded to control the outside diameter, and the sizes of pipes shall be to the metric convention. The allowed

tolerances are in accordance with ISO 11922-1, Table 5 for wall thickness and Table 1, Grade B for outside diameter. The out-of roundness of the outside diameters of the pipes shall be within the values for Grade N given in Table 2 of ISO 11922-1.

ii) 20°C and 80°C Pipe Performance Requirements

All batches of pipes shall be subjected to a single 100 h 20 °C pressure test. In addition, one randomly selected pipe shall be tested for 165 h 80°C pressure test using notched pipe. The 100 h test is as at 12.4 MPa, the 1000 h test at 8.0 MPa (PE-100 SDR 11 pipes) pipe hoop stress and the pipe shall not fail. The notched pipe test requires the pipe to have four (equally spaced around the circumferences), axial notches machined into the pipe wall to a minimum depth of 19% of the pipe wall thickness. Such notches simulate the abuse pipe can be subjected to on-site and the higher ambient temperatures in the Gulf. The test procedures shall be in accordance with ISO 1167.

iii) Tensile Properties of Pipe

Tensile samples taken from the wall of PE 100 pipes shall exhibit a minimum failure strain of at least 500%. At a crosshead speed of 50 mm/minute, the tensile strength at yield shall be greater than 231 MPa for PE 100 pipes. Tests shall be undertaken at 20 °C using a sample shape defined in ASTM D638, and shall be made with each production run of pipe.

iv) Offset Butt Joint Performance

For all pipe diameters one butt fusion joint shall be prepared with the two pipe axes parallel but offset by 20% of the pipe wall thickness. Jointing shall be undertaken using the recommended butt fusion jointing parameters. The welded pipe is to be tested at a pipe hoop stress of 4 MPa at 80°C and the lifetime shall be equal to or greater than 500 hours for black pipe. This test is a type test.

b) Jointing of PE Pipes

The Contractor shall employ only manufacturer's certified staff to perform all of the following jointing techniques to create PE pressure pipe systems. An approved sub-contractor may be used only with the Engineer’s approval. The original certificate of each certified staff shall have an individual registration number and shall be produced for the Engineer’s inspection. The certificate shall have been issued not more than two years prior to commencing the work and shall remain valid for the duration that each staff is undertaking welding. If in the opinion of the Engineer any certified staff are not strictly following the manufacturer's instructions and procedures, the Engineer has the right to immediately remove the certified staff from the site and another approved certified staff shall replace that person.

The manufacturer shall provide accurate and easy-to-understand assembly instructions in English which can be used at any subsequent time for reference purposes.

Transition fittings manufactured specifically for that purpose shall be used to join PE pipes to metal pipes. Restrained flange adaptors for DI/HDPE pipe shall be used for joining HDPE pipe to DI pipe adjacent to valve chambers and at all other locations where HDPE pipe is to be joined to DI pipe. Flanges shall be drilled to drilled to class designation PN 16 in accordance with ISO 2531. Gaskets shall be EPDM to BS EN 681 Type WA. The restrained flange adaptor for DI/HDPE shall incorporate a gripping mechanism suitable to resist pipe pullout of the HDPE pipe to the performance requirements of WIS 4-24-01 and ISO 14236.2 and the Contractor shall provide a warranty from the manufacturer to this effect. The flange adaptor must be supplied fully pre-assembled, not requiring disassembly prior to installation. Flange adaptor shall be constructed from ductile iron to BS EN 1563 Grade EN-GJS-400-18 or equivalent. PE stub flanges with metal flanges will not be permitted.

Only electrofusion fittings shall be used to install off-takes or metal restrained couplings for use with HDPE.

The Contractor shall take all measures to prevent contamination of the pipe ends to be joined during the heating and fusion process. Fusion welding shall not be conducted on site under conditions where the wind causes sand to blow onto the joint to be joined.

For jointing HDPE pipe and/ or fittings with HDPE pipe and/ or fittings, the Contractor may use ductile iron couplings or flange adaptors with restrained type joints for use with HDPE instead of fusion welding. Couplings and rings shall be constructed from ductile iron to BS EN 1563 Grade EN-GJS-400-18 or equivalent.

c) Pipe to Pipe Butt Fusion Jointing

The Contractor shall adhere to the following guidelines in respect of butt fusion jointing HDPE pressure pipes:

i) All butt fusion welding shall be in accordance with the latest edition of DVS 2207 1 “Welding of Thermoplastics – Heated Tool Welding of Pipes, Pipeline Components and Sheets made from HDPE”. The Contractor shall make available a complete copy of this document on site.
ii) Pipes of the same outside diameter but either different wall thickness or different classes of resins shall not be joined by butt fusion.
iii) PE pipes made from very high molecular weight resins (e.g., Philips Driscopipe M 800 Series) shall not be used.
iv) The Contractor shall use automatic butt fusion machines as specified herein.

d) Fittings

All HDPE fittings shall be manufactured by injection moulding. Fabricated HDPE fittings will not be permitted. In any case where HDPE injection moulded fittings are not manufactured from approved suppliers, a ductile iron fitting with restrained joints for use with HDPE shall be provided.

The Contractor may use ductile iron fittings with restrained joints for use with HDPE instead of injection moulded fittings.

HDPE Fittings shall comply with EN 12201.

e) Electrofusion Fittings

All fittings shall be packed in such a way to allow instant use on site without additional cleaning.

The heating coils contained in each individual fitting and saddle shall be so designed that only one complete process cycle is necessary to fully electrofuse the fitting to the adjoining pipe or pipes. Heating coils shall not be exposed and shall be fully imbedded into the body of the fitting for protection purposes during assembly.

An individual data carrier card in compliance with ISO standards containing a magnetic strip and an appropriate barcode or barcodes for data transfer purposes shall be supplied with each fitting. All fittings shall have moulded-in identification and product information.

Process voltage of all fittings must not exceed 40 volts. Insulated contacts for the terminal pins shall be provided. A limited path style fusion indicator acting for each fusion zone as visual recognition of completed fusion cycle shall be incorporated into the body of the fitting. The design of the indicators shall prevent the escape of fusion melt.

All internal or externally threaded transition adaptors in the outside sizes up to and including 50 mm shall be designed with an integral polyethylene collar from PE 100 and shall not rely on rubber or synthetic seals. Threaded adapter bodies may be from brass or stainless steel and shall be of modular type and shall not be moulded into an electrofusion fitting socket.

f) Electrofusion Saddles

All saddles up to at least mains size outside diameter 250 mm shall be designed with two separate halves having a single hinge type attachment and shall be correctly processed without specialised external spring-loaded tooling.

The top half of the saddle shall be equipped with an outlet which can accept various other system components such as tapping tees, adapters, valve tees, caps, stop-off attachments, and the like that are simultaneously fused together with the saddle to mains joint in one operation.

Each branch outlet shall be equipped with an integral clamping device.

All pipe saddle sizes from above outside diameter 63 x 40 mm shall allow a 360^{o} rotation of the branch outlet.

Safe tapping into a mains must be possible under the defined allowable maximum water pressure according to the respective pipe series and ambient temperature.

The tapping saddle cutter shall be designed to seal-off the central passage in the uppermost position and the cutter design must fully contain the cut-out coupon. The saddle shall be capable of permanently seal-off the top of the saddle with an electrofused cap in the mains sizes from outside diameter 63 mm and above.

g) Electrofusion Control Units

The control units shall operate with magnetic card and/or barcode data transfer method transmitted via a reader pen or a scanner.

The initial power supply to enable the control unit to function correctly for all fitting and saddle sizes up to outside diameter 500 mm shall not exceed 4 kWA.

The unit shall be designed with an automatic compensator so that it can fully operate within input tolerances of between 180V and 264 V, respectively 45 and 65 Hz. The units shall operate with a stabilised fusion voltage. The range of fusion voltage shall be between 8 and 42 volts.

A galvanic separation shall exist between the primary and secondary circuits by means of a high frequency transformer

The unit liquid crystal display shall show information in English.

The display shall be backlit, be easily readable and give relevant information including:

- recognition of fitting type, dimension and manufacturer
- resistance of connected fitting
- a check-system prior to commencement of fusion process
- actual running and final fusion time in seconds
- primary voltage and frequency
- ambient temperature
- individual fusion number and unit number
- mode of data transfer
- appropriate cooling time.

A temperature sensor shall be provided. The operating range of ambient temperatures shall be at least +50°C.

The unit shall be capable of processing various manufacturers' products.

A lightweight transport box with internal document pocket shall be provided. The complete control unit shall be fully contained and the weight including all primary and secondary cables shall not exceed 15 kg.

An external memory bank shall be able to record at least 300 fusion records and be easily accessible and exchangeable. The supplier shall provide a full range of system software and data transmission accessories as applicable for data processing. The ability to download fusion records from all memory systems via an RS 232 interface shall be provided. A back-up internal reserve memory with override shall be provided. Peripheral information such as operator and job number shall be able to be coded-in for fusion record purposes.

A blocking system to prevent unauthorised use shall be incorporated into the design.

The protection class of the unit shall be at least IP 65. All control units shall fulfill the Electro-Magnetic Compatibility regulations in accordance with the latest European standards.

h) Butt Fusion Control Units

Butt fusion machines and equipment shall comply with the requirements of the latest edition of DVS 2208-1. The Contractor shall make available a complete copy of this document on site.

The equipment shall employ data storage and data retrieval to record the conditions used for butt fusion jointing.

Any butt fusion machines and equipment that do not fully comply with this Specification and DVS 2208-1 shall be indelibly marked as in non-compliance and shall be removed from the site and replaced immediately.

3.2.5 Special Types of Joints

a) General

The requirements of this Clause shall be read in conjunction with Clause 3.11.

In addition to the types of joints specified for each type of pipe specified, the following joints may be shown on the Drawings or otherwise specified particularly for force mains.

The special joints shall be supplied complete with joints and rings, and galvanized nuts, bolts and washers and in conformity with BS 4395 and BS 4320 or approved standard and shall be capable of withstanding the test pressures appropriate to the pipes for which they are supplied.

b) Mechanical Couplings

These shall be used, where indicated, with AC, cast iron, and ductile iron pipes, and joints between pipes manufactured from each of the materials.

In jointing plain-ended pipes of these materials, the Contractor shall follow the manufacturer's recommendations regarding the methods and equipment to be used in assembling the joint. The ends of the two pipes to be joined shall be rendered smooth to allow the sleeves to slide freely and where necessary or directed the Contractor shall recoat the pipe ends with two coats of polyurethane paint.

Where directed by the Engineer or shown on the Drawings, end movement of pipes joined shall be restrained by a steel work harness fabricated in accordance to the typical details shown on the Drawings and or specified herein and on completion the harness shall be cleaned and painted with two coats of polyurethane paint as directed by the Engineer.

c) Flange Adaptor Joints

These shall be used on asbestos cement, cast iron and ductile iron pipes and joints between each of the materials as shown on the Drawings and or specified herein.

Flange adaptors shall be fitted in accordance with the manufacturer's recommendations. Flanges shall be to PN 16 in accordance with ISO 2531. The flange gaskets shall be the metal reinforced type.

d) Mechanical Joints

Mechanical joints approved by the Engineer shall be used on asbestos cement, cast iron and ductile iron pipes, and joints between each of the materials as shown on the Drawings.

The joints shall be assembled taking into account the manufacturer's recommendation regarding the methods and equipment to be used in assembling the joint. In particular a gap of 10 mm shall be left between adjacent pipes.

All flexible couplings, flanged adaptors and other mechanical joints shall be provided with a factory applied externally and internally fusion bonded epoxy coated using electrostatic/fluidized bed process conforming to DIN 30677 or approved equal, with a minimum thickness of 300 microns, non-toxic, and holiday-free conforming to AWWA C550 and colour code RAL 5015. Before application of epoxy coating the surface shall be sand blasted to a minimum of SA 2.5 and air blown to ensure good bond.

3.3 PRODUCT HANDLING, DELIVERY AND STORAGE

3.3.1 General

Pipe shall at all times be handled with equipment designed to prevent damage to the interior or exterior coating of the pipeline. Pipe with cement mortar lining or having any other special coating or lining shall only be handled with wide canvas or rubber covered slings. Bare cables, chain hooks, or metal bars shall not be allowed to come in contact with the coating.

All pipe ends shall suitably protected against damage during delivery and handling. All flanges shall have wooden disc bolted on. Plain and sleeve ends shall be wrapped or cushioned to protect from damage to external protection.

All pipes, valves and fittings shall be provided with adequate protection against corrosion, mechanical damage deterioration and exposure during handling, delivery and storage until they are incorporated in the Works. The Contractor shall submit his proposals for protecting the pipes and fittings for approval by the Engineer.

Submit arrangements for offloading and handling each type or class of product on site. Submit arrangements for storing and protecting each type or class of product on site.

3.3.2 Shipping

When making shipments, all chains, cables and hold-down equipment shall be carefully padded where in contact with the pipe.

3.3.3 Unloading

Unloading from the trucks shall be done with care using appropriate slings and cables for ductile iron pipe. No pipe shall be allowed to fall from trucks. Pipe shall only be unloaded using a crane or fork lift. Pipe shall not be permitted to strike other pipes or other objects, and shall not be rolled freely or dragged along the ground.

3.3.4 Storage

The Contractor shall take into temporary protective storage all pipe and appurtenant materials not required for immediate installation in the Works or, in the case of pipes, for stringing out along pipelines. The Contractor shall not string out along pipelines more pipe than can be installed in one day. Jointing materials shall be stored under cover until they are required for installation.

Pipes in storage shall be laid on wedged timber bearers so as to be at least 100 mm clear of the ground; pipes may be stacked up to three pipes high if suitable protective packing is placed between layers and additional bearers are provided where necessary to prevent damage to sheathed and coated pipes. Pipes strung out along pipelines shall be raised 100 mm above the ground on timber bearers.

3.3.5 Gaskets

Gaskets shall be stored in containers or wrappers that will protect the gaskets from ozone and other atmospheric deterioration.

3.3.6 Polyethylene Sleeving

Polyethylene sleeving shall be stored with protective packaging and out of direct sunlight.

3.3.7 Gaskets and Jointing Materials

Gaskets, gasket lubricants, bolts, and jointing materials shall be delivered in separate, clearly marked boxes.

3.3.8 Spare Jointing Materials

As part of the quantity delivered, the Contractor shall include in his bid 10% additional gaskets and loose bolts nuts and washers than may be theoretically required for the amount of pipe furnished to cover field losses.

3.4 VALVES AND APPURTENANCES

3.4.1 General

All valves supplied shall be suitable for use with water temperatures up to 50^{o}C and in climatic and soil conditions encountered in the Sohar Town. The nominal working pressure shall be 16 bar.

All hydrants, valves and appurtenances shall be externally and internally fusion bonded epoxy coated using electrostatic/fluidized bed process conforming to DIN 30677 or approved equal, with a minimum thickness of 300 microns, holiday-free, non-toxic and colour code RAL 5015. Before application of epoxy coating the surface shall be sand blasted to a minimum of SA 2.5 and air blown to ensure good bond.

The valves shall be supplied complete with metal reinforced flange gaskets and galvanized steel nuts, bolts and washers for flanges as specified under Clause 3.2.2 (b). Unless otherwise detailed or specified herein, gate and butterfly valves shall be supplied complete with stainless steel type AISI 304L extension spindles and appurtenances such that the squarenut operator is within 500 mm of the top of the chamber cover slab.

Attaching hardware of all valves and appurtenances shall be stainless steel type 304L or 316L.

All valves shall be tested to the appropriate test pressure at the manufacturer's works, and shall be supported by a test certificate from the manufacturer. Work tests on valves 300 mm diameter and larger shall be witnessed and certified by an approved independent testing agency at no extra cost to the Employer.

Markings of valves shall include the following:

- manufacturing standard
- manufacturer's name or trademark
- nominal diameter(s) (ND) in mm
- pressure rating in bars
- an individual serial number which relates directly to the manufacturer's test certificate
- month and year of manufacture.

The pressure rating of the by-pass valve shall be the same as that of the main valve.

Position indicators shall be provided on all gate, butterfly and check valves.

The maximum effort required to operate the valve against the maximum unbalanced head applied at the circumference of the hand wheel or end of the tee-key shall not exceed 15 kNm, where necessary gearing shall be provided as specified herein to achieve this.

Tee-key operators shall be supplied at the rate of on tee-key per 3 valves of the same diameter.

Inspection, function test and strength test shall be made in accordance with DIN 3230 or approved equal.

The Contractor shall supply the original manufacturer's test certificate endorsed by the approved independent testing agency for each valve supplied. The certificate shall relate to the individual number cast on each valve and shall give the date of test.

Valves shall be manufactured by an ISO 9000 series certified company who has had several years of experience in the manufacture of valves and shall have a fully equipped technical back-up and service facility in Oman. The manufacturer of the valves shall confirm the particular application of the valves for the intended use and shall provide a warranty of minimum 5 years based on a replacement basis including labour and material at no extra cost. The warranty shall be issued directly to the Employer.

Before proceeding with any manufacturing, the Contractor shall submit Shop Drawings for Engineer's prior written approval. The Contractor shall describe the items being submitted; show dimensions, physical configurations, components and their composition, coating systems, etc.; include material specification lists that summarize the specification features as called for in these Specifications; and include such other necessary data as would provide a complete and adequate specification for re-ordering any spare part or an exact duplicate of the original from the manufacturer at some future date.

3.4.2 Gate Valves

Gate valves shall conform to the provisions of MEW WO4, and DIN 3352 Part 4A and B, or approved equal, and as further specified herein. The valves shall be inside screw, non-rising stem, clockwise closing wedge gate valves suitable for underground use. The direction of opening and closing shall be clearly marked.

Valve pressure ratings shall equal the class of pipe and shall be designed for the "Closed End Test".

Gate valves shall be gun metal seated for diameters greater than 300 mm. The valve body and wedge shall be ductile iron GGG 40 to DIN 1693. Stems shall be stainless steel 1.4057 complying with DIN 17440 or approved equal and stem nut of gun metal LG2 to BS 1400 or approved equal. Stem collars shall be cast or forged solid with the stem; welding is not permitted. Stems shall be of such length that the thread of the stem nuts shall be entirely engaged with the valve in closed position. Stem sealing shall be toroidal 'O' seals.

The packing shall be double 'O' ring recessed into the grooves in the ring plate only. Grooves shall not be in the stem unless the thickness of the stem at the smallest diameter of the groove equals that of a stem required without a groove.

Gear-operated valves shall be fitted with cast iron hand wheels of suitable size. Other valves shall be provided with operating nuts and tee-keys. Gear cases shall be totally enclosed and equipped with indicators to show valve position and designed for full differential pressure of 16 bars.

Valve actuator shall have an integral grease case and shall be spur-geared with the pinion shaft parallel to the stem where an operating nut is specified, and bevel-geared with the pinion shaft at right angles to the stem where an operating hand wheel is specified. Other details of the actuator shall be as specified under Clause 3.4.3 (Butterfly Valves).

Gate valves 300mm or less shall be soft seating gate valves, inside screw and bolted bonnet connection with straight-through port. The wedge shall be low clearance-guided in the body and shall have an inner core of ductile iron GGG 50 conforming to DIN 1693 or approved equal, fully encapsulated with EPDM. The rubber covering shall have a minimum thickness of not less than 2.5 mm on both flow sides and on sealing surfaces the minimum thickness shall be not less than 4 mm with no body-metal exposed. The spindle thread shall be of the rolled type. The spindle sealing shall be designed in the form of at least two 'O'-rings of EPDM, spindle sealing should be replaceable under pressure. The body, bonnet and wedge shall be of ductile iron GGG 40 conforming to DIN 1693. Valve spindle shall be made of stainless steel 1.4462 to DIN 17440 or approved equal. Stem nut shall be of zinc-free bronze 2.1050.01 to DIN 17007, BS 1400 CTI-C or approved equal. Manual operation shall be by hand wheel or by tee-key as specified.

Valve ends shall be compatible with the pipe couplings supplied.

Unless otherwise shown on the Drawings and or specified herein all gate valves shall be flanged and drilled to PN 16 in accordance with ISO 2531. Face to face length shall be in accordance with EN 558-1/14.

All gate valves shall be designed to provide 100% watertight shut-off at all specified pressures.

Valves shall be clockwise closing using a square nut operator. Valves above 300 mm diameter shall be gear-operated and hand wheels shall be provided where directed by the Engineer.

Flanged spigot adaptors for double flanged valves shall be of ductile iron. The length and size of bolts shall suit the thickness of the flanges of the fittings, as well as the valve flange.

3.4.3 Butterfly Valves

Butterfly valves shall be of the double-eccentric, clockwise closing, rubber-seated type conforming to MEW WO6, and DIN 3354 Part 2 or approved equal, and suitable for flow in both directions and for underground use. The flange drilling shall be as for Class PN 16 to ISO 2531. The valve body shall be ductile iron

GGG 40 to DIN 1693. Body ends shall be flanged ends with short body laying length complying with DIN 3202, Part 4.

The butterfly valve disc shall be of the offset and pinned design to provide a full 360 degrees seating surface uninterrupted by shaft holes. The disc shall be constructed of ductile iron GGG 40 to DIN 1693 with no external ribs transverse to flow. Non-metallic discs are not acceptable.

The resilient seat shall be EPDM designed to provide 100% watertight shut-off at all specified pressures. The seat shall be mechanically retained on the disc edge by means of corrosion-resistant screws of stainless steel 1.4490 to DIN 17440 or approved equal, and must be capable of mechanical adjustment in each direction without the use of special tools. The seat must also be capable of being replaced in the field without chipping, grinding or burning out of the old seat or retaining substance.

The valve seat shall be absolutely corrosion proof wear resistant nickel weld overlay microfinished and mechanically retained to assure a leak-proof design.

Valve shafts shall be of the two piece "Stub" type extending into the disc hubs for a distance of at least 1-1/2 shaft diameters or of a single piece "through" type. In either case the valve shafts shall be of stainless steel 1.4462 complying with DIN 17440 or approved equal.

Valve shafts shall be securely attached to the disc by means of bolts, dowel pins, taper pins or a combination of the three. Shaft bearings shall be contained in the valve body integral hubs. Bearing shall be self-lubricated, sleeve-type of Ni-resist material. The valve assembly shall be furnished with single two-way thrust bearing bush of Ni-resist material designed to centre the disc in the body at all times and to absorb thrust forces. The bearing cover and flange shall be ductile iron GGG 50 to DIN 1693.

The drive end shaft seal shall be of the cartridge type with 'O' rings to provide positive sealing.

The valves shall be suitable for throttling with carefully balanced disc and without any vibration in partially opened position.

The valve actuator shall be bevel or worm-geared and integrally mounted on the valve mounting flange and shall be of the self-locking travelling nut type and designed for full differential pressure of 16 bars having protection class IP 68 to prevent water entry to a pressure of 7.5m head pressure. Limit stops in open end positions at gear entrance giving high resistance to fracture caused by excessive operating force shall be provided. Actuators shall have a standard operating wheel, shall close clockwise with indicators to show valve position. Actuator design must permit repositioning of actuator in 90-degree increments, allow changing direction of rotation for valve closure, and permit adjustment of the valve disc, all without removal of housing cover.

3.4.4 Air Valves

Air valves shall be designed to:

- discharge air during filling of pipelines,

- admit air during emptying of pipelines,
- discharge air accumulated at high points in pipelines during normal operation.

Air valve bodies shall be flanged, with flanges drilled to PN 16 in accordance with ISO 2531. Each valve or valve assembly shall be installed complete with isolation valve, whether or not indicated on the Drawings. Valves shall be designed for a water working pressure of not less than 16 bar and shall have floats made of stainless steel 1.4541 to DIN 17440 or approved equal or ABS plastic, all working parts and bolts made of stainless steel 1.4541 to DIN 17440 or approved equal, seat made of EPDM with body and cover made of ductile iron GGG 40 to DIN 1693 or other approved non-corroding materials. Valves shall be internally and externally coated with fusion bonded epoxy or nylon approved for drinking water.

a) Double Orifice Air Valves

These shall combine both large and small orifices within one valve. The large orifice shall be sealed by a buoyant rigid ball and the chamber housing shall be designed to avoid premature closing of the valve by the air whilst being discharged. The small orifice shall be sealed by a buoyant ball at all pressures above atmospheric, except when air accumulates in the valve chamber.

b) Single Orifice Air Valves

These shall have a small orifice only, operating in a manner identical with the small orifice in a double orifice valve.

c) Isolation Valves

Isolation valves for use with air valves shall be compact wafer type butterfly valves, flanged with flanges drilled to PN 16 in accordance with ISO 2531. The valve body shall be cast iron or ductile iron. The disc shall be of stainless steel. The shaft and pins shall be of stainless steel. Bolting shall be of stainless steel. The resilient seat shall be EPDM designed to provide 100% watertight shut-off at specified pressure. The valve actuator shall be a locking disc hand-lever type. Valves shall be internally and externally coated with fusion bonded epoxy or nylon approved for drinking water.

3.4.5 Check Valves

Check valves shall be of the quick acting, single door, metal seated, swing type for horizontal use with offset disc and slanted seat, complete with internal damping device, position indicator and limit stop in open position. Electric limit switches shall be provided where shown on the Drawings or directed by the Engineer.

The face to face length shall be to DIN 3202, Part 4. Unless otherwise shown on the Drawings and or specified herein all check valves shall be flanged and drilled to PN 16 in accordance with ISO 2531.

The valve shall be of double eccentric design. The body of the valve shall be of ductile iron GGG 40 conforming to DIN 1693 and the disc GGG 50 with hinge pin/shaft stainless steel 1.4462 to DIN 17440 or approved equal.

The valve shafts shall be supported in bearings of self-lubricated material of zinc-free bronze 2.1050 to DIN 17007 or approved equal.

The seat in the valve body and on the disc shall be made of corrosion-proof and wear-resistant nickel weld overlay, microfinished.

3.4.6 Pressure Reducing Valves

Pressure reducing valves shall be capable of maintaining a constant downstream pressure from a higher constant or variable pressure, for varying rates of flow without causing shock or water hammer on the system. The valve shall be drop tight under no flow conditions with a renewable resilient seal.

The valve shall be of the self-contained, hydraulically operated, differential piston type. The main valve shall contain just one moving part which is the piston. The piston shall be provided with a replaceable cup and seat and it shall be possible to remove the liner or piston without removing the valve from the pipeline.

The main valve shall not contain a diaphragm. There shall be no stems, guides or spokes within the waterway.

Throttling shall be performed through vee ports and shall not be by the valve seating surfaces.

The valve operation shall be achieved by the interaction of the inlet pressure, outlet pressure and an intermediate pressure produced by a pilot valve acting on the upper side of the main valve.

The pilot valve system shall be actuated by a diaphragm connected to the outlet pressure on the underside and a constant pressure on its upper side derived from a spring loaded to permit convenient adjustment over the required operating range. The pilot valve system shall be fitted with isolation valves at each connection point, a Y type strainer, and adjustable speed control valve.

The valve shall incorporate an indicator to show valve position.

One pressure gauge shall be fitted upstream and one fitted downstream to indicate upstream and downstream pressures.

The material for the valves shall be as follows:

- Body of the valve shall be of cast or ductile iron.
- Internal trim shall be zinc-free bronze.
- Piston and liner shall be zinc-free bronze.
- All controls shall be of non-corrosive material.
- All piping shall be copper and fittings zinc-free bronze or gunmetal.

All internal parts including the valve seals shall be easily accessible when the valve cover is removed.

Nominal pressure shall be 16 bar, and body ends shall be flanged and drilled to PN 16 in accordance with ISO 2531.

3.5 VALVE AND GATE OPERATORS

3.5.1 Lifts

Lifts shall be designed to operate the gate of the specified head with a maximum of 15 kNm torque applied to the device. The lift shall be a liftnut for T-bar or gear/handwheel operation as shown on the Drawings.

3.5.2 Liftnut

The liftnut shall be hexagonal, bronze and internally threaded to fit the stem. The housing shall be cast iron and suitable for mounting the head angle, gate frame extension or wall mounted bracket. The liftnut shall be flanged to maintain position in the housing and to accommodate the thrust developed during gate operation. Each lift shall be furnished with a bronze stop nut. The nut lift shall accept a T-bar operator or handwheel. Suitable T-bar operators shall be furnished. T-bar operators shall be supplied at the rate of one T-bar per 3 valves of same diameter unless the valve is to be installed in an isolated location in which case one T-bar shall be supplied for each valve location.

3.5.3 Gear Lift

The gear lift mechanism where required shall be of the crank-operated type with either a single or double gear ratio, depending on the lift load. Each type shall have a cast bronze liftnut threaded to fit the operating stem. Ball thrust bearings shall be provided above and below the flange on the liftnut to take the load developed in opening and closing the gate. Gears shall be of cast iron or steel accurately machined with cut teeth, and smooth running with suitable shafts running in bronze sleeve bearings or roller bearings of ample size. All geared lifts shall be suitable for auxiliary motor operation. All gears and bearings shall be enclosed in a cast iron housing. Fittings shall be provided so that all gears and bearings can be periodically lubricated. The removable cast iron crank shall be fitted with a rotating handle. The lift mechanism shall be supplied with a cast iron pedestal, machined and drilled to receive the gear housing and suitable for bolting to the operating floor wall bracket. The maximum crank radius shall be 400 mm. The direction of rotation to open the gate shall be indicated on the lift mechanism. A cast iron stop nut shall be provided for each lift. All exposed cast iron shall be coated according to Section 7.

3.5.4 Handwheel

The housing shall be cast iron and shall be suitable for mounting on the head angle or pipe frame extension. The lift nut shall be flanged to maintain position in the housing and to accommodate the maximum thrust developed during gate operation. The lift nut shall be bronze and internally threaded to mate with the stem. Each lift shall be furnished with a bronze stop nut. The steel or cast iron hand wheel shall have a slide rim and shall be smooth and free of sharp edges and an arrow and the word "OPEN" shall be cast in the rim or attached to the hand wheel. Hand wheels generally shall be positioned on a head stock 750 mm above operating level.

3.5.5 Pipe Supports and Brackets

Pipe supports and brackets shall be as designated on the detailed Drawings or approved shop drawings. Adequate and rigid brackets and supports shall be provided on all piping.

3.6 STOP COCKS

Stopcocks shall be gunmetal BS 1010 or brass stop valves supplied with double female threaded ends. The valves shall be lockable type as approved by SDO and provided with a master key, with the spindle shielded so as to prevent unauthorized operation with a wrench.

3.7 WATER METERS

3.7.1 Household Type

Water meters for measurement of flow for potable water shall be volumetric or multi-jet type up to 25 mm diameter and generally conform to standard MEW-WO1, Class C requirements, and be suitable for operation in water systems and site conditions prevalent in the Sultanate of Oman. The meter shall have a maximum pressure rating of 16 bar. The meters shall have an integral non-return valve and metal, corrosion-resistant casings. They shall have a sealed register with seven figure totalizer and registration of 1 litre.

3.7.2 Turbine Flowmeters

Flowmeters with nominal diameters in the range from 40 mm to 300 mm shall be removable element Woltmann (turbine) type meters unless otherwise specified. They shall be to BS 5728 Part 1 or ISO 4064 Part 1 and shall conform to metrological Class B requirements.

A sealed magnetically driven register capable of being viewed from above shall include seven figure totaliser and a centre sweep hand with a registration of 100 litres for 40 mm to 80 mm, and 1 000 litres for 100 mm to 300 mm meters.

The meter shall operate with a maximum water temperature of 60^{O}C, have a maximum pressure rating of 16 bar and flanges drilled to drilled to PN 16 in accordance with ISO 2531. Meter bodies shall be of corrosion-resistant metal.

The meter shall be fitted with an in-line strainer.

All flowmeters shall have an approved epoxy coating on both internal and external surfaces.

All meters shall be capable of connection to a data logger.

3.7.3 Electromagnetic Flowmeters

a) General

Magnetic flow meters shall use the principal of electro-magnetic induction to produce a DC voltage proportional to the rate of liquid flow. Coil excitation shall be DC. The coils shall generate a magnetic field, which in

turn induces a voltage in the following liquid, which is sensed by a pair of electrodes in contact with the fluid.

The coils shall be protected from contact with the liquid and the electrodes shall be made of AISI, type 316 stainless steel and shall be provided with a minimum preamp input impendence of 1,000,0000 megohms. The meter housing shall be splash and drip-proof and shall withstand submersion up to 4 m for a period of 48 hours. They shall otherwise be housed in a dust and weatherproof case. The metering tube shall be suitably lined to withstand abrasion of the fluid.

Unless otherwise specified, the meters shall be designed to operate from a 240 V, 50 Hz, single-phase, power supply and a 10 percent variation in power line voltage shall not affect the meter output accuracy in excess of 0.1 percent of full scale. Power consumption shall not exceed 35 watts for meters 150 mm or smaller or 5 watts per 25 mm of diameter for meters 200mm and larger. All printed circuit boards shall be contained in a plug in module and be interchangeable for any size without requiring test equipment.

Each meter system shall have an accuracy within ± 0.25 percent of the flow rate over the application operating range when the velocity is within 0.3 m/s to 10 m/s. Meters shall have a repeatability of 0.1 percent of full scale. Accuracy shall be maintained for an ambient temperature range of 0°C to 50°C and liquid temperature of 40°C.

Each meter shall be equipped with a signal converter to transmit an analog 4-20 mAdc signal. Meters of diameter 200 mm and smaller may have meter-mounted electronics unless submergence proof is required. A frequently and/or a scaled pulse (at 26 plus or minus 4 Vdc) to drive totalising counters shall also be transmitted. The pulse rate shall be scaled to provide on pulse per unit of measurement. Signal shall be linear with flow within the accuracy specified above. The converter shall be surface mounted adjacent to the meter housing except when panel or integral mounting is specified. Local indicators shall be supplied with all panel and surface mounted converters. Integral converters shall have wall or pedestal mounted local indicators. The meters shall have automatic zero correction. Inter-connection between meters and signal converters shall be by cable furnished by the manufacturer.

Each meter shall incorporate a detector to constantly monitor whether the pipe is running full and all electronics, electrodes, sensors and cable connections are operating correctly. Any fault shall be indicated immediately via a relay.

The meter shall also incorporate a command feature allowing a menu selection and changes to be made from outside the housing via hall-effect sensors. It shall not be necessary to remove covers, panels or fasteners to accomplish a calibration or program changes. The meter software shall incorporate a password, preventing inadvertent program changes.

b) Construction

The magnetic flow meters shall be of short-form type with a laying length as recommended by the manufacturer. Meters shall be designed with PN16 flanged end connections. Field coils shall be either completely encapsulated in the meter lining material or the meter tube shall be 304 stainless steel with a suitable liner. A suitable protective shield shall be provided where indicated at each end of the liner to withstand the scouring velocities of the process fluid at the maximum flow rates.

c) Grounding

The flow meter shall be equipped with built-in grounding electrodes of the same materials as the sensing electrode and with a grounding circuit. The Contractor shall provide grounding rings, grounding electrodes or protective shields to serve as a liquid ground, when the meter is installed in a non-conductive line or when directed by the Engineer.

d) Remote Signal Converter and Transmitter Unit

The system shall be provided with a portable calibration unit for complete electrical checkout.

The transmitter shall be of smart type with automatic self-diagnosis, built-in and local digital display for configuration at site. It shall have the facility to provide a 4-20 mA output corresponding to the flow range. Fault alarm potential free contact shall be provided. The integral cable between flow meter head and transmitter shall be supplied.

The enclosure shall be to IEC 144, standard IP 65 or better. The transmitter shall be provided in a protection box with from transparent door and sunshade.

Continuously adjustable zero point controls shall be provided.

The unit shall have LCD display unit and keypad to allow display of different parameters.

e) Pressure Test

Prior to calibration a hydraulic pressure test shall be performed at a pressure of at least 1.5 times the maximum working pressure.

f) Calibration

Meters shall be calibrated on cold water at the manufacturer's plant or an approved testing facility. Calibration data shall be provided at time of shipment.

g) Installation

Care shall be taken in handling the meter. Lifting lugs shall be used and great care used to avoid damaging the liner.

Flange bolts shall be tightened evenly and moderately to avoid liner damage.

Flow meters installed in a vertical pipeline shall have upwards flow direction.

Meters installed in horizontal lines shall have electrodes located in the horizontal plane to ensure that trapped air cannot act as an electrode insulator.

There shall be a minimum of five pipe diameters of straight pipe upstream of the plane of the electrodes and three pipe diameters downstream.

Means shall be provided to stop flow in the meter to enable zero checks to be made.

Particular attention shall be paid to flow meters installed in systems that have cathodic protection. Insulating flanges and copper straps shall be used as appropriate.

3.8 WASTE METERS

The waste meters shall be installed at the locations shown on the Drawings or as directed by the Engineer. The layout shall be as shown on the Drawings.

The waste meters shall be insertion flowmeters as specified hereunder.

The insertion flowmeter shall be capable of insertion into a pipeline for measurement and withdrawal for inspection and maintenance without interruption to flow in the pipeline, or the necessity of pipeline pressure reduction.

The turbine flowmeter shall be stainless steel and mounted on the end of a stainless steel insertion tube. The insertion tube shall pass through a pressure seal system that permits movement of the meter head to any point within the pipeline. The signal generated by the flowmeter shall be amplified and fed to a connecter on the flowmeter's headbox to allow local or remote indication of fluid velocity. The insertion flowmeter shall allow a full velocity profile check to be made within the pipeline from which true flow conditions may be easily and quickly ascertained.

The flowmeter shall have negligible pressure drop, with a pulse output directly and linearly proportional to fluid velocity. The flowmeter shall be specifically suited to portable application.

The flowmeter shall be fitted with a direction sensing pickup which gives simultaneous outputs of flow velocity and flow direction.

Linearity shall be better than 0.5% f.s. over normal range. Repeatability shall be better than 0.05%. Pressure rating shall be 20 bar minimum. Temperature range shall be 0 ºC to +80 ºC. Pressure drop shall be negligible (<2" w.g. in 100 mm pipe at 3 m/s). Bearings shall be ball race, pivot jewel, tungsten carbide journal options. Insertion lengths shall be suitable for the pipe diameter specified.

The velocity range shall be at least 0.05 m/s to 3.0 m/s.

The flowmeter shall be calibrated by dynamic-gravimetric method and have a single point accuracy better than 0.05% and each flowmeter shall be supplied with a calibration certificate.

Three compatible data loggers shall be supplied for use with all of the supplied flowmeters.

One pipeline gauging rod to measure the internal diameter of the pipe into which the flowmeter is to be inserted shall be supplied for each size of insertion flowmeter. All welded parts of the gauging rod shall be stainless steel.

3.9 FIRE HYDRANTS

The pillar type fire hydrants shall be installed adjacent to public roads for the use of Civil Defence as directed by the Engineer. The hydrants shall be to the approval of the Directorate General of Civil Defence.

The hydrant shall be tested and approved by Factory Mutual (FM) and shall meet all the requirements of applicable AWW A and NFPA standards and listed by UL.

The upper part and lower part of the barrel shall be from ductile iron. Bolts and nuts shall be from cadmium-plated steel. The diameter of the barrel shall be:

- Not less than 180 mm for the use in crowded or heavily trafficked roads.
- Not less than 150 mm for the use in quite or lightly trafficked roads.

The upper part of the hydrant shall contain three outlets:

a) Two male outlets 2.5 inch (65 mm) diameter to be installed on opposite sides of the barrel. Each outlet shall be instantaneous in accordance with the type used by the Directorate General of Civil Defence. The outlets shall be valved in accordance with BS 5041.

   Each landing valve shall be screwed into a bronze adaptor which is bayonet fixed into the fully coated nozzle section with an ‘O’ ring seal.

   The landing valves shall be locked to the hydrant nozzle by means of a grub screw of stainless steel 1.4301 to DIN 17440 of 6 mm diameter. The grub screw shall be drilled and tapped through the hydrant barrel and landing valve wall into hydrant nozzle. The head shall be cut and filed flush with the hydrant barrel as an anti-theft device. The grub screw shall be factory installed.

b) One male 4 inch diameter British Standard type screw connection in the middle of the barrel, complete with cover. This outlet shall face the street or road and shall be suitable for feeding the fire pumps with water through a 4 inch suction hose.

The distance between ground level and the lowest discharge outlet shall be between 400 mm and 500 mm.

The operating nut shall be at the top of the hydrant and made from cast bronze. The nut shall directly actuate the hydrant rod and provide with a grease groove to ensure complete lubrication.

The hydrant rod shall be steel and of two-part construction held together by a rod coupling with bronze pins.

The hydrant valve shall incorporate a top and bottom valve support in ductile iron with cone-shaped valve moulded from EPDM.

The hydrant shall be provided with a drain valve made from non-corrodible materials.

The direction of operation shall open anti-clockwise.

Friction loss through the hydrant shall not exceed the values at the following flows:

Flow (l/s)	Friction Loss (kPa)
16	7
32	14
47	21
63	28

All barrel castings shall be lined and coated in accordance with the requirements of the Directorate General of Civil Defence. Each hydrant shall be connected to the distribution pipelines in accordance with the arrangement shown on the Drawings, complete with isolating valve and protective barriers.

Sufficient wrenches and tools required for operation and maintenance of the hydrants shall be provided.

Hydrants shall be provided with a locking arrangement for the three outlets with three master keys.

Extension pieces shall be provided for all hydrants to suit at each location at the contractor's expense.

The general locations of the hydrants are shown on the Drawings; however, the precise location of each hydrant shall be fixed on site together with the Engineer, such that each hydrant does not interfere with the entrances of plots or otherwise cause obstruction."

3.10 MANHOLE COVERS, FRAMES AND DRAINAGE GRATINGS

3.10.1 Manhole Covers and Frames

Manhole covers, frames and drainage gratings shall be of ductile iron material.

Castings shall be smooth, true to pattern and free from projections, sandholes, blow holes or other distortions.

The term "heavy duty" means Class D 400 covers. The term "medium duty" means Class B125 covers and the term "light duty" means Class A 15 covers. In

general, all covers and frames used in the works shall be heavy duty, unless otherwise specified and/or directed by the Engineer.

The frame for manholes shall be shall be square with a circular clear opening of 600 mm diameter or as sized on the Drawings, and shall be single sealed.

Manhole covers shall meet or exceed minimum wheel loading requirements as defined for the specified grade test load in accordance with BS EN 124 and having machined seatings to prevent rocking and rattling under traffic loading.

Manhole covers shall have marked clearly on them the BS No./ Grade/ Manufacturer's name and the name of service shall have the words 'WATER", "FOUL SEWAGE", "STORMWATER" etc., as appropriate embossed in both English and Arabic.

Covers, frames and gratings shall be fettled and grit blasted to SA 2. Coatings shall be solvent free two-component epoxy amine or 40% glass reinforced unsaturated polyester coatings at a minimum of 500 µm in two coats. Coating systems must be resistant to pedestrian and traffic abrasion and to continuous condensing humidity at temperatures of 50°C.

Two manhole cover lifting keys shall be provided for every 30 covers supplied.

All manhole covers shall be lockable to prevent theft and keys shall be provided for every 30 covers supplied.

The Contractor shall furnish to the Engineer, manufacturer's certificates certifying compliance of the manhole cover, frames and gratings to the Specification.

3.10.2 Surface Boxes

Surface boxes shall conform to BS 5834, Grade A loading unless otherwise specified and size 150 mm x 150 mm. All other properties shall be as specified for manhole covers and frames.

All surface boxes shall be lockable to prevent theft and keys shall be provided for every 30 boxes supplied.

3.11 MECHANICAL COUPLINGS

3.11.1 Grooved End Couplings

Couplings shall engage and lock the grooved or shouldered pipe ends allowing some degree of contraction, expansion, and angular deflections. Coupling housing shall be of ductile iron or malleable iron and shall consist of two or more segments held securely together by at least two steel bolts. Sealing gasket shall be of such design that internal pressure in the pipe increases the tightness of the seal and shall be of materials suitable for the intended service. The coupling shall have a rated working pressure not less than the pressure rating of the pipe.

3.11.2 Flexible Couplings

The requirements of this Clause to be read in conjunction with Clause 3.2.4.

All couplings shall be provided with all necessary nuts, bolts, washers and gaskets plus an extra 10% to cover wastage. All nuts, bolts and washers shall be of galvanized steel. Bolts and nuts shall be supplied with two washers per bolt. The bolt length shall be such that after the joints are made up, the bolts protrude through the nut, but not more than 12 mm.

Flexible (sleeve) couplings shall be of the full sleeve long type, split sleeve type or flanged adaptor type, as shown on the Drawings, specified herein, or as otherwise permitted by the Engineer.

They shall provide the requisite pipe flexibility without jeopardizing pipe joint integrity due to hydraulic thrust, and shall have the same pressure rating as the pipe. Couplings shall have all metal bearing surfaces and shall be provided with galvanized steel bolts and nuts. All flexible couplings and flanged adaptors shall be bolted type restrained unless the Engineer has given his approval to omit this feature for specific cases.

Couplings shall be internally and externally fusion bond epoxy coated with a minimum thickness of 300 microns as specified under Clause 3.4.

a) Full Sleeve Couplings shall be the long type, properly gasketed and shall be of a diameter to fit the pipe. Each coupling shall consist of a steel middle ring, 2 steel followers, 2 gaskets, and the necessary steel bolts and nuts to compress the gaskets. Stepped Couplings of this general type shall be used when stepping from one pipe material to another of the same nominal diameter.

b) Split Sleeve Couplings shall consist of one gasket, 2 housing clamps, and 2 bolts and nuts to obtain the flexibility for connecting the piping. Steel shoulders shall be provided and welded to the pipe ends to accommodate the couplings.

c) Flexible Flanged Coupling Adaptors shall be of the sleeve type, consisting of steel middle ring, steel followers, gaskets, and steel bolts, nuts and washers to compress the gaskets. The couplings shall contain anchor studs of strength adequate to hold the pipe together under a pull equal to the longitudinal strength of the pipe at a tensile stress of 140 MPa.

END OF SECTION 3

SECTION 4

PIPELINE INSTALLATION

4.1 GENERAL

4.1.1 Scope of Work

The work included in this Section consists of laying, jointing, cleaning, swabbing, disinfection, testing, repairing and retesting where necessary, and commissioning of pipelines for water supply. The Contractor shall provide all labour, materials and equipment necessary including removing from storage, transporting to sites, excavation, backfilling and compaction, laying, jointing and testing, disposal of excess excavated materials, and removal of surplus pipes, fittings, valves and jointing materials. The responsibility for the safety and soundness of all material shall rest with the Contractor.

The Contractor is advised to carry out any tests, at his cost, needed to satisfy himself regarding the soundness of the pipes, fittings, valves and appurtenances, and jointing materials including the pipeline installation before acceptance for testing by the Engineer.

4.1.2 Definitions

The following terms shall have the meanings hereby assigned to them except where the Contract clearly renders these meanings inapplicable:

"Pipe"	Means pipe or pipes, bends, fittings, junctions and other specials and fittings and includes joints, jointing parts and materials.
"Valves"	Means gate valves, butterfly valves, air valves and the like and includes jointing materials, operating gear and associated fittings.
"Installation"	Means removing from storage, loading, hauling, handling, placing, fixing, jointing in position, and testing whether in trench or elsewhere in the Works.
"Pipeline"	Means those parts of the Works comprising pipe, fittings, connections to the existing system, valves, valve chambers, other chambers, anchors, thrust blocks and all other appurtenances required for proper functioning, operation and maintenance of the pipeline.

4.1.3 Tools

The Contractor shall supply all necessary tools for cutting, chamfering, jointing, testing and for any other requirement for satisfactorily installing the pipelines.

4.1.4 Handling and Transport of Pipeline Materials

The requirements of this shall be read in conjunction with Clause 3.3, Section 3.

During handling and transporting every precaution shall be taken to prevent damage to the pipeline materials. Dropping or bumping of pipe will not be permitted. Pipes shall not be dragged over the ground and if rolled, shall be

rolled only over adequate timber bearers to prevent damage. All pipeline materials handling and transportation facilities shall be as recommended by the manufacturer and as approved by the Engineer.

a) Cranes and other appliances approved for use by the Engineer shall be provided wherever it is necessary to lift or lower pipes, valves, meters and fittings. Such articles shall not be dropped and the Contractor shall provide the facilities and supervision necessary to ensure that the ends of pipes prepared for jointing and the coatings of valves and fittings are not damaged or distorted in transit or in storage.

b) For Asbestos Cement (AC) 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 fittings. Pipes shall not be lifted by hooks nor shall they be dropped or dragged.

c) AC pipes being transported shall be supported by timbers, sandbags or padding arranged so that adjacent pipes do not touch. The height of the load for the various pipe diameters shall be as recommended by the manufacturer and approved the Engineer. Each load shall be secured by ropes or other lashing arrangements so that pipes do not move or chafe. No Stacking of pipe larger than 900 mm shall be allowed during transport.

d) Pipe fittings and specials shall be supported by sandbags or other padding and lashed down as described above so that they are not damaged during transport.

4.1.5 Storage of Pipes and Appurtenances

The requirements of this clause shall be read in conjunction with Clause 3.3, Section 3.

All pipes and materials shall be stored in accordance with the manufacturer's recommendations and the following:

Jointing materials and operational gear shall be stored under cover. Pipes may be stored in the open, but shall be placed on adequate timber bearers to prevent damage to sheathing or sockets. Pipes not delivered on manufacturers' pallets may be stacked one above the other up to three pipes high provided suitable protective packing is placed between them. If any pipes or fittings show signs of corrosions or deterioration during storage either they shall immediately be treated at no extra charge by the Contractor to arrest and prevent the corrosion or removed from site as the Engineer directs.

The Contractor shall properly stack the pipes in his storage area and the stacks shall be laid out in a regular pattern and the limits of each stack marked so that the movement of cranes and vehicles is restricted to access tracks between stacks and the control of delivery and removal of pipes is facilitated.

a) The number of tiers of AC pipe stacks shall be as per the Manufacturer's instructions and approval of the Engineer. 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.

b) 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.

c) The outermost pipes in each course shall be secured against rolling by sandbags or by wedges.

d) Where the pipes are to be delivered and stacked by the Contractor on sites along the pipeline route, the areas where the pipes are to be stacked shall, if required, be graded flat by the Contractor at his own expense to provide a firm and even surface, and shall be kept free from loose stones, rubble or waste liable to damage the pipes.

e) Jointing materials, valves, glass reinforced plastic fittings and specials, meters, gauges and polyethylene sheeting shall be stored in covered storage areas until required for installation.

f) Pipe shall be removed from storage and directly distributed to their point of installation only in such quantities as can be installed in one week.

4.1.6 Inspection at Time of Installation

Pipes and fittings including any sheathing, sleeving, lining or protective coating, shall be inspected by the Contractor immediately before and after installation and any damage shall be repaired by the Contractor as directed by the Engineer before the pipe or fitting is installed or jointed as the case may be. Any specified material required for the repair of pipe, sheathing, sleeving, lining or coating shall be obtained by the Contractor and shall be used in accordance with the Supplier's recommendations. The Engineer may himself, and without thereby relieving the Contractor of any of his obligations, inspect and test the pipe and appurtenances by any means he considers appropriate and any damage discovered by such inspection shall be repaired by the Contractor as aforesaid. The Contractor shall remove from the Site any pipe or appurtenance which in the opinion of the Engineer is so damaged as to be unfit for incorporation in the Works. Replacement for damaged pipes or fittings shall be obtained by the Contractor at no extra cost to the Employer.

4.1.7 Control of Water

The Contractor shall furnish, install and operate, as described in Section 2, all necessary machinery, appliances, and equipment to keep the excavation sufficiently free from water during construction of the work to permit proper laying and jointing.

4.1. 8 Closures and Short Sections

For the purpose of reducing the angular deflections at pipe joints, and for closure sections, the Contractor shall be permitted to install pipe sections of less than standard length. Closing pieces and short sections of pipe shall be fabricated and installed by the Contractor as found necessary in the field. Where closing

pieces are required, the Contractor shall make all necessary measurements and shall be responsible for the correctness thereof.

4.1.9 Polyethylene Sleeving

Polyethylene sleeving of thickness not less than 250 microns shall be installed around all buried ductile iron and cast iron pipelines in accordance with AWWA C-105 unless otherwise directed by the Engineer. Polyethylene sleeving shall not be stored in direct sunlight.

4.1.10 Materials Supplied by the Employer

In the event that pipes and ancillary fittings, specials, valves and meters shall be supplied by the Employer, these shall be supplied to the Contractor at Sohar Development office's storage yard. The Contractor shall load, transport and unload the materials so supplied at his own storage area and/or the site of works and shall be responsible for proper unloading, stacking and storing.

a) The pipes shall be unloaded from the trucks in an approved manner and the Contractor shall take utmost care not to damage pipes or any of the materials so supplied. Any materials damaged in loading, transport and unloading at the site of works shall be repaired or replaced by the Contractor at his own expense in accordance with the Engineer's instructions and to his satisfaction.

b) The Contractor shall sign vouchers for any materials supplied to him, and shall keep a proper stores record book to show at any time the quantity of materials received and those which have been taken from the stores for use in the works. The Engineer shall have the right to inspect at any time the store record books, and to check the materials in the stores and on the site of the works to satisfy himself that everything is in order. The Contractor shall account for any discrepancy found.

c) The Contractor shall at his own expense provide and constantly maintain day and night watching and shall be responsible for the theft or loss of 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 own expense.

d) 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 Specification and shall be at the Contractor's expense.

e) Any materials not accounted for shall be replaced by the Contractor at his own expense or alternatively, at the Employer's discretion, shall be charged to the Contractor's account on the basis of current C.I.F. price for delivery to the Employer's storage yard, plus 20% handling fee.

4.2 PIPE INSTALLATION

4.2.1 Working Drawings for Pipeline Installation

The requirements specified in Clause 1.7, Section 1 shall form part of this clause.

The Contract Drawings show the approximate lines and levels to which the pipelines are to be constructed and are subject to amendment. Prior to the commencement of pipeline installation the Contractor shall make a topographic survey of the pipeline alignment and shall also expose and take the level of all underground services along the alignment. The Contractor shall consult with all service authorities to ascertain the location of their services and shall fully comply with their rules and regulations regarding excavation to expose their apparatus and subsequent restoration.

On the basis of the topographic surveys, and information on underground services, the Contractor shall prepare and submit for the Engineer's approval detailed working drawings for pipeline installation including valves, chambers, etc. to a scale of 1:1000 horizontal and 1:100 vertical. The drawings shall generally follow the alignments and levels shown on the Contract Drawings, where possible.

4.2.2 General

The Contractor shall, after excavating the trench and preparing the proper bedding for the pipe in accordance with Section 2, furnish all necessary facilities for properly lowering and placing sections of the pipe in the trench without damage and shall properly install the pipe. The section of pipe shall have a uniform bearing upon the bedding material and if the pipe has a projecting socket or flange, suitable excavation shall be made to receive the socket or flange that shall not bear on the subgrade.

No pipe shall be rolled into place for lowering into the trench except over suitable timber planking free from roughness likely to damage any coatings. Before laying, each pipe shall be cleaned out and inspected for defects. Cast iron or ductile iron pipes shall be rung with a light hammer while the pipe is suspended clear of the ground to detect cracks. Any defective, damaged or unsound pipe shall be rejected.

Any injuries to protective coatings and linings shall be carefully repaired before installation. All sheathed pipes shall be checked for continuity of the applied protection by a "Holiday" detection unit. Discontinuities and pinholes indicated by the test shall be made good. Pipes shall be inspected for damage to any internal concrete lining and all damages shall be repaired before installation.

Pipes shall be laid with any class identification marks uppermost. Pipe sections shall be so laid and fitted together such that the pipeline has a smooth and uniform interior. The pipeline shall be clean and unobstructed at the time of its completion and acceptance and shall be true to the line and grade as shown on the plans and profiles.

Spigot and socket pipes shall be laid upgrade without break from structure to structure and with the socket end upgrade.

Whenever work ceases on any pipeline the unfinished end of the pipeline shall be securely closed with a tight fitting plug or cover.

Each pipe shall be carefully lowered onto its prepared bed by means of necessary slings and tackle. A recess shall be left in the prepared bed to permit the sling to be withdrawn. If the prepared bed is damaged the pipe shall be raised and the bed made good before pipe laying is continued. Any pipe which is not in true alignment, both vertically and horizontally, or shows any undue settlement after laying, shall be taken up and relaid correctly by the Contractor at his own expense. All adjustments in line and grade shall be made by scraping away or filling and tamping in under the barrel of the pipe and not by wedging or blocking. All pipelines adjoining structures shall have a flexible joint within or at 400 mm from the face of such structure or as detailed on the Drawings. Sub-soil water shall be controlled as specified in Clause 2.1.10, Section 2. In no case shall pipes be jointed before being lowered into position. If any damage should occur to any pipes through failure of the Contractor to comply with these conditions, the damage shall be made good at the Contractor's expense.

The minimum cover over the crown of the pipelines shall normally be 0.9 m. Where cover is less than this minimum, the pipe shall be encased in concrete.

4.2.3 Flotation of Pipework

The Contractor shall be solely responsible for ensuring that flotation of the pipework does not occur during construction. The extent of the backfill placed over each pipe after laying and before testing shall be such as will prevent floatation.

Should any section of the pipework float out of line or level, the section of pipework so affected shall be removed and re-laid in accordance with the Specification to the satisfaction of the Engineer at the Contractor's own expense.

4.2.4 Pipe Bedding

The surface shall be firm and true to grade. If soft, spongy, unstable, or similar other material is encountered upon which the bedding material or pipe is to be placed, this unsuitable material shall be removed to a depth ordered by the Engineer and replaced with suitable densified crushed rock bedding material and paid for at the unit rate in the Bill of Quantities. Bedding shall be in accordance with details on the Drawings.

The minimum granular mat below the pipeline shall be as shown in the following table:

Pipe Dia (mm)	Depth of granular mat (mm)
Up to 600	150
> 600 to 1200	200
> 1200	300

Where granular bedding is specified the bedding material supporting the pipe or conduit shall be durable gravel, disintegrated granite, crushed aggregate, native granular material, or other material approved by the Engineer. After trimming, granular bedding material shall be spread in the trench bottom and screeded with a template. The Contractor's rates shall include for provision of suitable material

for granular bedding, and also for removal and disposal of excess material arising from the trench excavations, due to the granular bedding.

Granular bedding material shall meet the requirements of BS 882.

Granular material shall conform to the requirements as shown in the following table:

Pipe Type	Pipe Dia (mm)	Aggregate Grading Requirements
Rigid pipes	Up to 1200	Crushed 20mm -5 mm. All passing 20 mm and ≤ 20 % passing 5 mm sieves
-do-	> 1200	Crushed 37.5 - 5mm. All passing 37.5 mm, ≤ passing 45% passing 20 mm and ≤ 20 % passing 5 mm sieves
GRP and thermoplastics	All sizes	14 - 5 mm (single size crushed nominal

The bedding material shall be encased continuously all around the pipeline with the specified geotextile with overlaps of at least 300 mm between sheets.

If through the Contractor's neglect any trench bottom is excavated below the grade shown on the Drawings, it shall be refilled to grade of pipe invert with bedding material thoroughly densified into place or with concrete at the Contractor's expense and at the Engineer's discretion.

Concrete pipe trench cut-offs shall be formed in granular bedding surrounding the pipes to prevent the bedding acting as a sub-soil drain. Cut-offs shall be provided at a maximum spacing of 500 m with one at each chamber and at least one barrier between two adjacent chambers. Where the slope of the pipe exceeds 5%, the maximum spacing of cut-offs shall be 50 m. Cut-offs shall be Grade 20 concrete. Cut-offs shall be installed across the full cross-section of the granular bedding material and shall be at least 300 mm in length along the axis of the pipeline. The cost for the provision of concrete cut-offs shall be deemed to be included in the rate for granular bedding.

4.2.5 Joints

a) General

The requirements of this clause shall be read in conjunction with the particular requirements specified elsewhere for joints of particular kinds.

Joints shall be made in accordance with the manufacturer's instructions and as specified herein.

Before making any joints the Contractor shall ensure that the interior of each pipe or valve is clean and that it remains clean. Immediately before starting a joint the Contractor shall clean the end of each pipe to be jointed and shall otherwise specially prepare the ends for jointing as may be necessary for the particular kind of joint. All mechanical joints shall be cleaned and have their paintwork or coating made good before assembly.

The Contractor shall use only the proper jointing materials (gaskets, nuts, bolts, washers, lubricants) as specified and obtained through the

respective suppliers of pipes, couplings or valves. All joints shall be accurately made and shall be capable of passing tests for individual joints and for the completed pipeline as may be specified.

Graphite grease shall be applied to the threads of bolts before mechanical or flanged joints are made.

Any site damaged paint system shall be repaired with the same system.

b) Storage of Joint Materials

Until required for incorporation in a joint each rubber ring or gasket shall be stored in the dark, in containers or wrappers that will protect against deleterious effects of heat, cold, ozone and other atmospheric deterioration and shall be kept flat to prevent any part of the rubber being in tension.

c) Asbestos Cement Collars

Joints between AC pipes shall be made with flexible joints comprising an asbestos cement collar and rubber sealing rings.

In making these joints the Contractor shall take account of the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor shall ensure that rubber rings are correctly positioned and free from twists. The rubber rings and any recommended lubricants shall be obtained only through the pipe supplier. The bucket or any other part of a mechanical excavator shall not be used to apply thrust directly to pipes or collars in order to make joints. The excavator bucket may, however, be used in a Stationary position as a backstop for a manually-operated hydraulic jack (to be approved by the Engineer) which is used to apply a thrust to pipes and collars.

d) Rubber Ring Joints

Immediately before assembling each joint incorporating a rubber ring seal, the rubber shall be inspected for cracks, every part of the ring being deformed by hand to about 50 mm radius. If under this deformation any cracks are either revealed or initiated the ring shall be rejected, cut through completely to prevent inadvertent use, and the matter reported forthwith to the Engineer. If more than three successive rings inspected in this way are rejected, the Contractor shall on the instruction of the Engineer stop all pipe jointing until the cause of the defect has been proved and remedied to his satisfaction.

Only lubricants recommended by the manufacturer shall be used in rubber rings. They shall be suitable for the climatic conditions at the site and shall contain an approved bactericide. The lubricants shall not contain any constituent soluble in the fluid carried in the pipe.

The rubber ring shall be placed in the groove on the collar or socket or spigot ring, and the spigot end of the pipe then entered into the socket of the adjoining pipe collar and forced into position. Care shall be taken to

avoid twisting or cutting the ring when jointing the pipe. The inside surface of the socket shall be lubricated with a compound recommended by the manufacturer that will facilitate the telescoping of the joint.

e) Mechanical Joints

Where mechanical joints are approved, installation shall be in accordance with the manufacturer's recommendations. The Contractor shall render the end of each pipe perfectly smooth so as to allow the joint sleeve to slide freely and where necessary shall coat the pipe ends with two coats of an approved quick drying sealing and protective compound. Where specified and or directed by the Engineer, end movement of pipes jointed by the coupling shall be restrained by a steel work harness, which shall be cleaned and painted with two coats of polyurethane paint or painting system compatible with that of the pipe. The joint shall be moulded with a suitable material as recommended by the manufacturer or directed by the Engineer.

Installation of couplings and flanged adaptors shall be strictly in accordance with the manufacturer's instructions and the tightening of bolts shall be done progressively drawing up bolts on opposite sides a little at a time. Re-tighten with a torque wrench to the torque recommended by the manufacturer so as to ensure even pressure all round the joint.

The Contractor shall use the appropriate lubricants as recommended by the manufacturer when installing gaskets, in the absence of which soapy water may be used as directed by the Engineer.

The greatest gasket pressure loss occurs throughout the first 24 hours after pressurising the main and the Contractor shall re-torque the bolts again to that recommended by the manufacturer after 24 hours and ensure that the pipe is supported adequately all round.

f) Flanged Joints

Flanged joints for ductile iron and cast iron pipes and specials shall be made with rubber joint gaskets and steel bolts and nuts which shall include two washers per bolt. The use of jointing paste or grease will not be permitted. The gasket may be fastened to the bolts with cotton thread. The bores of abutting pipes or fittings shall be concentric and no jointing material is to be left protruding into the bore. All nuts shall first be tightened by hand and nuts on opposite sides of the joint circumference shall then be alternately and progressively tightened with a torque wrench to the torque recommended by the manufacturer so as to ensure even pressure all around the joint. The joint shall be moulded with suitable material as recommended by the manufacturer or directed by the Engineer.

g) Anchorage

Anchorage lugs shall be provided for socket and spigot fittings and socket clamps and tie rods used where there is a possibility of pulling the joint under pressure. Concrete thrust blocks shall be used in lieu of the above where socket and spigot pipe is used below ground.

h) External Protection of Joints

Unless otherwise specified, metallic mechanical joints, flanged joints and ferrule straps shall be protected by the cold application of 1.5 mm thick self-adhesive bituminous wrapping similar to Densyl tape or approved equal. The application of tape with primer, mastic and outer wraps shall be strictly in accordance with the manufacturer's recommendations at no extra cost to the Employer.

4.2.6 Concrete Protection of Pipe

Where indicated on the Drawings, or ordered by the Engineer, pipe shall be encased, haunched and/or backfilled with concrete in accordance with the details shown on the Drawings. Shuttering shall be utilized if it is required to provide a stabilized pipe trench as directed by the Engineer. Concrete shall be Grade 20. Such concrete shall not be placed until the joints at each end of the pipe have been completed. Each pipe to be encased shall be supported on at least two purpose-made precast concrete blocks, which shall be left in place, and the full width and depth of concrete encasement shall be placed in layers not greater than 150 mm thick or as directed by the Engineer and carefully tamped beneath the pipe. Unformed surfaces shall be of spade finish. The pipe shall be prevented from floating or otherwise moving during concreting. Except where shown otherwise or ordered by the Engineer, the continuity of concrete backfill or encasement to pipe with flexible joints shall be broken at each joint. The rates for concrete backfill and encasement are deemed to cover all the requirements of this clause, in addition to other requirements detailed.

At all locations where AC pipe is to be encased in concrete, the pipe shall be wrapped with a minimum of two layers of 7 kg asphalt impregnated building felt in such manner that the concrete does not form a bond with the pipe.

Trench foundations shall be compacted to a minimum of 95 percent Proctor before placing of the blinding concrete. If the compaction cannot be achieved then the soft material shall be removed and replaced with either concrete or gravel as described in Section 2.

4.2.7 Flexible Joints in Concrete Beds and Surrounds for Pipes

Flexible joints in concrete beds and surrounds to pipes shall be formed with suitable compressible fibrous board or other similar approved material. The thickness of the joints shall be as shown on the Drawings.

4.2.8 Backfilling

Granular bedding material or selected fill material as shown on the Drawings shall be placed in accordance with the conditions specified in Section 2.

Where filter fabric is used to enclose granular pipe surrounds, the fabric shall be placed on the prepared trench formation and carefully supported during pipelaying operations. When the pipe has been laid complete with granular surround to the correct level the filter fabric shall be closed by forming a lap equal to trench width. Care shall be taken that membrane is not punctured or damaged in any way during these operations and backfilling the trench.

Where concrete bedding or surround is specified, concreting shall be carried out as specified in Section 5. The backfill other than first 150 mm of cover shall not be placed before the compressive strength of the concrete has reached 15 MPa. The remaining portion of the trench shall be backfilled as specified in Section 2.

4.2.9 Cutting Pipes

The Contractor shall be responsible for taking the measurements required to determine the lengths of cut portions of pipes for insertion as closing lengths in pipelines. The pipe and methods of jointing shall be such that the location of fittings and lengths of pipe can be adjusted in the field to suit field conditions and variations in stationing. No extra payment will be made for such adjustments nor for any welding, couplings, fittings, or special lengths required to meet this requirement.

The cutting of ductile iron and AC pipes for inserting specials, fittings or closure pieces shall be performed by the Contractor. Cutting shall be carried out in a neat and workmanlike manner with an approved cutting machine without damage to the pipe and coating and lining, if any, and so as to leave a smooth end at right angles to the axis of the pipe. The cut ends of pipes shall be chamfered. The Contractor shall take every precaution to ensure that both the measurements and the cutting of pipes are to the accuracy required and should any errors occur the Contractor shall remedy same at his own expense and as the Engineer directs.

The Contractor shall take measures to ensure that personnel engaged in cutting and preparing the ends of AC pipe avoid the inhalation of asbestos fibres. These measures may include, but are not limited to, water spray, free vacuum devices or vacuum devices fitted to the cutting equipment. Face masks shall be worn by the operatives during cutting operations.

4.2.10 Deflection at Joints

Where the Engineer orders or allows a change of direction to deflect pipelines from a straight line, either in the vertical or horizontal planes, to avoid obstruction or where long radius curves are permitted, the amount of deflection allowed shall not exceed that required for satisfactory connection of the joint and shall be approved by the Engineer. The maximum deflection shall not exceed 75 percent of that recommended by the manufacturer unless otherwise approved by the Engineer.

Where a change of direction cannot be made by deflection at the joints of ordinary straight pipes, bends shall be used. The locations of such bends and other specials are indicated on the Drawings and their exact positions shall be determined on site by the Contractor and approved by the Engineer.

4.2.11 Deflection Criteria for Flexible Pipelines (GRP, uPVC and HDPE)

All flexible pipelines will be subjected to deflection measurements at site and any sections of pipe failing to meet the specified deflection criteria shall be removed from the trench and provided the pipe itself is not damaged, relaid. This procedure shall be repeated until the pipeline is found to be satisfactory. Removal from the trench and relaying shall be at the Contractor's expense. If the permanent set or deflection, after removal, exceeds the limits set out below, the

pipes shall be deemed to be damaged and will therefore be condemned. The pipes so condemned shall be indelibly marked, removed from the site and replaced at the Contractor's expense.

Deflection Criteria for Flexible Pipes with Granular Bedding (Measured In-situ)

After Completion of Surround	One Month after Reinstatement of Trench	Immediately Prior to Issue of Final Certificate (Sewers and Drains)	Immediately Prior to Commissioning (Pressure Mains)
0 percent	2 percent	4 percent	4 percent

Deflection of pipes installed with concrete surround shall be measured once the concrete has set and in no circumstances shall deflection exceed 2 percent. Any pipe exhibiting a greater deflection shall be broken out.

Deflection shall be considered as the maximum difference between the measured in-situ diameter and the stated non-deflected diameter on any axis divided by the non-deflected diameter and shall be measured by an approved mechanical device at any points determined by the Engineer.

4.2.12 Watercourse Crossings

Work at any crossing of a watercourse shall be carried out as expeditiously as possible to the satisfaction of the Engineer and all responsible authorities. Details of any temporary works that may affect the flow of the watercourse shall be submitted to the Engineer at least 14 days before starting work. Where the pipeline passes underneath a wadi, river, stream or ditch, unless otherwise detailed on the Drawings, it shall be encased in concrete Grade 20. The minimum thickness of the encasing concrete shall be 150 mm. Unless otherwise shown on the Drawings, the depth of cover shall be not less than 1500 mm from the bed of the wadi, watercourse or ditch to the top of the pipe. The Contractor shall fill the trench in both banks with rockfill or concrete up to levels as shown in the Drawings or as directed by the Engineer. The extent of this work may be varied to suit each individual crossing. Unless otherwise ordered, the concrete encasement of the pipe shall extend at least to a section vertically below the tops of the banks. Protection against erosion to the banks shall be provided by means of riprap, grouted riprap, or gabions where shown on the Drawings.

4.2.13 Pipe Supports

Pipe hangers and supports shall be of standard manufacture and provided as shown on the Drawings and in compliance with the following general requirements. Piping shall be supported independently from equipment to which it is affixed. All weight of piping and contained fluids shall be transferred to a structural or foundation system through the individual or combined use of bedding, pipe saddle supports, or overhead hanger systems. A support shall be provided for each pipe at or near the point where it is connected to machinery or valves. A support shall be provided for each valve and special fitting.

4.2.14 Building-in Pipes

All pipes built into a concrete wall or structure shall be provided with two flexible joints adjacent to the structures at the distances shown on the Drawings.

Unless otherwise shown on the Drawings, where pipes pass through a concrete wall or structure (except for valve chambers) they shall be protected with surround of concrete Grade 20 integral with the external face of the wall or structure. For pipes less than 500 mm diameter, the surround shall extend by 400 mm and the width and depth of surround shall be a minimum of 300 beyond the outside face of the pipe. For pipes 500 mm diameter and greater, the surround shall extend by 500 mm and the width and depth of surround shall be a minimum of 500 mm beyond the outside face of the pipe.

Any over-excavation adjacent to a structure and/or beneath the formation level of a pipeline, either to be constructed under the Contract or in a future contract, shall be backfilled with Grade 20 concrete. Alternatively the Contractor may propose a different method for supporting the pipeline for the approval of the Engineer. Approval to the use of compacted backfill alone will not normally be given.

4.2.15 Pipework within Structures

a) Pipework shall be supplied to the general arrangements and limits indicated on the Drawings and shall be supplied complete with all joint rings, gaskets, washers, to each side of a bolted joint, nuts, bolts and grease and any other components necessary for the complete installation.

b) The layout and design of the pipework shall be such as to facilitate its erection and the dismantling of any section for maintenance or associated plant by inclusion of approved mechanical couplings or flange adaptors.

c) Where a common delivery pipe is used, individual pump delivery branches unless otherwise shown on the Drawings shall be jointed to it in a horizontal plane and angled to prevent sharp changes of flow.

d) Unless otherwise specified or directed, adequate supporting and anchoring arrangements for all pipes shall be included which may take the form of straps, hangers, stay, tie bars, concrete cradles or a combination of these.

e) Unless otherwise specified or directed, pipes shall be provided with puddle flanges where they pass through the walls of underground or water retaining structures.

f) Small bore pipework for sump pumps, vents, etc., may be DI as detailed or directed.

g) All pipes connected to pumps, etc. shall have flanged connections.

h) All pipes shall be checked for alignment and mating of flanges and connections before being secured. Pipes shall not be sprung into position.

4.2.16 Cleanliness of Pipelines

a) Sewers and Drains

On completion of all pipelines and pipeline structures, they shall be cleaned out and flushed with water, all silts, mortar, concrete debris and other obstructions being removed. All testing of pipelines shall thereafter be carried out as specified.

b) Water Pipelines

Every precaution shall be taken to prevent foreign material from entering the pipeline. During laying operations, no debris, tools, cloth or other material shall be placed in the pipe. Pipeline components shall be carefully cleaned before jointing. On completion of all pipelines and pipeline structures, they shall be cleaned out and flushed with water, all silt, mortar, concrete debris and other obstructions being removed. A cleaning device about 5 mm smaller than the internal diameter of the pipe shall be kept in the pipe at all times and shall be pulled forward as the work progresses. When pipelaying is not in progress including overnight, the open ends of pipelines shall be plugged with a temporary watertight fitting approved by the Engineer. The pipe shall be suitably held down so that the pipe does not become buoyant in the event of the trench becoming flooded. Pipelines shall be swabbed before the hydraulic test on completion as specified in Clause 4.3.5.

4.2.17 Pipeline Marker Tape

All pipe trench lines shall be marked with a high quality acid and alkali resistant blue polyethylene or PVC detectable warning tape with a minimum width of 300 mm. This tape shall be placed during backfilling 500 mm below the finished ground level, or as directed by the Engineer. The tape shall be clearly marked in black lettering with "SDO-CAUTION-WATER MAINS BELOW" as appropriate in English and Arabic with a maximum longitudinal spacing of 1 m. This tape shall have a minimum strength of 125 kg/sq cm in the longitudinal direction and 105 kg/sq cm transversely. The minimum thickness of the tape shall be 0.5 mm. A metallic strip shall be incorporated in the tape, which shall be aluminium foil not less than 50 mm wide and not less than 10 microns thick. The foil shall be totally enclosed within the tape laminate such that the edges of the foil are completely protected against corrosive attack. The aluminium foil shall be detectable from the ground surface using a buried cable locator. The manufacturer shall provide methods for jointing and terminating the tape to enable a low resistance connection to be made to the aluminium foil. Electrical connection points shall be made at each chamber along the pipelines.

4.2.18 Pipeline Marker Posts

The pipeline route shall be marked with marker posts. Marker posts shall be 100 mm diameter galvanized mild steel pipe filled with grout and set in concrete to the dimensions and at the locations shown on the Drawings or at locations established by the Engineer. Marker posts shall normally be placed at 50 m intervals.

Marker posts shall be capped at its top surface with a suitable plastic or

galvanised steel cap. If welding is utilized, welds shall be continuous and dressed flush with the surface of the metal.

Marker posts shall be painted with a corrosion resistant marine coating system to a total DFT of at least 250 µm. The final top coat shall be a an acrylic urethane with a DFT of 50 µm.

Marker plates shall be aluminium plates 120 x 80 x 3 mm thick with rounded comers and secured to the marker post with 4 rustproof screws as shown on the Drawings. They shall be engraved before installation as shown on the Drawings and if the marker post is offset, the offset distance shall also be engraved.

4.2.19 Connections to Existing Pipelines

When connecting into existing mains the Contractor shall be responsible for:

a) Making timely and proper applications to the relevant authorities.

b) Exposing the existing pipes to confirm the pipe size and type and the fittings necessary to make the connection.

c) Conforming to the requirements of the relevant authorities in making the connections.

d) Flushing and re-sterilising the part of the existing system affected by the connection prior to putting that part of the system back into service.

The Contractor shall submit his plans and schedules for making any such connections to the Engineer for approval. The connections shall be scheduled so as to minimize disruption to the existing system.

4.3 PIPELINE STRUCTURES AND APPURTENANCES

4.3.1 Manholes

At each change of gradient or direction, at each intersection with other sewers or drain pipelines and at such other points as shown on the Drawings or as directed by the Engineer, a concrete manhole shall be constructed to the form and to the dimensions shown on the Drawings. Short lengths of pipe with flexible joints shall be provided at entry and exit to manholes. Manhole floors shall be constructed with concrete formed to the required shapes with GRP formers. Manholes shall have protective linings and coatings as described in Sections 7 and 8. Manholes covers generally shall be set to the paved area surface. Manhole covers located in unimproved areas shall be set at an elevation to prevent the entry of surface water as directed by the Engineer. All manholes shall be watertight on completion and where leakage is discovered the Contractor shall perform such work and provide all materials as are necessary to render such faulty work watertight. The Contractor is warned that he should expect rubbish and debris to be deposited in the manholes during the course of construction and he should take necessary measures to ensure that the manholes are not used as rubbish and waste dumps. The Contractor shall keep pipelines and manholes clear of such rubbish and debris at all times.

4.3.2 Valve Chambers and Similar Structures

Chambers for valves, air valves, washouts, etc. shall be built into the pipelines where shown on the Drawings and shall be constructed in accordance with the details shown on the Drawings, or as directed by the Engineer.

4.3.3 Anchor and Thrust Blocks

The Contractor shall construct all anchor and thrust blocks as required and where directed by the Engineer and as shown on the Drawings. In general, thrust blocks shall be placed at all changes in pipe direction greater than seven degrees.

Thrust blocks shall be constructed to the dimensions shown on the Drawings. The thrust blocks are designed for soil parameters as shown on the Drawings. Where considerably better ground conditions, such as rock, are encountered, the dimensions of the particular thrust blocks may be reduced. Supporting calculations for any reduced size thrust blocks must be submitted to the Engineer at least 48 hours before construction of that particular thrust block commences.

Unless otherwise specified or directed, anchor blocks shall be provided on pipelines laid to gradients steeper than 1:20; up to 1:15 every third pipe shall be anchored, up to 1:10 every second pipe and up to 1:5 every pipe shall be anchored.

Concrete shall extend to undisturbed ground on thrust faces or thrust blocks on both faces of anchor blocks.

Each thrust block shall be designed to have a sufficient bearing area and shall be placed to safely transmit to the surrounding point. Thrust devices shall be cast-in-place concrete. Thrust blocks shall be constructed of Grade 30 concrete and shall be placed between fitting and trench wall or trench bottom, as the case may be. The bearing faces of the block shall be placed against freshly cut and undisturbed trench wall or bottom of sound material. If the thrust exceeds the bearing value of the surrounding soil, the soil shall be pre-compacted before placing concrete. All concrete shall be kept behind the sockets and flanges of fittings. Formwork shall be constructed wherever necessary to confine the concrete to the prescribed dimensions for the block. All form lumber shall be removed before testing.

The depth of the pipeline shall be increased if necessary so that the top of the thrust/anchor block does not project above ground level.

The blocks shall, unless otherwise shown or directed by the Engineer, be so placed that the pipe and fittings joints will be accessible for repair.

Before internal pressure is applied to a pipeline, all concrete thrust blocks shall have been constructed and cured for a minimum of 7 days.

4.3.4 Valves

The Contractor shall obtain the necessary installation drawings from the manufacturer and shall store, transport, handle and install the valves, gates, etc. in strict accord with the manufacturer's drawings and recommendations. Care

shall be taken during mounting of gates to avoid warping the gate frames and to maintain clearance between seating faces.

Valves and all pipeline appurtenances shall be tested as specified for the pipeline in which they are installed.

Sluice gates shall be adjusted so that they operate smoothly, seat properly, and are installed to the tolerances recommended by the manufacturer.

After the equipment has been operated and adjusted, the Contractor shall perform a field leakage test on each gate in the presence of the Engineer in accordance with the applicable provisions of the latest edition of AWWA C501. Both seating and unseating heads shall be tested as applicable. If any of the equipment fails to meet the above test, it shall be modified as required and retested in accordance with these Specifications, until the maximum allowable leakage, per DIN 3230, is not exceeded. Any modifications or adjustments required to meet the test shall not impair the smooth operation of the equipment.

4.3.5 Pipeline Swabbing

Upon completion of water pipeline installation but before hydraulic testing, a foam swab shall be passed through between successive swabbing points. Foam swabs shall comply with the recommendations set out in the British Water Research Association, Technical Inquiry Report TIR 130 of 1966, in particular the following:

a) Swab Size

Pipe Diameter	Swab Diameter
up to 300 mm	pipe diameter + 25 %
over 300 mm	pipe diameter + 75 mm

b) Swab Quality

i) Hard: Where restriction in the pipeline does not reduce the diameter of the pipeline to less than two thirds of the swab diameter

ii) Soft: Where restriction in the pipeline is in excess of the above but does not reduce the diameter of the pipeline to less than one half of the swab diameter.

4.4 TESTING, DISINFECTION AND CLEANING OF PIPELINES

4.4.1 General

It shall be a condition precedent to the issue of a Certificate of Substantial Completion that all parts of the pipework shall be subjected to a successful final pressure test and finally cleaned out, satisfactorily disinfected, and refilled with potable water as specified hereafter.

The Contractor shall submit for the Engineer's approval details of his proposed methods and programme for testing (including details of test equipment) and shall arrange for all tests to be witnessed by the Engineer. Unless otherwise

directed by the Engineer, the Contractor shall ensure that no section of pipeline remains untested with pipe trenches and joints left exposed for more than 7 days after laying each pipeline section. The method of achieving this shall be entirely the Contractor's responsibility and no time extension or additional payments whatsoever shall be entertained on account of Contractor's failure to achieve this condition.

The Contractor shall provide all things necessary for carrying out testing and cleaning including potable water, pumps, gauges, pipes, connections, stop-ends, and all other temporary works.

Pipelines shall be properly completed and supported before being put under test except as hereinafter detailed.

The Contractor shall provide for transmitting the unsupported end thrusts to solid ground at the ends or into the sides of the trenches.

Before testing any pipeline, the Contractor shall ensure that the anchorage of bends is complete and thrusts from all branch outlets are properly stayed.

No testing will be permitted until seven days after thrust blocks and other holding down works have been completed.

Open ends shall be stopped with plugs, caps, or blank flanges properly jointed and restrained from movement.

No claims whatsoever will be entertained on account of leaking valves, or any other difficulties in closing of lengths of pipework for testing, which shall be entirely at the Contractor's expense.

All water required for testing and cleaning the pipelines shall be potable water from the SDO water supply system drawn off at locations approved by the Employer and shall be provided by the Contractor at his cost.

In addition to any tests of individual joints or other interim tests which may be specified elsewhere, the Contractor shall submit all parts of the pipelines to a final acceptance test. Notwithstanding the foregoing the Contractor may at any stage of construction, carry out such other tests as he considers desirable to check materials and workmanship on the pipeline, but this shall not relieve the Contractor of his obligations to achieve successful tests under the Contract.

The Engineer shall have power to require the Contractor to vary any test procedure or pressure as the Engineer deems necessary at no extra cost to the Employer.

The Contractor should note that neither the satisfactory testing of pipeline, section of a pipeline or any other pipework, nor the acceptance of such testing by the Engineer or his representative shall in any way relieve the Contractor of any of his responsibilities and obligations under the Contract.

The Contractor shall notify the Engineer at least 24 hours before hand of his intention to test a section of pipeline having satisfied himself in the first instance that the section of pipeline to be tested in the presence of the Engineer is satisfactory in all aspects.

Gauges used for testing pressure pipelines shall either be of conventional circular type, not less than 300 mm diameter, calibrated in metres head of water or shall have a digital indicator capable of reading increments of 0.1 metre head. Before any gauge is used, the Contractor shall arrange for it to be checked independently and a dated certificate of its accuracy shall be provided to the Engineer.

One additional gauge as above shall be handed over to the Engineer for purposes of verification during testing.

Calibration of pressure gauges shall be carried out by the Contractor at regular intervals as required by the Engineer.

The Contractor shall remain responsible for the care of the works during testing of the pipework.

4.4.2 Interim Pipeline Testing

For purposes of interim testing, the pipeline shall be divided into sections and each section shall be separately tested to the Engineer's satisfaction for deflection and pressure when each section is completed and before the joints are covered in the case of buried pipes.

The Contractor shall submit to the Engineer detailed procedures for performing hydrostatic pressure tests of installed piping, fittings, valves, meters and appurtenances for approval. Procedures for performing hydrostatic pressure tests for each section of pipeline shall indicate the location and capacity of the test pump, test pressure at the pump as well as that at the highest and lowest points procedures for venting the air from the pipeline and disposing the water after satisfactory testing.

Each pipeline or section thereof shall be filled with water and all air removed as far as possible. If permanent air vents are not located at all high points, the Contractor shall install suitable cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled, all cocks shall be closed and the test pressure applied. The line shall be filled slowly to prevent possible water hammer. The test pump and gauge shall be connected to the pipeline at a location other than the highest point in the line to facilitate the release of air from the highest point.

The pressure in the pipeline shall then be raised steadily up to and maintained at rated pressure of the pipe for a period of not less than 24 hours to allow for absorption and achieve conditions as stable as possible for testing. The standing period shall commence from the time at which the rated pressure was reached successfully, after which all exposed joints shall be carefully inspected for evidence of leakage.

If neither appreciable movement of the pipeline nor any leakage has been observed during the visual inspection the section shall be subjected to the pressure test proper.

Pumping shall then be resumed and the pressure slowly raised to the specified test pressure (stated below) at the highest point of the section of pipeline under

test subject to that at the lowest point of the section of pipeline under test shall not exceed the works test pressure or as directed by the Engineer.

a) 24 bar test pressure for DI pipes of Class K9 rated for working pressure of 16 bar
b) 13.5 bar test pressure for AC pipes of Class 18 rated for working pressure of 9 bar.

The test pressure shall be continuously maintained by the use of the pump for a period of at least 4 hours and the amount of make up water required to maintain the pressure shall be accurately measured (to the nearest 1/8 litre) regularly every 30 minutes throughout the test.

The pipeline shall be deemed to have passed the test if:

a) no water is visible coming out of the pipe or joints at any point,

b) the amount of make-up water required does not exceed the rate of 0.1 litre per millimetre of pipe diameter per km of pipeline per 24 hours for each 30 m head of pressure applied, and

c) the maximum drop in pressure (during the last half hour of the test period, when no further make-up water may be pumped in) shall not exceed 10% of the maximum test pressure.

During all testing, the trench generally and the joint pockets in particular shall be kept clear of water and should the trench become unstable due to work or leaking on testing or re-testing it shall be excavated to solid ground and made up with lean mix concrete or such other material as the Engineer may direct, all at the Contractor's expense. Should a test fail, the Contractor shall at his own expense replace defective pipes or fittings or make good leaking joints or otherwise rectify defective work. Cleaning, inspection and testing shall then be repeated until the work is to the Engineer's satisfaction and at no extra cost to the Employer.

The length of the section of pipeline to be tested shall not normally exceed 1000 m or as directed by the Engineer.

A simple stop end consists of a section of steel pipe about 0.5 to 1.0 m long onto which a closing plate has been welded, containing the necessary opening for accommodating ingoing water and out-coming air. The stop end may also include an opening through which the test water may be pumped from the line, if necessary. The stop end may be jointed to the pipe to be tested by means of a standard coupling or other method approved by the Engineer. Thrust blocks or temporary anchorages shall be provided to hold the stop end in place against the test pressure. The Contractor may also use proprietary restrained joints in lieu of thrust blocks.

4.4.3 Interim and Final Acceptance Testing

The interim test shall be carried out after the pipeline section to be tested has been laid, jointed and backfilled to a depth of at least 300 mm above the crown of the pipe but leaving the joints exposed. The section to be tested shall be approved by the Engineer. The joints between each tested section shall then be left exposed until the pipeline has passed the Final Test on Completion.

The final acceptance test shall be carried out after all lengths have been joined together on completion of construction and interim tests have been carried out satisfactorily on the entire length of the pipeline, or such other length as may be determined by the Engineer.

Final pipeline acceptance and procedures shall be as described for Interim Pipeline Testing. Test pressures shall be the rated pressure of the pipe under test.

4.4.4 Gravity Sewers and Drainage Pipelines

All gravity sewer mains shall be tested by the following tests, to be selected by the Engineer. The Contractor shall, at his own expense, furnish all equipment and materials for making the test. Test (a) shall be performed before backfilling is commenced and tests (a) or (b) and (c) after backfill and compaction is complete, dewatering system removed and after all utilities are in the ground including sewer laterals, but prior to placing of permanent resurfacing. Tests shall be performed in the presence of the Engineer, and shall include the main and laterals as a unit. All pipes are to be clean and empty at the time of testing. When leakage or infiltration exceeds the amount allowed by the Specification, the Contractor shall, at his own expense, overhaul the pipe and make the necessary repairs or replacements in accordance with the Specification to reduce the leakage or infiltration to the specified limits. However, any individual detectable leaks shall be repaired, regardless of the results of the test. Leakage tests shall be made on completion of gravity sewer lines as described hereinafter.

a) Leakage Due to Internal Pressure (Air Pressure Method)

The Contractor shall plug all pipe outlets with suitable plugs, and brace each plug securely where needed. The air test equipment is to be approved by the Engineer prior to testing. Air shall be pumped in slowly to the pipe until a pressure of 100 mm water gauge is indicated on a manometer connected to the system. After the internal pressure of 100 mm water gauge is obtained, two minutes shall be allowed for the air temperature to stabilize within the pipe. Air may be added to restore the pressure to 100 mm water gauge. During a further period of 5 minutes, the pressure should not fall below 75 mm water gauge without further pumping.

b) Leakage due to Internal pressure (Water Pressure Method)

The pipeline to be tested shall be plugged at all pipe outlets with suitable plugs, and each plug securely braced where needed. The testing equipment is to be approved by the Engineer prior to testing. A standpipe, preferably of the same diameter as the pipe to be tested, shall be connected at the top end of the sewer either using a 90 degree bend or a hose. The standpipe should extend up to 1.2 m above the crown of the sewer. The loss of water head shall be measured over a period of 30 minutes by adding water from a measuring vessel at 10 minutes intervals and the quantity of water added shall be recorded. The average quantity added shall not exceed 1 litre per hour per meter of nominal internal diameter per meter of sewer tested.

c) Leakage Due to Infiltration

The upper ends of the sewer and laterals shall be closed sufficiently to prevent the entrance of water and pumping of water groundwater shall be discontinued for at least 3 days prior to the test for infiltration. The infiltration shall not exceed l litre per mm diameter per kilometre per day of that portion of sewer being tested, and includes the length of house laterals entering the section. The total length tested in one section shall not exceed 1000 m in length. This length is dependent upon the type of deflection measuring equipment proposed by the Contractor if flexible pipes are used.

4.4.5 Valves

Valves and all pipeline appurtenances shall be hydraulically tested together with the pipeline in which they are installed. Valves shall be tested for operation under working pressure and shall be adjusted so that they operate smoothly, seat properly and are installed to tolerances recommended by the manufacturer.

Before pressure testing is started the Contractor shall re-check pipes and valves for cleanliness and shall re-check the operation of all valves. The “open" ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts and wedges. All anchor and thrust blocks shall have been completed and all pipe straps and other devices intended to prevent the movement of pipes shall have been securely fastened.

Proposals for testing where thrusts on structures are involved, even where thrust collars on the piping are installed, shall be submitted with the calculations of the forces to be carried, to the Engineer for approval.

4.5 PIPELINE DISINFECTION

4.5.1 General

Pipelines shall be disinfected after they have been thoroughly cleaned and at the time the pipeline final acceptance testing is satisfactorily completed.

4.5.2 Disinfection of Pipelines

All potable water pipe, fittings, valves, meters and appurtenances shall be disinfected by the Contractor as specified herein.

All water and chlorine required for disinfection of pipelines shall be provided by the Contractor at his own expense. Bacteriological testing shall be performed at a laboratory approved by the Employer the cost of which shall be borne by the Contractor.

The attention of the Contractor is directed to the requirements of these Specifications whereby he is responsible for preventing the entry of foreign material of any kind into the pipework. The Contractor shall take extreme care to keep the interior of the pipework free of dirt and other foreign material. If in the opinion of the Engineer, dirt or other foreign material enters the pipework, which cannot be removed by flushing, then the Contractor shall clean and swab the

interior of the pipework with a five percent hypochlorite disinfecting solution to the satisfaction of the Engineer.

After testing and immediately before commissioning, all pipelines shall be washed out and disinfected as follows:

a) All mains shall be flushed out with clean water until there is no evidence of foreign matter or colour in the waste flushing water.

b) A stock disinfecting solution shall be prepared by mixing for not less than 5 minutes, in a clean container, sodium hypochlorite solution (15 percent available chlorine) and distilled water in the proportion of 0.8 litres to 1000 litres of water by volume. After mixing, the solution shall stand for a further 5 minutes after which the clear supernatant liquid shall be decanted into another clean container. Stock solutions shall be made up fresh daily.

c) The main to be disinfected shall be filled with potable water at the same time as the stock solution is added through a convenient air valve in such quantities (to be determined by the Contractor and approved by the Engineer) as will result in a final solution containing 50-70 mg/l free chlorine. Care shall be taken to ensure that the stock solution is added at a constant rate, commencing when water is fed into the main and ending as soon as the main is full.

d) Every main charged with disinfection solution shall stand for 24 hours. A sample shall then be taken at a washout valve by the Contractor in the presence of the Engineer, from whom the sampling bottle shall be obtained. If the sample does not show at least 2 mg/l free chlorine, disinfection shall be repeated. If the sample is satisfactory the main shall be emptied, flushed out, and filled with potable water and allowed to stand for 1 hour.

e) Two further samples shall then be taken as before, one for a further determination of free chlorine and the other, in a sterilized bottle, for bacteriological analysis. If the free chlorine determination shows more than 4 mg/l free chlorine the main shall be flushed out again. If the bacteriological analysis is unsatisfactory, disinfection and sampling shall be repeated until satisfactory results are obtained before the main is commissioned.

f) The Contractor shall provide all equipment, materials and testing apparatus, etc., as may be necessary for the effective disinfection of all pipelines.

4.5.3 Cleaning of Pipework

All pipework shall be cleaned by the Contractor after all pressure tests and disinfection operations have been performed and accepted by the Engineer. However, it is the responsibility of the Contractor to prevent all dirt and foreign matter from entering the pipework and for cleaning each length of pipe and all fittings, valves, meters and appurtenances, of sand, dirt and foreign matter during the installation. Cleaning of chlorinated lines shall conform to the recommendations of the Chlorine Institute.

All potable water required for testing, flushing and disinfection of pipelines shall be provided by the Contractor at his own expense.

4.5.4 Disposal of Water Used for Testing, Disinfection and Cleaning

The Contractor shall provide suitable means for disposal of water used for testing, disinfection and flushing such that no damage results to facilities, structures or property. These means shall be subject to the approval of the Engineer and local authorities. Details shall be submitted to the Engineer upon request. The Contractor shall be responsible for any damage caused by his filling, testing, disinfection, flushing and wastewater disposal operations.

4.6 TESTING BY LEAKAGE SOUNDING

Where the Engineer determines that pipeline testing, after installation or repair, as described in Clause 4.4 is impracticable, the Contractor shall, after initial inspection for leakage and backfilling, sound the alignment of a pipeline, and/or the area of a repair, for leakage. The Contractor shall use only trained personnel for this purpose and shall furnish to the Engineer a written report on the investigations. At his discretion, the Engineer may on occasion use his own personnel to check the Contractor's investigations, using equipment supplied by the Contractor.

END OF SECTION 4

SECTION 5

CONCRETE AND REINFORCEMENT

5.1 GENERAL

The Muscat Municipality Construction Specification Sections 501 through 504 is included separately at the end of Section 5.

This Section 5 shall be read in conjunction with the Muscat Municipality Construction Specification, but in the event that there is any conflicting statements the Muscat Municipality Construction Specification shall take precedence over this Section 5.

5.2 MATERIALS

All materials shall be as specified and shall be approved by the Engineer before they are used. The Engineer shall have the right to reject any materials, which he has not approved and the Contractor shall remove such materials from the site immediately at no extra cost to the Employer.

5.2.1 Cement

Refer to Muscat Municipality Construction Specification.

5.2.2 Admixtures

Refer to Muscat Municipality Construction Specification.

5.2.3 Water

Refer to Muscat Municipality Construction Specification.

5.2.4 Aggregates

Refer to Muscat Municipality Construction Specification.

5.2.5 Reinforcing Steel

a) Uncoated Reinforcing Steel

All reinforcing steel except otherwise noted shall be Type 2 deformed bars conforming to BS 4449. Dowel bars shall be mild steel plain bars with sawn cut ends conforming to BS 4449.

Steel fabric shall be in accordance with BS 4483.

The Contractor shall supply the Engineer with certificates of the manufacturer issued in accordance with BS 4449 and BS 4483, for all the required tests including the re-bend test in respect of each consignment delivered to Site.

Wire for tying steel bars, metallic spacers and fixing clips shall be compatible with the reinforcement, and shall be to the approval of the Engineer.

Subject to the Engineer's approval the Contractor may supply steel reinforcement manufactured and bent in accordance with approved equivalent Standards provided he first demonstrates that the reinforcement he is supplying meets the requirements set down in the above specified Standards. Cold worked steel bars shall not be used in the Works.

b) NOT USED

c) Testing of Reinforcing Steel

Tests shall be carried out in strict accordance with BS 4449 and at the discretion of the Engineer from time to time.

Tensile tests providing information on following will be required from each delivery of reinforcing steel:

- Elastic limit
- Ultimate strength
- Stress-strain curve
- Cross-sectional area
- Deformation/bond characteristics of deformed bars.

Submit type tests as per BS 4449 or alternatively approved third party product verification certificate.

The Contractor shall allow for tensile, bond, rebend and chemical tests at his own cost, for each size of bar to be used in the concrete construction.

Tests shall be carried out for each nominal diameter as follows:

	Number of Tests				
Delivery	Tensile	Bond	Rebend	Chemical Composition	Carbon Equivalent Value
= 100 tons	3	1	1	1	1
> 100 ton	3	1	1	1	1
Addl. Each 100 tons or part of 100 ton	1	1	1	1	1

Test results for each bar size shall be submitted to the Engineer 3 weeks before concrete work commences on Site.

Further tests may be called for when the source of supply of reinforcing steel changes in which case the cost of such extra testing will be borne by the Contractor.

When any test results do not conform to the relevant standard, the reinforcing steel shall be removed from the Site and all costs resulting therefrom shall be borne by the Contractor.

5.2.6 Jointing Materials

Prior to purchase and delivery of materials, the Contractor shall submit the following and obtain the Engineer's approval:

- Technical data by the manufacturer of the proposed materials.
- Manufacturer's printed preparation and application instructions.

All materials shall be obtained from a manufacturer with a minimum of ten years experience in the Middle East. The manufacturer shall operate a quality system program registered under ISO 9001. The manufacturer shall also supply technical backup service during installation, at no additional cost to the Engineer.

The Contractor shall accurately form recesses at expansion and contraction joints on both faces of the concrete work except on the underside of floor or ground slabs.

The Contractor shall prepare the surfaces of the recess and shall supply a joint sealant and fill or caulk the recess completely with it. One part polyurethane sealant shall be used. Over and above the sealant all expansion Joints shall be sealed with a sealing strip membrane.

Sealants shall be obtained from manufacturers approved by the Engineer and shall be used in accordance with the manufacturer's instructions inclusive of the supply and application of any priming materials and debonding tapes. Joint sealing shall not be commenced without the approval of the Engineer.

The Contractor shall supply the manufacturer's test certificates for each type of joint sealant delivered to site and shall if requested supply to the Engineer sufficient samples of each type and consignment for confirmatory test to be carried out in accordance with the appropriate test procedure.

A programme for the joint sealing work shall be submitted to the Engineer for approval prior to commencement of joint sealing. The programme shall take into account the following requirements as far as practicable:

- Sealing shall be delayed until just before the structure is put into service.
- Sealant shall not be placed when the air temperature is more than 30°C.

a) Joint Sealants

All concrete substrates shall be primed prior to application of the sealant. The primer shall be of a specially formulated grade suitable for hot climates, one-part chemically active brush applied material. The primer shall be from the same manufacturer as the sealant.

One part polyurethane base compound for joint sealing shall comply with U.S. Federal Specification TT-S-00230C Type II Class A and U.K.

Agreement Board 83/1106 and shall be "gun grade" except that the application life shall not be less than 4 hours. The total curing time shall be not more than 30 days. The system shall be approved by WRC for use in contact with potable water.

The movement capacity of the sealant shall be at least 20 percent of the joint width. The final method of application shall be established by site tests to ensure that there is no sagging. All surfaces shall be clean, dry and free from all loosely adhering particles before receiving sealant.

Performance Properties of the sealant shall be as follows:

Type	:	Polyurethane Elastomer
Storage Conditions	:	Away from moisture and heat
Shelf Life	:	9 months when unopened and stored at max 25°C
Density	:	1.2 kg/litre
Shore <A> Hardness	:	Approx. 25
Service Temperature	:	-30°C to +70°C
Application Temperatures	:	5°C to 35°C (>35°C -non sag site tests)
Cure Rate (Depending on RH-Level and Temperature)	:	Approx. 0.5 to 1 mm/day
Tensile Strength	:	50% elongation at 20°C = 0.15 to 0.18 N/mm^2 100% elongation at 20°C = 0.2 to 0.2 N/mm^2
Elongation at Break	:	$\geq$ 400%
Resilience	:	$\geq$ 80%
Toxicity	:	No restriction

b) Joint Filler

For all water-retaining structures, expansion joints fillers shall be non-absorbent, semi-rigid, closed cell heat laminated polyethylene filler board. The joint filler shall be non-tainting in accordance with BS 6920 and WRC approved or equivalent. The joint filler shall be fully compatible with the surface sealants and if elastomeric sealants are used the joint filler shall act as a bond breaker.

Performance properties of the joint filler shall be as follows:

Recovery	:	Greater than 98% after 50% compression.
Extrusion	:	Nil (three edges restrained and sample compressed by 50%)
Density	:	64 kg/m^3
Water Absorption	:	less than 1%

For non water-retaining structures, expansion joints fillers may be impregnated fibreboard to ASTM D1751, bonded cork to ASTM D1752 or low-density closed-cell polyethylene filler to ASTM D3575 unless otherwise shown on the Drawings.

c) Sealing Strip Membrane

Where indicated on the Drawings, expansion joints shall be sealed with a sealing strip system. The joints shall be presealed using a one part polyurethane sealant prior to laying sealing strip membrane.

The sealing strip system shall comprise hypalon high-polymer flexible membrane bonded to the concrete surfaces on either side of the joint using suitable epoxy resin adhesive. The system must be approved by WRC for use in contact with potable water.

Prior to installation or delivery, the Contractor shall submit all technical data, manufacturer's printed preparation and application instructions for Engineer's approval. The system proposed shall have high performance and shall allow considerable movements in more than one direction while maintaining a high quality seal.

The width of the flexible membrane shall be 250 mm and the minimum thickness shall be 1.5 mm. The minimum unbonded width of the membrane shall be 50 mm centre on the joint to allow greater movement potentials. Masking tape shall be applied to achieve the required debonded width. The final sealing strip system shall be able to accommodate movement that results in the debonded area being extended up to 100 percent of the debonded width.

Concrete surfaces onto which the sealing membrane is to be laid must be sound, dry and dust free. New concrete must be fully cured and free from curing compound. The concrete surface shall ideally be wood float finished and free from irregularities. Where sealing membrane has to be turned up walls, parapets or the like, a splay should be provided either cast in-situ or formed with epoxy concrete so that the change in direction is smooth and progressive. The concrete surfaces shall be primed prior to application of epoxy adhesive.

The manufacturer's instructions with respect to membrane jointing, adhesive mixing, application procedures etc., shall be strictly adhered to ensure that the final installed sealing strips provide a permanent watertight seal.

Performance Properties shall be as follows:

Density	:	Approx. 1.65 kg/litre (adhesive)
	:	Approx. 1.50 kg/m^2 (hypalon 1mm)
Service Temperature	:	- 30° C to +70° C
Application Temperatures	:	Type Normal min. 10° C Type Rapid 5° C to 15° C
Bond Strength to concrete	:	Dry or Damp = Min. 4N/mm^2 (concrete failure)
Bond Strength to Steel	:	Approx. 6 N/mm^2 (strip failure)

Tensile Strength	:	Approx. 6 N/mm^2
Peel Strength	:	Approx. 4.5 N/mm^2
Elongation	:	>350 %

d) Slip Membrane

Plastic slip strips shall be used as a separating membrane in sliding joints to permit free movement between wall and roof slab. Technical data sheet and manufacturer's printed instructions shall be furnished for Engineer's approval. The slip membrane must be approved for use in contact with potable water.

Slip strip membrane shall be made of dense extruded polyethylene sheet suitable as a low friction structural slip membrane, and shall satisfy the following criteria:

Maximum load	:	0.7 N/sq mm
Coefficient of static friction	:	0. 15
Thickness	:	1.5 mm

The membrane shall be WRC approved for use in contact with potable water.

Slip membrane shall be used as two layers to provide a low-friction sliding interface. The strip should be cut if necessary to the required width and placed on top of the other, binding the edges together with approved adhesive tape to form into an enclosed envelope to prevent ingress of fines and concrete grout. Joints between the upper and lower lengths of the strip should be staggered. The concrete bearing surface should have a steel float finish and be true, smooth, dry, free from dust and debris before bonding the two layers of slip strip onto the surface. Fixing procedure and adhesive used shall be all in accordance with the manufacturer's instructions.

5.2.7 Waterstops

Waterstops and associated materials shall be sourced and supplied by a single manufacturer with a minimum of ten years experience in the Middle East. The manufacturer shall operate a Quality System that is registered to ISO 9001.

Shop drawings for waterstop network shall be prepared by the manufacturer and approved by Engineer. Technical back-up service during application shall be supplied by manufacturer on site at no extra cost.

Waterstops shall be extruded from a high grade elastomeric polyvinyl chloride compound which contains the necessary plasticizer, resins, stabilizers and other materials necessary to meet the performance requirements of this Specification and shall be the ribbed type to provide better watertight sealing than dumbbells. Waterstops shall not contain any filler, reclaimed material or scrap material.

The waterstops shall be so designed that a fully continuous and coordinated ribbed-type waterstop network to be provided throughout the structure. All waterstop intersection and transition pieces shall be factory produced moulded and or prefabricated segments of the network to minimize site jointing and

simplify site assembly and shall have long legs to facilitate field butt splicing when required.

The waterstops shall be WRC or equal approved for use in contact with potable water.

Before waterstop material is installed in any structure the Contractor shall obtain approval the Engineer's approval for current test reports and written certificates indicating that all waterstops meet the following physical properties:

a) External and Internal Waterstops

External and internal waterstops shall be extruded from high quality polyvinyl chloride compounds having a minimum tensile strength 13.8 N/mm^2, elongation at break 300%, Shore A hardness 80-90, compound to be tested in accordance with BS 2782, US Corps of Engineers' specification CRD-C572-74 and BS 6920.

b) External Waterstops

Waterstops in base slab expansion joints shall be minimum 250 mm wide with four ribs and parallel lines of fins, the height of ribs shall be 25 mm. The centre box section shall be 25 mm wide and flat to accept a filler board. The waterstop shall have an outer nailing flange with a reinforced and profiled edge to resist tear when fixed to shuttering with double headed nails, and provide additional key when cast into the concrete.

Waterstops in base slab construction and contraction joints shall be minimum 250 mm wide with four ribs and parallel lines of fins, the height of ribs shall be 25 mm. The waterstop shall incorporate groutite fin to be in the central section. The waterstop shall have an outer nailing flange with a reinforced and profiled edge to resist tear when fixed to shuttering with double headed nails, and provide additional key when cast into the concrete.

c) Internal Waterstops

Waterstops in wall and roof expansion joints shall have a centre box to accommodate movement, be minimum 250 mm wide with four ribs and parallel lines of fins, the height of ribs shall be 25 mm. The centre box section shall be flat to accept a filler board. The web shall be 10 mm thick with a thickened central section to transfer stresses to the centre bulbs. The waterstop shall have a reinforced eyeleted outer flange for secure fixing of the waterstop into position.

Waterstops in wall and roof construction and contraction joints shall be minimum 250 mm wide with four ribs and parallel lines to fins. The web shall be 10mm thick with a thickened central section to transfer stresses to the centre bulbs. The waterstop shall have a reinforced eyeleted outer flange for secure fixing of the waterstop into position.

Waterstops and reinforcement shall be so arranged that there is at least 25 mm clearance between them. Waterstops shall not be nailed or damaged in any way and the Contractor shall ensure that the concrete

surrounding the waterstop is fully compacted without the waterstop being displaced.

5.2.8 NOT USED

5.2.9 NOT USED

5.3 STORAGE OF MATERIALS

Materials for concrete shall be stored in such a manner as to prevent deterioration or the intrusion of foreign matter. Any material that has deteriorated shall not be used for concrete and shall be removed from the Site.

5.3.1 Cement Storage

Refer to Muscat Municipality Construction Specification.

5.3.2 Aggregate Stockpile

Refer to Muscat Municipality Construction Specification.

5.3.3 Reinforcing Steel Storage

Reinforcing steel shall be stored on racks or sills that will permit easy access for identification and handling. Steel reinforcing bars shall be kept clean and shall be free from pitting, loose rust, mill scale, oil, grease, earth, paint, or any other material which may impair the bond between the concrete and the reinforcement.

Epoxy coated reinforcing steel shall be stored in accordance with the coating manufacturer's recommendations.

5.4 CONCRETE MIXES

Refer to Muscat Municipality Construction Specification.

5.5 CONCRETE TESTS

Refer to Muscat Municipality Construction Specification.

5.6 FORMWORK

5.6.1 General

Formwork shall conform to the shape, lines and dimensions of the members as shown on the Drawings and shall be substantial and sufficiently tight to prevent leakage of mortar.

Forms, shoring and false work shall be adequate for imposed live and dead loads, including equipment height of concrete drop, concrete and foundation pressures, stresses, lateral stability and other safety factors during construction. Formwork shall be designed and constructed to produce finished concrete conforming to tolerances specified.

All trades that require openings for the passage of pipes, conduits, and other inserts shall be consulted and the necessary pipe sleeves, anchors, or other required inserts shall be properly and accurately installed by respective trades. Openings required by other trades shall be reinforced as indicated and required. Conduits or pipes shall be located so as not to reduce the strength of the construction, and in no case shall pipes other than conduits be placed in a slab 125 mm or less in thickness. Conduit buried in a concrete slab shall not have an outside diameter greater than 1/3 of the thickness of the slab nor be placed below bottom reinforcing steel or over top reinforcing steel. Conduits may be embedded in walls provided they are not larger in outside diameter than 1/3 the thickness of the wall, are not spaced closer than three diameters on centre, and do not impair the strength of the structure.

The Contractor shall properly form all required reglets and rebates to receive flashing, frames and other equipment. Dimensions, details, and precise positions of all such reglets and rebates shall be ascertained from the trades whose work is related to or contingent upon same, and the concrete work formed accordingly.

5.6.2 Shop Drawings

The Contractor shall submit shop drawings for approval showing proposed location and type of required construction for any joints, and sequence of forming and concrete placing operations at least 15 working days in advance of form fabrication.

5.6.3 Formed Surface Finishes

No treatment to the finished concrete other than that specified in the class of finish shall be carried out without the Engineer's approval. Finishes to formed surfaces of concrete shall be left sound, solid, free from voids and classified as F1, F2 and F3, or such other special finish as may be particularly specified. Where the class of finish is not specified all internal concrete shall be finished to Class F3. All exposed concrete comers and edges shall have 20 mm x 20 mm chamfers. The permitted tolerances for concrete surfaces are shown in Table 5.3.

Table 5.3
Permitted Tolerances for Concrete Surfaces

	Maximum Tolerance (mm) in:			
Class of Finish	Line and Level	Abrupt Irregularity	Gradual Irregularity	Dimension
U1	+12	6	+6	--
U2	+6	3	+3	--
U3	+6	3	+3	--
F1	+12	6	+6	+12, -6
F2	+6	6	+6	+12, -6
F3	+3	3	+3	+6

a) Class F1

External concrete below ground shall be finished to Class F1, where such surfaces are to be tanked by covering with point or shearing, the formwork shall be capable of achieving a finish suitable for the proposed tanking as directed by the Engineer. Where a surface is partly below and partly above the final ground

level the finish for exposed surfaces shall extend for 500 mm below the final ground level.

Formwork for Class F1 finish shall be constructed of timber, or any suitable materials which will prevent loss of grout when the concrete is vibrated.

b) Class F2

There are two categories of Class F: Class F2S and Class F2R.

i) Class F2S is for all exposed surfaces that shall not be rendered.

The finish shall be obtained from forms designed to produce a hard smooth surface with true, clean arrises. No surface blemishes shall be permitted and there shall be no staining or discoloration. The formwork shall be faced with plywood or equivalent material in large sheets rigidly supported so as to prevent distortion under load. The sheets shall be arranged to coincide with architectural features, or changes in direction of the surface. All joints between panels shall be straight and either vertical or horizontal unless otherwise directed and the joints between panels to slab soffits shall be parallel to the supports. Suitable joints shall be provided between sheets to minimise joint marks and to maintain accurate alignment in the plane of the sheets.

ii) Class F2R is for all exposed surfaces that are to be rendered or plastered.

This finish is for all exposed surfaces that are to be rendered or plastered. The formwork shall be faced with plywood or equivalent material in large sheets rigidly supported so as to prevent distortion under load. All joints between panels shall be straight and either vertical or horizontal unless otherwise directed. Suitable joints shall be provided between sheets to minimise joint marks and to maintain accurate alignment in the plane of the sheets. The surface of the formwork shall be unplaned so as to produce a rough concrete finish to provide a good key for the render or plaster.

c) Class F3

Exposed concrete surfaces shall have Class F3 finish unless otherwise specified or shown on the Drawings. Formwork to the wetted surfaces of water-retaining structures shall be Class F3. Great care shall be taken to ensure that the finish to the exposed concrete on the external and internal surfaces are of the highest quality to produce a smooth concrete surface of uniform texture and appearance without visible imprint of grains, steppings or ridges.

Formwork for Class F3 finish shall be lined with as large panels as possible of non-staining material with a smooth unblemished surface such as sanded plywood or hard compressed fibre board, arranged in a uniform approved pattern and fixed to back formwork by oval nails. The same type of lining shall be used throughout any one structure. All joints between panels shall be straight and

either vertical or horizontal unless otherwise directed. Suitable joints shall be provided between sheets to minimise joint marks and to maintain accurate alignment in the plane of the sheets. Unfaced wrought boarding or standard steel panels will not be permitted.

5.6.4 Un-Formed Surface Finishes

The following Classes shall apply for unformed surfaces:

a) Class U1

Class Ul finish is for surfaces where a superior finish is not required. It is also the first stage for finishes U2 and U3. The finishing operations shall consist of grading, tamping and screeding the concrete to produce a uniform, plain or ridged surface.

b) Class U2

Class U2 finish is a smooth matt finish such as may be achieved by a wood trowel, as required, to receive mastic pavings, block or tile pavings bedded in mastic or screeds. Smoothing shall be done only after the concrete has hardened sufficiently, and may be by hand or machine. Care shall be taken that the concrete is worked no more than is necessary to produce a uniform surface free from marks.

c) Class U3

Class U3 finish is a smooth steel-trowelled finish for surfaces of concrete pavings, tops of walls, copings and other members exposed to weathering or water, surfaces to receive thin flexible sheet, tile pavings bedded in adhesive, and seatings for bearing plates and the like where the metal is in direct contact with the concrete. Trowelling shall not commence until the moisture film has disappeared and the concrete hardened sufficiently to prevent excess laitance from being worked to the surface. The surfaces shall be trowelled by hand or machine under firm pressure and left free from trowel marks.

5.6.5 Fixing Formwork

All formwork shall be constructed of timber or other approved material. It shall be firmly supported, adequately strutted, braced and tied to withstand the placing and vibrating of concrete and the effects of weather. The tolerance on line and level shall be such that the finished concrete surface is within the tolerances shown in Table 5.3.

The Contractor shall be responsible for the calculations and designs for the formwork and if required, shall submit them to the Engineer before construction. On formwork to external faces that will be permanently exposed, all horizontal and vertical formwork joints shall be so arranged that joint lines will form a uniform pattern on the face of the concrete. Where the Contractor proposes to make up the formwork from standard sized manufactured formwork panels, the size of such panels shall be approved by the Engineer before they are used in the construction of the Works. The finished appearance of the entire elevation of the structure and adjoining structures shall be considered when planning the

pattern of joint lines caused by formwork and by construction joints to ensure continuity of horizontal and vertical lines.

Faces of formwork in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects, and all formwork shall be clean and free from standing water, dirt, shavings, chippings or other foreign matter. Form joints and tie holes shall be sufficiently watertight to prevent the escape of mortar or the formation of fins or other blemishes on the face of the concrete.

Formwork shall be provided for the top surfaces of sloping work where the slope exceeds 15 degrees from the horizontal (except where such top surface is specified as spaded finish) and shall be anchored to enable the concrete to be properly compacted and to prevent flotation, care being taken to prevent air being trapped.

The Contractor shall provide temporary openings in forms wherever directed or necessary for access for concrete placement and vibration. Temporary openings shall be of size adequate for tremies and vibrators, spaced at maximum 1.8 m centres horizontally. Temporary openings shall be tightly closed and sealed before placing higher concrete. Temporary openings for inspection of the inside of the formwork and for the removal of water used for washing down shall be provided and so formed as to be easily closed before placing concrete.

Metal form ties shall be prefabricated rod, snap-off, threaded internal disconnecting type of tensile strength to resist all imposed loads. Snap-off type ties shall have integral washer spreaders of diameter to fully close tie holes in forms.

Before placing concrete, all bolts, pipes or conduits or any other fixtures which are to be built in shall be fixed in their correct positions, and cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cut in any concrete without the approval of the Engineer.

Unless otherwise ordered by the Engineer all exterior angles to concrete exposed to view in the completed structure shall be cast to the true angles evenly throughout the length and great care shall be taken to ensure that no waviness occurs along the angle and that no spalling occurs to the concrete on removal of the formwork. Unless otherwise ordered exterior angles on the finished concrete of 90 degrees or less shall be given 20 mm x 20 mm chamfers.

Ties or bolts or other devices shall not be built into the concrete for the purpose of supporting formwork without the prior approval of the Engineer. The whole or part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be nearer to the surface than the cover required for reinforcement. The surface of concrete shall be rubbed down smooth in an approved manner within 3 days of removing the formwork and holes left after removal of such supports shall be neatly filled with non-shrink epoxy grout of suitable consistencies and matching colour. In the case of water-retaining structures the Contractor shall ensure that measures adopted will not impair the water-tightness of the structure.

Formwork in contact with the concrete shall be treated with a suitable non-staining mould oil to prevent adherence of the concrete. Care shall be taken to

prevent the oil from coming in contact with reinforcement or with concrete at construction joints. Surface retarding agents shall be used only where ordered by the Engineer.

Devices of the tell-tale type shall be installed on supported forms and elsewhere as required to detect formwork movements and deflection during concrete placement. Required slab and beam chambers shall be checked and correctly maintained as concrete loads are applied on forms. Workmen shall be assigned to check forms during concrete placement and to promptly seal all mortar leaks.

5.6.6 Removal of Formwork

The Engineer shall be notified prior to the removal of any formwork. Formwork shall be designed so as to permit easy removal without resorting to hammering or levering against the surface of the concrete.

Concrete shall be thoroughly wetted as soon as forms are first loosened and shall be kept wet during the removal operations and until curing media is applied. Potable water supply with hoses, having fine fog spray attachments shall be ready at each removal location before operations are commenced.

The periods of time elapsing between the placing of the concrete and the striking of the formwork shall be approved by the Engineer after consideration of the loads likely to be imposed on the concrete and shall in any case be not less than the periods shown in Table 5.4. Where soffit formwork is constructed in a manner that allows the removal of the majority of the formwork and the retention during and after such removal of a sufficient number of adequate supporting props in an undisturbed condition, the Contractor may, with the agreement of the Engineer, remove the formwork at earlier times than those listed below provided that the props are left in position.

Stripping of formwork within the time limits listed in Table 5.4 does not relieve the Contractor from successfully crushing test cubes (under identical conditions) and achieving specified compressive strength results.

If the 7-day test results meet or exceed the specified 28-day strength, the Engineer may reduce the minimum stripping times specified below.

Notwithstanding the foregoing the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

Table 5.4
Time for Stripping of Formwork

Structural Component	Minimum Time for Removal Elements of Formwork (days)
Beam sides, walls and columns	1
Beam and slab soffits (props left under)	7
Props to beams and slabs	14
Beams and slabs (no props)	14

5.6.7 Defects in Formed Surfaces

Workmanship in formwork and concreting shall be such that concrete shall normally not require making good, the surface being perfectly compacted and smooth.

If any blemishes are revealed after removal of formwork, the Contractor shall propose remedial measures which shall be subjected to the Engineer's approval. These measures may include, but shall not be limited to, the following:

a) Fins, pinhole bubbles, surface discoloration and minor defects may be rubbed down with sacking immediately after the formwork is removed

b) Abrupt and gradual irregularities may be rubbed down with carborundum and water after the concrete has been fully cured.

These and any other defects shall be remedied by methods approved by the Engineer which may include using a suitable epoxy resin or, where necessary, cutting out to a regular dovetailed shape at least 75 mm deep and refilling with concrete over steel mesh reinforcement sprung into the dovetail. Cracks in concrete shall be filled in all cases using an approved epoxy resin, method of application which may include pressurized injection techniques.

5.6.8 Holes to be Filled

Holes formed in concrete surface by formwork supports or the like shall be filled with non-shrink epoxy grout subject to the approval of the Engineer.

The Contractor shall clean any hole that is to be filled with non-shrink epoxy grout and where the surface has been damaged the Contractor shall break out any loose, broken or cracked concrete or aggregate. The concrete surrounding the hole shall then be thoroughly soaked after which the surface shall be dried so as to leave a small amount of free water on the surface. The surface shall then be dusted lightly with ordinary Portland cement by means of a small dry brush until the whole surface that will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water by the cement. Any dry cement in the hole shall be removed.

The grout material shall then be placed and packed in layers having a compacted thickness per the manufacturer's instructions. The compaction shall be carried out by use of a hardwood stick and a hammer and shall extend over the full area of the layer, particular care being taken to compact the dry-pack against the sides of the hole. After compaction the surface of each layer shall be scratched before further loose material is added. The hole shall not be over-filled and the surface shall be finished by laying a hardwood block against the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

5.6.9 Building in Pipes

Pipes and pipe specials through concrete walls and floors shall as far as possible be positioned and built in during construction and shall be protected as specified. They shall be exactly positioned and true to line and level. The Contractor shall

take particular care to ensure that fully compacted concrete is in contact with the pipe at all points.

The supply and delivery of the built-in pipework should be clearly shown on the detailed construction program to be submitted by the Contractor.

Where it is impracticable to cast pipes and specials in the concrete, box holes shall be formed in the shuttering subject to the approval of the Engineer notwithstanding that no such approval will be given for boxed-out holes where a pipe has a puddle flange to take thrust nor where a pipe passes through a water-retaining structure. The box shall have six or eight sides, depending on the pipe diameter, and shall be no larger in size than will give adequate clearance for the subsequent positioning and grouting in of the pipe. The sides of the box hole shall be provided with a tapered central annular recess to provide a positive key. The box hole shall be provided with a grout hole and, at the top of the central annular recess, a vent hole. The box hole shall be stripped with the main shuttering and the concrete surface thoroughly cleaned and roughened. When the pipe is later fixed, the remaining hole shall be re-shuttered and filled with non-shrink grout or non-shrink concrete.

5.7 FABRICATION AND PLACING OF REINFORCING STEEL

5.7.1 Bending and Fixing

The Contractor shall furnish shop drawings showing the details of fabrication and placement of the reinforcing steel to the Engineer for approval.

The Contractor shall prepare and submit for the Engineer’s approval detail fabrication and placement drawings for all reinforcing steel which are correlated with forming and concrete placement techniques and requirements, including sections, plans and details clearly showing locations, sizes spacing and shapes of all reinforcing steel, caps and splices, supporting bars and accessories; and bar-bending schedules and diagrams for reinforcing steel bars to indicate bends, sizes and lengths of all reinforcing steel bars prepared in accordance with BS 4466.

The Contractor shall prepare and submit for the Engineer’s approval a separate set of shop drawings that show the construction joint locations, shall show all floor openings, wall openings and edges of concrete

No work shall be fabricated until both sets of shop drawings (reinforcing steel and concrete dimensions) have been reviewed by the Engineer (with corrections and re-submittals as required by the Contract Documents). After review by the Engineer, the Contractor shall furnish all copies needed for fabrication and erection. The Contractor shall be fully responsible for furnishing and installing all materials called for or required by the Contract Documents even though these materials may have been omitted from the reviewed shop drawings. The Engineer's review and approval of shop drawings will apply to the sizes, locations, types of bars and dimensions of bar lap splices only. Dimensions shown on the shop drawings are the responsibility of the Contractor and Engineer's approval of shop drawings shall not constitute approval of dimensions thereon. The approval of shop drawings, or revised bar schedules shall in no way relieve the Contractor of his responsibility for the

correctness of such drawings or schedules. The Contractor shall allow 14 days for the Engineer's review of shop drawings.

Bars shall be cut and bent in accordance with the provisions of BS 4466. All bending shall be done cold with the use of an approved bending machine. The heating of reinforcement for bending or straightening will not be permitted. Bars which have become bent shall not be straightened or re-bent for incorporation in the Works shall be immediately marked as rejected and removed from the Site. Bars partially embedded in concrete shall not be bent.

Reinforcement steel bars shall be handled and stored in a manner to prevent damage to bars or the epoxy coating. Bars or epoxy coating damaged in handling or other operations shall be satisfactorily repaired at no additional cost to the Employer. All systems for handling the epoxy coated bars shall have plastic mandrel and padded contact areas wherever possible. All bundling bands shall be padded and all bundles shall be lifted with a strongback, multiple supports or a platform bridge so as to prevent bar to bar abrasion from sags in the bar bundle. The bars or bundles shall not be dropped or dragged.

Before the reinforcement steel bars are lowered into place and prior to placement of the concrete, the coated bars will be inspected by the Engineer for damage to the epoxy coating. Sheared ends of bars and other areas requiring limited repair due to scars and minor defects shall be repaired, using the specified patching or repair materials.

All reinforcement shall be securely and accurately fixed in positions shown in the Contractor's drawings to ensure that the reinforcement steel framework as a whole shall retain its shape, and the framework shall be so temporarily supported as to retain its correct position in the forms during the process of depositing and consolidating the concrete. The ends of all tying wires shall be turned into the main body of the concrete and not allowed to project towards the surface.

The distance between any two parallel bars shall not be less than 5 mm more than the nominal maximum size of aggregate in the concrete, except at approved laps.

Correct concrete cover to reinforcing steel shall be maintained with the aid of approved concrete blocks or a proprietary plastic reinforcement spacers Cover spacers shall be as small as practicable consistent with their purpose and shall be designed to maintain the specified cover to reinforcing steel. Cover spacers shall be capable of supporting the weight of reinforcement and construction loads without breaking, deforming or overturning. The strength and durability of concrete blocks and proprietary concrete cover spacers shall not be less than that of the surrounding concrete.

Except where otherwise shown on the Drawings, the concrete cover to the nearest reinforcement exclusive of plaster or other decorative finish and concrete blinding shall be:

a) For external work, for work against earth face, and in water-retaining structures: 75 mm.

b) For internal work, in non water-retaining structures:

i) For beams and columns: 50 mm to the main steel and in no place less than 40 mm to the bar nearest the outside wall.

ii) For slab reinforcement: 20 mm to all bars or the diameter of the largest bar, which ever is the greater.

No part of the reinforcement shall be used to support access ways, working platform, or the placing of equipment or for the conducting of an electric current.

At the time of concreting, all reinforcement steel shall have been thoroughly cleaned and freed from all mud, oil or any other coatings that might destroy or reduce the bond and it shall also have been cleaned of all set or partially set concrete which may have been deposited thereon during the placing of a previous lift of concrete.

Immediately prior to concrete placing the reinforcing steel shall be washed thoroughly with potable water to remove any deposited salts.

The placing of all reinforcement steel bars will be checked by the Engineer and in no case is concrete to be placed around any reinforcement steel that has not been approved by the Engineer.

The insertion of bars into or the removal of bars from concrete already placed will not be permitted by the Engineer. Reinforcement steel temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer.

No reinforcement shall be cut other than as shown on the Drawings and Schedules without prior approval of the Engineer.

Where reinforcement has to be cut to leave an opening in the concrete, unless otherwise indicated on the Drawings or instructed by the Engineer trimming bars shall be provided and fixed such that the total area of steel in each direction shall be not less than the area of steel cut in that face and direction. Length of each bar shall be so as to provide not less than 1 lap length beyond the point where it crosses the main reinforcement on either side of the opening.

5.7.2 Splicing

Splicing, except where indicated on the approved shop drawings, will not be permitted without the approval of the Engineer. Lap lengths shall be as indicated on the Contractor's drawings or ordered by the Engineer.

Splicing of vertical bars in concrete will not be permitted except at the indicated or approved horizontal construction joints. For horizontal bars lap splices shall have at least one continuous bar between adjacent splices.

Splices in any run of bar shall be spaced at least 6 m apart with splices in adjacent bars offset at least 3 m. Where double mats of bars occur in walls, lap splices in opposite mats shall be offset at least 1.5 m.

The main wires of adjacent sheets of steel fabric reinforcement shall be lapped at least 300 mm and the transverse wires at least 150 mm.

5.7.3 Welding of Reinforcing

Reinforcing steel shall not be welded unless otherwise specified.

Reinforcing steel that is specified to be welded shall be welded by any process which the Contractor can demonstrate by bend and tensile tests will ensure that the strength of the parent metal is not reduced and that the weld possesses a strength not less than that of the parent metal. The welding procedure established by successful test welds shall be maintained and departure from this procedure will not be permitted.

Following the establishment of a satisfactory welding procedure, each welder to be employed on the Works shall carry out welder performance qualification tests on reinforcing bars of the same metal and size as those on the Works. The requirements of ASME Code Clause IX of 1959 shall be observed.

5.7.4 Substitution of Sizes

Substitution of sizes of reinforcing steel that the Contractor is unable to obtain may be allowed subject to the Engineer's approval, but no additional payment will be made for any increase in the amount of reinforcing steel used as a result of such substitution.

5.8 MISCELLANEOUS REQUIREMENTS

5.8.1 Blinding Concrete

Immediately upon completion of the excavation and where shown on the Drawings or ordered by the Engineer a blinding layer of concrete Grade 20 not less than 75 mm thick or as shown on the Drawings or ordered by the Engineer, shall be placed to prevent deterioration of the formation and to form a clean working surface for the structure. The blinding concrete shall extend beyond the outside edge of the structural concrete at least 100 mm.

5.8.2 NOT USED

5.8.3 Cement Mortar

Cement shall be as specified in Clause 5.2.

Plasticisers shall comply with BS 4887 and BS EN 934 and be used only as recommended by the manufacturer.

The dry ingredients of cement mortar shall be thoroughly mixed with just sufficient water to make it workable to the correct degree. With the approval of the Engineer a non-shrink admixture may be used subject to the provisions of Clause 5.2.

Cement mortar which has begun to set shall not be used or reworked for use in the Works.

Mortar shall be mixed in a batcher mixer of a type approved by the Engineer or mixed by hand if instructed by the Engineer.

The proportions of mortar shall be:

a) Type MI

Mortar for blockwork and building in ancillary components such as sills, copings, lintels.
Cement:Sand 1:3

b) Type M2

Mortar for:
i) bedding steel flooring system support angles;
ii) packing cavities between pipework or embedded plant and the surface of structural concrete or blockwork;
iii) packing under horizontal surfaces such as stanchions and machine baseplates;
iv) grouting of steel channels or support frames for switchboard and electrical equipment.

Cement:Sand 1:1

Immediately before mortar packing, the space between the concrete and base plate shall be cleaned and thoroughly wetted. All excess water shall then be blown away by means of a compressed air jet.

5.8.4 High-Strength Non-Shrink Cementitious Grout

All high-strength non-shrink cementitious grouts shall be proprietary extended workability materials approved by the Engineer complying with the requirements of ASTMC 1107 (Types B or C). They shall have a 28-day minimum compressive strength of 55 N/mm^2 and flexural strength of 9 N/mm^2 when tested in accordance with BS 1881, BS 4551 or BS 6319 as appropriate.

Surface preparation, mixing, placing and curing shall be in accordance with the manufacturers instructions unless otherwise specified.

Grout shall be mixed in a batcher mixer of a type approved by the Engineer or mixed by hand if instructed by the Engineer.

Immediately before grouting, the grout pockets shall be cleaned and thoroughly wetted to 12-hour prewet-saturated surface dry. All excess water shall be blown away by means of a compressed air jet.

The grout shall be transported directly from the mixer to the placing point in such a way that the materials do not segregate. Grout shall be placed within 30 minutes of being mixed.

Grout shall be worked into position with rods or other suitable instruments until the whole of the space is completely filled with the grout. Mechanical vibrators shall not be used.

The main grouting and the grouting of bolt sleeves and pockets should normally be carried out at the same time. Where separate operations are specified bolt sleeves and pockets shall be grouted up to approximately 50 mm below the level of the concrete foundation before the main grouting.

5.8.5 Precast Concrete

Precast concrete units shall where appropriate be constructed in accordance with the appropriate British Standard, being hydraulically pressed where possible.

At least l4 days prior to production commencing a method statement for the approval of the Engineer shall be provided of the proposed method and location of manufacture, curing, testing and storage of the units. The statement shall include a program for construction of the moulds and carrying out trial mixes. All details of the aggregate, cement, water and reinforcement, as required by this Specification shall be supplied. Any proposed method for accelerated curing shall ensure that during the hardening period the concrete is protected against harmful influence the surroundings and the hydration heat.

Moulds for precast units shall be so constructed as to provide a Class F3 finish to the units unless otherwise specified.

The moulds for precast concrete units shall be strongly constructed with smooth casting faces so that a true sound surface of concrete is obtained. Joints shall be completely tight and closed to prevent the escape of liquid from the concrete. All details of the precast units shall be provided where required. Loose mould components that effect the integrity of the mould shall be clearly identified as being part of the main mould.

The Contractor shall prepare trial units using the first set of moulds. The internal dimensions of the mould shall be measured to 0.1 mm before each trial pour. One trial unit shall be cast from each mould. The units shall be provided with a full reinforcement cage.

The units shall be cured and stored in conditions equivalent to those to be used during works production. Each mould for concrete work that is specified or approved by the Engineer to be precast shall have a different embossed or recessed identification mark in a position to the approval of the Engineer. Each precast unit shall be indelibly marked with the date of casting and after the mould is removed shall not be disturbed for 28 days.

All precast concrete members shall be clearly and neatly engraved with the word "TOP" on the appropriate face. Each precast unit shall, where required, be provided with lifting eyes and holes located to avoid excess stress during handling to the satisfaction of the Engineer. Units requiring removal at a later date for inspection/maintenance shall be provided with permanent lifting points. These shall be proprietary fixings allowing easy removal of the units and shall have suitable protection against corrosion. They shall not protrude above the finished surface of the concrete.

Temporary lifting points shall be removed or covered up and any holes or recesses shall be filled after installation of the precast units.

Precast units must be handled with sufficient care to avoid permanent damage. The Contractor shall take steps to ensure the even seating of all pre-cast members on their bearings to the satisfaction of the Engineer.

5.8.6 Screeds

Screed shall be prepared, placed and finished as follows:

a) Concrete Screed

The Engineer may at his discretion direct that the maximum aggregate size in the concrete screed be reduced from 20 mm to 10 mm and that the maximum water cement ratio be reduced to not lower than 0.48.

b) Sand Cement Screed

Sand cement screed shall have a cement: sand ratio of 1:3.

c) NOT USED

d) Mixing

Mixing shall be carried out in pan or paddle type mixers of a capacity matched to the rate of placing.

e) Admixtures

A styrene-butadiene co-polymer latex shall be used to increase resistance to water penetration, improve abrasion resistance and durability. Admixtures shall be prepared and applied in accordance with the manufacturer's instructions/recommendations.

f) Surface Preparation

Where the screed concrete is placed less than 1 hour after the base concrete and provided that no curing compound has been used the screed shall be placed directly on the concrete.

Where the screed concrete is placed more than 1 hour after the base concrete, the base concrete shall be brushed with brooms or wire brushes to remove laitance and expose clean aggregate as soon as the base concrete has sufficiently hardened.

Where the screed is placed more than 12 hours after the base concrete, loose particles and dust shall be cleaned away from the prepared surface and the surface then soaked with water. Immediately before placing the screed concrete the water shall be mopped from the surface and a stiff cement/water grout shall be brushed in.

g) Screed Bay

Screed bays shall whenever possible be rectangular and shall not exceed 15 m^2; the length of a bay shall not exceed 1.5 times its width. Screed bays shall not span joints in base concrete. Alternate bays shall be cast

initially and no screed concrete shall be placed against other screed concrete placed less than 48 hours previously.

h) Screed Battens

Screed battens shall have a thickness the full depth of the adjoining screed and shall be fixed firmly to the base concrete so that they do not move under the action of the screeding board. Fixing shall be such that screeding battens can be removed without disturbing the screed concrete. Battens shall not be removed until adjoining screed concrete has been placed for at least 12 hours.

i) Placing and Finishing

The screed concrete shall be placed as soon as possible after mixing. It shall be worked into place and tamped with a screeding board with the screed alongside the battens trowelled into the corners. A preliminary pass with a vibrating screed board shall be made where possible. Unless otherwise shown screeds shall have a finish as specified in Clause 5.6.4.

5.9 NOT USED

5.10 NOT USED

5.11 JOINTS IN CONCRETE

5.11.1 General

The Contractor shall submit to the Engineer for his approval, as soon as practicable after the acceptance of his Tender and not less than 3 weeks before the commencement of concreting, detailed proposals for the sequence of placing concrete, sizes of concrete pours and positions of all vertical and horizontal construction joints and lifts, where movement joints are to be located and details of the intersections and changes of direction to a scale that shows the position of any joint or shape of any moulded section, and installation of waterstops. The proposals shall comply with this Specification.

Waterstops shall be provided at all formed construction joints and movement joints in members which are to be water-retaining and where shown on the approved Contractor's drawings. Waterstops shall comply with the Clause 5.2.7. Waterstops shall be fully supported in the formwork, free of nails and clear of reinforcement and other fixtures. Damaged waterstops shall be replaced and during concreting care shall be taken to place the concrete so that waterstops do not bend or distort. No additional payment shall be made for construction joints and movement joints or for the waterstops at these joints, the cost of which shall be deemed to be included in the Contractor's rate for concreting.

The Contractor shall comply with the instructions of manufacturers of proprietary jointing materials and shall, if required by the Engineer, demonstrate that the jointing materials can be applied satisfactorily.

No concreting shall be started until the Engineer has approved the method of placing, pour size, the positions and form of the construction joints, movement joints and lifts.

5.11.2 Construction Joints

The construction joints shall be located so as not to impair the strength of the structure. Rebates, keys or notches shall be formed and waterstops inserted as required. The position of construction joint and size of formwork panels shall be coordinated so that where possible the line of any construction joints coincides with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines appear as a regular and uniform series. For all exposed horizontal joints and purposely inclined joints, a uniform joint shall be formed with a batten of approved dimension to give a straight and neat joint line.

Concrete placed to form the face of a construction joint shall have all laitance removed and the aggregate exposed prior to the placing of fresh concrete. The laitance shall wherever practicable be removed by spraying the concrete surface with water under pressure and brushing while it is still green or by the application of surface mortar retarder followed by washing and scrubbing with a stiff broom. Where the laitance cannot be removed while the concrete is still green the whole of the concrete surface forming part of the joint shall have the aggregate exposed by means of a proprietary power driven scabbling/bush hammer as approved by the Engineer. Hacking, chipping, chiselling and the like shall not be permitted. All loose matter shall be removed and the exposed surface thoroughly cleaned by wire brushing, air blasting or washing, and the surface to which fresh concrete is applied shall be clean and damp.

Construction joints shall generally be located as follows and adjacent sections shall be poured after the specified time period or as agreed by the Engineer:

a) Columns

Joints in columns shall be made at the underside of floor members and at floor levels. Haunches and column capitals shall be considered as part of and continuous with the floor or roof.

b) Suspended Floors and Roofs

Joints in the system shall be located at or near the middle of the spans in slabs, beams or girders, unless otherwise instructed by the Engineer.

c) Walls

Vertical joints shall be away from corners. Horizontal joints shall be above splays or openings. Construction joints shall be placed at intervals not exceeding 5.5 m.

Where the concrete wall is monolithic with the floor slab or footing, the pouring of the wall shall commence within 7 days of placing the floor slab or footing with which it corresponds. Successive lifts in walls shall be placed within 3 days.

The circular walls of tanks with a sliding joint between floor and wall are not subject to the 5.5 m panel limits referred to above if a lift in the wall is concreted as a continuous ring. Concreting shall then be carried out continuously in both directions until the ring is complete.

d) Ground Slabs

Slabs bearing on ground shall be cast in panels defined by movement joints subject to the 5.5 m panel limits. Where no movement joints are specified or where the distance between movement joints exceeds 5.5 m in any direction for ground slabs and exceeds 5.5 m in length for wall slabs (except as described above under walls) shall be subdivided by properly formed construction joints into panels of dimensions not exceeding 5.5 m. The panels shall be separately concreted and, except as detailed below, no panel shall be concreted until the concrete in adjacent panel is at least 7 days old. The proposed sequence of casting panels as called for in this subclause shall be submitted for Engineer's approval before commencement of concreting.

This requirement will generally be met by casting in alternate bays. If long and short bays are proposed, the long bays shall be concreted first. Reinforcing bars extending across in fill bays shall not be continuous and a splice shall provided within the in fill bay.

If the Contractor adopts this or other approved methods to accommodate shrinkage the Engineer may agree to a reduction in the 7-day time, but in no case will the approved period be less than 4 days. The periods referred to above do not apply to successive lifts in walls. The peripheral ring beam in the floor of a circular tank shall not be concreted in advance of its integral floor slab.

5.11.3 Movement Joints

Typical movement joints provided are expansion joints, complete contraction joints, partial contraction joints and sliding joints.

As far as possible jointing on Site shall be confined to the making of butt joints in straight runs of waterstops. Where it is agreed with the Engineer that it is necessary to make, on Site, an intersection, change of direction or any joint other than a butt joint in a straight run, a preliminary joint, intersection or change of direction piece shall be made and submitted to such tests as the Engineer may require.

The surface of set concrete in a movement joint shall be painted with two coats of bituminous paint and new concrete shall be placed against it only when the paint is dry. Expansion joints shall be formed by a separating strip of approved self-expanding preformed joint filler.

Caulking grooves shall be provided. At all joints where a caulking groove is formed, immediately prior to caulking, the groove shall be wire-brushed and loose material removed and blown out by compressed air. After the groove has dried it shall be primed and caulked with approved jointing compound applied in accordance with the manufacturer's instructions. Unless the Engineer shall instruct otherwise, at all caulked joints, the face of the caulking strip and 50 mm

width of concrete on either side shall be painted with two coats of paint having the same base as the caulking compound.

In expansion joints the part of the dowel bar to be free to move shall be coated with bond breaking compound, encased in a rigid PVC or metal sleeve and fitted with a compressible cap of joint filler or other materials approved by the Engineer. The diameter of the sleeve should be the minimum necessary to allow free movement of the bar after concreting.

In full contraction joints the part of the dowel bar to be free shall be coated with bond breaking compound.

In joints between roofs and walls of reservoirs vertical dowel bars shall be provided with a rigid PVC or metal sleeve so packed with compressible material as to allow adequate free movement in any direction in the horizontal plane.

5.12 NOT USED

5.13 PROTECTION OF CONCRETE AND CEMENTATIOUS SURFACES

a) All external faces of reinforced concrete structures in contact with the ground shall be protected by a waterproofing membrane system as specified in Section 8.

b) Polymeric coatings for concrete surfaces are specified in section 7.

5.14 CLEANING OF WATER-RETAINING STRUCTURES

All water-retaining structures shall, on completion, be carefully cleaned, to the complete satisfaction of the Engineer as follows:

a) The structure shall be cleared of all debris and shall be brushed down on all internal faces with a stiff broom while still dry, and all resulting debris removed, all associated reservoir pipework shall be cleaned in accordance with the Specification requirements.

b) The structure shall then be flooded with approximately 75 mm of clean water and the whole of internal faces shall be carefully brushed down with stiff brooms using the water continuously until all faces are clean, the water shall then be drained off, and the walls and floors hosed and flushed with clean water until perfectly clean.

5.15 TESTING OF WATER-RETAINING STRUCTURES

5.15.1 Description

The Contractor shall test water-retaining structures all as described herein.

5.15.2 Scope of Work

The work included in this Clause includes the following:
a) Storage reservoirs.
b) Other miscellaneous structures that required to be watertight.

Structures intended and designed to be water-retaining (including all tanks, reservoirs, channels, sumps, chambers, etc. and any other structures designated as water-retaining by the Engineer) shall be tested for water-tightness after completion, in accordance with the following method or as directed by the Engineer.

In the case of structures which are sub-divided into individual tanks (such as the reservoirs), each individual tank shall be tested separately. In the case of underground or semi-underground structures, the testing is to take place before any perimeter drain or filter material or backfilling is placed against the walls. No placing of any material whatsoever against the walls shall take place until the Engineer has given his written approval and acceptance of the tank as watertight.

In the case of hopper-bottomed tanks, this shall be taken to mean that no material is placed against the vertical external walls of the tank, the sloping walls of the hopper bottoms of the tanks being assumed built direct against the excavation apart from the blinding concrete.

The testing shall not be undertaken until the structure to be tested has been completed structurally (including roof if any) and has been passed by the Engineer in writing as satisfactory in all respects other than water-tightness, especially in regard to the final finish of the work, the filling shall not take place earlier than 28 days after the casting of the final sections of the structure which will be stressed by the filling of the structure.

Before and during testing, flows in the reservoir underdrainage shall be monitored, measured and recorded. Each underdrain shall be numbered and observations reported by underdrain number to facilitate analysis of the data. All leaks shall be repaired within one month of their detection.

Two sets of evaporation trays shall be provided along with two sets of rain gauges.

Levels in the trays and reservoir shall be made and recorded by a hook gauge with vernier attachments.

The structure shall be filled with potable water in stages not exceeding one metre in height and held at each water level for such time as the Engineer may require. Should any dampness or leakage occur at any stage, the water shall be drawn off and the defects remedied to the satisfaction of the Engineer.

5.15.3 Testing of Structures other than Storage Reservoirs

As soon as possible after the completion and cleaning of water-retaining structures, they shall be tested for water-tightness by filling them with water and allowing them to stand for three days to allow for absorption. The structure shall be considered satisfactory if subsequent to this period, there shall be no fall in level over a period of 24 hours, after making due allowance for rainfall and evaporation, and no visible leaks.

In the event that any water-retaining structure fails to pass the test, the Contractor shall make good and re-test at his own expense. The procedure shall be repeated until the structure passes the test.

5.15.4 Testing of Storage Reservoirs

After completion and cleaning of the reservoir and all associated pipework, the Contractor shall fill the reservoir with water up to top water level and leave for 7 days. Water shall be added over this period to maintain the top water level. The Contractor shall ensure that all pipes and specials are available in ample time ahead of testing.

On the eighth day two shallow watertight G.I. evaporation trays of area 0.4 sq m shall be filled with 75 mm depth of water and placed to float in the tank. The water levels shall be recorded and the test commenced and carried out over the next 7 days. Readings of the water levels in the reservoir and trays shall be made and recorded every 24 hours over this period.

The fall of water level in the tank over the test period of 7 days, after allowing for evaporation and rainfall shall not exceed 1/500 of the average water depth of the full reservoir or l0 mm whichever is less.

Notwithstanding the satisfactory completion of the 7-day test, any leakage, cracks, wet/damp patches and sweating visible on the outside faces of the structure shall be rectified from the water face as directed by the Engineer, a repair making the outerface only watertight will not be accepted, this also applies to bobbin holes. The structure shall be re-tested until the water-tightness is approved by the Engineer.

The roofs of reservoirs and tanks shall be tested for water-tightness by lagooning the roof slabs to a minimum depth of 50 mm for a period of 72 hours. The roof slab shall be regarded as satisfactory if no leaks or damp patches appear on the soffit.

The roof covering shall be completed as soon as possible after testing.

Should the part of the structure under the test fail the above tests in any respect, the Contractor shall immediately take such steps as may be necessary to ascertain the nature and positions of any defects or leakages, shall empty the structure, and remedy the defects in a manner approved by the Engineer, employing men or a firm specialising in this class of work.

When the remedial work has been completed in a manner approved by the Engineer, the testing and if necessary rectifications, shall be repeated until a satisfactory test is achieved.

If necessary, in extreme cases of lack of water tightness, the Engineer may reject the structure or any member or section of a member of the structure, in accordance with Clause 49 of the Conditions of Contract.

All expenses in materials (including the supply of water) plant, labour and all other costs including overheads and profit if required involved in the satisfactory water-tightness testing of all the water-retaining structures in the Works shall be included in the rates entered by the Contractor in the relevant items in the Bill of Quantities.

Any costs, as above, incurred by the Contractor in remedial or replacement work necessary to achieve the satisfactory testing shall be entirely at the expense of the Contractor.

5.15.5 Source of Water for Testing

All water used for testing shall be potable water and as approved by the Engineer. The cost of obtaining this water shall be borne by the Contractor at his expense.

5.16 DISINFECTION OF STORAGE RESERVOIR

5.16.1 General

After testing and completion of remedial measures, all dirt and construction materials still remaining inside the reservoir, shall be removed and disposed of off site. The interior of the reservoir shall then be thoroughly cleaned and disinfected to the satisfaction of the Engineer.

5.16.2 Disinfection of Reservoir

The Contractor shall fill the reservoir with potable water up to the top water level and charge with chlorine to a dosage of 50 mg/l of effective chlorine. All internal surfaces above the top water level shall be prepared and brushed vigorously with a 100 mg/l chlorine solution and left for a contact period of one hour before flushing with clean water. The reservoir shall then be left to stand for 24 hours. After confirming the water quality by bacteriological testing, the water in the reservoir shall be disposed to waste.

Alternatively, the reservoir may be disinfected by manual means whereby the entire internal structure shall be cleaned and sprayed with a 100 mg/l chlorine solution. The cleaning and spraying shall commence at one far end of the structure and proceed to the opposite end. A contact period of one hour shall be maintained prior to flushing with clean water.

All water, chlorine and equipment required for disinfection shall be provided by the Contractor. Bacteriological testing shall be carried out by the Contractor at a laboratory approved by the Engineer.

The criteria for a satisfactory result shall be as defined in the latest edition of "Guidelines for Drinking Water Quality" published by the World Health Organisation. In addition for a satisfactory result there shall be no coliform organisms in any two samples of 100 ml.

The cost of sampling, testing and reporting on bacteriological quality of water shall be borne by the Contractor.

The Contractor shall ensure that all construction personnel are adequately equipped with proper safety equipment during the disinfection process.

5.17 DISPOSAL OF WATER USED FOR TESTING AND DISINFECTION

The Contractor shall provide suitable means for disposal of water used for testing, disinfection and flushing such that no damage results to facilities,

structures or property. These means shall be subject to the approval of the Engineer and local authorities. Details shall be submitted to Engineer on request. The Contractor shall be responsible for any damage caused by his filling, testing, disinfection, flushing and wastewater disposal operations. No separate payment shall be made for disposal of water used for testing and disinfection and it shall be deemed to be included in the cost of other items in the Bill of Quantities.

END OF SECTION 5

Section 501: General Concrete Specification

A. DEFINITIONS

Approval of a plant
An acceptance that the plant and production management are being operated in accordance with the specification, expected level of professional skill and competence, international industry norms and the expected professional conduct, without major or critical non conformances. Events and practices, ocassional, intermittent or persistent, that affect the approved, promised or expected quality.of concrete shall be deemed but not solely to be major and critical violations.

Approved plant
A plant which has been assessed by the Assessor and found to be compliant with the requirements of the specification.

Assessment
A detailed appraisal of the procedures and working practices at a plant interpreted against the requirements of the specification.

Assessor
A representative appointed by the The Municipality to perform a technical audit.

Audit
A series of checks, inspections, queries that assesses plants, methods, activities, functions, practices and systems in the concrete industry against the requirements of the specification, industry norms, professional practice, quality assurance and control systems, the plant and equipment manufacturer's requirements and instructions and any technical claims written or verbal made by the Producer or his sub-contractors that has a bearing on the quality of output from the plant or factory..

Audits will be based on a random sampling of between 1 – 5 %. The audit will be extended to greater sampling if the first sampling reveals major deficiencies.

Concrete
Concrete or any cementatious mix or product.

Document
Any form of record and this includes company procedures, work instructions, plans, analysis sheets, reports, technical data and information sheets in the form of or combinations of manuals, memos, faxes, charts, drawings, illustrations, letters, records and electronic media and whether printed, electronically stored, typed or handwritten.

Durability
ability of a construction or a component to maintain its properties, attributes, adequate levels of stability and performance during its designed working life under intended use with anticipated maintenance but without excessive unforeseen maintenance

Factory production control
A technical and managerial surveillance practice in which a manufacturer or producer performs his own surveillance on his processes and practices in order to ensure consistent production of his product to meet the specification and any additional claims he makes for the product and according to a set of rules formally documented in his acceptable quality assurance scheme that meets the norms of international practice and standards

Maintenance audit
An audit based on a lower percentage sampling than a full audit.

Non-structural concrete
Concrete that is not considered as contributing to structural or durability requirements and generally used as 'blinding'.

Producer's approved plant
A concrete plant approved by The Muscat Municipality.

Producer's quality system
The Producer's company structure, activities and resources which in combination provide the means to enable the company to produce concrete consistently to the specified and approved quality.

Qualified consultant
A consulting engineer who is qualified technically to supervise an activity that requires specialised knowledge and competence. The Muscat Municipality shall approve consulting engineers in the respective fields covered by the specification. Note that qualification is given to the individual engineer and not to the consulting company.

Quality assurance
All the activities and functions concerned with attaining the stated quality of concrete.

Quality control
The operational techniques and activities that sustain the daily production of concrete to the quality set out in the company's Quality Manual, the specification and in accordance with the specification.

Sub-contractor
means any third party other than The Contractor who supplies materials, product or services to the project

Supplementary mineral additives
The term 'Supplementary mineral additives' has been selected to collectively describe Silica fume, GGBFS and PFA. [The term originates from The Canada Centre for Mineral and Energy Technology (CANMET)].

Time of loading
The time of first contact between cement and water or wet constituent material.

The Client
The Client shall mean the Muscat Municipality

The Contractor
A company under contract to The Client.

The Municipality
Refers solely to The Muscat Municipality.

The Producer
A company in the business of producing fresh concrete from dry constituent ingredients. This classification includes independent readymix companies, contracting companies, concrete product manufacturers [such as manufacturers of concrete pipe, concrete tiles and blocks, hollow core elements] and precast yards producing their own concrete from dry constituent ingredients.

Type testing
Tests carried out to verify the reliability of the design or process

B. SYMBOLS

f_{ck}, cube
Cube characteristic compressive strength at 5% confidence limit

f_c, cube
Cube compressive strength

f_{cm}, cube
Mean compressive strength of concrete cubes

C. ABBREVIATIONS AND NOTATIONS

ACI
American Concrete Institute

MM
The Muscat Municipality

ASTM
Standards published by the American Society for Testing and Materials

BS
Standards published by the British Standards Institute

BS EN [British Standards Institute - European Norm]
European standards adopted by The British Standards Institute

C_3A
Tricalcium aluminate

CGLI
City and Guilds London Institute

Cl^-
Chloride ion

CO_2
Carbon dioxide

CD-R
Compact Disc-writable

GGBFS
Ground granulated blast furnace slag

GRC
Glass fibre reinforced concrete [or cement]

Mg^{2+}
Magnesium ion

$[NH_4]^+$
Ammonium ion

OPC
Ordinary Portland Cement

PFA
Pulverised fly or fuel ash

QA
Quality assurance

QC
Quality control

QM
Quality Manual

RC
Reinforced concrete

SF
Silica fume

SMA
Supplementary mineral additives – a collective noun describing GGBFS, PFA and SF

SO_4^{2+}
Sulphate ion

SRPC
Sulphate Resisting Portland Cement

SSD
Saturated surface dry

w:c
Water cement ratio

C. CONVENTION FOR MEASUREMENT SYSTEM

SI system
All units used in the specification are in the metric SI system.

Unit for the supply of concrete
The unit of supply is one cubic metre of fresh fully compacted concrete. The volume is calculated from the total mass of the batch from the approved mix design.

1. DESIGN WORKING LIFE

Structural concrete shall have a designed working life of at least 50 years without having to conduct unforeseen or expected repairs during the period.

2. COMPLIANCE REQUIREMENTS

2.1. General provisions

The Contractor including his subcontractors shall be in compliance with the specification. Exclusions, additions and variations to the main specification will be included in the 'Particular specification' issued with each project contract document.

The level of management and engineering skills demonstrated during every aspect of project execution shall be of the first order equivalent to internationally acceptable professional practice and best end engineering and technology application and practice. Workmanship applied during construction tasks shall be equivalent to that of high end artisanship or craftsmanship. The Engineer reserves the right to require the Contractor to remove any member of the Contractor's staff involved in the project and who does not perform as expected, irrespective of whether he is working on or off site. The Contractor shall replace the staff removed immediately with staff who can perform competently to meet the requirements of the project.

The Engineer shall be allowed to inspect any facility, document, location, material and equipment pertaining to the project and its operation without hinderance, delay or obfuscation at any time during the project period. All appropriate requests by the Engineer, written or verbal, shall be facilated immediately. Information and documents requested by the Engineer shall be provided within 24 hrs or as otherwise agreed.

2.2. Costs for compliance

All costs expended to meet the specification, any corrective instructions issued by the Engineer and investigations caused by a lack of performance by the Contractor for whatever reason shall be bourne entirely by the Contractor.

2.3. Qualifications and skills of key staff

Engineers and technicians shall possess the skills and knowledge with regard to concrete as shown in Table 501.1.

Table 501.1. Skills and knowledge required of Engineers and Technicians

	Task	Party	Knowledge	Skill
1	Preparing concrete submittals Production of concrete	The Producer The Contractor Sub-Contractor	Basic concrete science International standards Specification requirements Mix design calculations Basic automatic control production engineering Basic quality principles	Technical analytical skills Designing of concrete mixes Practical skills in concrete production and testing
2	Reviewing and approving mix designs Site supervision	The Contractor	Basic concrete science International standards Specification requirements Mix design calculations The specification Basic quality principles	Technical analytical skills Reviewing skills
3	Site quality control and testing	The Contractor Sub-Contractor The Producer [if relevant] The laboratory	Basic concrete science International standards Basic quality principles The specification	Systematic inspection skills Practical skills in concrete production and testing Engineering judgement Technical analytical skills Interpret computer printout Detect non-conformances Testing fresh concrete Making cubes Testing cured concrete Site practices & workmanship

The Contractor's engineers with responsibilities shall be qualified, skilled and knowledgeable in the various fields that cover their tasks and shall demonstrate their competence in the work produced under the contract. Skills and knowledge of practising engineers and technicians from the various disciplines must be of a proessional standard of the first order and found to be sufficient for performing tasks demanded by the

project. Artisans and craftsmen shall be skilled in the category of the first order. The Engineer will instruct the Contractor to remove any staff that do not perform to the standards stipulated.

Where the Contractors staff lacks the necessary skills or knowledge in any particular area, he shall sub-contract the task to a third party.

2.4. Applicable standards and documents

The applicable standards are listed in: Appendix 501.1

Where a standard has been superceded or made obsolete, the replacement standard shall be used. The fact that a superceded or obsolete standard is valid or still being specified in another country will not be a valid argument in The Sultanate of Oman.

Where there is a conflict between the specification and a standard, the specification shall prevail.
BS EN 206-1, BS 8500-1 and BS 8500-2 are used as the dominant standards governing specification, performance, production and conformity of concrete. The BS EN standard was primarily written for conditions in Europe. The standard recognises that different climatic, geographical conditions, regional traditions and experiences exist. It therefore allows provisions valid in the place of use of the concrete to be used. Provisions that do not have any relevance to the Sultanate of Oman will not be observed.

The contents of applicable standards and documents are not reproduced in the specification. The Contractor shall refer to relevant parts of the standards for compliance.

2.5. Quality Assurance system

The Contractor including his subcontractors shall have a Quality Assurance Scheme augmented with a Quality System. An ISO 9001 or a Factory Production Control system shall be in operation. Testing and calibration bodies shall have a system in compliance with BS EN ISO 17025. It is not necessary to have the system accredited but the system shall be operated to the requirements of the standards.

An accredited ISO 9001 or BS EN ISO 17025 certificate shall not be automatically construed to mean that the manufacturer or producer is in compliance for the purposes of the project. An ISO 9001 certificate is only relevant to the needs of the project if the certified quality system is practised without exception or let and meets the requirement of the specification consistently.

A BS EN ISO 17025 certificate is only relevant to the needs of the project if the testing required by the specification is in the list of tests for which the laboratory has been qualified and that the certified quality system is practised without exception or let or hindrance and meets the requirement of the specification exactly.

Quality accreditation companies

Quality accreditation companies shall meet the requirements of BS EN 45012. Since specification deals with technical and specialised products and services, technical competency testing shall be included in the audit for accreditation as required by the quality standards.

The Quality Manual

The Quality System shall maintain a Quality Manual that reflects the details of the actual working practices and procedures of the organisation and the requirements of the Client's specification. All staff will have be familiar with its contents and especially with those parts that is relevanty to their job functions.

Universal, generic or exagerated descriptions in The Quality Manual or associated documents will not be acceptable. Statements shall iterate the actual practices of the organisation's operations.

2.6. Production and delivery of concrete

The Contractor shall deliver a concrete that when mixed, transported, pumped, compacted and wet cured will produce a structure without unwanted defects and satisfy the requirements of the specification and The Client's directive.

Where the mixer efficiency is found to be poor, The Engineer shall stipulate a longer mixing time. The correct and practical sequence of additions and the dry pre-mixing times shall be determined during the site trial mix.

3. APPROVED CONCRETE PLANT

3. 1 General provisions

Concrete shall be sourced from a plant approved by The Muscat Municipality according to the requirements stipulated in Appendix 501.11. The Contractor shall refer to the current list of approved Producers. The list is issued and updated by MM. The Contractor shall determine the status of approval of a plant before making his proposal. [Note: Approval is awarded to a specific plant and not to The Producer as a corporate entity.]

There shall be no difference in the quality and production capabilities expected from 'site mixed concrete', a concrete product factory, a precast yard or a stand alone 'ready mix company'.

The approval of a plant by the Muscat Municipality does not relieve The Contractor of his responsibilities to continue surveillance and vigilance during the project. The Municipality approval merely confirms that the approved plant has the capability to meet the quality requirements demanded of the project. Approval of the plant by The Municipality does not guarantee that every load of the concrete delivered to the project will be conforming. The Producer's own system shall detect non-conformance and refrain from delivering non-conforming concrete. It shall be the Contractor's responsibility to check for conformance. The Contractor shall maintain constant surveillance within his own system to ensure that every load of concrete delivered meets the project specification without exception. In the event, The Producer delivers non-conforming concrete The Contractor shall reject non conforming concrete, record the non-conformance and report it to The Engineer immediately.

The Contractor shall ensure that The Producer has sufficient resources and capacity to supply the project without delay and compromise. A second approved plant from a secondary Producer shall be proposed in the event that the primary Producer becomes incapacitated. Where the project demand is beyond the capacity of any individual producer, a joint venture, amalgamation or association between the approved suppliers will be acceptable subject to approval of The Engineer.

3. 2 Computer controlled fully automated batching plants

All concrete shall be wet batched in a fully automatic computer controlled concrete plant unless exceptional permission is sought from the Municipality. The plant's computerised automated control capability shall be fully activated to maximise production process control with the minimum of human intervention. It shall be capable of storing the production data and parameters and be able to provide a secure printout with the data required by the specification.
Under certain conditions [e.g for remote sites or for low volume production rates] permission will be granted to The Producer to operate semi-automated and manual plants.

3. 3 Manually mixed concrete

The Engineer may allow handmixing of concrete at site for a non-structural concrete where a volume of less than $1m^3$ is required at any one instance. The Contractor shall make a submittal for approval.

4. TRUCK MIXING

4.1. Wet mixing in a rated truck

Under certain exceptional circumstances, dry mixes without the addition of water or wet or moist constituent materials [such as washed or discernibly moist aggregate, slurry or aggregate soaked after rainfall] will be allowed to be transported to the site and subsequently mixed with wet ingredients under controlled conditions. Such permission is reserved for a situation where the journey time from batch plant to site is more than 90 minutes. A dry mix shall only be transported in a rated truck mixer. In such an instance, water and other wet ingredients shall be added by experienced operators from The Producer at the site and shall be witnessed by The Engineer.

4.2. Cube sampling requirements for truck mixed concrete

Cubes shall be made from samples taken from each third of the drum and tested for 28 day compressive strength and density. The results in addition shall conform to the requirements stated in the specification Appendix 501.11 Table 2 .

4.3. Addition of air entraining, foaming and expansion additives at site

Solid additives shall be dispensed into the concrete contained in the drum of a certified truck mixer in the form of a water based high flow premixed slurry. The consistency of the slurry shall be low enough to cause rapid dispersion.The premixed slurry shall be made immediately before addition and dispersion shall be produced with a mechanical stirrer. The slurry shall be introduced into the drum in five equal portions, the

drum being rotated at maximum speed for at least 60 seconds in each interval between the additions of portions. The water to be added to the slurry shall be accounted for in the specified limits for the w:c ratio for the mix.

5. CONCRETE MIX DESIGNS

5.1. General classification of concrete mixes

The following classes of mixes are permitted:-

1. Designed mix
2. A mix supplied as a proprietary mix or marketed under a registered trade name
3. Any other mix stipulated in the contract specifications
4. A mix offered as an alternative to meet the specification or where there is no specification

Prescribed mixes are not permitted under the specification.

5.2. Definition of a family of mix designs

A family of mix designs shall be categorised on the basis of the closeness of proportions of its constituent materials. Those falling within 5% of variation in the range in any individual constituent material can be grouped as a 'family' provided the same admixture and constituent materials of the same type and from the same sources are used. Mixes with aggregates, cements, admixtures and SMAs of different types and from different sources shall not be classified into a single family under any circumstance. A family shall not be based on closeness of strength or other singular property of the concrete.

A technically competent person can sometimes derive a family of mixes from a well developed mix without conducting a full developmental programme on all the mixes in the family.

5.3. Preliminary mixes

The Producer shall develop the mix design [or a family of mix designs] of his own accord without supervision by The Contractor or The Engineer, culminating in his own plant trials. He shall have established the fresh and cured properties of the mix before offering it as a product suitable for considerations of approval. He shall provide evidence of preliminary test results with the submittal.

The time and resources of the project shall not be used by The Contractor or his sub-contractor to discover the properties of his proposed mix design for the first time or for prototype testing.

Plagiarising a mix design from another owner and offering it as one's own is not acceptable.

5.4. Derivation, calculation, materials, data and submission

Concrete mixes and constituent materials shall meet the requirements of The Specification and The Client's directives. The Contractor shall provide The Producer with complete copies of the specification and The Client's directives concerning the concrete.

The mix design and all the associated documents shall be produced and compiled by The Producer.
Concrete designers shall not assume that strength, performance values and other technical relationships obtained in colder regions such as in Europe [Note BS 8500-2 clearly provides caution in this regard in the 'Introduction'] are applicable in The Sultanate of Oman. The Producer shall establish local values and relationships by collecting relevant data and parameters pertinent to concrete cast in The Sultanate of Oman.

The Producer shall have performed preliminary mixes and initial laboratory tests on his calculated mix design to prove that the properties of the concrete meet the requirements of the specification and the Client's directives. Where experience with a similar concrete or family is cited in lieu of preliminary mixes, The Producer shall submit statistically valid test data from actual production runs of the similar concrete or family. Production data shall consist of least 35 results from batches that have been made on at least 30 different days.

The specification and The Client's directives shall be systematically studied by a competent person, usually the Technical Manager in The Producer's company, to interpret the specified requirements and derive the appropriate criteria for the mix design. Where the specified requirements cannot be met or are contradictory, The Producer shall submit proposals for amendments, correction or provide alternative solutions. Alternative proposals to the stipulated requirements in the specification shall be clearly identified as such in the mix design submission. The Contractor shall await formal approval of his proposal by The Engineer before supplying the project.

Each mix design shall be initially checked and reviewed by the The Contractor and he shall ensure that it meets the requirements of the specification and The Client's directives. It shall then be submitted for approval by The Engineer. Approval of the mix design shall occur only after the trial mix has been carried out under approved supervision and the 28 day results are found to be conforming.

The properties to be achieved and monitored on site placements shall be based on the mix design submitted, the trial mix results and the population mean and ranges characterised for the submitted mix design. The values of the properties to be achieved on site placements shall include the margins and targets to be achieved and they shall include the variations that will be encountered for each property due to inevitable variations during batch production, placement, curing, sample preparation and testing.

5.5. Basic Parameters for mix designs

Use of specification limits
The maximum-minimum values stipulated in the specification are provided as ranges within which the concrete parameters shall fall. They shall not to be interpreted as lower or upper targets to be achieved in a mix design or as ranges for acceptance of performance. Each mix design shall be engineered to achieve the properties required for performance. The Producer shall declare his own specific tolerances to maintain consistency of the engineered quality but within the parameters set by the specification. The characteristic tolerances specified by The Producer in the approved mix design shall be used as the acceptance criteria.

Basis for calculation
Mix designs shall be calculated on a saturated surface dry [SSD] basis.

w:c ratios

The maximum w:c ratios are shown in Table 501.2. w:c ratios for structural concrete shall not exceed 0.4 and for blinding concrete 0.5.

The target water:cement ratio shall be lower than that submitted [which may not be synonymous with the maximum in the specification] by 0.02 to allow for variations that occur during batching.

Slump
There are three slump values to be considered. These are the 'production', 'delivery to site' and 'placement' slump values. The three values will be different as there will be elapsed periods between the three events and slump losses will occur in the interim periods. The specification stipulates the absolute minimum slump at placement. Slump values specified shall not be modified under any circumstance or by the application of any standard. The Contractor shall adjust his production slump accordingly taking into consideration all the factors that will affect the final placement slump value. Slumps shall be such that segregation shall not occur during transportation or placement. The Contractor shall deliver concrete with a target placement slump of at least +20 mm above the specification stipulated minimum slump.

Bleed
Maximum bleed for structural concrete shall be ≤ 0.5 % when tested in accordance with ASTM C 232.

Drying shrinkage
Maximum drying shrinkage for structural concrete shall be ≤ 0.05 % when tested in accordance with BS EN 1367-4 as modified by the specification.

Fresh concrete temperature at placement
The fresh concrete temperature at placement shall not exceed 30 ^{O}C. Flaked ice shall be used if ice is added directly to the mix. If crushed ice is added to the mix directly the crushed particle shall be no larger than 2mm in diameter.The producer shall have appropriate ice crushing equipment that includes a vibratory sieve to ensure compliance.

Ambient temperature at concrete placement
The ambient temperature during placement shall not exceed 40^{O}C.

Air content

The air content for concrete that is not air entrained shall not exceed 2 %. The Producer shall ensure that during his preliminary trials the plasticiser or other additives do not have a propensity to stabilise visible air bubbles and significantly increase air entrapment other than minor amounts of entrained air especially when dosed at the highest addition amount envisaged.

Cement and cementatious content
The ranges for cement content of concretes are expressed in Table 501.2.

Where SMAs are used, the cement content shall mean the cementatious [i.e. cement + SMAs] content. The k coefficient stipulated in BS EN 206 shall not be used to reduce or increase the stipulated limits for cement content when SMAs are used.

Table 501.2. Limits for cement content and w.c ratios per m^3

Concrete Class $f_{ck,\ cube}$	Maximum aggregate size (mm)	Range of cementitious content (kg/m^3)	Maximum free [effective] w:c ratio	Characteristic 28-day cube strength (N/mm^2)
45/20	20	350 - 380	0.40	45
40/20	20	345 - 370	0.40	40
37/20	20	330 - 350	0.40	37
35/20	20	320 - 330	0.40	35
30/20	20	300 - 310	0.5	30
25/20	20	250 - 275	0.5	25
15/20	20	230 - 250	0.5	15
with 7.5% Silica fume	20	360 - 375	0.42	55
with 50 % GGBFS	20	360 – 410	0.40	45

Lower water cement ratios may be used provided the Contractor is specialised in handling, placing and curing concrete with very low w:c ratios
If the maximum aggregate size is

- reduced to 10mm, the maximum cement content may be increased by up to $20kg/m^3$
- reduced to 5 mm, the maximum cement content may be increased by up to $40kg/m^3$
- increased to 40mm, the maximum cement content may be decreased by up to $30kg/m^3$

Where the concrete requires a high placement slump of ≥150 mm, the max. cement content may be increased by 20 kg/m^3.

For pre-cast products using low or zero slump concrete and very high frequency form vibrators, the minimum cement content may be reduced by 40 kg/m^3.

6. SETTING PRODUCTION TARGET VALUES

6.1. Target permeability values
ASTM C 1202 RCP measurements can be expected to vary by 25 %. The target values set in the absence of proper population ranges from at least 35 data sets, shall fall at least 25 % below the minimum specified.

6.2. Target w:c ratios
The w:c variations during batch weighing can be expected to be as much as 0.02. Target w:c ratios to be set shall be below actual by at least 0.02.

6.3. Target slump values
The minimum placement slump range for normal concrete shall be 75 - 110 mm with a target of 90 mm; for concrete containing SMAs above the threshold values, the minimum shall be 100 mm with a target of 120 to 140 mm; for piling concrete the range shall be 150 - 200 mm with a target of 180 mm.

7. CONCRETE DURABILITY

7.1. General provisions
Durable concrete shall have a low permeability to ionic transport and therefore the addition of one or a combination of SMAs is essential.

The normal data allowing the amount of Cl^- incorporated in cured concrete shall not be applied to Cl^- that permeates the concrete from the external environment. In a wetting and drying environment, moving concentration fronts of chloride within the concrete bear very little significance to the environmental concentration or to the average threshold limits of chloride before corrosion is initiated.

7.2. Permeability parameters

The 28 day permeability values shown in Tables 501.3 and 501.4 shall be set for RC and non-RC structures. The permeability tests employed are the ASTM 1202 RCP and the DIN 1048 or BS EN 12390-8 tests.

Tables 501.3 and 501.4 provide permeability limits for structures built in areas where the ground conditions have not been determined.

Table 501.3 Limits of permeability for various exposures – RC structures

	Exposure condition	**ASTM C 1202**	**DIN 1048 or BS EN 12390-8**
		max. coulombs	**max. penetration**
		C	**mm**
1	+ 0.5 m GL and below in presence of coastal seawater table	1000	5
2	+ 0.5 m GL and below in presence of inland water table	2000	5
3	+ 0.5 m GL and below in permanently dry condition	2000	15
4	All parts of a bridge including foundations, columns & decks	2000	5
5	Wet areas [permanent or intermittent] [Note 1]	2000	5
6	+0.5 m GL [coastal regions up to 50 km to shoreline	2000	15
7	+0.5 m GL [non-coastal regions]	5000	25
8	Seawater or in extremely aggressive agents in environment	See specification clause 7.2	
9	+0.5 m GL [inland Cl^- free, dry region] [Note 2]	5000	25
10	Industrial floor [corrosive environment] [Note 4]	1000	5
11	Industrial floor [non corrosive environment]	2000	15
12	Mild conditions as Tables 501.5 and 501.6	5000	15
13	Moderate and severe conditions as Tables 501.5 and 501.6	2000	5

Table 501.4 Limits of permeability for various exposures – non RC structures

	Exposure condition	**ASTM C1202 RCP**	**DIN 1048 [or BS EN 12390-8]**
		max. coulombs	**max. penetration**
		C	**mm**
1	Underground and elevated structures	5000	25
2	Extremely aggressive agents in environment	See specification clause 7.2	
3	Seawater or in severe sulphate environment	2000	15
4	Industrial floor [corrosive environment] [Note 4]	1000	5
5	Industrial floor [non corrosive environment]	2000	15
6	Mild conditions as Tables 501.5 and 501.6	5000	15
7	Moderate as Tables 501.5 and 501.6	2000	5
8	Moderate as Tables 501.5 and 501.6	2000	5

Where feasible the exposure environment must be analysed for agents corrosive to concrete and reinforcements as outlined in Tables 501.5, 501.6, and 501.7. Durability parameters shall be then be set accordingly to Tables 501.3 and 501.4. Where there is a possible confusion as to the required permeability values the lowest permeability requirements set in Tables 501.3 and 501.4 shall prevail.

Table 501.5. Aggressive conditions in ground water

Dissolved ion concentrations [See Note 10]					
Attack target	**Agent**	**Unit**	**mild**	**moderate**	**severe**
Concrete	pH [Note 5]	-	> 6.5	6.0 – 6.4	5.5 – 5.9
Reinforcement	Cl^-	mg/l	100	100 - 500	501 - 3000
Concrete	$[SO_4]^{2-}$	mg/l	≤ 200	200 - 600	601 - 3000
Concrete	CO_2	mg/l	≤ 15	15 - 40	41 - 100
Concrete	$[NH_4]^+$	mg/l	≤ 15	15 - 30	31 - 80
Concrete	Mg^{2+}	mg/l	≤ 300	300 -1000	1001 – 3000

Table 501.6 Aggressive conditions in soil (dry or wet)

Based on liquid extract [BS EN 1744] - Concentrations are based on oven dried soil					
Attack target	**Agent**	**Unit**	**mild**	**moderate**	**severe**
Concrete	pH [Note 5]		≥ 6.5	6.0 – 6.4	5.5 – 5.9
Concrete	$[SO_4]^{2-}$ [Note 7]	mg/kg	≤ 2 000	2 000 – 3 000	3 000 – 12 000
Reinforcement	Cl^-	mg/kg	100	100 - 500	501 - 3 000
Concrete	$[NH_4]^+$ [Note 8]	mg/kg	≤ 15	15 - 40	31 - 80
Concrete	Mg^{2+} [Note 9]	mg/kg	≤ 300	300 -1000	1001 – 3000

Table 501.7. Extremely aggressive conditions in water and soil [See Note 3]

Attack target	**Agent**	**Ground water**		**Soil**	
		Unit	**Concentration**	**Unit**	**Concentration**
Concrete	pH [Note 5]		< 5.5		< 5.5
Concrete	$[SO_4]^{2-}$ [Note 7]	mg/l	>3 000	mg/kg	> 12 000
Reinforcement	Cl^-	mg/l	> 3 000	mg/kg	> 3 000
Concrete	CO_2	mg/l	> 100	-	-
Concrete	$[NH_4]^+$ [Note 8]	mg/l	> 80	mg/kg	> 80
Concrete	Mg^{2+} [Note 9]	mg/l	> 3 000	mg/kg	> 3 000

Note 1: 'Intermittent wet areas' include the capillary zones above the water table, areas subject to condensation caused by cyclic changes in temperature including diurnal or seasonal rhythms or humidity above 80 % at any time.

Note 2: A Cl^- free environment in a dry region is attained when the fines [below 63 μm] of the soil in the vicinity contains less than 100 mg/kg of water soluble Cl^-.

Note 3: Concrete in water and soil environments containing very high levels of $[SO_4]^{2-}$, $[NH_4]^+$, Cl^-, Mg^{2+} or CO_2 as shown in Table 8 may require additional measures and protection.

Note 4: Corrosive environments in industrial areas may require additional protection depending on the corrosive agent.

Note 5: Portland cement concrete or cementatious surfaces shall not be directly exposed to an environment with a pH of less than 6.5 [i.e. in an acid environment].

Note 6 The aggressive agent Cl^- is only considered for reinforced concrete.

Note 7 The extract from soil is to be made with acid as stipulated in BS EN 1744-1.

Note 8 The extract from soil is to be made as for chloride in BS EN 1744-1.

Note 9 The extract from soil is to be made with acidified water as stipulated in BS EN 1744-3.

Note 10 Equivalent test methods in BS EN 1744 may be used instead of that in BS EN 196.

All concrete placed below ground level in excavations or against backfills shall be tanked with a torch on membrane system as stipulated in the specification irrespective of the environmental conditions. Bridge decks shall be waterproofed below the asphalt layer with a torch on tanking as stipulated in the specification.

In extremely aggressive conditions as shown by Table 501.7, extra measures shall be taken such as the use of combinations of double membrane tanking, chemically resistant coating, ASTM C 1202 RCP of < 1000 C. The Contractor shall make sound proposals with the cooperation of professional chemical resistant material manufacturers who shall provide warranties for the designed life of the structure.

7.3. Carbonation control

Concrete containing GGBFS exposed to partially dry conditions, where the intermittent or permanent relative humidity (RH) is between 50 – 85%, e.g. in drying-wetting conditions, induces high rates of carbonation. This fact shall be taken into account when proposing concrete containing GGBFS for specific applications.

7.4. Extended wet curing times for concrete containing SMAs

GGBFS and PFA require extended wet curing times to deal with the slower latent hydration reactions. Where it is inconvenient to provide extended wet curing their use is limited to concrete placed in environments where the environment has a permanent RH greater than 85 % or in permanently water submerged areas. Where they are to be used in permanent dry conditions where the RH is less than 50%, the permanent wet curing time shall be extended from the normal 10 days, the extended time being established from permeability data obtained at the trial between the limited wet cured in situ dummy concrete and the 28 and 56 day wet cured cubes.

7.5. Threshold values for SMA addition

All the SMAs have threshold values of addition below which significant durability or strength parameters do not develop. Nominal threshold addition values are indicated in Table 501.8. The actual amount will depend on the quality of the SMA and mix design parameters.

Table 501.8. Threshold addition values for SMAs

	SMA	Nominal threshold value
01	Silica fume	7% on [cement + silica fume]
02	GGBFS	50 % on [cement + GGBFS]
03	PFA	25 % on [cement + PFA]

7.6. Limits of addition

The upper limiting addition percentage values for each SMA as shown in Table 501.9 based on cementatious [cement plus SMA] content shall apply.

Table 501.9. Supplementary mineral additives [SMAs] – ceiling limits for addition

	SMA	Max. %	Applicable conditions
01	Silica fume	10	For all exposures
02	GGBFS	55	For permanent dry [RH ≤ 50%] or damp [RH ≥ 85%] conditions
03	PFA	30	For underground damp exposures [RH ≥ 85%]
04	GGBFS	70	For concrete buried in permanently wet conditions
05	PFA	45	

When mixtures of SMAs are designed into the same mix, calculations based on proportionate replacement based on the limiting values shown in Table 501.9 shall be derived by the use of Equations 1 and 2.

The following equations shall be used for calculating the limiting partial proportions of each mineral additive in the mix design:-

Where x is the % of Silica fume incorporated
y is the % of GGBFS incorporated
and z is the % of PFA incorporated

- For normal concrete [c.f Table 10: conditions 01, 02 and 03]

$$\frac{x}{10}+\frac{y}{55}+\frac{z}{30}=1 \qquad \text{…….(Equation 1)}$$

- For wet or dry situations [c.f. Table 10: conditions 01, 04 and 05]

$$\frac{x}{10}+\frac{y}{70}+\frac{z}{45}=1 \qquad \text{…….(Equation 2)}$$

- An example of calculating limiting proportions in a multiple SMA system is given below.

  Problem: For a ternary cementatious system [i.e. Silica fume, GGBFS and OPC] calculate the limiting amount of GGBFS if 5 % Silica fume is selected.

  Using Equation 2

$$\frac{x}{10}+\frac{y}{55}+\frac{z}{30}=1 \qquad \text{and its derivative} \qquad \frac{y}{55}=1-\frac{5}{10}-\frac{0}{30}$$

where y = the limiting proportion of GGBFS
= 27.5 % by weight [based on cement plus SMA content]

A mixed SMA containing concrete must meet the permeability and strength requirements specified for each specific environment.

Interground or SMAs premixed with cement shall not be used. The SMAs shall be added from separate silos at The Producer's plant.

All mix designs containing SMAs need extended mixing times in the concrete plant mixer as stipulated in the specification.

7.7. Water:cement ratios for SMA
The k coefficient enumerated in BS EN 206-1 has already been taken into consideration in the maximum w:c ratios specified in Table 501.2 and does not require further adjustment.

7.8. Use of SMAs at low percentages
Additions below the threshold values do not significantly reduce permeability or increase strength. Low percentage additions can be made to reduce bleed, improve pumpability and increase the cohesiveness of the concrete.

8. PRODUCT STATISTICS

8.1. Statistical data
The Producer shall maintain statistical records for each mix design produced in each plant. Population means for a family of mixes shall be derived by computing the individual population means of every mix in the family. The population mean for the family shall not be computed collectively from the individual sample means of mixes in a family.

8.2. Probability marker for characteristic strength
The acceptable percentage of defects in a mix shall be the 5% probability fractile of a normal population (Gaussian) distribution below the specified characteristic value. An additional limit to the 5% fractile value is imposed in that none of the sample results shall fall below the designed characteristic value by 3 N/mm^2.

8.3. Target population mean strength and range
A mix design submitted for approval based only on trial mix results without a validated production history will not have the supporting statistical data. Therefore, the actual population statistical characteristics will not be known. It will also not be known which part of the statistical domain or map, the singular trial mix strength stands.

Where validated production statistics do not exist, an estimated target [arithmetic] population mean will be assigned to a successfully trialed mix during the approval stage, according to Table 2. An estimated standard deviation will be made as a population or sample standard deviation for the particular mix will not exist. A standard deviation for a well controlled plant will be as low as 2.5 N/mm^2 [i.e. a mean population variance no greater than 6.5 N/mm^2] and a standard deviation for any acceptable plant should not exceed 3.5 N/mm^2 [i.e. a mean population variance no greater than 12.25 N/mm^2]. The specification, however, provides a generous margin.

An estimated lower limit to the range shall also be set so that the actual variations are limited from being excessive and wildly fluctuating.

The following considerations shall be applied to the application of target strengths and ranges:-
If the estimated or actual target mean or the estimated lower limit of the range is not maintained but the minimum stipulated $f_{ck,cube}$ or the $f_{c,cube}$ is satisfied, the concrete does not have to be rejected. Nevertheless, corrective action shall be taken by The Producer where continued and persistent failures occur in maintaining the mix's population mean and the limits to the range.
When the concrete properties deviate widely from the quality set at the trial mix, it is to be assumed that the quality of the concrete has changed. The concrete may be acceptable for the purposes of the design intentions for the structure, if it is above the f_{ck},cube or f_c,cube specified. However, it is not the same quality

offered and accepted by the client initially during the submittal or at the trial mix stages. Such changes can only occur either from significant changes to the mix design, from a lack of production control, from a neglect of the quality of constituent materials or for other reasons. It will not be acceptable where, for instance, a concrete with a trial mix strength of say 55 N/mm^2 is produced at a consistently mean strength of say 42 N/mm^2 during project deliveries, even though it is above the $f_{ck,cube}$ or the $f_{c,cube}$. The Producer shall take corrective action immediately.

8.4. Mix design strength margin and target mean strength

The mean strength shall be computed for each specific mix or family of mix as defined in the specification and not from a mixture of different mix designs.

Mix designs shall aim for the parameters shown in Table 501.10. The minimum margin required above the $f_{c,cube}$ or $f_{ck,cube}$ derived in Table 501.10 is based on a plant with a standard deviation of approximately 3 to 4 N/mm^2. For plants with a greater standard deviation, apply the appropriate standard deviation using Equation 1.

$$\text{standard deviation} = \sqrt{\text{variance}} \qquad \text{..... Equation 1}$$

The factor 1.64 σ, found in generic formulae, is applicable to a normal [Gaussian] distribution. There is no data yet in the Sultanate of Oman to show that mix design strengths and data from a single plant falls under a normal curve in the short or medium term. Mappings derived from actual validated production data shall be produced to prove the type of distribution.

The actual target mean strength shall be derived from population samples taken from actual production runs. The minimum sample population used for deriving the statistic shall be 35 results taken from at least 30 separate loads on different days.

The lower limit of the range in Table 501.10 is set to ensure that the variations do not reach

Table 501.10 : Mix design strength classes, margins, target means and range limits.

	$f_{ck,cube}$ or $f_{c,cube}$ [N/mm^2]	Min. margin [N/mm^2]	Estimated target mean [N/mm^2]	Lower limit of range [N/mm^2]
01	< 30	+ 9	Trial mix mean less 4	Trial mix mean less 8
02	30	+ 9	Trial mix mean less 4.5	Trial mix mean less 9
03	40	+10	Trial mix mean less 5	Trial mix mean less 10
04	50	+12	Trial mix mean less 6	Trial mix mean less 12
05	60	+15	Trial mix mean less 7	Trial mix mean less 14

very low values indicating poor control of production and generation of poor quality. When the cube strengths start to fall below the lower limit of the range persistently, it indicates a marked change from the quality established initially. When such events occur The Producer shall investigate to determine the cause and make corrections.

Where the actual population data is not available at the mix design submission stage, an estimated target mean strength shall be set by the specifier during the initial approval stage according to Table 2, assuming that the plant is known to perform to a standard deviation of around 3 to 4 N/mm^2. Otherwise a higher standard deviation shall be assumed.

The estimated target mean strength shall be replaced with the actual population target mean strength as soon as a minimum of 35 validated data is analysed and made available.

8.5. The Producer's actual production statistical analysis

The Producer is required to take his own samples from his production based on a predetermined frequency to monitor and validate the consistency of his production. Since variations are inevitable, they should be limited to an acceptable range. The range shall be influenced by acceptable variations in constituent materials, production plant operations, site practices, curing, sample preparation and testing. They shall not arise from a lack of control or neglect of constituent materials limits, operating the plant outside its limiting parameters or from poor practices at the plant, at site and during testing.

The Producer shall maintain a register for product data obtained from production batch tests for each mix design or a family of mix designs for strength and durability tests where appropriate. He shall produce the statistical data as shown in Table 501.11.

Table 501.11. Required statistical data

01. Arithmetical mean
02. Standard Error
03. Median
04. Mode
05. Standard Deviation
06. Sample variance
07. Type of dispersion [kurtosis, skew, normal]
08. Range
09. Minimum
10. Maximum
11. Sum
12. Count
13. Confidence Level [5 & 95 %]
14. Frequency distribution.

Note: The statistical analytical tools for 'Descriptive Statistics' are found in computer products such as Excel, as an example. 1. Check that it is enabled by Clicking on taskbar - Tools/Add-ins/check the Analysis Toolpak in the dialogue box. 2. Click on the taskbar again for the Tool - Tools/Data analysis/Descriptive Statistics.

9. MIX DESIGN SUBMITTALS FOR APPROVAL

9. 1 General provisions

Submissions for each mix of concrete must be made during the mobilization period. A site trial mix in the form of a dummy placement must be conducted in accordance with Appendix to determine the properties of the fresh and cured concrete proposed. In addition the site trial will enable assessment of The Contractor's ability to perform formwork and rebar construction, quality checks, placement and curing tasks.

The Contractor shall review the information provided by The Producer and ensure that the information is complete and free of errors and omissions. Deficient or poorly reviewed submittals will be returned to the Contractor without review by The Engineer.

Approval for concrete mixes shall only be given after submission of the relevant complete documentation and the results of the site trial are found to be satisfactory. Approval will not be given on the strength of documentary submissions only. When the mix has been approved, variations shall not be made in the proportions, type or the source of the constituent ingredients except for minor adjustments without the consent of the Engineer. Liquid plasiciser and retarder variations will be accepted to meet the changing climatic conditions provided the fresh and cured properties meet the specification. A new submission shall be made by the Contractor in the event any of the approved concrete parameters changes other than that allowed by the specification.

The specification stipulates limits for properties in the form of minima-maxima. These limits must not be construed as targets to achieve. The designer must aim for a target mean for each property to attain the quality of concrete required. The mean target for each property must take account of the range of variations obtained during production and testing.

9. 2 Requirements for all submittals

Submittal for the mix and calculations shall be forwarded in the format specified in Appendix 501.2. All submittals shall contain the following [additional requirement for each specific type of concrete is listed under their respective headings]:-

Product identification

- product designation and type [e.g. designed, designated, alternative etc]
- its unique mix design number

Plant data

- the location of the plant by its sector coordinates and by description
- the plant number
- the MM approved plant number
- the unique computer serial number for the specific plant

Delivery data

the estimated journey time for the delivery of fresh concrete from plant to the placement site

Independent testing laboratory
- submit the names of two [primary and backup] approved laboratories for testing
- indicate the primary laboratory selected

Spacer blocks
- submit method statement for the manufacture of spacer blocks
- submit test results for strength and permeability data for spacer blocks
- submit 5 samples of each size or type

Bonding agents
- submit product data sheet and method statement for bonding agent, if relevant.
- submit 100 cc sample

9. 3 Additional submittal information requirement for all concretes
A submittal shall contain in addition at least the following:-

Constituent material data
- the manufacturer or producer of the ingredient
- product ID and type
- mass and volume fraction of each constituent material in 1 m^3 of fully compacted fresh concrete based on SSD

Cement data
Cement test certificate [not older than 2 months]

Aggregate data
- from an independent laboratory, the validated aggregate test certificate [to be no more than six months old as indicated in Appendix 501.7
- the sieve analysis for each nominal size
- the total grading curve with its limiting envelope
- percentage makeup of the nominal aggregate sizes by mass and volume on total aggregate
- the fineness modulus of the fine aggregate
- the dune sand content of the total aggregate weight by mass which shall not exceed 10 % if unwashed 5mm sand is used and 14% if washed 5mm sand is being used
- 2 kg sample of each nominal size of aggregate

Admixture data
- a validated 1 page summary of type test results to BS EN 934-2 issued by an approved independent laboratory [to be not older than 5 years] as indicated in Appendix 501.8.
- a sample routine production batch test certificate to BS EN 480 by the manufacturer [to be not older than 3 months] as indicated in Appendix 501.9.
- product information

Concrete data
- the free water:cement ratio [or the effective water:cement ratio, c.f. BS EN 206-1]
- total chloride content
- total sulphate content
- For the mix design or from a similar design from a same family of mix designs, produce either The Producers initial preliminary test results or the actual production statistical data for the cured concrete [e.g. strength, mean strength, density, permeability values, where applicable, based on at least 35 different loads produced on at least 30 different days
- fresh concrete properties [e.g. production and placement slumps, fresh concrete density, delivery temperature]
- concrete ratios [e.g.aggregate:hydrated paste ratio by volume]

9. 4 Additional submittal information requirement for concrete containing SMAs
The mix design containing SMAs shall be trial mixed against a mix design not containing the SMA to establish the differences in beneficial properties. The composition formulae shall be identical except for the substitution of the cement with the proportion of SMAs. This is to ensure that any elevation in properties caused by the SMA is seen against a reference equivalent in composition [though not of properties].

9. 5 Additional submittal information requirement for truck mixing when permitted

- Method statement for addition of liquid constituent materials
- Control of mixing by qualified technician
- Sampling plan for testing

9. 6 Additional submittal information requirement for sprayed concrete [shotcrete]
- experiential details of the nozzle man
- storage mode of constituent materials at site [unbagged dry mixes shall not be stored on site longer than 24 hours]
- details of quality control, application method and curing at site
- sampling method and details of testing
- submit a 500 gram sample of each aggregate
- submit samples of reinforcement, dowels and resin anchors if applicable

9. 7 Additional submittal information requirement for mortars or plasters [readymixed or site mixed]

A submittal for mortar or cementatious plaster shall contain at least the following:-

In general
- identify the type of mortar or plaster
- if a wet mix is transported to site, the name of The Producer and the plant
- mix design and parameters, if site mixed
- product properties
- list of standards to which the product complies with [specification and test methods]
- the setting time
- the useable life of the mix from batching at different ambient temperatures

Site control information
- details of quality control, application method and curing at site
- sampling methods and details of testing
- the delivery mode
- the storage mode at site
- a 500 gram sample of the sand

10. PROVISIONS FOR EQUIPMENT AND MATERIALS AT SITE

10.1. Provisions for equipment at site

The Contractor shall provide and maintain the equipment listed in Table 501.12, on site for the Engineer's use during the contract period.

Table 501.12. List of equipment to be provided at site

	Min quantity	Description
01	one	Calibrated 2mm sieve to BS EN 933-2
02	sufficient	150 mm^3 standard molds for test cubes and their accessories
03	two	Standard slump cones and their accessories
04	one	Digital cover meter (for measuring cover depth)
05	three	Laboratory grade glass thermometer 0-50^{0}C
06	two	Tape measures (readability 1mm)
07	one	Portable anemometer [optional if evaporation rate is measured directly]
08	one	Wet and dry thermometer [with humidity chart]
09	one	1 metre calibrated spirit level
10	one	1 metre calibrated metal square

10.2. Spacer blocks

Spacer blocks shall be of the same or better quality than the concrete being placed especially with regard to strength, permeability, bonding to fresh concrete and wetting and drying expansion.
Tie wires shall be free of corrosion and shall not bridge the cover to the reinforcements.

The Contractor shall use any one of the following materials for making or providing spacer blocks:-
- a dry proprietary premixed bagged mortar mixed according to the manufacturer's instructions
- mortar sieved from the concrete mix of the same class delivered for site placement and without the addition of additional constituent ingredients

- mortar mix proposed by The Contractor
- pre-manufactured cementatious spacer blocks

Freshly made spacer blocks shall be cured using the wet curing procedure for normal concrete.
Plastic spacer blocks will not be permitted due to their inability to bond to fresh concrete.
The spacer block shall be made to the required dimensions with a tolerance of 0 [zero] to + 2 mm.
The surface of the spacer block shall be roughened before installation to ensure it bonds with the fresh concrete.

10.3. Polymeric bonding agents

A polymeric bonding agent may be necessary to bond fresh concrete to cured concrete.
The types of bonding agents are listed in Table 501.13.

Table 501.13. Bonding agents - types

01	Alkali tolerating polymer emulsions [e.g. PVA, Acrylic, SBR]
02	Slow curing solvent based 2 component epoxy – polyamide or epoxy polyamine
03	Slow curing moisture curing epoxy
04	Slow curing solvent free 2 component epoxy – amide or epoxy – polyamine
05	Slow curing solvent free 2 component epoxy – polysulfide (not for direct exposure to sewage).
06	Slow curing solventfree 2 component polysulfide (not for direct exposure to sewage)
07	Slow curing water-based 2 component epoxy-polyamide or polyamine.

The exposure conditions for each type is listed in Table 501.14.

Table 501.14. Bonding agents - areas of applicability dependant on exposure conditions

		Bonding agent types	
Exposure Condition		**Rigid bonding**	**Elastomeric bonding**
01	Permanently dry area only or above 1m GL	1	5,6
02	Exposed to seasonal rain only	1,2,3,4,7	5,6
03	GL to 1 metre above ground level	2,3,4,7	5,6
04	Exposed to permanent damp [but not soaking wet conditions]	2,3,4	5,6
05	Below ground water or under immersed situations	4	5,6

10.4. Joint devices and filler materials

The following types of joint devices or filler materials shall be used:-
- preformed compressible cellular and resilient materials.
- granulated cork bound with an insoluble synthetic resin – for portable water service
- granulated cork bound with bitumen – for pavements
- proprietary compressible water impermeable material

The joint filler shall be placed to the required dimensions and secured in its location. It shall be located from the bottom of slab to within 25 mm of its free surface. Where the depth of joint between the concrete surface and the waterstop does not exceed 500 mm, the filler shall be placed as a single section.

10.5. Joint Sealant

The following shall be complied with:-
The sealant shall be elastic and non-degradable under long term exposure to its environment.
The sealant shall have a contraction-expansion capability of at least + 12 percent after ageing
a penetrating primer shall be used on the bare concrete surface before applying the sealant
primers and bond breakers shall be obtained from the same manufacturer as the sealant.
A polysulphide [or sulfur containing polymers] shall not be used in direct exposure to sewage environments or in exposures to sulfate reducing bacteria

11. SITE CONTROL PRACTICES

11.1. Ambient weather conditions

Hot weather concreting

The guidelines set out in ACI 305R shall be followed for hot weather concreting. Concrete shall not be placed if the rate of evaporation of water exceeds 1kg/m^2/hr.
The Contractor shall prior to placement measure the evaporation rate by one of the following methods:-

250 ml of clean water shall be placed in a flat tray [dimensions of tray: area 0.25 m^2; height 5mm; placed on a level surface in an unsheltered spot in the placement area]; concrete shall not be placed if all the water evaporates from the tray in or before an hour
provide at the location of concrete placement, a wet-dry bulb thermometer and an anemometer; from the readings of temperature, humidity and wind velocity, compute from the nomogram in ACI 305R the evaporation rate

It will be seen from the ACI 305R nomogram that the limiting evaporation rate is exceeded at an ambient temperature of 40 ^{O}C, irrespective of the states of humidity or wind speed. Therefore, 40 ^{O}C becomes the limiting ambient condition for concrete placement under any circumstances.

Monitoring ambient weather conditions
The Contractor shall:-
- record the wet and dry bulb temperatures three times daily
- wind velocity [before a pour if using the ACI 305 R nomograph]
- perform an evaporation test [if not using the ACI nomogram]

11.2. Slump control
Slump loss in a freshly mixed concrete will occur with time. Higher ambient temperatures accelerate the rate of slump loss. Slump loss will also be greater with higher fresh concrete temperatures. Hence, the amount of admixture specified in the approved mix design will vary depending on ambient conditions, which in turn will relate to the heat content of the constituent materials, the rate of heat transfer between the mix and the atmosphere and ultimately the rate of reaction of cement compounds in the solution phase.

The addition of a retarding admixture is necessary during all weathers in The Gulf region. However, the addition of excessive retardants is to be avoided. Certain admixtures that are powerful retardants cause unwanted effects in concrete such as delayed setting times, reduction of final strength, increased bleed, reduction in durability and in-homogenous cellular formation. The use of retarders containing more than 4% reducing sugars is prohibited.

11.3. Secondary dosing of admixtures at site
Secondary dosing of admixtures at site shall not be used to overcome The Producers lack of control of constituent materials at the plant or his inability to apply technical knowledge to batch production controls.

The addition of secondary doses of admixtures to the load at site is prohibited except under exceptional circumstances. Exceptional circumstances are confined to situations where the delivery time to the site is longer than 90 minutes or where foaming agents for foamed concrete is to be used or where expansion agents have to be added. Secondary dosing will require prior approval. The Contractor shall make the proposal during his submittal of the mix design.

For delivery times of less than 90 minutes, The Producer shall be able to use his technical judgment to dose the mix with the correct amount of admixture during plant batching, taking into account the slump loss that will occur during delivery with his specific mix design.

The addition of admixtures to mixing trucks shall be performed by an experienced and trained technician from The Producer. Powdered foaming agents will involve a well dispersed liquid master mix just prior to addition to the truck. The details of addition and the technician dedicated to such additions shall be submitted at the submittal stage.

11.4. Addition of water to ready mixed concrete
The addition of extra water or any other constituent ingredients to a plant wet batched readymixed concrete is prohibited if the addition is made ouside of the mixer and not logged in the computer printout.

12. CONCRETE TRIALS

12.1. General provisions
A supervised trial for the concrete before approval is an important procedure in establishing and verifying the fresh and cured properties of the mix and its physical behavior during transportation and placement. The physical behavior of fresh concrete changes with elapsed time and it is important to reproduce the delivery

time and conditions to the site during a trial mix in order to establish the nature of the changes and to determine the acceptability of such changes. The Delivery conditions include numerous processes and quality checks to be performed by The Contractor at site as detailed hereunder.

Laboratory or in-plant trial mixes cannot reproduce the conditions experienced with delivery to the site or demonstrate good practices and competencies at the site and are therefore are not accepted as the de facto trial.

Where SMAs are proposed, the trial shall include a reference concrete with no additive to demonstrate the extent of the benefit gained by adding SMAs.

When GGBFS or PFA is proposed for use in reducing the exotherm generated, comparative temperature data from the centre of a $1m^3$ block shall be measured and logged to demonstrate the extent of the reduction of heat generated.

12.2. Full site trials

A site trial that involves the placement of concrete into a dummy structure after the elapse of 75 minutes from mixing together with various assessments is to be performed in accordance with Appendix 501.2.

Various parameters and abilities need to be assessed during the trial and they include:-

- slump reduction over time
- increase of concrete temperature over time
- transporting cubes properly from the site to an approved independent laboratory
- the correlation between strength and durability values of 28-day wet cured cubes and the 7-day wet cured structure
- The Contractor's ability to construct leak free formwork
- The Contractor's ability to provide shaded and suitable areas for sampling and cube making
- The Contractor's competence in sampling and performing fresh concrete tests
- The Contractor's competence in sampling, making and protecting cubes
- The Contractor's ability to place, compact and cure the concrete
- The Contractor's ability to perform quality control

The Contractor need only conduct a site trial for a representative concrete in a family and not necessarily for each mix design within a family. Where the fresh concrete properties, application, placement or handling method are different for each mix, site trials shall be conducted for each mix separately.

12.3. Partial site trials where validated historical data for the mix exists

Where a concrete mix from a specific plant [not a specific Producer] has been site trialed satisfactorily by the same Consultant on a previous project within the previous six months and the results have been satisfactorily documented in detail, the same mix need not undergo a full site trial to establish or verify concrete properties again. However, in all instances, a partial site trial shall still be conducted to determine The Contractor's ability to process and place the concrete properly.

The Contractor cannot be exempted from the partial trial mix if he has conducted a similar trial in another project as the personnel employed in the current project will invariably be different from the previous project and hence the current competencies will be unknown.

Full testing of the concrete for cured properties in partial site trials need not be performed but this is left to the judgment of The Engineer. However, in all cases cores shall be taken from the dummy structure to determine visually, compaction efficiency and the absence of unacceptable voids and defects.

13. SUBSTRATE PREPARATION

13.1. Protection of the formation for concreting

The Contractor shall place a concrete blinding layer immediately upon completion of an excavation and before concreting or when instructed by The Engineer to prevent deterioration of the formation and to form a clean working surface for concreting. Blinding concrete shall be laid to a minimum thickness of 100 mm or to the depth shown in the contract drawing. The polyethylene impermeable layer below the blinding layer shall be at least of 1000 gauge. Where the structure is to be tanked the surface of the blinding shall be covered with torch on membrane before placing concrete on it.

13.2. Bonding fresh concrete to cured concrete

The concrete surface to be bonded shall be scarified to provide a sound rough surface. The coarse aggregate in the substrate shall be partially exposed without detachment from the substrate. Dust, debris and unsound surfaces shall be removed from the substrate before placing fresh concrete. When new concrete is dowelled to an existing concrete structure, the dowels inserted into pre-drilled holes shall be bonded with an approved non-shrink grout or a proprietary polymeric adhesive. The use of polymeric bonding agents is essential if the substrate concrete is aged over 10 days. Fresh concrete can be bonded to previously placed concrete without polymeric bonding agents if the latter is not more than 10 days old.Cement slurry shall not be used as a bonding agent.

14. PRE PLACEMENT INSPECTION AND APPROVAL

14.1. Pre-placement submittal

At least 7 days prior to a concrete placement The Contractor shall submit the following:-

- details of site management plan and capabilities for receiving, pumping, placing, compacting, sampling and curing concrete
- details of the logistics for the placement [e.g. rate of placement, acess, rate of delivery, resources deployed]
- the plan for utilising resources [equipment, materials and men] to ensure that the concreting operation runs smoothly without errors and in a timely fashion
- a named list of the trained concrete crew
- a list of equipment and materials to be available on site before the concreting operation
- the arrangement for sampling, making of cubes, curing, transport and testing of cubes.
- the quality control plan
- construction of proper and safe working platforms and means of access

14.2. Pre-placement checks and approval

At least 24 hours prior to a concrete placement The Contractor shall check that:-

- the formwork is according to specification and design and properly secured
- anchors, seats, plates, joint fillers, reinforcement, spacers, waterbars and other items to be cast into concrete are accurately placed, positioned securely and that they will not be displaced from their positions during placement
- lines, dimensions, geometry, spatial orientations and elevations are correct as specified and to approved tolerances
- safe access and proper work platforms are erected
- when new concrete is placed over old concrete, that the substrate preparation is adequate
- adequate lighting is in place if the placement is being conducted at night or out of bright daylight

The Consulting Engineer shall verify that The Contractor is in compliance before giving approval.

Immediately prior to [but not earlier than 2 hours from] the concrete placement, The Contractor shall ensure that:-

- site conditions are dry and favourable
- resources [men, machines and materials] required for proper concrete placement are available
- he has all the necessary equipment [slump cones, thermometers, cubes, vibrators and ancillary tools] and the curing materials [polyethylene and hessian] ready before the load arrives on site
- that the items inspected 24 hours previously and approved have not changed

The Consulting Engineer shall verify that The Contractor is in compliance before giving approval.

15. PLACEMENT

15.1. General provisions

The slump of the concrete at placement shall be such that it is easily compactable. Fresh concrete shall not be placed if the slump of the concrete being compacted falls below the approved minimum placement slump. The placement slump is not synonymous with the delivery slump if there is a lag between delivery and placing. The approved placement slump may be modified by the Engineer depending on various placement factors some of which may include the flowability of the mix during compaction, delays in pouring, compacting rates, the size of the pour, the time lag involved in conjoining freshly compacted elements to concrete that has been compacted but left idle for some time and the need for revibration in certain volumes.

The constituent materials shall not separate during placement operations. Fresh concrete shall be poured at the place for compaction. It shall not be dragged into position across the placement area using implements such as shovels and vibrators.

The placement shall be conducted in accordance with the approved plan, written method statement and the approved submittals. Only the previously nominated, approved and trained crew shall conduct the placement.

Concrete shall begin to be placed within 90 minutes from the time of loading; the time of loading being the time of first contact of water and cement in the first batch of the load.

Concrete shall not free fall from a height where segregation occurs. The maximum height generally should not be greater than 1.5 metres. Chutes, tremie pumps or conveyor belts shall be used to transport concrete to its final location. The concrete shall be placed and compacted in horizontal layers not exceeding 0.5m.

Idle times greater than 10 minutes during placement shall not be exceeded. If a cold joint appears to form, the concreting operation shall be halted. In such an event, the placement shall be cut back and stopped to an area of thorough compaction and a construction joint formed. The uncompacted concrete shall be removed immediately from the placement area.

When placing concrete against horizontal or inclined elements of waterstops, the concrete shall be properly placed and compacted around the lower end and around the waterstop.

The period for a single continuous placement shall not be longer than 2 hours before the initial setting time of the concrete.

Where concrete with SMAs are used or during evaporation rates higher than 0.6 kg/m^2 is encountered, dedicated fog spray units shall be used continuously during all stages of the placement from pouring till final finishing and plastic film protection to prevent excessive evaporation. Spray nozzles that do not produce an ultrafine mist shall not be used.

Water must not be sprayed other than by a fog mister or splashed on to fresh concrete before the final set. Water shall not be splashed on to fresh concrete surfaces during trowelling to produce a polished surface.

15.2. Compaction of normal slump concrete

Non air entrained concrete shall be placed and compacted such that appreciable amounts of entrapped air other than entrained air are not retained.

Fresh concrete transferred to the structure whether compacted or uncompacted shall not be left open to loss of water. Polyethylene sheets shall be placed over the concrete if there is a lag in the compaction, levelling and finishing operations.

Poker vibrators shall operate at frequencies of greater than 6,000 cycles/min. The radius of compaction for each vibrator shall be determined before concreting begins by immersing the activated poker into a sample of the fresh concrete and measuring the compacted radius. Poking shall be organised such that it is performed on an imaginary grid with poking distances smaller than the measured compaction radius. Poking points shall be followed sequentially along the poking distances systematically on an imaginary grid. Random poking methods will not be allowed.

Whilst every part of the placement shall be compacted, attention shall be paid to compacting the cover to the reinforcements, corners and areas where the rebar density is high. The vibrator shall penetrate the fresh concrete lift and dip below into the surface of the compacted concrete beneath. It shall be dipped so that it descends and ascends vertically along the same coordinates into which it was immersed. It shall not be dragged whilst it is still immersed in the concrete. An activated poker will not be allowed to rest in fresh concrete.

Concrete shall be compacted to the levels desired. Compacted concrete shall not be moved or displaced. In the event compacted concrete is moved, the disturbed concrete shall be re-compacted if the slump is greater than the agreed minimum placement slump. Otherwise, The Engineer shall direct that the affected concrete be removed from the placement. The concrete shall not be overworked nor shall it be under worked. Dwell times of pokers in concrete shall be adjusted to achieve thorough compaction but not long enough to cause segregation or laitence to be formed.

Other forms of compaction equipment such as form vibrators and vibrating beams shall be used according the manufacturers' instructions and the requirements of the job.

Vibration, shock or other perturbations shall not be transferred to the reinforcements, formwork and compacted concrete until the concrete has fully hardened [i.e. well past its final setting time].

15.3. Compaction of Zero slump concrete

When the concrete is designed to have no slump [as in the manufacture of precast pipes, kerb blocks, masonry blocks and paving tiles], the concrete shall be compacted by the use of high frequency form vibrators or by the use of a uniform compressive load. The design of zero slump concrete shall be such that the desired compaction is achieved in the process free of voids [except in the case of a cellular product such as thermal masonry blocks].

16. FINISHING

16. 1 General provisions

The compacted concrete shall not be left open to water loss by evaporation. Polyethylene sheets shall be placed over the concrete if there is a lag between completion of compaction, levelling and finishing operations.

The surface of the fresh concrete shall be finished using the appropriate tools. The concrete shall not be floated with steel trowels when it is not necessary to obtain a polished surface. Troweling a freshly cast slab to a fine finish means leaving the surface open to evaporation loss which in turn leads to the development of drying shrinkage cracks. Excessive troweling produces laitance which in turn produces a weak surface layer. Water shall not be cast on the surface to aid troweling.

Where a slab requires a fine finish, the structural portion of the slab shall be cast separately. After sufficient time is allowed for the structural slab to cure, a trowelable screed formulated to give the level of finish required shall be cast on the slab. Similiarly, the use of dry shake finishes shall be used on a secondary screed and not directly on a structural slab.

16. 2 Finished surface texture

The Contractor shall appropriately provide the texture of finish described below and as shown in the drawings.

1. Exposed surfaces and surfaces designed to be in contact with liquid.
Surface texture to be similar to that obtained from contact with formwork of a smooth and flat face of metal or similar. The surface shall be subsequently coated or tanked as indicated.
2. Concealed surfaces.
Surface texture to be similar to that obtained from the use of formwork of sawn close jointed timber or better.

3. Steel trowel finish
Surfaces shall be smooth, free of discontinuities and pits. Laitence shall not be formed by excessive working with a steel trowel. Water shall not be splashed on to fresh concrete surfaces during trowelling to produce a polished surface.

4. Surfaces to be tanked
Surface texture to be similar to that obtained from contact with formwork akin to the "mechanical face" of hardboard.

5. Surfaces to be coated
Surfaces shall be flat, free of pock marks and bubble entrapment. Surfaces shall be blasted to remove the surface layer.

6. Concrete road, pavement and hardstanding surfaces
Surface finish to be obtained by the conventional use of a hand tamper or vibrating beam.

7. Areas to be mortared, rendered or surfaced with proprietary cementatious materials
The surface shall be adequately scored with a comb to provide an effective key.

8. Surfaces to be butted or conjoined by blockwork

All necessary wall ties shall be cast into the concrete faces, at minimum distances of 400 mm vertically and 800 mm horizontally against which blockwork is to be subsequently built. Ties for structural block walls shall be spaced at the designed intervals. The type of ties shall be approved by the Engineer. Steel ties shall be hot dipped galvanised to at least 120 µm. The surface of the concrete shall have a comb scored finish.

9. Non-slip surfaces
Surface texture shall be obtained by the use of a wooden float, stippled or an approved quality of aggregate to be cast onto the concrete whilst wet.

10. Exposed arises
To be formed with a 20 mm by 20 mm chamfer or other dimensions as approved by The Engineer.

17. FLOOR AND ROOFING SCREEDS

17.1. General provisions
The Contractor shall:-
- prepare the substrate in accordance with the requirements of 'surface preparation' in this specification.
- secure dowels and anchors if required by the specification
- place the required dividers, edge strips, reinforcements and other items to be cast in
- apply bonding agent to the substrate in accordance with the approved submittal
- place concrete screed to the required line and level
- place the screed in checkerboard fashion
- the dimension of each concrete panel shall not exceed 6 m in any one direction
- finish the screed to the surface finish and slopes or levels as specified

17.2. Internal Flooring - Screeds, floors and finishes
Flooring screeds refers to a layer of well compacted material laid in-situ onto a structural base.

The Contractor shall:-
- lay screeds to the drawings and to the recommendations contained in The Ciria Report 184, 'Screeds, flooring and finishes' taking into account local conditions in The Sultanate of Oman
- apply further layers and finishes as detailed in the drawings.

18. WET CURING

18.1. General provision
The fresh concrete and the freshly placed concrete shall be protected from evaporative losses of water. The concrete shall not be dried out at any stage during placement, between the casting and the curing period and thereafter till the end of the wet curing period. Specialist fog spray devices shall be used to prevent evaporative losses of water during the fresh concrete placement stage. Methods involving spraying water from hoses, sprinkling and pouring water manually as the only means of wet curing is prohibited.

Polyethylene sheets and wet hessian or wet cotton or wool blankets shall be made available on site before the placement begins. Dry hessian or blankets shall not be placed on fresh wet concrete.
All overlaps of the polyethylene shall be sufficient to prevent evaporation of water from the overlaps.
The retention of moist conditions on the surface of the concrete shall be continuously maintained without any gaps during the curing period. If the concrete surface is allowed to dry at any time during its mandatory wet curing period, large pores will develop. Once the large pores are formed, subsequent wetting will not seal the pores.

Continuous wet curing shall be conducted for a minimum period of 7 days for ordinary concrete and 10 days for concrete containing silica fume. Concrete containing GGBFS and PFA may require extended curing times and is dependent upon the results obtained during the site trials.

A chemical curing membrane shall not be used unless testing shows that not more than 10 % of the water is lost through a cast film [ASTM C 156] during the entire mandatory curing period at an ambient temperature of 50 ^{O}C. It shall not be of such a viscosity that application results in insufficient retention of thickness in the microscopic or macroscopic peaks and slopes of the concrete surfaces. Multiple coats of the curing membrane applied within minutes of each other shall be used in actual usage to achieve a continuous film. Test results are required before its approval for the project.

Chemical curing membranes if applied shall be completely removed after the curing period by grit blasting if cementatious or polymeric surfacing systems such as a waterpoofing or coating system are to be to be bonded subsequently to the concrete surface.
The Contractor shall ensure that proficient and effective continuous wet curing procedures are not neglected at any time.

18.2. Wet Curing [First stage]

The freshly compacted concrete shall be temporarily covered with overlapped polyethylene sheets immediately after pouring and before finishing if the concrete is going to be left exposed to evaporative water loss. The cover shall be partially removed to finish the concrete before re-covering it to protect the concrete.

After finishing, the fresh concrete shall be covered with overlapped polyethylene sheets of at least 500 gauge. Overlapping shall be at least 100 mm. The sheets shall be secured to prevent displacement by wind or other forces.

Where there are starter bars that prevent sheet polyethylene from being placed, the concrete shall be protected by tucking heavy layers of wet hessian covered with water impervious material in between the bars.

18.3. Wet Curing [Second stage]

24 hours from placement, the polyethylene sheets shall be removed and wet hessian laid on the surface and the hessian covered with overlapped polyethylene sheets. The overlap should be at least 100 mm. The polyethylene shall be secured against displacement by wind and worksite traffic.

The maintenance of a continuous humid environment on the surface of the concrete during the wet curing period prevents evaporative loss of water from the concrete itself.

The enclosed space between the impervious polyethylene sheet and the concrete surface shall be kept continuously in a 100% condensing humid state for the whole of the wet curing period. This requires monitoring and maintenance. During monitoring, the obvious visual indicator for confirming a 100 % humid state is the presence of condensed water on the underside of the polyethylene surface. Maintenance requires that water is fed into the enclosed space at periodic intervals to replace water that is lost from the enclosed space.
Evaporative water loss can occur if the edges of the polyethylene sheets are not secured tightly against the concrete suface and when there is continuity between the enclosed space and the atmosphere. Attention shall be paid to battening down the edges of the polyethylene sheet.
Alternatively, the curing water could be drip-fed into the space between the polyethylene sheet and the concrete surface by means of a network of irrigation dripfeed system.

19. POST PLACEMENT WORK

Saw cut any required joints within 24 hours after placing. Use at least a 1.5 mm thick blade and cut into one quarter the depth of the slab thickness.

20. LOADING AND PROTECTION OF NEWLY CONSTRUCTED STRUCTURES

The Contractor shall not apply a load of any kind to any part of a concrete structure until the concrete has matured for at least 7 days and then only with the approval of the Engineer and after confirmation that the required strength of the structure for the load envisaged has been attained. The full designed load shall not be applied until a period of 28 days has elapsed after casting and the 28 day designed strength has been attained.

Backfilling around a structure below GL will only be permitted after at least 21 days have elapsed from the date of casting and after waterproofing protection has been installed.

The structure shall not be subjected to any flooding, hydrostatic pressure or contamination until the concrete has been fully protected in accordance with the specification.

21. QUALITY CONTROL AND PRACTICES AT SITE

21.1. General provisions

The Contractor shall:-

1. have a qualified and approved Concrete Quality Control Technician at site
2. sample approximately 1 kg of fresh concrete in a 2 mm sieve to determine the type and origin of the aggregates [every load]
3. once every 100 m^3 or when required by The Engineer, collect approximately 5 kgs of fresh concrete in a clean polythene bag, seal it and send it to an approved independent laboratory to identify the type, source and grading of the combined aggregate
4. provide cores from the structure once every 100 m^3 or when required by The Engineer to determine values on defective concrete: the cores shall be sent to an independent laboratory and the following determined:-
   - cylinder compressive strength
   - density
   - % excess voids
   - permeability [ASTM 1202 and DIN 1048 or BS EN 12390-8]
   - chloride content
5. perform any additional sampling and testing required the specification and The Engineer
6. keep properly indexed and cross referenced records relating to casting locations in the form of maps, notes, documents and drawings; the records are to be incorporated in the monthly report shall contain at least the following:-
   - date of placement
   - location of placement
   - batch numbers of concrete marked in the plan and elevation of the structure
   - validated batch plant computer printouts
   - names of concrete crew
   - results of tests
   - number and sizes of compaction equipment
   - weather data
   - start and finish times
   - problems encountered
   - dates and times of deshuttering
   - non compliance report and corrective action report
   - defect report
   - approved remedial measures
7. submit the site QC report together with the original test certificates to the Engineer within 3 days after each placement and after each testing.
8. submit the monthly report containing a summary of the placements and test reports as shown in: Appendix 501.10 to The Engineer before the 14th of the month following.

21.2. Validating the batch plant computer printouts at site

The computer controlled Batch Plant Printout as shown in Appendices 501.5 and 501.6 is a document that The Contractor shall use for quality control on site. Approved batch and load plant printouts shall accompany the delivery of each load of concrete. The Contractor's site engineers shall be competent in reading, understanding and interpreting the printouts.

The data in the delivery documents form critical elements in continuing the quality control tasks associated with the concrete in its transition from The Producer's plant to The Contractor's site. The approved secure batch plant computer printout relates and records accurately the events and data relating to the production of the concrete at The Producer's plant. Study and examination of this document at the receiving point by The Contractor will to a large extent validate the integrity of the mix design and the level of consistency in the quality of control without the frequent presence and monitoring of The Producers plant by The Contractor or The Engineer.

The Contractor shall check the computer batch plant printout for each load to verify the following:-

- that the delivery is the approved mix
- the actual free [effective, c.f. BS EN 206-1] water cement ratio is not exceeded
- the % variation for the individual batches and the load are not exceeded
- the wet mixing time is correct
- that the ice content is appropriate for the time of the year
- note the time of mixing

The computer printouts shall be checked at intervals by The Contractor to ensure that the computer calculations are correct. The printout checks shall be additional to the other tests and checks that are required to be performed on the wet concrete for each delivery.

The computer printout will not validate the following:-
- that the aggregate of the correct type has been used
- that additional ice has not been added outside of the weigh system
- that additional water has not been added outside of the weigh system

The determination of the items above can be deduced from a study of the batch plant printout. The Contractor shall conduct the following tasks to make the determinations:-
- check the aggregate type by washing away the paste from a sample at site and comparing it with the submitted sample
- note the mixing water temperature, the ambient temperature and check that the correct amount of ice for that part of the year has been added through the weigh system and is recorded automatically in the printout.
- study the strength of 28 day cubes and ensure that the values do not persistently fall below the minimum set from the approved mix target strengths [such as the agreed mean target strengths and lower limit on range: note that this reference is not synonymous with the design minimum $f_{c,cube}$ or the minimum characteristic design strength $f_{ck,cube}$].

All of the above actions together with a study of the non-simulated computer printout will validate that the correct mix has been processed properly and under control.

The Contractor shall enter his measurements of the wet concrete properties [such as site slump, temperature and reference numbers of the cubes] in the respective spaces in the Delivery Note as indicated in Appendix 501.4, make his acceptance or rejection comments and affix his signature.
An original of the signed and completed Delivery Note and the batch plant computer printouts shall be retained by The Contractor, a copy shall be retained by The Consultant and one copy returned to the Producer for his records.

The Consulting Engineer shall verify The Contractors actions.

22. LABORATORY TESTING AND REPORTING

22.1. General provisions

Test samples shall be tested on the date assigned by specification with a tolerance of +2 days
Laboratory reports shall provide references that ensure full traceability of the test samples
A comprehensive sampling certificate shall be created at the time of sampling to be submitted with the test report. Reports on concrete shall have the unique mix number stated in the report. Each report shall state clearly the test standard and sub-methods used, where applicable

Laboratory reports shall be handed to the Engineer within 72 hours after the completion of tests

22.2. Sampling, testing fresh concrete, making and protecting cubes

Qualified technicians shall perform the tasks of making cubes and testing fresh concrete.

Valid data pertaining to the concrete placed can only be obtained if cubes are properly made, cured in a permanently wet state and tested properly. The Contractor shall ensure that a firm and level ground is provided for the testing of fresh concrete and for the making of cubes. The area shall be shaded against direct sunlight and wind. The moulds shall conform to BS EN 12390.

The Contractor shall sample the concrete and take cubes according to the specification and The Client's directive. The cubes shall be made from a single spot sample of fresh concrete. A sample shall not consist of different sub-samples taken from different spots in a load or made up from different loads.

The cube shall not be subjected to drying out at any time before it is tested. Each freshly made cube shall be sleeved completely with a polyethylene bag secured with an elastic immediately after making to prevent the loss of water from the specimen. The protective cover to the cube shall not allow the free passage of air over the surface of the fresh concrete. Merely throwing a cover over the mold without sealing the ends of the cover shall not be acceptable.

Cubes shall be labelled immediately they are made to prevent loss of data. Labelling may consist of nesting and isolating cubes made from one sample and writing the cube number on each individual PE protection. The number shall be transferred to the cube using alkali and water resistant indelible markers. The surface of the cube shall not be scored [e.g. by scratch labelling] or be deformed in other ways.

The cubes shall be protected immediately after de-moulding. If there is a delay between de-moulding and immersion in a temperature controlled curing tank, the fresh cubes shall be wrapped in wet hessian and sealed tightly in a double plastic bag. The cube shall be protected from damage and drying out during transportation, handling and curing.

The cube shall be transported to the vicinity of the curing tank not earlier than 12 hours but not later than 36 hours from it's making. The Producer is prohibited from handling the cubes or transporting them to the laboratory without supervision once they have been made. The Engineer shall be the custodian of the cubes till they are tested.

Cubes shall be tested in an approved independent laboratory. They shall not be tested in The Producers laboratory.

Test cubes for zero slump concrete shall be made using a vibrating table.

22.3. Specimen shape and size

Standard cubed test specimens shall be 150 mm^3 for compressive strength, DIN 1048 and BS EN 12390-8 measurements. The shape and size of the test specimen has a significant influence on the measured strength. Strengths for shapes and sizes other than 150mm^3 shall be derived from numerous data accumulated during proficiency testing. Where proficiency test data for differing shapes are not in existence, the actual correlation data measured at the trial mix stage may be used as an indication.

Standard cored specimens for compressive strength and ASTM C1202 permeability testing shall be a nominal 100 mm Ø and 100 mm in length.

22.4. Sample sizes for obtaining a test result

A set consists of a number of individual samples as stated hereunder.

A compressive strength test result shall be the arithimetic mean of a set of three individual cubes or on each core extracted from the cured structure.
A cured concrete density test result shall be the arithimetic mean of a set of three individual cubes or on each core extracted from the cured structure..

A DIN 1048 or BS EN 12390-8 test result shall be the arithimetic mean of a set of three individual cores extracted from cubes or on each core extracted from the cured structure.

An ASTM C1202 test result shall be obtained from each core.

A split tensile test result shall be the arithimetic mean of a set of three individual cores.

An extra cube shall be made as spare in case a test result appears to be invalid.

22.5. Sampling frequency

The following sample frequency shall be applied

Table 501.15. Frequency of sampling [Note 1]

	Test	Source of sample sets	
		From fresh concrete	From cured structure
01	Compressive strength & density	Every 50 m^3 or 1 per day which ever is the lesser	Every 200 m^3 or upon a cube test failure
02	ASTM C 1202 Permeability	Every 100 m^3	Upon a cube test failure
03	DIN 1048 Test	Every 100 m^3	Upon a cube test failure
04	Flexural beam strength [Note 1]	Once every 100 batches or once every week which ever is lesser	1 from each structure or from a single placement which ever is the lesser
05	Visual examination	On each crushed cube	On every core
06	Bleed	Trial mix only	NA

07	Drying shrinkage	Trial mix only	NA

Note 1: The Engineer reserves the right increase the frequency if the quality of the mix appears to be less than expected or is inconsistent or whenever a possible defect is suspected. The Contractor shall bear all costs arising from The Engineer's actions under the circumstances defined.

22.6. Rate of loading for compression testing

The rate of loading by the compression test machine has a significant influence on the measured strength. The rate of loading during a test in compression is not synonymous with the rate of advance of the platens under a non-loaded condition. The loading rate tends to change during the compression cycle and shall be controlled to be within a constant target range till the test is complete. Some types of compression testing machines automatically control the targeted loading rate and provide a printout with the loading rate data. Compression testing machines that do not have a digital pace indicator are unsuitable in the context of the specification. Manual control of pace of loading without a machine generated indicator shall not be used.

The target loading rate for the purpose of the specification shall be set to 0.31 N/mm^2 per second [equivalent to 7 kN per second for a 150 mm^3 specimen]. Loadings for cubes shall be adjusted accordingly to attain the same rate of loading.

22.7. Flexural strength

Concrete for paving or precast units shall be tested to BS EN 12390 and shall have a minimum flexural beam strength of 3.5 N/mm^2 at 28 days. If the concrete has a measured strength of 40 N/mm^2 or greater, the minimum flexural strength shall be 4 N/mm^2.

22.8. Rapid chloride permeability test to ASTM C 1202

ASTM C 1202 Clause 10 is modified as follows:

- Specimens and electrodes shall not be edge sealed with sealants. Vulcanised rubber rings shall be used.
- 5mm of the cast surface shall be planed off in preparing the test specimen.
- A water soluble Cl^- [Volhard's method] and a water soluble $[SO_4]^{2+}$ determination to BS EN 1744-1 shall be made on the specimen before the test to determine the background chloride and sulphate in the specimen. After the test, the tested specimen shall be dust drilled in advancing 10 mm depths. The five dust specimens, each representing a sample for each 10 mm of the total 50 mm thickness shall be tested for water soluble Cl^- and $[SO_4]^{2+}$ contents. A Cl^- and $[SO_4]^{2+}$ profile for the entire thickness of the test specimen shall be tabulated and plotted graphically.

22.9. Bleed test to ASTM C 232

Sealed wet samples shall be extracted from the plant immediately after production and laboratory measurements shall begin within 45 minutes of first contact with water by the first batch in the load. The Producer shall deliver the batch plant computer printout to the testing laboratory to verify the start time of the first batch in the load. The start time of the batch shall be used as the starting time for the test. Method A in ASTM C 232 shall be used.

22.10. Drying shrinkage to BS EN 1367-4

All the ingredients of the mix shall be delivered to the independent laboratory seperately. The laboratory shall batch the mix in a laboratory mixer and prepare the specimens to the requirements of the standard. The actual mix design proposed including the liquid admixtures shall be used instead of the mix stipulated in the standard. The laboratory shall be provided with the SSD mix design, SSD specific gravities and absorption and moisture content of the aggregates by The Producer. The aggregates shall not be sieved to remove oversizes and fines as required by the standard but used in the delivered condition after homogenising.

22.11. Visual examination

Every core shall be visually assessed for compaction efficency, lack of defects such excessive air bubble entrapment, cracks and segregation.

Visual checks on each compressively crushed cube shall be made and reported to ascertain that the correct type and nominal size of aggregate has been used in the mix.

22.12. Correlations between laboratory cured cubes and in-situ cores

The correlation for the 28 day laboratory cured cubes and the insitu cores shall be obtained from tests performed at the trials at the start of the project.

23. ACCEPTABILITY OF TEST RESULTS

Cube compressive strength test
An acceptable compressive strength test result for a cube is obtained when all the following conditions are fulfilled without exception:-

- the fresh sample has been correctly extracted and processed
- the cube is correctly made
- the cube is labeled properly for its unique identification and traceability
- the cube is kept permanently under wet curing conditions without drying out during any of the stages involving its making, demolding, transportation to the curing tank and until the test is performed
- the cube is not damaged at any stage prior to the test
- the cube is tested in the correct manner by competent personnel using properly calibrated equipment

The compressive strength result for cubes shall be the arithmetic mean of each set of three cubes where each individual value is within 15% of each other. In the event that one value is non corforming, it shall be discarded as an outlier and the arithmetic mean of the remaining two cubes shall be considered as being valid. In the event that three individual values appear as non conforming, the spare cube shall be tested. The spare cube shall not differ in age from the rest of the cubes by + 2 days. In the event the spare cube result appears to be non-conforming or misfits with the values already obtained, the entire set shall be considered to be non-conforming and the values reported but not considered as being valid. Where the set is declared to be non conforming three cores from the cured structure taken in close proximity to the affected batch shall be extracted and tested.

Only 5% of the population value for each mix shall fall below the f_{ck} value of the mix. The established f_{ck} value of the mix is not synonymous with the specified minimum f_{ck} value. The test results are expected to attain the natural f_{ck} value of the mix and not the f_{ck} value defined in the specification. In any event, no compressive strength result shall fall below the specified minimum f_{ck} value minus $3N/mm^2$.

24. TEST CUBE FAILURE

24.1. Action on test failure
If a test cube fails to produce the minimum specified strength or density when tested at 7 days, The Contractor may await at his own risk the result of the 28 day test. If the 28 day results [for strength, density and permeability] fails to attain the required values specified, The Contractor may opt to test cores from the relevant part of the structure. The results from the cores shall be in line with the correlations obtained during the trial mix and placement.

If the cores show that the concrete properties are not in compliance with the specification, The Contractor shall remove the structure of which the cubes and cores represent or execute such additional works or adopt such additional measures as the Engineer may direct or approve at The Contractor's expense.

If the results do not attain values stipulated, it will be concluded that there is uncertainity about the fitness of the unit represented by the failed or invalid test result and the following actions may be instructed by the Engineer:

- Extracting and testing cores from the cured structure
- Non-destructive testing of the structure
- Load-testing relevant structural units.
- Cutting out and replacing defective concrete
- Any other actions determined by discovery of causes not covered in the specification

24.2. Coring of the hardened concrete structure
In certain cases, the Engineer may direct The Contractor or The Contractor may, with the prior approval of the Engineer, obtain cores from the cured structure to establish additional results.

A metal detector shall be used before coring to avoid embedded steel in cores. Cores shall be trimmed down nominally to 100 mm Ø by 100 mm in length before compression strength tests. Cut surfaces shall be straight, smooth and free of corrugations, uneveness or visible nicks. The dimensional and geometric tolerances stipulated in BS EN 12390-1 shall apply.

Correlation data between cube and core obtained at the trial mix shall be used to ascertain the acceptability of strength and permeability values.

In the event that The Engineer declines to permit coring of the cured structure, The Contractor shall not make any claim in consequence thereof. All costs incurred in the investigation of concrete quality shall be borne by The Contractor.

25. CONCRETE PLACEMENT REPORT

The Contractor shall maintain a cumulative placement report for each mix of concrete in the form shown in Appendix 501.10. The cumulative report shall be included in the monthly report to The Engineer. The cumulative population statistical data as required by the specification for each mix shall be enclosed.

26. DEFECTIVE CONCRETE, RESTITUTION AND REPAIR

26.1. Defective or non-compliant fresh concrete

Defective or non compliant fresh concrete is defined when one or more of the following occurs:-

- not in compliance with the specification, The Client's directives or The specification
- contains constituent materials not in the approved mix design
- the maximum water:cement ratio is exceeded
- insufficient wet mixing time
- excessive bleed [above limits set by specification]
- inhomogenous mix
- does not final set within 9 hours of casting
- delivery not accompanied by the plant batch and load computer printouts

The Contractor shall reject defective wet concrete and not allow its placement in the project

26.2. Defective or non-compliant hardened concrete

Defective or non-compliant cured concrete is defined when one or more of the following occurs:-

- not in compliance with the specification or The Client's directives
- not conforming to required levels, lines, details and elevations
- failure to attain the required concrete strength, density, permeability or finish
- improper placement
- improper installation of embedded items
- presence of unacceptable voids
- improper bonding of a previously cured concrete to new concrete
- insufficient cover
- substantial mortar leaks through formwork
- honey-combing
- segregation in the bulk of the concrete
- presence of unacceptable or abnormal cracking
- damaged surface
- exposed reinforcement
- unsatisfactory surface for finishing work on the concrete.
- presence of fins
- excessive pock marks on the surface due to poor air bubble release
- flooding before 28 days have elapsed from placement and before waterproofing
- poor surface finish

The concrete surface shall be of an even texture and colour. The surface shall be free of cellular deformations, visible microcracks or other textural defects.

26.3. Defect report and restitution of defective cured concrete

The Contractor shall inspect the concrete immediately upon the removal of wet curing. He shall record all defects and submit to The Engineer a report with a proposal of corrective actions and where applicable the repair of defective concrete. Where the concrete is to be repaired, The Contractor shall make a submittal of materials, method and proof of feasibility for each repair. The repairs proposed shall meet at least the durability, strength, themal, aesthetic and mechanical properties of the existing concrete.

The Contractor shall not carry out any remedial work until The Engineer has inspected the structure and approved the submission for repairs. The Engineer has the right to instruct the removal of the structure in part or whole, if he deems that the structure is irreparable or the repair proposed is not consistent with restoring the fitness of the structure.

Surface rendering of defective concrete using cement slurry, cementatious plaster or mortar as a means of making good will not be permitted.

The Engineer's or The Client's decision shall be final in all aspects related to the repair or demolition of defective concrete structures.

27. SPECIAL CONCRETE 1 - SPRAYED CONCRETE [SHOTCRETE]

27. 1 General provisions

The normal parameters for concrete and its control shall be applied. Some of those parameters and control requirements will be altered by items stipulated in this section.

The wet mix method shall be used. The wet mix shall be produced in an approved concrete plant. The concrete shall not be used before 20 minutes have elapsed after the making of the last batch in the load.

27. 2 For all mixes

1. ACI 506 R shall be used as a guide for reaching the aggregate grading.
2. The cement content for wet mixes shall be in the range of 400 – 500 kg/m^3.
3. The permeability of the concrete shall be as stated in Tables 501.3 and 501.4.
4. Accelerators shall not be added to hasten the setting time of the concrete.
5. Rebound losses and segregation shall be minimised by the use of silica fume. Silica fume may be used in combination with one other SMA.
6. The mix shall not flash set during or after spraying.
7. Water soluble or swellable thixotropic polymer additives shall not be used.

27. 3 Wet mixes

The wet cone slump of wet mixes shall be between 80 - 200 mm.
Wet mixes shall be sprayed to a minimum thickness of 80 mm at any single placement.

27. 4 Reinforcements for shotcrete

At least one of the following reinforcements shall be used in sprayed concrete.

27.4.1. Short staple steel fibres

If steel fibres are proposed, they shall be cold drawn, milled or melt extracted, have rough surfaces, be bent, deformed or twin headed. Fibres shall have a high aspect ratio with a maximum length of 50 mm. Galvanised steel fibres shall not be used. Ordinary stainless steel fibres shall not be used in chloride environments. The correct grade with a nickel content of greater than 25% and stabilised with the correct temper shall be proposed.

When steel fibres are used the ultimate exposed surface shall be finished with a sprayed concrete using a finer grading free of steel and not lesser than 25 mm in thickness. The final layer shall have an ASTM C 1202 RCP permeability of less than 1000 C. Alternatively, a high performance surface coating such as a two component solventfree epoxy-amine shall be used in an aggressive environment.

27.4.2. Plastic fibres – short staple polypropylene or acrylic fibres

Plastic fibres may be used to prevent shrinkage cracking of the sprayed concrete.
The fibres shall not be collated and free from water soluble glues. The fibres shall be evenly distributed in the sprayed concrete. The fibres shall not be deposited in a 'nested' condition.

Where durability requirements apply to the exposure condition, the relevant ASTM C 1202 RCP permeability test shall be attained as required in Table 501.3.

27.4.3. Steel fabric or standard steel bar reinforcements

Sprayed concrete shall not be applied where the steel is congested. Minimum gaps behing rebars or steel fabrics that has to be sprayed shall be 20 mm.

Steel fabrics shall have wires with ≤10 mm Ø and a spacing of ≤150 mm. They shall be secured in such a way that they are rigidly held and not subject to displacement or 'spring and rebound' during spraying.

Sand pockets, uncompacted and segregated material caused by deflection of the wet concrete off the steel shall not be incorporated into the body of the concrete.

27.4.4. Steel dowels and anchors
Dowels may be required for anchoring steel fabrics and reinforcement, The Contractor shall submit details of anchors, method of anchoring together with calculations.

27. 5 Substrate preparation
The substrate for spraying should preferably be an absorbent surface with adhesion to the cured and dried aged sprayed concrete. The surface shall be clean of contaminants, be roughened by scabbling or grit blasting and be dust free. Old cementatious surfaces will require the removal of coatings, weathered and carbonated surfaces. The dry absorbent surface shall be moistened [not laden with running water] to reduce suction.

For rock facing, adhesion to the existing substrate or the presence of existing cracks in the rock can cause a problem. The surface shall be grit blasted, high pressure washed and the existing cracks grouted with non-shrink structural grouts to stabilise the surface.

Layering onto freshly sprayed concrete surfaces requires the removal of overspray, fine material and rebounded deposits.

Where separate sprayed panels are to be joined, where panels are being joined to old concrete as in the case of repairs, or to rock faces, the edges of panels or cutouts shall be bevelled to 45^{0} angles to prevent rebound entrapment.

27. 6 Application
The nozzle man shall have the experience and skills required. He shall demonstrate such skills during the trial.
Spraying shall be started from the bottom-most end and progress upwards to prevent rebounded material from being entrapped or embedded in the concrete. To mark the required thickness to be reached, fine wires shall be stretched out across the intended spray area. Alternatively, the surrounding projection of a finished level may be used as the datum.

After application, the body of the concrete shall not be disturbed by trowelling or levelling. The finish can be left as the shot surface which will have an undulating and rough topography. For a smoother finish, the concrete can be built up above the required thickness [determined by the thickness measured in the valleys of the topography], allowing the concrete to initially set or stiffen and using a steel trowel to cut down the surface to its finished level. The alternative method of finishing is to undershoot by about 5 mm and spray a finishing coat containing a finer grading to smooth out the contours.

27. 7 Curing
The concrete shall follow the normal wet curing procedure [PE film and wet hessian] required of all concretes. The wet curing period shall not be less than 7 days.

27. 8 Sampling and testing
Test specimens shall be obtained during actual application by switching the spray into a collection box made from non-absorbent formwork. The spraying into the box shall be performed without arresting or altering the sprayed concrete in any way. The concrete shall be cured in the manner of the main structure.

Cores of nominal 100 mm Ø and 100 mm length shall be taken from the sample box and at periodical intervals from in-situ concrete and tested at the stipulated periods for cured properties.

27. 9 Sprayed concrete in concrete repairs
Extensive trials and validation of previous experience in repairing structures using materials that include sprayed concrete is required. The Contractor shall propose a detailed plan depending on the individual outcome of the condition survey.

Cutting out and cleaning of areas to be repaired shall be performed carefully and using techniques such as hydrocutting and hydrodemolishing that does not damage existing sound concrete and steel reinforcements.

Where sprayed concrete is used for repairing older and deteriorated structures, the following additional requirements shall be included:-
- a successful repair will require a high level of investigative and design inputs, removal of existing deterioration, correct selection of repair materials and a very high degree of workmanship

- The Contractor shall submit a detailed plan that meets the repair situation; he shall not include extraneous and superfluos procedures, materials, labour and testing unwarranted by the situation or requirements

Sprayed concrete projects require a sizable continuous area for application. It is not suitable for discontinuous small areas. The final repair shall be compatible with the rest of the existing structure in terms of thermal and cyclic loading.

28. SUBMITTALS AT PROJECT CLOSEOUT

The Contractor shall at project closeout submit records of:-

- concrete batch data for the entire project [from The Producer in the form of a CD-R]
- submit aggregated reports of:-
- placement reports
- statistical data for measured concrete properties for each mix
- defect reports and their repairs or restitution

29. SUMMARY OF PROPERTIES AND PARAMETERS OF CONCRETE FOR THE PROJECT

The properties and parameters of the concrete for the project are summarised in Table 501.16.

Table 501.16. Summary of concrete requirements and limits [Specifier shall enter his actual required parameters]

	Property	Unit	min/max	Subclass		
				1	2	3
1. DESIGN PROPERTIES [The specification and also Part 2: Section 1: Clause 05.]						
01	Application	-	-	Structural RC	Piling	Blinding
02	Test specimen type and size	-	-	150 mm^3	150 mm^3	150 mm^3
03	28 day design strength [$f_{c,cube}$]	N/mm^2	min	40	40	20
04	Target 28 day strength for trial mix [Note 2]	N/mm^2	min	Design + 10	Design +10	Design + 7
05	28 day density	kg/m^3	min	2400	2400	2400
06	Maximum aggregate size	mm	nominal	20	20	20
07	Cement type	-	-	OPC	OPC	OPC
08	Cement content [Note 1]	kg/m^3	min-max	360 - 380	380 - 420	250 -300
09	water:cement ratio [Note 2]	-	max	0.4	0.4	0.5
10	Total Cl^- content [on cement]	%	max	0.15	0.15	0.15
11	Total SO_4^{2+} content [on cement]	%	max	4	4	4
12	Air content	%	max	2	2	-

2. PRODUCTION REQUIREMENTS						
01	Ambient shade temperature	^0C	max	40		
02	Central mixer wet mixing time [Note 3]	s	min	30	30	30

3. DELIVERY						
01	Delivery note	-	-	Yes	Yes	Yes
02	Batch plant computer printouts	-	-	Yes	Yes	Yes

4. FRESH CONCRETE PROPERTIES							**TEST FREQUENCY**
01	Slump at placement [Note 2]	mm	range	75 -125	150 -200	75 -125	Every load at site
02	Target delivery slump [Note 2]	mm	min	100	200	100	Every load at site
03	Concrete temperature at placement	^0C	max	30	30	30	Every load at site
5, HARDENED CONCRETE PROPERTIES							**TEST FREQUENCY**
01	**Mechanical properties**						
A	Compressive strength [7 and 28 day]	N/mm^2		Range and target mean set by trial mix results			Every 50 m^3 or part thereof per day
B	Density [7 and 28 day]	kg/m^3	min				

02	**Checks on crushed concrete specimen**						
A	Aggregate check for type [7 and 28 day]	-		as per approved mix design			Every compression test
B	Aggregate check for size [7 and 28 day]	mm	nominal	20	20	20	Every compression test

03	**Durability**						
A	ASTM 1202 RCP [28 day]	coulomb	max	See Note 2 and 4		-	Every 100 m^3
B	DIN 1048 or BS EN 12390-8 [28 day]	mm	max			-	Every 100 m^3

04	**Others**						
A	Bleed [ASTM C232:Method A]	%	max	0.5	0.5	-	See Note 5
B	Drying shrinkage [BS EN 1367-4]	%	max	0.05	0.05	-	See Notes 5 and 6
	Cores from structure						
03	Visual checks [See Note 7]						Every 200 m^3 or every core

Notes:

Note 1: See The specification: Part 2: Table A.

Note 2: See The specification: Part 2: Clause 10.

Note 3:: See The specification:Part 3.

Note 4: Each ASTM C 1202 test shall also be subjected to the following additional tests and procedure:-

a. An water soluble chloride [Volhard's method] and water soluble sulphate content shall be performed on the sample cube before the test according to BS EN 1744-1.
b. An water soluble chloride [Volhard's mehod] and water soluble sulphate profile shall be made on the entire thickness of the disc after the test by analysing each 10mm depth dust drills according to BS EN 1744-1.
c. 5mm of the cast surface shall removed from the bulk test specimen by the testing laboratory before preparing the specimen for the test.
d. Target ASTM C 1202 values shall be set to be lower than the maximum stipulated to allow for variations in production batches, sampling and testing.

Note 5: Tests at trial mix stage only. Further, The Engineer will instruct the conduct of these tests whenever a possible defect is suspected.

Note 6: The submitted mix design shall be used instead of the mix design stipulated in BS EN 1367- 4 and the aggregate shall not be sieved but used in the as-received condition.

Note 7: Cores shall be examined for consolidation, segregation, aggregate density, aggregate type, aggregate bonding, aggregate distribution, cracks, excessive bubble entrapment and other defects.

APPENDIX 501.1

Applicable standards and references. The latest superceded standard in lieu of the listed standard shall be used. Out dated and withdrawn standards shall not be used.

A. CONSTITUENT MATERIALS

01. CEMENT

BS EN 197: Cement specification

197-1	Composition & specification
197-2	Conformity evaluation

BS: Specification

4027	Sulfate resisting portland cement

BS 4550: Methods of testing cement

Part 3.8	Test for heat of hydration
Part 4	Standard coarse aggregate for concrete cubes.
Part 6	Standard sand for mortar cube

BS EN 196: Methods of testing cement

196 - 1	Strength
196 - 2	Chemical analysis
196 - 3	Setting time & soundness
196 - 6	Fineness
196 - 7	Sampling

ASTM: Test methods

C 227	Potential alkali reactivity of cement-aggregate combinations [mortar-bar method]
C 452	Potential expansion of portland-cement mortars exposed to sulfate
C 1356	Quantitative determination of phases in portland cement clinker by microscopical point-count procedure
C 1356M	Quantitative determination of phases in portland cement clinker by microscopical point-count procedure [metric]
C 1365	Determination of the proportion of phases in portland cement and portland-cement clinker using x-ray powder diffraction analysis

ASTM: Practice

C 1222	Evaluation of laboratories testing hydraulic cement

02. AGGREGATE

BS EN

12620	Specification for Aggregates

BS: Testing aggregates

812 103.2	Particle size distribution by sedimentation
812 - 4	Qualitative and quantitative petrographic examination of aggregates.
812 - 123	Alkali silica reactivity – prism method

BS EN: Tests for general properties

932 - 1	Sampling
932 - 2	Reducing laboratory samples
932 - 3	Procedure and terminology for simplified petrographic description
932 - 5	Common equipment and calibration
932 - 6	Definitions of repeatability and reproducibility

BS EN: Tests for geometric properties

933 - 1	Particle size distribution - sieving method.
933 - 2	Particle size distribution - test sieves: nominal size of apertures.

933 - 3 Particle shape - flakiness index.
933 - 4 Particle shape - shape Index
933 - 5 Percentage of crushed and broken surfaces in coarse aggregate particles
933 - 6 Surface characteristics - flow coefficient
933 - 7 Shell content - percentage of shells in coarse aggregates
933 - 8 Fines – sand equivalent
933 - 9 Fines – methylene blue
933 - 10 Fines – grading of fillers [air jet sieving]

BS EN: Tests for mechanical properties
1097 - 1 Resistance to wear [micro-deval]
1097 – 2 Resistance to fragmentation
1097 - 3 Loose bulk density and voids.
1097 - 4 Voids of dry compacted filler
1097 - 5 Water content by drying in a ventilated oven
1097 - 6 Particle density and water absorption
1097 - 7 Physical density of filler – pyknometer method
1097 - 8 Polished stone value

BS EN: Tests for thermal and weathering properties
1367 - 2 Magnesium sulphate test
1367 - 3 Boiling test for 'Sonenbrand' basalt
1367 - 4 Drying shrinkage
1367 - 5 Resistance to thermal shock

BS EN: Tests for chemical properties
1744 - 1 Chemical analysis

ASTM: Specification
C 33 Concrete aggregates
C 637 Aggregates for radiation-shielding concrete
C 144 Aggregate for masonry mortar [AASHTO: M45]

ASTM: Guide
C 295 Petrographic examination of aggregates for concrete

ASTM: Test methods
C 40 Organic impurities in fine aggregates for concrete [AASHTO: T21]
C 87 Effect of organic impurities in fine aggregate on strength of mortar
C 88 Soundness of aggregates by use of Na sulfate or Mg sulfate
C 117 Materials finer than 75-micrometers [no. 200] sieve in mineral aggregates by washing
C 123 Lightweight particles in aggregate [AASHTO: T113]
C 128 Density, relative density [specific gravity], and absorption of fine aggregate
C 131 Resistance to degradation of small-size coarse aggregate by abrasion and impact in the los angeles machine
C 142 Clay lumps and friable particles in aggregates [AASHTO: T112]
C 227 Potential alkali reactivity of cement-aggregate combinations [mortar-bar method]
C 289 Potential alkali-silica reactivity of aggregates [chemical method]
C 535 Resistance to degradation of large-size coarse aggregate by abrasion and impact in the los angeles machine
C 586 Potential alkali reactivity of carbonate rocks for concrete aggregates [rock cylinder method]
C 1252 Uncompacted void content of fine aggregate [as influenced by particle shape, surface texture, and grading]
C 1260 Potential alkali reactivity of aggregates [mortar-bar method]
C 1370 Determining the chemical resistance of aggregates
D 2419 Sand equivalent value of soils and fine aggregate
D 3042 Insoluble residue in carbonate aggregates
D 3744 Aggregate durability index
D 4792 Potential expansion of aggregates from hydration reactions
D 5711 Adherent fines
PS 118 Water-extractable chloride in aggregate [soxhlet method]

ASTM: Practice

C 1077	Laboratories testing concrete and aggregates
D 3319	Accelerated polishing of aggregates using the british wheel
E 660	Accelerated polishing of aggregates or pavement surfaces using a small-wheel, circular track polishing machine

03. PLASTICISING ADMIXTURES

BS EN: Admixtures for concrete, mortar and grout

934 - 2	For normal concrete
934 - 4	For pre-stressing tendons
934 - 6	Sampling, conformity control and evaluation of conformity

BS EN: Test methods for admixtures for concrete, mortar and grout

480 - 1	Reference concrete and reference mortar for testing
480 - 2	Setting time
480 - 4	Bleeding
480 - 5	Capillary absorption
480 - 6	Infrared analysis
480 - 8	Conventional dry material content
480 - 10	Water soluble chloride content.
480 - 11	Air void characteristics in hardened concrete.
480 - 12	Alkali content

ASTM: Specification

C 869	Foaming agents for producing cellular concrete

ASTM: Test methods

C 233	Air entraining
C 796	Foaming agents for producing cellular concrete
G 109	Effects of admixtures on corrosion of embedded steel

04. WATER

BS EN

1008	Mixing water for concrete

05. SUPPLEMENTARY MINERAL ADDITIVES

General

ASTM

C 311	Sampling and testing fly ash or natural pozzolans for use as a mineral admixture
C 441	Effectiveness of mineral admixtures or ground blast-furnace slag in preventing excessive expansion of concrete due to the alkali-silica reaction

a. Fly ash

BS EN

450 -1	Definitions, requirements and quality control

ASTM: Specification and guide

C 618	Coal fly ash and raw or calcined natural pozzolan for use as a mineral admixture
D 5759	Characterization of coal fly ash and clean coal combustion fly ash for potential uses

b. Silica fume

ASTM

C 1240	Use of silica fume in concrete, mortar and grout

c. Ground granulated blast furnace slag [GGBFS]

BS

6699 Ground granulated blast furnace slag [GGBFS]

ASTM: Specification

C 989 Use of GGBFS in concrete, mortar and grout

ASTM: Test method

C 1073 Hydraulic activity of ground slag by reaction with alkali

06. PIGMENTS FOR CONCRETE

BS EN: Specification and test methods

12878 Pigments for Portland Cement.

ASTM

C 979 Pigments for Portland Cement

07. HYDRATED LIME

ASTM: Specification

C 141 Hydraulic hydrated lime for structural purposes
C 206 Finishing hydrated lime
C 207 Hydrated lime for masonry purposes

B. CONCRETE

01. CONCRETE: SPECIFICATION,

BS EN: Concrete specification, performance and production

206 - 1 Specification, performance, production and conformity

BS: Complimentary standard to BS EN 206-1

8500 - 1 Method of specifying and guidance for the specifier
8500 - 2 Specification for constituent materials and concrete

ASTM: Specification

C 94 M Readymixed concrete specification
C 685M Concrete made by volumetric batching and continuous mixing

02. CONCRETE TESTING

Testing fresh concrete

BS 1881:

Part 125 Mixing and sampling fresh concrete in the laboratory
Part 128 Analysis of fresh concrete
Part 129 Density of partially compacted semi dry concrete

BS EN: Testing fresh concrete

12350 - 1 Sampling
12350 - 2 Slump
12350 - 3 Vebe test
12350 - 4 Degree of compactibility
12350 - 5 Flow table
12350 - 6 Density
12350 - 7 Air content - Pressure method

ASTM: Test methods

C 138M	Density [unit weight], yield, and air content [gravimetric] of concrete [AASHTO: T121]
C 143M	Slump of hydraulic-cement concrete
C 173M	Air content of freshly mixed concrete by the volumetric method
C 231	Air content of freshly mixed concrete by the pressure method
C 232	Bleeding of concrete
C 403M	Time of setting of concrete mixtures by penetration resistance
C 995	Time of flow of fiber-reinforced concrete through inverted slump cone
C 1064M	Temperature of freshly mixed portland cement concrete

Testing hardened concrete

BS 1881:

Part 5	Testing hardened concrete for other than strength
Part 109	Making test beams
Part 112	Accelerated curing of test cubes
Part 113	Making and curing no-fines cubes
Part 119	Compressive strength from beams broken in flexure
Part 121	Static modulus of elasticity in compression
Part 122	Water absorption
Part 124	Analysis of hardened concrete
Part 127	Verifying the performance of a cube using the comparative
Part 130	Temperature matched curing of specimens

BS EN:

12390 - 1	Requirements for specimens and moulds
12390 - 2	Making and curing specimens for strength tests
12390 - 3	Compressive strength of test specimens
12390 - 4	Compressive strength – specification for testing machines
12390 - 5	Flexural strength for test specimens
12390 - 6	Tensile splitting strength of test specimens
12390 - 7	Density
12390 - 8	Depth of penetration of water under pressure

ASTM : Test method

C1202	Rapid determination of chloride permeability of concrete.

DIN: Test method

1048	Permeability Test

Hardened concrete - structure

BS EN: Guide

13791:	Assessing concrete strength in structures

BS 1881:

Part 201	Guide to the use of NDT for testing concrete
Part 203	Measurement of the velocity of ultrasonic pulses
Part 204	Recommendations – Use of electromagnetic covermeters
Part 205	Recommendations – Radiography
Part 206	Recommendations – Strain determinations in concrete
Part 207	Recommendations – Assessment of strength by near to surface tests
Part 208	Recommendations – Determination of initial surface absorption test
Part 209	Recommendations – Measurement of dynamic modulus of elasticity

BS EN: Testing concrete in structures

12504 - 1	Cored specimens – Taking, examining and testing in compression
12504 - 2	NDT – Determination of rebound number

ASTM: Specification

C 511	Moist cabinets, moist rooms, and water storage tanks used in the testing of hydraulic cements and concretes

ASTM: Test methods

C 157M	Length change of hardened hydraulic-cement mortar and concrete
C 192M	Making and curing concrete test specimens in the laboratory
C 418	Abrasion resistance of concrete by sandblasting
C 457	Microscopical determination of parameters of the air-void system in hardened concrete
C 512	Creep of concrete in compression
C 597	Pulse velocity through concrete
C 617	Capping cylindrical concrete specimens
C 642	Density, absorption, and voids in hardened concrete
C 779M	Abrasion resistance of horizontal concrete surfaces
C 878	Restrained expansion of shrinkage-compensating concrete
C 900	Pullout strength of hardened concrete
C 1105	Length change of concrete due to alkali-carbonate rock reaction
C 1138	Abrasion resistance of concrete [underwater method]
C 1202	Electrical indication of concrete's ability to resist chloride ion penetration
C 1293	Determination of length change of concrete due to alkali-silica reaction
C 1399	Obtaining average residual-strength of fiber-reinforced concrete

ASTM: Practice

C 856	Petrographic examination of hardened concrete
C 1451	Determining uniformity of ingredients of concrete from a single source

C. PRECAST CONCRETE

01. GENERAL

BS EN:

1169	General rules for factory production control
13369	Common rules for precast concrete products

D. MORTARS AND PLASTERS

BS 5838: Dry Packaged Cementitious Mixes

Part 1	Prepacked concrete mixes

ASTM: Specification

C 387	Packaged, dry, combined materials for mortar and concrete
C 887	Packaged, dry, combined materials for surface bonding mortar
C 897	Aggregate for job-mixed portland cement-based plasters
C 926	Application of portland cement-based plaster
C 932	Surface-applied bonding compounds for exterior plastering
C 1032	Woven wire plaster base
C 1063	Installation of lathing and furring to receive interior and exterior portland cement-based plaster
C 1506	Water retention of cement-based mortars and plasters

ASTM: Test methods

C 87	Effect of organic impurities in fine aggregate on strength of mortar
C 109 M	Compressive strength of cement mortars – [50-mm] cube specimens
C 157 M	Length change of hardened hydraulic-cement mortar and concrete
C 185	Air content of hydraulic cement
C 243	Bleeding of cement pastes and mortars
C 265	Water-extractable sulfate in hydrated hydraulic cement mortar
C 341	Length change of drilled or sawed specimens of mortar and concrete
C 348	Flexural strength of hydraulic-cement mortars
C 349	Compressive strength of mortars [using prisms broken in flexure]
C 404	Aggregates for masonry grout
C 596	Drying shrinkage of mortar containing hydraulic cement
C 780	Evaluation of mortars for plain and reinforced unit masonry
C 944	Abrasion resistance of concrete or mortar surfaces [rotating-cutter method]
C 952	Bond strength of mortar to masonry units

C 1152 M Acid-soluble chloride in mortar and concrete
C 1218 M Water-soluble chloride in mortar and concrete
C 1506 Water retention of hydraulic cement-based mortars and plasters

ASTM: Practice
C 305 Practice for mechanical mixing of cement pastes and mortars

E. FLOORING SCREEDS

BS
BS 8204: Codes of practice: screeds, bases and in-situ floorings
Part 1 Code of practice - Bases and screeds to receive floorings
Part 2 Code of practice - Concrete wearing surfaces
Part 3 Code of practice - Polymer modified cementitous wearing surfaces.

F. GROUTS

ASTM: Specification
C 404 Aggregates for masonry grout
C 1107 Packaged dry, hydraulic-cement grout (non-shrink)

ASTM: Test method
C 1090 Measuring changes in height of cylindrical specimens

G. LATEX CONCRETE BONDING AGENTS

ASTM: Specification
C 1059 Latex agents for bonding fresh to hardened concrete
C 1438 Latex and powder polymer modifiers for concrete and mortar

ASTM: Tests and practices
C 1042 Bond strength of latex systems by slant shear
C 1404 M Bond strength of adhesive systems as measured by direct tension
C 1439 Polymer modified mortar and concrete

H. CONCRETE REPAIR MATERIALS

ASTM: Specification
C 928 Packaged, rapid-hardening cementitious materials for concrete repairs

I. ANCHORS IN CONCRETE

ASTM: Specification
F 1554 Anchor bolts, steel, 36, 55, and 105-ksi yield strength

ASTM: Test method
D 4435 Rock bolt anchor pull test
D 4436 Rock bolt long-term load retention test
E 488 Strength of anchors in concrete and masonry elements
E 1190 Strength of power-actuated fasteners in structural members
E 1512 Testing bond performance of bonded anchors

J. WORKMANSHIP

BS: Workmanship relating to concrete, mortars and grouts
BS 8000: Workmanship on building sites: Code of practice
Part 2 Sec 2.1: Mixing and transporting concrete
Part 2 Sec 2.2: Sitework with in situ and precast concrete

Part 9 Cement-sand floor screeds and concrete floor toppings

K. TERMINOLOGY

ASTM: Terminology relating to Concrete

C 125 Concrete and concrete aggregates
C 294 Descriptive nomenclature for constituents of concrete aggregates
C 882 Concrete pipe and related products
C 1209 Concrete masonry units and related units

APPENDIX 501.2
Site trial dummy specification

A. Dimensions
The dummy dimensions are to be as follows:-

	Type	Length [mm]	Width [mm]	Height [mm]	Reinforcement
1.	Wall	1600	300	1600	Half reinforced - 200 mm centres
2.	Column	1000	1000	1600	Fully reinforced - 200 mm centres
3.	Slab	1200	1200	400	Half reinforced - 200 mm centres
4.	SCC	5000	3000	400	Fully reinforced
5.	Piling	1000 diameter		1600	Fully reinforced

B. Concrete spacers
Concrete spacers shall be of the same quality as the concrete and adequate in number and spacing. Cover to be the same as the project specification.

C. Reinforcement
To be of nominal size as specified in the project and as shown in the table above. Where the concrete dummy is half reinforced and half unreinforced, there should be no cracking at the junction between the two states when observed at 28 days.
Spacing of 200 mm is to allow for obtaining reinforcement-free cores.

D. Formwork
To be of the same quality to be used in the project.

E. Curing method
Polyethylene only for the first 24 hours – properly sealed.
Deshutter after 24 hours.
After first 24 hours, cover with wet hessian and overlay with overlapped polyethylene.and secure.

F. Curing period
Follow the specification requirements.

G. Cubes for each class of blinding concrete

No: of 150 mm^3 cubes	Tests
three	7 d compressive strength & density
three	28 d compressive strength & density

H. Cubes for each class of structural concrete

No of 150 mm^3 cubes	**Tests**	**Comments**
three	7 d compressive strength & density	
three	28 d compressive strength & density	
three	7 d compressive strength [for 100 mm cores]	See I
three	100 mm cores for 28 d compressive strength	See I
one	ASTM 1202 RCP – 28 d	
three	DIN 1048 28 d	
three	Spare cubes	

I. Cores from dummy for each class of structural concrete.
Cores must not contain embedded reinforcements. Use metal detector and mark before coring operation.

No: of 100 mm Ø cores	**Source**	**Tests**
three	From cube	7 day compressive strength
three	From cube	28 day compressive strength & density
three	From dummy [reinforced part]	7 day compressive strength & density
three	From dummy [unreinforced part]	28 day compressive strength& density
three	From dummy [reinforced part]	7 day compressive strength& density
three	From dummy [unreinforced part]	28 day compressive strength& density
one	From dummy [reinforced part]	28 day ASTM 1202 RCP
three	From dummy [reinforced part]	28 day DIN 1048
two	From dummy [reinforced part]	Spare core

The report by The Engineer or an approved third party shall include the following:-

Section 1: Provide details of the Contract and the approved concrete plant to contain the following:-

Contract No: and description
Contractor
Consultant
Estimated transport time from plant to site

Concrete Producer
Unique mix No:
Mix description
Plant No:
Plant location by description and plot No:
Unique plant computer serial No:

Section 2: Report on the contractors ability and competence in:-

1. Workmanship
2. Performing slump measurements properly
3. Cube making and protection from drying
4. Providing a shaded and level area for slump measurements and cube making
5. Proper transportation of cubes from the site to an approved independent laboratory
6. Constructing leak free formwork
7. Reinforcement construction
8. Making proper spacer blocks
9. Placing, compacting and curing concrete
10. Performing quality control
11. Having proper control checklists and forms
12. Defect report after formwork removal and 7 days after the termination of curing
13. Any other significant matters

Section 3: Report on a summary sheet the:-

1. Slump reduction over 90 minutes
2. Concrete temperature over 90 minutes
3. Ambient conditions [ambient temperature, humidity, wind speed or evaporation rate]

4. 7 day and 28 day compressive strength and density results for the:-
   a. Cubes
   b. Cores from the cubes
   c. Cores from the reinforced part of dummy
   d. Cores from the unreinforced part of dummy

5. 28 day ASTM C 1202 RCP results [including the Cl and SO4 profiles] for the:-
   a. Cube
   b. Core [reinforced part of the dummy]

6. 28 day DIN 1048 or BS EN12390-8 results for:-
   a. Cubes
   b. Cores [reinforced part of the dummy]

7. The bleed test results [ASTM C 232[
8. The aggregate drying shrinkage test results [BS EN 1367 – 4]

Section 4: Provide the:-

1. Correlation data for the 7 day and 28 day results between the cube, the core from the cube and the cores from the dummy for strength, density and permeability

2. Statistical derivation of the estimated target mean strength and the lower limit of the range

Section 5:- Enclose the following:-

1. The mix design
2. Comparison sheet – spec. vs trial mix
3. The Computer printout
4. The delivery Note
5. Site checklists
6. Site QC and control forms
7. The fresh and cured concrete test result sheets
8. The names and designations of persons at the trial

APPENDIX 501.3
Concrete mix design summary form

MUSCAT MUNICIPALITY
Concrete mix design summary form

01. GENERAL

Date of submission	Concrete supplier
Contract No	Unique mix No
Consultant	Plant No
Contractor	Location of plant
	Mixing time

02. MIX PARAMETERS

Strength Class and Type [Designated, designed, etc]	Attach previous production statistical results [if available]
Required. 28 day strength [N/mm²]	Trial mix 28 day Mean compressive strength [BS EN 12390-3] [N/mm²]
Target mean 28 day strength [N/mm²]	Trial mix 28 day Rapid chloride permeability [ASTM C1202] [coulombs]
Dry density [kg/m^3]]	Trial mix 28 days permeability [DIN 1048] [mm]
Target water:cement ratio	Trial mix 28 day Water absorption [BS EN 1097-6] [%]
Required placement cone slump [mm]	Trial mix Bleed [ASTM C232] [%]
Approximate distance from plant to site and delivery time	Trial mix Aggregate drying shrinkage [BS EN 1367-4] [%]

03. MIX DESIGN PROPORTIONS FOR ONE CUBIC METER OF CONCRETE (SSD BASED)

Ingredient	Type	Source	Manufacturer or Producer	Weight (kg)
Cement				
Supplementary mineral additive [GGBFS, PFA, Microsilica]				
Coarse aggregate [20mm, 10mm] [crushed, semi crushed, natural]				
Fine aggregate [5mm, dune sand] [crushed, natural] [washed, unwashed]				
Liquid admixtures				
Free water				
Other additives or admixtures				

Aggregate breakdown		Calculated ratios and parameters	
20mm (%)		Fineness modulus	
10mm (%)		Paste volume fraction	
5mm (%)		Free water :cement ratio	
Dune sand (%)		Total Cl content	
Total fines passing 0.075mm (%)			

04. GRADING : % Passing sieve										
					Fine aggregates			Combined aggregates		
Sieve size [mm]	20 mm	10 mm	5 mm	Dune sand	% gradation	Envelope limits		% gradation	Envelope limits	
						Min.	Max.		Min.	Max.
20										
14										
10										
5										
2.36										
1.18										
0.600										
0.300										
0.150										
0.075										

Graphical representation of combined aggregate particle size distribution [total grading] [including limiting envelopes]

	PRODUCER	CONTRACTOR	CONSULTANT
Name of Company			
Name of Person			
Position			
Signature			
Date			
Declaration of intellectual and property right: I declare that I am the owner of this mix design and all of the test results shown above. Name of owner: Signature:			

Notes:

Attach test certificates to support design calculations and derivations [e.g. SSD densities, sieve analysis].

The Producer shall retain in his records all the detailed calculations involved.

Attach production statistical analysis and data for proposed concrete mix designs (if available)

Where there are no existing production statistical data, estimated population target mean shall be assigned.

5. The minimum estimated target mean strength and the minimum range shall be set below the trial mix 28 day strength according to the specification.

The Producer shall complete this form. The form shall be signed by the Producer, Contractor and Consultant.

The Producer shall sign and affix his stamp/seal on all pages of this form.

APPENDIX 501.4
Sample of Delivery note

MUSCAT MUNICIPALITY
Sample Delivery note

COMPANY NAME-LOGO-ADDRESS [ENGLISH]	**COMPANY NAME-LOGO-ADDRESS [ARABIC]**
ADM-CCC Plant approval No:	
Delivery note serial No:	**Cross reference to load printout ticket No:**

Contact number for Technical Manager – enter name and mobile phone number:

Date:	Unique mix design No:	Order No:
Plant No:	Grade of concrete:	Log ID:
Plant location:	Target mean strength:	Project ID:
Truck No:	Required slump at site:	Customer:
Driver	Target free w:c ratio:	Delivery point:
Driver No:	Ambient temperature:	Quantity ordered:
Loading time: *[1]		Quantity delivered:
Arrival time:		Quantity this load:

Plant checks	Checked by Plant QC [Name]:	Signature:

Time [hrs]	Cone slump [mm]	Concrete temperature [^{o}C]	Cube reference number:

Site checks	Checked by The Contractor's QC [Name]:	Signature:

Time [Hrs]	Cone slump [mm]	Concrete temperature [^{o}C]	Aggregate check [washing]	Time started discharge	Time finished discharge	Cube reference number:

Received, checked and accepted by The Contractor		**Verified by ADM or The Consultant**	
Name:	Signature:	Name :	Signature:
Position:		Position:	

Comments:	[Seal of The Producer]

Legend for abbreviations used in the batch printout and delivery note:

It is not necessary to reproduce the format of this document. The details contained in this document must however be shown in the Delivery Note.

*[1] Loading time is the time of first contact of water added to the first batch in the load
All free boxes shall be filled: if an action was not taken then enter "NIL".
The load summary printout can be incorporated into the delivery note

APPENDIX 501.5
Sample of a computer controlled batch plant printout - Load summary

MUSCAT MUNICIPALITY
Computer controlled batch plant printout - Load Summary

Name of The Producer:	**Software serial number:**

NON SIMULATED	Printout Number:

Contract number:	Log ID:	Contractor:	Mix Design No
Batch start time:	Batch finish time:	Printout date and time:	Plant No:
Batching number:	Batch volume:	[Number of batches] : Note 1	Plant Location:
Wet mixing time : Note 1	Inlet water temperature: Note 1 & 2	Ambient temperature : Notes 1 & 2	Plant Serial No:

LOAD SUMMARY PRINTOUT

Material		**Approved mix design 1 m³ [SSD] kg**	**Required quantity kg**	**Batched quantity kg**	**% Variation**	**Aggregate absorption %**	**Aggregate total moisture %**	**Adjusted water kg**
Dune Sand	[A]*4							
20mm	[B]*4							
10mm	[C]*4							
5mm	[D]*4							
Cement *1	[E]*5							
Admixture 1 *2	[F]*5							
Admixture 2 *2	[G]*5							
Additive *3	[H] *5							
Water	[I]							
Ice	[J]							
Other	[K]							

It is not necessary to reproduce the format of this document. The details contained in this document must however be shown in the batch printout.

Note 1: These items may alternatively be shown on the individual batch printout.
Note 2: These temperatures shall be automatically detected by remote sensors.

All abbreviations (e.g., A, B, C…...) shall be explained in legends separately in the Delivery Note or any Printout.
*1 Enter type of cement e.g OPC, SRC etc.
*2 Enter product number of admixture.
*3 If additive is supplementary mineral additive – enter type e.g SF, GGBFS, PFA.
*4 Abbreviations for these items shall show quarry, washed or unwashed, fully or semi crushed, natural.
*5 Abbreviations for this item shall show manufacturer.

✓ "Non-simulated" shall be automatically printed in all batch and load printouts.
✓ Target w:c, and actual w:c may shall be printed in The Load Summary printout.
✓ Water temperature at concrete mixer inlet shall be measured and entered automatically by the computer.
✓ The number of batches making up the load shall be entered either in The Load Summary printout.
✓ The actual wet [not the preset] mixing time for each batch of concrete shall be entered automatically.

APPENDIX 501.6
Sample of a computer controlled batch plant printout - Individual batch

MUSCAT MUNICIPALITY
Computer controlled batch plant printout – Individual Batch

Name of The Producer	

NON SIMULATED	Printout Number:

Contract number	Log ID	Contractor	Mix design No:
Batch start time	Batch finish time	Printout date and time	Plant No:
Batching number	Batch volume	[Number of batches] Note 1	Plant location:
Wet mixing time Note 1	Inlet water temperature Note 2	Ambient temperature Notes 1 & 2	Plant serial No:

INDIVIDUAL BATCH PRINTOUT

Material		**Approved mix design 1 m³ [SSD] kg**	**Required quantity kg**	**Batched quantity kg**	**% Variation**	**Aggregate absorption %**	**Total moisture %**	**Adjusted water kg**
DS	[A]*4							
20mm	[B]*4							
10mm	[C]*4							
5mm	[D]*4							
Cement *1	[E]*5							
Admixture 1 *2	[F]*5							
Admixture 2 *2	[G]*5							
Additive *3	[H] *5							
Water	[I]							
Ice	[J]							
Other	[K]							

It is not necessary to reproduce the format of this document. The details contained in this document must however be shown in the batch printout.

Note 1: These items may alternatively be shown on the Load summary printout.
Note 2: These temperatures shall be automatically detected by remote sensors.

All abbreviations (e.g., A, B, C…...) shall be explained in legends separately in the Delivery Note or The Printout.
*1 Enter type of cement [e.g. OPC, SRC etc.]
*2 Enter product number of admixture.
*3 If additive is supplementary mineral additive – enter type [e.g MS, GGBFS, PFA.]
*4 Abbreviations for these items shall show quarry, washed or unwashed, fully or semi crushed, or natural.
*5 Abbreviations for this item shall show manufacturer.

✓ "Non-simulated" shall be automatically printed in all batches.
✓ Water temperature at concrete mixer inlet shall be entered automatically.
✓ Enter number of batches making up the load either at the end of the individual printout.
✓ The actual wet mixing time for each batch of concrete to be entered automatically.

APPENDIX.501.7
Validated summary sheet for aggregate tests

MUSCAT MUNICIPALITY
Validated summary sheet for aggregate tests

Crush Independent Test Laboratory

Validated summary sheet for aggregate tests

Reference number for the summary sheet	Name of The Concrete	
Clear sample description	Aggregate producer [The Quarry]	
Laboratory reference number for the sample	Producer's batch number of sample	Sampled by whom
Date and place of sampling	Location of original test sheets in The Concrete Producer's documentation system	
Sample storage details		

Test sheet	Date of test	Test std	Description	Required value	Test result	Pass/Fail

Declaration by The The Concrete Producer: I have checked and verify the accuracy of data entered in this document. Signature..... Quality Manager name:..... Dated.....	Declaration by The Independent Laboratory: We confirm that the above is a true extract from Test result sheets issued by us. Signature..... Quality Manager name: ..... Dated	[Seal of the independent laboratory]

APPENDIX 501.8
Validated summary sheet for admixture type tests

MUSCAT MUNICIPALITY
Validated summary sheet for admixture type tests

Independent Test Laboratory

Validated summary sheet for admixture type tests [EN 934]

Product number	Name of the admixture manufacturer	
Reference Number for the summary sheet	Location of original Test sheets in admixture manufacturer's documentation system	
Laboratory reference number for the sample	Manufacturer's batch number of sample	Sampled by whom
Date and place of sampling	Location of original test sheets in The Concrete Producer's documentation system	
Sample storage details		

Test sheet reference no:	Date of test	Test std	Description	Required value or range	Test result	Pass/Fail

Admixture chemical type	
Dosage limits	

Declaration by The The Admixture Manufacturer: I have checked and verify the accuracy of data entered in this document.. Signature…… Quality Manager's name:…… Dated……	Declaration by The Independent Laboratory: We confirm that the above is a true extract from the Test Result Sheets issued by us. Signature…… Quality Manager's name: …… Dated ……	[Seal of the independent laboratory]

APPENDIX 501.9
Summary sheet for manufacturer's routine admixture tests

MUSCAT MUNICIPALITY
Summary sheet for manufacturer's routine admixture tests

ABC Admixture Company

Summary sheet for manufacturers routine admixture tests

Product number	Name of the admixture	
Reference number for the summary sheet	Location of original test sheets in admixture manufacturer's documentation system	
Laboratory reference number for the sample	Manufacturer's batch number of sample	Sampled by whom
Date and place of sampling	Sample storage details	

Test sheet reference no:	Date of test	Test std	Description	Required value or range	Test result	Pass/ Fail
Admixture chemical						
Dosage limits						

Declaration by The Quality Manager: I have checked and verify the accuracy of the data entered in this document.. Signature…… …… Quality Manager's name:…… Dated…… ……	Declaration by The Technical Manager: I confirm that the above is a true extract from The Test Result Sheets. Signature…… …… Technical Manager's name: …… Dated …… ……	[Seal of the admixture manufacturer's laboratory]

APPENDIX 501.10
Concrete placement report sheet

CONCRETE PLACEMENT REPORT [Use one sheet for each mix design and for each Producer]					
Project Name and Description		Description of structure		Contract No:	

		CONCRETE PROPERTY		DESIGN REQUIREMENTS	TRIAL MIX RESULTS	TARGET MEAN
Concrete producer		28 day strength	N/mm^2			
Testing laboratory		28 day density	kg/m^3	min.		
Consultant		28 day ASTM 1202 value	C	max		
Contractor		28 day DIN 1048 or BS EN 12390-8	mm	max.		
Sub-contractor [if any]						

Casting ID			Concrete data				Site cube details			7 day compression test				28 day compression test					ASTM C 1202 Test					DIN 1048 or BS EN 12390-8 test			
Placement No:	Date of casting	Location Drawing Ref.	Volume of concrete	Placement slump	Ambient ^0C	Concrete ^0C	No cubes cast	Cube ref No:	Lab Ref No:	Test date	Density kg/m^3	Strength N/mm^2	Average Strength	Lab Cube No:	Test date	Density kg/m^3	Strength N/mm^2	Average Strength	Lab specimen No:	Test date	Result [C]	Chloride profile	Sulphate profile	Lab specimen No:	Test date	Depth mm	Average Depth

Section 503: Formwork for Concrete

FORMWORK FOR CONCRETE AND CONCRETE PRODUCTS

1. DESIGN REQUIREMENTS

Forms and moulds shall be designed to

- withstand the maximum lateral pressure exerted on the formwork during forming of fresh concrete with a safety margin: the lateral pressure includes the hydrostatic pressure, vibrations transmitted during compaction and from the environment, temperature induced forces and other dynamic forces induced during placement till final set.
- maintain the position, geometry and dimensions of the concrete structure to be formed as designed
- to be impermeable
- reproduce the cast shape, texture, patterns and dimensioned structure as described in the specification and/or shown in the drawings and within the tolerances specified

The design of the formwork shall include considerations of the following factors:

a. Vertical loads – dead and dynamic
b. Height
c. Rate of pour
d. Placement temperature
e. Increases in temperature of the placement up to removal or easing of the form
f. Ambient temperature
g. Rheology of the concrete
h. Features of the concrete mix
i. Wind load
j. Placement impact forces
k. Unit stress
l. Rigidity and stability
m. Safety factors
n. Safe working platforms

The Contractor may use the formulae contained in Ciria report 108: ‘Concrete Pressure on Formwork’ as a template for calculations).

2. SUBMITTAL REQUIREMENTS

The Contractor shall provide a single comprehensive submission for formwork or moulds for each placement that includes comprehensive details of:

a. Materials of the form, formwork accessories and items to be embedded
b. plan and elevation detailed scaled drawings and calculations
c. Position of embedded items
d. Restraints such as shoring, ties, props and braces
e. Formwork accessories including clamps, release agent
f. safe working platforms for erection of the formwork and ensuing concrete works with safe load calculations and the appropriate warning signage
g. Method for forming architectural recesses, embossments, motifs or patterns, if applicable
h. Measures to be undertaken to ensure safety to site personnel, the public and their property
i. Poker or bar vibrators
j. Fixed vibrators and their positions, where applicable
k. Location of construction, contraction and expansion joints
l. Lift size or rate of continuous pour
m. Pre-erection preparation such as preparation of substrates of previous concrete and construction of the reinforcement cage
n. Repair compounds
o. Samples, where appropriate
p. The Contractors technical audit report on the capabilities of his erection sub-contractor, if applicable.

Additional provision for post tensioned structures
Details and location of post tensioned tendon conduits

3. GENERAL PROVISIONS

a. The Contractor shall submit materials, methods of construction and recommendations provided by a knowledgeable manufacturer.
b. Formwork construction shall be such that the cover to the cured concrete is maintained throughout the structure.
c. Forms shall be erected as per the approved submission.
d. Forms shall be stiff and stable and shall not be displaced or deflect during the concrete forming process. If a deflection is expected to take place the construction dimensions of the form in its free state shall be adjusted accordingly.
e. Forms shall be water tight so as not to allow loss of water by evaporation at the joints or leak mortar during placement of the concrete. Tapes and form joint compounds shall not cause marks or become embedded in the concrete cast.
f. Form restraints shall be stiff, rigidly anchored and not deflect or be displaced during placement
g. When a single form is assembled from more than one section, the jointing edges shall be of a tight fit without any gaps. All joints shall be sealed externally with a strong reinforced aluminised duct tape applied on to a clean adherent surface.
h. Each and every concrete spacer shall be abutted tightly against the form's internal surface.
i. All items to be embedded shall be placed accurately and prevented from being displaced during placement of the concrete.
j. Forms and moulds that are reused shall be free of damage. Previous concrete stains and adherents shall be thoroughly cleaned off using a 5% dilute solution of acetic acid (vinegar) or citric acid. The acids shall be hosed off with copious amounts of water using a hose. The cleaning of forms shall be conducted in an isolated area of the site. Cleaning shall not be conducted in or near the placement area or where construction is to occur.
k. Working platforms shall not be connected to the form unless it has been included in the design calculations. Working platforms shall be fitted with suitable rails and access. Platforms shall not be overloaded. The safe load limit for the working platform shall be calculated and clearly signposted at site.
l. Form designs for underwater concreting shall take into consideration, additional forces and behaviour such as extra load forces, bouyancy and stability.
m. Pouring shall take into effect the impact on the form during discharge. Suitable methods for discharge shall be selected to minimize the impact forces on the form.

4. TYPES OF FORMS

4.1. Temporary forms and moulds

Temporary forms and moulds may be constructed with metal, marine grade coated plywood, stiffened GRP and stiffened GRC.

4.2. Permanent forms

Permanent forms may be constructed with steel profile sheets, precast steel reinforced concrete planks or shapes, steel stiffened GRP and steel reinforced GRC.
De-bonding and separation of the permanent form from the composite structure shall not occur throughout the life of the structure.
All permanent forms immersed in seawater shall be protected against the ingress of marine tubing mollusks and marine fouling of the surface.
Limestone aggregates shall not be used in concrete forms submerged in the tidal zone.

4.3. Other types of forms

Details and methods of construction of special cases of formwork that are not covered by the specification, such as caissons and coffer dams shall be provided by The Contractor.

4.4. Additional provisions for bridges

Steel, GRC and GRP permanent formwork shall not be used in bridge construction.
Permanent formwork for bridges shall comply with the requirements of BS 5400 Part 5 as modified by the requirements of the project specification.
The permanent formwork shall be incorporated into the in situ cast concrete to form a composite integral unit by means of steel shear connectors.
Crack widths under exposure conditions shall not exceed 0.25 mm as provided in BS 5400 : Part 4.

5. FORM MATERIALS

5. 1 Marine grade plywood
Wooden forms shall be made from marine grade plywood with a suitable surface coating that is impermeable to water. Forms shall not swell or contort on exposure to high humidity or when the forming surface is exposed to wet concrete.

5. 2 GRC and GRP forms
GRC and GRP shall not be used below ground level or in damp or wet conditions unless extra protection is provided against wicking expansion.
Multi-skinned GRC form panels shall not be used.

5. 3 Steel forms
Steel forms shall be adequately protected against corrosion by a combination of hot dip galvanizing to BS EN ISO 1460 and a marine grade coating on the side exposed to the environment.
Shear connectors shall not be indented in the troughs of the profile.

5. 4 Steel reinforcements and stiffeners in forms
Welded reinforcements in precast concrete planks and shapes shall not fail under static or dynamic loading of forces experienced in its location in the structure.
All surfaces except for the in-situ concrete bonding surface shall be coated with the specified concrete coating system.
Reinforcing metal stiffeners in GRP shall be protected from corrosion by galvanizing to BS EN ISO 1460 and a suitable coating appropriate to the environment.
Reinforcements in GRC and precast concrete shall be protected from corrosion in the form of durable concrete with a ASTM C 1202 permeability of less the 2000 C with the addition of coatings selected for its protection capabilities in the exposure environment. In severe, buried or submerged environments, protection such as torch on tanking membranes, impermeable sleeves or chemically resistant coatings shall be appropriately selected.

6. FORMWORK ACCESSORIES

6.1. Form hangers
Form hangers shall be preformed in a factory.

6.2. Tie rods
Upon removal of the form, tie rods shall not reduce the cover to any part of the concrete structure or form capillaries or holes from the external surface into the cured structure.

Tie rods shall made of steel or plastic with fixed or adjustable lengths provided by a competent manufacturer. Ends of tie rods shall be removable at least to the cover depth. Cone ended tie rods shall be used if shown in the drawings. Through tie rods secured with end grip bolts shall not be used. Cavities formed by the tie rods shall be repaired using a proprietary cementatious material of at least the same strength and permeability as the parent concrete. Repair materials shall form a permanent bond to the parent material. The bonding area shall be appropriately prepared.

6.3. Form release agent
Release agents shall be a proprietary material that will not stain concrete surfaces or contain materials that inhibit the hardening of fresh concrete. Form release agents shall be spayed evenly on to the concrete form before erection.

6.4. Chamfers
All internal and external corners of the concrete structure shall be cast with a chamfered edge. Roughly 12 mm x 12 mm triangular fillets of planed wood shall be fixed securely to the forms to create the external chamfers. The corners abutting internal angles shall be planed off to the correct dimensions. Larger chamfers may be used if indicated in the drawing.

6.5. Nails
Nails and fixings for fastening forms and moulds shall not become embedded in the cured concrete.

6.6. Formwork restraints - clamps, straps, props, braces and other accessories

All restraints shall be stiff and not deformable under the stress encountered in the placement. Both ends of the restraint shall be suitably anchored and shall be immoveable. Restraints shall not be placed directly on soil without using load spreader plates. Wooden restraints without knots and splits shall be at least 100mmx100mm in cross section. Restraints shall not be point anchored directly to formwork by means of nails or screws. Restraints may be fixed to the formwork by use of suitable spreader cleats secured to the formwork.

6.7. Boxed cut outs

Boxed cut outs shall be accurately dimensioned, joints sealed to prevent leakage of mortar and supported properly and adequately. Supports of a temporary nature shall not be embedded in the cured concrete.

6.8. Dove tailed anchor slots

Dovetailed anchor slots shall be made from galvanized steel. Any fillings shall be made of foam material. Sealed slots shall have a release tape.

7. PERMANENTLY EMBEDDED MATERIALS IN FORMWORK

7.1. Water stops

Water stops shall be made of ribbed PVC or neoprene and have the attributes specified in Table 503.1. Only water stops from a single supplier shall be incorporated into a single structure. All welding of intersections, joints and straight runs shall be performed at the supplier's factory. Welds shall not be formed at the construction site. Welds shall be set away from any expansion, contraction and construction joints at a minimum distance of 300 mm. Water stops shall be fixed such that it will not be displaced by the ensuing construction processes.

Table 503.1. Water stop specification

	Properties and Attributes	Units	Limits	Values
01	Tensile strength	N/mm^2	min	14
02	Ultimate elongation	%	min	450
03	Unwired web thickness	mm	min	10
04	Wired web thickness	mm	min	4
05	Width	mm	max	230

7.2. Pipes, ducts and conduits

Pipes, duct and conduits shall be suitably placed, supported adequately, protected from damage, displacement and unacceptable deflections that might occur during the placement process. Supports shall be of a material that is approved by the Engineer. Electrical, electronic and communication conductors shall not be placed directly in contact with concrete.

7.3. Anchor bolts

Anchor bolts shall be placed accurately in location and depth, placed perpendicular to the plane of the cross section and the projecting threads from the concrete shall be protected from damage by sleeving it with a thick aluminized duct tape. The bolts shall be restrained sufficiently so as not to be displaced during concreting.

7.4. Structures of existing services to be buried in the placement

Existing services that are to be embedded in the placement shall be protected from displacement or damage during the construction and placement processes. Any inherent and existing damage or deterioration discovered at the time of exposure of the existing structure shall be reported to the Engineer who will then sanction repair or additional cautionary measures to be taken. The Contractor shall be solely and entirely responsible for any ensuing liability if any damage to the existing structure was not reported in a timely manner and is found after a construction process, irrespective of whether he was responsible for the damage or not.

7.5. Cleanliness within the concrete forming volume

Debris, dirt and contamination shall be cleaned from the forming surfaces before erection of the formwork. The floor of the formwork shall be cleaned by vacuum suction before the concrete is placed. Water or

compressed air may be used for cleaning if the form is fitted with removable cleanout ports. Under no circumstances shall compressed air or water be where such actions merely redistributes debris within the forming volume.

8. OTHER REQUIREMENTS

8.1. Storage and handling

Forms, accessories and materials to be embedded shall be stored appropriately and neatly so as not to cause damage, deterioration or a safety hazard. Where relevant the approved manufacturer's instructions shall be followed.

8.2. Partial assessment of contractor's ability

The Contractor shall demonstrate his ability to construct forms to the approved quality and workmanship described in the approved submission and the specification in the creation of a dummy form for the concrete trial.

8.3. Removal of temporary formwork and moulds

Impermeable formwork may be left in place during the wet curing period to prevent evaporation of the water from the concrete. Formwork shall not be loosened or dismantled without the Engineer's consent. The removal times stated in Table 503.2 for in-situ cast concrete shall be adhered to.

Table 503.2. Minimum times for form removal after concrete placement

	Type of placement	Elapsed time
01	Slabs on grade, sides of beams, columns and walls	48 hours
02	Slab and beam soffits	10 days

Forms shall be loosened carefully from the formed structure. Wedges, pry hammers or tools shall not be used in a manner that causes damage to the formed structure.

8.4. Workmanship and Quality

The Contractor's Quality Technician shall perform continuous and vigilant audits throughout the form construction process on the workmanship and quality that includes the following: -

a. Conformity to approved submission, international standards, professional practice, industry standards, the specification and the Clients Directive
b. Dimensional accuracy
c. Trueness of shape
d. Fit of joints, items to be embedded, restraints
e. Craftsmanship
f. Rigidity and stability
g. Neatness
h. Cleanliness
i. Fitness for purpose
j. Free of defects
k. Tidiness

The Engineer shall inspect, verify and report.

8.5. As built drawings

The as built drawings shall show accurately all the elements of the formwork, the location of the embedded materials and any existing services contained in the placement. The as built drawings shall cross reference the drawing to the approved submittal document.

Section 504: Environmental Protection and Health and Safety

01. Legislation already in existence

The Contractor and his sub-contractors shall comply with the Laws and Regulations, local bye-laws and orders in existence in The Sultanate of Oman pertaining to The Environment and Occupational Health and Safety.

02. Control of pollutants and hazards arising from The Concrete Industry

The Environmental clauses contained in this Section is confined to areas highlighting the dangers of pollutants and hazards created by the concrete industry and likely to cause a threat to the environment or endanger a person's health and safety. The Producer shall be guided by existing and relevant legislation and specialist know how governing these matters.

a. Dust control – Cement and Supplementary Mineral Additives

Cement dust is considered a hazard due to it's highly caustic nature. Dust seals and filters shall be installed in cement and supplementary mineral silos and weigh hoppers to prevent the the material from causing a dust nuisance and a hazard. All conveying equipment such as pipes and screw conveyors shall be enclosed and leakfree. The plant premises shall be cleaned and washed frequently to remove the accumulation of cement and other dust.

b. Dust control – Aggregate quarries and sand washing plants

Dust generated from aggregate producing plants shall be prevented from escaping into the atmosphere or from spreading into the crusher or aggregate processing worksite. Dust shall be contained, siphoned off into dust control units and collected for safe disposal.

c. Liquid waste

The wash water from cleaning trucks, mixers equipment and chemical tanks shall be collected in purpose built water tight containers, treated and disposed off using established procedures for handling Industrial waste. Concrete wash water, oils, solvents, admixtures, highly alkaline material and other liquid industrial wastes shall not be channeled into drains or pipelines connected to the arterial storm or sewage system of the Sultanate. Water drained from aggregate stocks shall be channelled into proper drains leading to purpose built soakaways.

d. Noise pollution

The Contractor and his sub-contractor shall limit the production of noise nuisance to levels limited by current legislation.

e. Spillage

Trucks delivering concrete shall not exceed the drum loading limits specified in the specification. Spillage of concrete from the drum shall not occur on public roads, pavements and on private property.

Trucks, handling equipment and general machinery shall be properly maintained so as not to leak oil, water and hydraulic fluids.

f. Personnel protection

Employees shall be provided with safety overalls, ear protectors, eye glasses and safety shoes.

Employees known to come into skin contact with fresh concrete shall be protected with barrier creams and protective gear. Safety showers and wash basins shall be installed within easy access to provide emergency washing facilities in the event of concrete or chemical spillages on a person.

g. Access ladders

Safe access ladders shall be provided to enable safe entry and exits to work locations.

h. Safe working platforms

Employees shall be provided with safe working platforms at work locations.

i. Concrete pumps

Concrete pump components and attachments shall be inspected and maintained at frequent intervals to ensure that catastrophic fractures and detachments do not occur during its working cycle. The pump shall be safely anchored on a sound substrate during its working mode.

j. Industrial machinery operators

Operators of heavy industrial equipments shall be adequately trained. They shall hold licenses when it is so required.

k. Warning and prohibitory signage

Warning signs shall be erected to inform workmen and members of the public of the dangers at the production locations and the worksite. Prohibitory signs, fences and security gates shall be erected to prevent members of the public from unescorted access to worksites. Signs must be clear, readable and legible at all hours of the day and in appropriate different languages.

SECTION 6

METAL WORK AND OTHER FITTINGS

6.1 GENERAL

6.1.1 Scope of Work

The work included in this Section consists of the furnishing of all labour, materials, apparatus, and appurtenances for work in connection with metal work and other fittings in accordance with this Specification.

The work includes, but is not limited to, the following:

- Ladders
- Handrailing
- Staircase
- Chequered plate and open mesh flooring
- Wall louvers and screens
- Step irons
- Anchors and other appurtenances
- Duct covers
- Roof and floor access hatches
- Chainlink fencing
- Any other work shown on the Drawings herein specified.

The following materials shall be isolated from each other by bitumen felt, flexible PVC strips, mastic tape, or neoprene gaskets as directed by the Engineer.

- Galvanized steel and stainless steel
- Galvanized steel and aluminium
- Aluminium and concrete.

6.1.2 Submittals

Shop drawings shall be submitted by the Contractor for approval before fabrication of any work. Shop drawings shall be based on plans, specification, and field measurements, and shall present complete information as to fabrication, installation and proper fitting with other construction. All welds, fabrication and finish details, and shop painting shall be shown on the shop drawings. The Contractor shall also submit for approval of the Engineer, complete detail of any information not shown on the Drawings but required in connection with the completeness of the work. Approval by the Engineer shall in no way relieve the Contractor of his responsibilities under the Contract.

6.1.3 Coordination

Work of this Section shall be fully coordinated with work of other trades. Particular attention is required for items to be embedded in concrete and masonry.

6.2 MATERIALS FOR STEEL WORK

6.2.1 General

The materials shall be new, sound and shall conform to the applicable standard given below.

6.2.2 Steel

Structural steel for structural sections and bars shall comply with the requirements of BS 7668, BSEN 10029, BSEN 10113 (parts I to 3), BSEN 10025, BSEN 10137, BSEN 10155 and BSEN 10210-1 in regard to manufacture, chemical composition, quality, rolling margins, weight, test requirements and marking. The dimensions tolerances and properties of hot rolled steel sections shall comply with the requirements of BS 4 Part 1, BSEN 10210-2, BSEN 10056-1 and BSEN 10067.

Grade 43A steel shall be used. All steelwork including angles, channels, flat bars, gratings, fishtails and the like shall be hot dipped galvanised after manufacture in accordance with BS 729.

6.2.3 Bolts and Nuts

Standard commercial quality steel units conforming to ASTM A307 shall be used. These units shall be galvanized when used with galvanized work.

6.2.4 Steel Pipe

Steel pipe shall conform to ASTM A53, Grade B, standard weight and shall be galvanized as required.

6.2.5 Ductile Iron Castings

These shall conform to ASTM A536 Grade 80-55-06 except as otherwise designated.

6.2.6 Stainless Steel

Stainless steel shall conform to ASTM A167 and ASTM A276 and unless otherwise specified, the alloy types shall be as follows:

a) Plates and basin dry locations -Type 316

b) Plates and basin wet or humid locations -Type 317L

c) Anchor bolts -Type 316.

All stainless steel that requires welding shall be the low carbon ‘L’ grade.

Fabrication shall be performed in an establishment that has all the required machinery and skilled personnel for the processes involved including finishing equipment required for producing work to the required finish. For example rough hand grinding to produce straight edge sections will not be allowed. Chamfers,

countersinks, deburring shall be performed using proper machine and tools to obtain the machine shop finish.

The fabrication establishment shall have a technical quality system and maintain detailed traceable records of the processes and quality inspections conducted.

All carbon steel items shall be coated with the appropriate coating system after galvanizing as indicated in Section 7.

6.2.7 Galvanizing

a) Iron and Steel

Galvanizing shall be done in accordance with ASTM AI23 with an average coating weight of 600 g/sq m and not less than 560 g/sq m.

b) Ferrous Metal Hardware Items

These shall be galvanized in accordance with ASTM A153 with an average coating weight of 400 g/sq m.

c) Touch-up Material for Galvanized Coatings

Galvanized coatings marred or damaged during erection or fabrication shall be repaired in accordance with the coating manufacturer's instructions.

6.2.8 Welding Electrodes

Welding electrodes shall be suitable for intended use.

6.3 MATERIALS FOR ALUMINIUM WORK

All aluminium alloys shall be selected as having properties appropriate to the particular application, method of fabrication and environmental and physical conditions.

All aluminium plate, pipe and structural shapes shall conform to ASTM B209, B221 and/or B308 for 6061-T6 alloy unless otherwise specified. All aluminium items embedded in concrete shall have one coat of zinc chromate primer. Where aluminium surfaces are in contact with concrete surfaces or with dissimilar metals PVC gaskets are to be used to isolate the aluminium. All aluminium shall be anodized after fabrication.

6.4 DESIGN OF STRUCTURAL STEEL WORK

All design shall be in full accordance with BS 5950. Two sets of design calculations shall be provided by the Contractor to the Engineer for approval prior to commencing any of the associated works. Approval by the Engineer shall in no way relieve the Contractor of his responsibilities under the Contract. All calculations shall be presented on calculations sheets. Completion of each sheet shall show, sheet numbers, identify the section of the design, design data, initials of the designer and checker.

The calculations presented for approval shall include:

- Index of calculations
- Design assumptions
- Reference to British Standards and Codes of Practice used in the design
- Reference to other documents on which design is based
- Full description of any computer software used including explanation on any computer input/output supplied with the calculations
- Design summary (simple diagram should be included).

Fabrication and erection drawings shall be made in accordance with BS 1192. The Contractor shall prepare workshop drawings incorporating sufficient information for the proper fabrication of the steelwork and cladding support steelwork together with marking drawings for erection purpose and all drawings necessary for setting out pockets and anchorage materials (including holding down bolts) to suit the steelwork. Copies of all detailed working drawings prepared by or on behalf of the Contractor shall be submitted to the Engineer for approval but the approval shall in no way relieve the Contractor of his responsibilities under the Contract.

The Contractor shall supply the Engineer with the relevant manufacturer's certificate for every load or batch of structural steel sections delivered to the site. The certificate shall state the process of manufacture and a test sheet giving mechanical test results on the steel and the chemical composition of the steel. Each certificate shall be signed by the manufacturer.

Clearances, cutting, holding, assembly, bolting, welding, machining, marking and painting shall also be carried out in accordance with the requirements of BS 5950. Any prefabricated units may be rejected on arrival at the site should they not comply with the approved drawing or should they not be in accordance with the above-mentioned standard in any respect.

All work on site in connection with the erection of steelwork including plant, equipment, storage, handling, setting out, security during erection, painting after erection, bedding of bases and encasing and bearing of beams and girders shall comply with the requirements of BS 5950.

6.5 FABRICATION AND ERECTION OF METAL WORK

6.5.1 General

Welding of all steel shall be carried out to the appropriate standards and codes of practice.

All assemblies shall be marked at the factory with distinguishing numbers, letters or marks corresponding to those on approved shop drawings or parts lists. Such marks if impressed before painting shall be clearly readable afterwards. Any temporary bolts for field erection shall be readily distinguishable from any bolts used for permanent connections.

The fabrication of stainless steel requires additional care and caution. Stainless steel shall be fabricated in an area free from iron or iron oxide contamination. Tools used in fabrication including measuring and marking instruments, cutting, guillotining, drilling, rolling, shaping, profiling, machining, turning, grinding and

finishing machines shall be iron free. Flame cutting shall be conducted with pencil thin plasma flame cutters on an automatic rail. Polishing shall be conducted using proper tools. The surfaces of finished stainless steel shall at least be finished to the original mill finish of the stock used.

Welded stainless steel when necessary shall be heat treated well below its softening point to decarburize and cause re-precipitation on the weld depletion area. Large items shall be heat treated using heater mats. Stainless steel shall not be heat treated at its solution temperature unless exceptional expertise exists in the establishment.

Stainless steel shall be pickled and passivated as stipulated in Section 7.

Where dissimilar materials come into contact with each other an insulating membrane or paint coating shall be applied to minimise direct contact.

6.5.2 Welding

Before fabrication, all steel shall be thoroughly wire brushed, clean of all scale and rust, and thoroughly straightened by approved methods that will not injure the materials being worked on. Welding shall be continuous along the entire line of contact except where tack or intermittent welding is permitted. Where exposed, welds shall be cleaned of flux and ground smooth. Welding shall be performed by experienced tradesmen, and made with specific electrodes or submerged arc Grade SA W-2.

6.5.3 Anchor Bolts

All anchor bolts shall be of stainless steel, and fabricated as shown, or as specified by the equipment manufacturer. Suitable expansion bolts may be used in lieu of anchor bolts at certain locations. It shall be the responsibility of the Contractor to request the substitution and obtain the Engineer's approval regarding type and location of expansion bolts proposed to be used before pouring concrete. Suitable insulating sleeves and washers shall be provided as necessary.

6.5.4 Galvanizing

Unless otherwise specified or designated, all ferrous metals shall be galvanized in conformance with referenced standards according to the nature of the work. The Contractor shall repair galvanized coatings marred or damaged during erection or fabrication using the specified touch-up material.

6.5.5 Shop Painting

Before leaving the shop all steel not shown or specified to be galvanized shall be given one coat of primer as specified in Section 7. Final painting shall be as specified in Section 7. That portion of steel to be embedded in concrete or masonry shall not be painted.

6.5.6 Steel Gratings and Racks

Gratings shall be welded, rectangular opening type, galvanized bar gratings with seat angles, anchors and supports of galvanized steel. All grating up to and including 1 m shall be furnished in pieces approximately 1 m in width and all

gratings for spans greater than 1 m shall be furnished in pieces approximately 0.8 m in width. All openings required in gratings shall be banded where openings are provided and shall be strengthened as necessary. Installed units shall be true to plane and free of warpage and irregularities. Units shall be divided for ease of installation and removal, using the following minimum size to span ratios unless otherwise shown on the Drawings.

Max Span (m)	Bearing Bar Size (mm)	Seat Angle (mm)	Shelf Angle (mm)	Bolt for Shelf Angle (mm)
1.2	25 x 3	45 x 45 x 6	75 x 50 x 6	15 @ 900
1.5	30 x 3	65 x 50 x 6	75 x 50 x 6	15 @ 750
1.8	40 x 3	75 x 50 x 8	75 x 50 x 6	15 @ 600
2.1	45 x 5	70 x 70 x l0	70 x 70 x 6	20 @ 600
2.2	50 x 5	70 x 70 x 10	70 x 70 x 6	20 @ 600

6.5.7 Steel Ladders

Ladders shall be as detailed on the Drawings. Where access ladders are provided as part of a structural steelwork installation they shall comply with BS 4211 and BS 5395: Part 3.

Stringers shall be flats minimum size 50 mm by 16 mm and solid rungs minimum 20 mm diameter. Rungs shall be at 250 mm centres, minimum 400 mm wide between stringers and minimum 200 mm from adjacent walls. Fixing brackets shall be at maximum 2000 mm centres. The rungs shall pass through and be welded to the stringers at each side of each stringer, and each weld shall be continuous. Supports shall be arranged to allow a minimum clearance of 230 mm behind the rungs to the wall or other obstruction. Each rung shall be capable of withstanding a point load of 5000 N applied at the centre of the rung and close to one end.

When supported horizontally over a span on 1.0 m with the climbing face uppermost and with a load of 1000 N applied at the centre of the span, the ladder shall not deflect more than 15 mm at the point of application of the load and shall show no permanent deflection after removal of the load. Each ladder fixing shall be capable of withstanding shear and pull-out loads of 5000 N.

Safety cages shall be provided where indicated or where the distance between landings exceeds 3500 mm. These shall be constructed on three vertical flats, minimum size 50 mm by 8 mm supported by flat hoops with a diameter of 750 mm. The hoops shall be at a maximum of 900 mm centres and the first hoop shall be 2400 mm above lowest platform level. No single hoops shall be used.

Ship type ladders shall comply with BS 5395 Part 3.

All welds shall be ground flush and smoothed and ladders hot-dip galvanized after fabrication. Connections to concrete or masonry walls shall be secure with

accurately positioned stainless steel anchor bolts. Ladders shall be mounted to produce a finished appearance that is plumb, straight and true to dimensions.

6.5.8 Steel Handrailing

Handrailing shall be in accordance with BS 6180. Unless otherwise shown on the Drawings or specified, handrailing shall be double rail 1100 mm high, and 900 mm high on stairs measured vertically from the nose of the tread. Handrails shall be 33.7 mm x 3.2 mm thick tubular steel to BS 6323 Grade 13. Joints shall be arranged to coincide with the spacing of stanchions where possible, otherwise they shall have butt joints with a tubular steel ferrule, plug welded or fixed with a 5 mm diameter countersunk head pin. Removable sections of handrail shall have half-lap joints secured with a countersunk head pin.

Handrailing shall be designed for a horizontal loading of 740 kN/m at the level of the top rail. The railing shall be mounted also as to produce a finished appearance that is plumb, straight, and true to dimension, free from kinks, twists, and abrasions. Curves, where indicated or necessary, shall be bent to a radius of not less than 100 mm.

Where shown or required, removable sections and toe plates shall be provided. Toe plates shall be fitted along the outer edges of all walkways and shall be part of the structure and not the floor panels. Toe plates shall extend 100 mm above the top level of the floor panels. Welds shall be ground flush and smooth and all components hot-dip galvanized after fabrication. Sleeves shall be provided for setting by other trades where embedded.

Unless otherwise shown on the Drawings or specified, stanchions shall be 38 mm diameter solid forged steel to BS 7668 grade 43A with 70 mm diameter solid forged steel balls at handrail locating points drilled to give 1.5 mm clearance to handrails. Each ball shall incorporate a concealed grub-screw with Allen-type head to secure the rail. Stanchions shall have a minimum base width of 60 mm, drilled for M 16 fixing bolts and be set at maximum 1800 mm centres (I000 mm on bends or changes of direction).

Stanchions on steel stringers shall have base plates or angles welded to bottom of pipe and bolted to stringer as detailed. Connections to concrete or masonry wall surfaces shall be secure with accurately positioned stainless steel type 316 anchor bolts, or with cinch anchors and bolts. Safety chains shall be installed across openings and shall be 12 mm diameter short link alloy steel grade 60 to BS 3113 and galvanized to BS 729 with eyebolt and harness type snap attachments.

Aluminium alloy handrailing may be offered as an alternative, manufactured in accordance with BSEN 485, BSEN 515 and BSEN 573. Where aluminium alloy handrailing is provided this shall be polished after manufacture is complete.

6.5.9 Steel Staircase Assemblies

Staircase assemblies shall be constructed to the overall sizes detailed on the Drawings and shall be manufactured of galvanized steel. Landings shall also have steel grating flooring. Staircases shall be complete with galvanized mild steel handrailing.

Where steel walkways, stairways, platforms, landings, and the like are shown on the Drawings or are billed in the Bill of Quantities without the precise details of construction, they are to be designed by the Contractor and the drawings submitted to the Engineer for approval before manufacture is commenced.

Floor panels shall be chequer plate (galvanized mild steel) or of galvanized steel open mesh, as specified, of adequate thickness, fixed, supported and stiffened as necessary. Floor panels shall be sized so that each panel does not weigh more than 50 kg. Structural members shall be designed in accordance with BSEN 10025. The whole structure, including floor panels, stairs, and the like shall be designed to carry the specified loading safely and without excessive deflection. The support structure shall be constructed so that it can be readily dismantled. Provisions shall be made in the design for adjustment to eliminate irregularities in structural floor levels.

The designs for the Engineer's approval shall include details of the fixing or building in methods proposed for adoption, using any of the methods permitted in this Specification, and the designer shall supply in good time before the construction requires full details of holes, pockets, and the like to be left in concrete for the later installation of the walkways and similar items.

All fixing bolts, nuts and the like shall be of stainless steel unless otherwise specified or approved by the Engineer.

Where aluminium floor panels are specified, these shall be insulated from supports and the like of other metals by the use of PVC or neoprene rubber gaskets, or similar. These shall be allowed for in the design and the Contract rates.

6.5.10 Steel Chequered Plate and Open Mesh Flooring

Open mesh decking shall be in accordance with BS 4592. The panels shall be constructed with bearer bars not less than 25 mm deep. Adjacent panels and panels at the same level shall span in the same direction and unless specifically required for frequent access, shall be secured together by stitching bolts with a minimum of two fixing clips when supported on structural steelwork.

Each panel shall be designed for a uniformly distributed load of 7 kN/sq m with a maximum deflection within 10 mm or 1/200th of the span whichever is the lesser.

Flooring shall be supplied in panel sizes suitable for removal by one man, and with appropriate cut-outs to permit its removal without disturbing any drive shafts, supporting brackets or pipework. Panels shall be supplied bound at the ends and shall have a plain top surface.

Steel chequered plate and open mesh flooring shall be mild steel to dimensions detailed. All holes shall be reinforced as necessary to support the service loads required. The plate thickness shall be measured excluding the pattern, which shall be raised self-draining non-slip pattern.

Thickness (mm)	Max. Span (mm)	Thickness (mm)	Max. Span (mm)
3	300	10	1000
5	450	13	1500
6	600	15	1750
8	750	20	2000

The raised lugs shall be diamond shaped and have an angled and opposed pattern. Lifting holes shall be provided in each plate and the Contractor shall provide two sets of lifting keys.

Mild steel flooring shall be hot dipped galvanized after fabrication.

GRP open mesh decking with a bonded grit surface satisfying the foregoing specification may be used in lieu of mild steel decking.

6.5.11 Mechanical Equipment Guards

All rotating belts, pulleys, and shafting shall be covered in conformance with applicable safety requirements or as directed by the Engineer.

6.5.12 Bar Gratings

Bar gratings, baffle braces support brackets, and angles shall be fabricated as shown on the plans, and shall be galvanized after fabrication.

6.5.13 Fixed Wall Louvers and Screens

Louver blades shall be formed of 18 gauge galvanized steel and set in formed frames and mullions as indicated on the Drawings. Louver frames shall be formed of 16 gauge galvanized steel and removable wire screen consisting of specified galvanized wire mesh attached to a formed metal frame. Stiffeners for screens shall be provided as required for louvers and attached to the inside of louvers.

6.5.14 Embedded Steel Channel and Angle Frames

Embedded steel channel and angle frames shall have continuously weld joints and exposed welds ground flush and hot-dip galvanized.

6.5.15 Fixings

a) General

All steel items though galvanized and painted to be in direct contact with a concrete surface shall be isolated with a strip of permanently tacky bitumen strip. All steel items that are fixed overlapped on to another steel item shall have a strip of permanently tacky bitumen strip in between the contact surfaces without forming a crevice.

Internally expanding type fixings shall not be used closer than 75 mm to edges of concrete, this dimension may be increased depending on the size and type of the fixing proposed. Holes shall be accurately drilled using sharp tools to the correct diameter and depth and after fixing the

remainder of the hole shall be sealed with an approved rubberised bitumen sealer or, if specified, cement/sand mortar.

The use of fixings of the type driven in by an explosive charge will not be permitted, either for permanent or temporary works.

The cost of all proprietary items, resin cartridges, nuts, bolts, washers and all other materials, plant, tools and labour involved in making fixings shall be included in the Contract rates.

b) Casting or Grouting into Concrete

Fittings such as ladders and handrails shall be fixed in one of the following three methods:

i) Held in exact position during concreting and cast in.

ii) A dovetailed hole boxed out during concreting, the fitting then held in exact position and grouted in, care being taken to ensure complete filling with grout. A riser shall be provided if considered necessary by the Engineer.

iii) A hole drilled into the concrete in a manner and with sharp tools to the approval of the Engineer and then as for (ii) above.

Methods (ii) and (iii) may only be used when the edge of the hole is more than 75 mm from the nearest concrete edge. The Contractor shall cover for all work necessary for the method he adopts in the Contract rates.

c) Fixings Using Epoxy Resin

Any fixing bolts, dowel bars, and the like fixed using epoxy resin shall be carried out using approved type/hardener cartridges, using in strict accordance with the manufacturer's recommendations.

Holes in the concrete shall be neatly drilled into the concrete using a diamond tipped or other sharp edged drill, holes shall be normally 5 mm to 10 mm greater in diameter than the bolts or dowel bars to be set in them, and shall be positioned accurately to within $\pm$ 5 mm.

The size or number of resin cartridges shall be determined based on the sizes of the hole and bolt or bar and the length of bond required for maximum strength. After installation and mixing the bolt or bar shall be supported in the precise position required until the resin has set.

6.5.16 Holding Down Bolts for Mechanical Equipment

Holding down bolts, base plates, nuts, washers, templates and packing required for the proper installation of the plant being supplied for mechanical equipment shall generally be supplied by and installed under the supervision of the equipment manufacturer.

Pockets for the holding down bolts shall be left by the Contractor in the correct positions, and shall be formed using expanded metal cylinders of 75 mm diameter left unfilled in the concrete floor, plinth or wall.

If the actual plant to be bolted down has been supplied before bolt holes are to be cast the Contractor shall measure the required dimensions or make templates from the plant itself, any discrepancies with the Drawings to be reported to the Engineer.

The Contractor shall recheck with the Engineer between one and three weeks before setting out holding down bolt holes that he has been supplied with up-to-date manufacturer's drawings showing the required dimensions. If there is any doubt as to the correctness of the dimensions supplied, on the Engineer's instructions the concrete shall be cast without holes that shall be drilled out later.

Seven days after the grouting of bolt holes the Contractor shall tighten the bolts and carry out a final alignment check. On receiving confirmation from the Engineer that the final alignment has been approved, the Contractor shall complete the grouting under the baseplates, ensuring that the grout completely fills the space and that it is thoroughly compacted and free from air pockets.

6.6 STEP IRONS

Step irons shall be 25 mm diameter PVC coated mild steel general purpose or precast concrete manhole pattern or moulded GRP with non-slip steps, 125 mm outstand from the wall and 150 mm wide as appropriate. They shall be provided in all chambers over 900 mm deep from the top of the cover slab to the base of the chamber.

Step irons shall be staggered 300 mm horizontally and spaced 225 mm vertically; they shall not be used for moving or lifting the precast rings or segments to which they are fixed.

6.7 DUCT COVERS

Duct covers shall be of cast iron to BS 1452 with concrete of approved grade infilling and unless otherwise specified, shall be capable of supporting a 5000 kg wheel load. The covers shall be single span, but multi-span with intermediate beams will be acceptable on larger openings subject to the Engineer’s approval. Duct covers and frames shall be continuous recessed and approved proprietary zinc coated. Stainless steel locking bolts shall be fitted. The covers and frames shall have edging strips and keyhole extensions of brass for floor finishes when provided in floors inside buildings.

A set of lifting keys shall be provided.

6.8 ROOF AND FLOOR ACCESS HATCHES

Roof and floor access hatches shall be of approved manufacturer and shall be suitable for mounting on a concrete slab. Access hatches shall be furnished and installed as shown on the. Locks, where required, shall match Employer’s standard locks. Drains shall be installed as required.

6.9 GRP FIXTURES

6.9.1 GRP Ladders

All GRP fixtures used on the works shall not be manufactured by the pultrusion process. GRP ladders shall be installed where indicated on the Drawings. GRP ladders shall have the same overall dimensions and design criteria as specified for steel ladders in this Section, except as modified hereunder.

GRP ladders and safety cages shall be fabricated from structural quality fibreglass shapes with chemical and ultraviolet resistance. Materials shall conform to the following:

a) Composition of glass reinforced plastic with a glass reinforcement content of 50% to 65%, and continuous glass strand mat type "E" or Advantex to BS 3496 and BS 3749. Stringers shall be minimum 50 mm x 50 mm x 4 mm square tube. Rungs shall be 25 mm diameter solid rod and top surface shall be provided with a non-slip grip surface. The structural components shall possess Class I fire retardant, with ASTM E84 flame spread rating of 25 maximum. Colour shall be safety yellow. Fibreglass components shall have a minimum ultimate tensile strength of 200 MPa; minimum ultimate compressive strength of 200 MPa; minimum modulus of elasticity 20.7 GPa; and a Barcol hardness of 50.

b) All cut or trimmed edges of the GRP ladder and braces shall be coated with a resin rich 2 mm thick layer consisting of an approved vinylester resin with at least two layers of "C" glass veil meeting 90 percent resin to 10 percent "C" glass veil ratio by weight.

c) GRP ladders shall be mechanically bonded into the concrete structure by means of suitable lugs or concrete anchors and also be bonded to the internal GRP lining of manhole and wet wells. The bonding lugs shall have a roughened surface to provide adequate bond with the concrete and shall project a minimum of 100 mm into the concrete.

6.9.2 GRP Handrailing

Materials for GRP handrailing shall be specified.

GRP handrailing shall be installed where indicated on the Drawings. Design shall conform to loading requirements of OSHA 1910.23 with a minimum factor of safety of 2 and capable of withstanding a concentrated load of 90 kg applied at any point non concurrently, vertically downward or horizontally or 740 N/m at the level of top rail, whichever is higher. Horizontal handrails shall be 1000 mm high with a 500 mm high intermediate rail.

Fixings used for anchoring GRP handrailing shall be approved stainless steel anchors. All fixing holes shall be grouted epoxy mortar and the exposed fixing material sealed with a coal tar epoxy or GRP coating as appropriate.

6.9.3 NOT USED

6.10 CHAINLINK FENCING

Security fencing shall be in accordance with BS 1722 Part 1. The chainlink fence system comprising fence and gates with barbed wire topping shall be as shown on the Drawings.

All tubes, pipes and rods shall be galvanised steel with epoxy polyurethane coated to 200 microns in green colour. Tubes shall be in accordance with BS 1387 medium grade. Wire shall be of galvanised steel wire with green PVC coating. All wire shall be to BS 4102.

Barbed wire shall be galvanised steel, double strand, each strand 2.5 mm diameter with 4 pointed 2.0 mm barbs interlocked at 85 mm at 7 mm pitch and integrally welded to fence posts. One strand of barbed wire shall be fixed at the bottom end of the fence mesh to posts.

Strainer posts shall be placed every 20 m of fence run and at corners and at ends. Strainer posts shall be provided with 2 brace supports boltable to main post through cleats and grouted into the ground at 45° to the vertical in the direction of fence run.

Single leaf for personnel access and double leaf for vehicle access gates shall be erected as shown on the Drawings.

The fencing shall be erected truly vertical.

The Contractor shall prepare and submit for approval of the Engineer complete shop drawings and details of the work not shown on the Drawings or specified elsewhere but required for completeness of the work.

END OF SECTION 6

SECTION 7

POLYMERIC COATING SYSTEM FOR STEEL, CONCRETE AND CEMENTATIOUS SURFACES AND METAL COATINGS FOR STEEL

7.1 POLYMERIC COATINGS – GENERAL REQUIREMENTS

7.1.1 Qualification of the Polymeric Coating Manufacturer

The coating system must be manufactured by a bonafide industrial paint manufacturer with professional R & D and batch testing facilities. The factory shall be equipped with the proper and appropriate equipment for manufacturing. The manufacturer shall have a knowledgeable and skilled coatings technician available at all times in Oman to service the Contractor when required. The Engineer reserves the right to inspect the manufacturer's factory if he deems it fit.

7.1.2 Polymeric Coating Properties

The coating system must be water and alkali resistant
The components of the system must have good adhesion to concrete and between inter-coats.

Pigments used in topcoat for daylight exposure must be resistant to substantial fading from UV light.
The Engineer shall select the colour.
Run down stains from mineral rich water [from condensation, water drips, rain and wash water] will occur. The topcoat must be washable. The topcoat must be resistant to acquiring permanent staining on its surface from such rundowns.
Where the coating is required in severe service conditions, long-term chemical resistance is required.

7.1.3 Service Life

The service life must be at least 10 years, within which time the coating system will not crack, contain permanent stains, de-bond or cause a major repair to the coating system. The service life does not include any surface repainting schedule recommended by the coating manufacturer or any damage caused by defects in the underlying concrete. The Contractor shall provide a warranty to satisfy the service life requirement. The paint manufacturer shall specify the period to first maintenance and what that maintenance should consist of.

The service life of solvent free epoxy or 40% glass filled vinyl ester shall be at least 30 years without maintenance. Colour changes and staining will be normal and expected.

7.1.4 General

The preparation application and conditions for work shall comply with the recommendations of BS-EN: ISO 12944-1-98 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.

Each coating system which includes anticorrosion primers, fillers, surfacers, undercoats, top coats and thinners shall be obtained from a single supplier.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use.

The temperature of the substrate should be minimum 10°C and minimum 3°C above the Dew Point of the air, temperature and relative humidity measured in the vicinity of the substrate. The substrate shall be grit blasted using the appropriate grit size to provide the blast profile recommended by the manufacturer for his system.

Test plates carrying finishes from the actual coating used may be required by the Engineer for inspection and test purposes.

To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white.

Priming to two mating surfaces shall be applied and cured prior to assembly.

All items of equipment shall be delivered to the site with the coating system that have been factory applied. All items for fabrication at site may be delivered to site with the complete coating system that has been factory applied or it may be delivered to site with the shop primer applied. After fabrication the item shall be fully coated with the system irrespective of the condition of delivery.

Colours of all paint finish-coats shall be as selected by the Engineer.

7.1.5 Submittals

The Contractor shall submit prior to any polymeric coating works, the following:

a) Coating Details from the Manufacturer:
   - i) A list of the items to be coated with the appropriate system
   - ii) The coating manufacturer's product data sheet and his recommended system
   - iii) The manufacturer's recommendations and for application including spray equipment and nozzle sizes
   - iv) The manufacturer's limitations on the ambient conditions for application
   - v) Details of the minimum and maximum WET and DFT for each coating in the system
   - vi) Details of the minimum and maximum intercoat times
   - vii) Colour card for the Engineer's selection

b) Details from the Specialist Applicator
   - i) Details of the specialist applicator
   - ii) Details of surface preparation including blasting medium type and size, blast profile to be attained and maximum time before coating
   - ii) A description of the blasting equipment and process method statement
   - iv) A description of the coating mixing equipment and mixing process method statement
   - v) A description of the application equipment, spare parts and process method statement
   - vi) Site temperature controlled storage facilities for the coating system

vii) Instruments for measuring ambient temperature and humidity and surface temperature of the steel
viii) Instruments and tools for measuring blast profile, wet and dry film thickness and detecting holidays
ix) Measures taken to prevent contamination of the applied coating in the wet state
x) If site applied, a description of protection and safe access and working platform provided for the workmen
xi) If site applied, a description of the measures taken to prevent nuisance and damage to members of the public from over spray, paint splatter and contact with wet paint
xii) Samples of site quality control and inspection sheets.

c) Contractor's Monitoring and QC
Details of the Contractor's overlay of QC and monitoring of the sub-contractor.

d) Samples
All samples shall be properly print labeled and adequately referenced
i) A 100 g sample of the blast medium
ii) A 100 x 75 mm steel panel with the blast profile
iii) A 200 x 300 mm stepped steel panel with the entire system applied by the applicator.

7.2 POLYMERIC COATING SYSTEMS FOR CARBON AND CAST STEEL

Preparation and finishes shall be in accordance with the following sub-clauses.

7.2.1 Surface Preparation

a) Steel
All steelwork including structural steel and steel doors and frames shall be prepared by blast cleaning in the Shop. Blast cleaning shall be to a visual standard in accordance with 1SO-8501-1 standard SA 2 at the time of painting.

Only dry abrasive blast cleaning techniques shall be employed. Abrasives shall be expendable garnet or hydro-garnet or re-usable iron and steel grit or shot. All surface defects, including cracks, surface laminations and deep pitting, likely to be detrimental to the protective painting system shall be removed as laid down in BS 7668. All fins at saw cuts, burrs, and sharp edges shall be similarly removed. Where extensive grinding has been necessary, the dressed areas shall be re-blasted to remove all rust and provide an adequate paint key.

After blast cleaning, before the surface has time to re-rust, and in any case within 4 hours of blast cleaning (2 hours for outdoor blast cleaning) the first coat of primer shall be applied.

Steel Structures 0.5 m Above Ground Level for Buildings in Non Condensing State

	System	**Film thickness (Mm DFT)**
1	Welding primer, if any welding is carried out	-
2	Solvent based two pack epoxy zinc rich primer (90 % minimum zinc content by volume to binder)	> 50 µ m
3	Solvent based shop primer if required [but not red oxide]	> 50 µ m
4	Solvent based surfacer as required	To manufacturer's spec
5	Solvent based marine grade coating micaceous iron oxide proprietary undercoat	> 50 µ m
6	2 coats two component polyurethane	> 50 µ m

Steel Structures Below + 0.5 m Ground Level for All Buildings

	System	Film thickness (Mm DFT)
1	Concrete encasement as per drawing - concrete to be of low permeability ASTM C 1202 at < 2000 Coulombs	-
2	Torch on waterproofing system below ground level to concrete surfaces	-

Ductile Iron Manhole Covers and Frames

	System	**Film thickness (Mm DFT)**
1	A two component solvent free based epoxy filler - knifed	-
2	Two coats of a two component solvent free epoxy-amine coating - roller or airless spray applied	Total > 500 µ m

7.3 METAL COATINGS FOR STEEL

a) Metal Sprayed Coatings to BS EN 22063 (Zinc)
The metal deposition shall be coated at once with two pack zinc chromate, etc. primer, and the first coat of the paint system shall be applied within l to 4 hours.

b) Galvanised Surfaces
Surfaces shall be lightly grit blasted using fine grit to provide a grease free surface with a suitable profile.

The cleaned and dried surfaces shall be prepared in accordance with the coating manufacturer's recommendations.

The clean dry surfaces shall then be primed with two pack zinc chromate etch primer followed by the first coat of the paint system within 1 to 4 hours.

c) Passivation Processes – Stainless Steel
All stainless steel items shall be pickled and passivated before installation. Pickling and passivation shall be carried out using proprietary chemical and method approved by the stainless steel manufacturer. Distilled iron

free water shall be used for washing processes in the method. Passivated items shall be packaged to prevent contact with iron containing items during transportation, handling and storage. Installation of passivated stainless steel shall be carried out using iron free tools and supports. In the event that iron contamination occurs the item shall be pickled and repassivated.

7.4 POLYMERIC COATINGS FOR CONCRETE AND CEMENTATIOUS SURFACES

7.4.8 Submittal

At least 45 days before commencing the works, the Contractor shall submit the following for approval:

a) Identification of the structure
b) Identify and provide details of the structure to be coated by way of plan and elevation drawings, map references, date of completion of casting of concrete and period of drying.

7.4.8 Information from the Coating Manufacturer

a) Identification, location and details of the coating manufacturer's factory including satisfaction of the qualifying requirements stipulated in this section
b) Location of the in-house research and development laboratory
c) Name and contact details of local technician
d) Product data sheets for each system
e) Sample of the manufacturer's inspection and quality control sheet
f) A statement from the manufacturer that the system meets all the requirements of the intended use and the specification
g) List of applications in the Middle East in which the same coating system was successfully applied and where it performed over the stipulated period under the same conditions of exposure
h) The manufacturer's recommendations on storage, handling, processing and application Health and safety data sheet to EU format.

7.4.8 Repair and Surface Preparation Materials

a) Identification of material providers such as cementatious repair mortars
b) Product data sheets
c) A statement from the manufacturer that the system meets all the requirements of the intended use and the specification
d) The manufacturer's recommendations on storage, handling, processing and application
e) Health and safety data sheet to EU format
f) A sample of the grit to be used in blasting.

7.4.8 Information from the Specialist Coatings Manufacturer

a) Identification and details of the specialist coatings contractor including satisfaction of the qualifying requirements stipulated in this section
b) A detailed method statement of the application process from substrate preparation to coating inclusive of the methods of application and quality control.

c) A list of tools and items required such as clean containers for mixing, filter arrangement for filtering the coating before application, lint free cloth,
d) A list of equipment that is required and possessed by the Contractor
e) A list of instruments such as thermometer, humidity meters, wet film thickness gauges, dry film thickness gauges suitable for non ferrous substrates and that are required and possessed by the Contractor
f) A sample of the Inspection and Quality Control documents to be used on site
g) Provisions for sheltering the freshly coated area from wind dust and other contamination
h) Details on how the Contractor will meet the requirements for workmanship, safety at work and safety to members of the public including details of safe access, working platforms, barriers, signs and containment of paint over spray and splatter
i) Exceptional Health and Safety measures regarding confined space entry and the provision of adequate ventilation in confined spaces especially when applying coatings that emit solvents and styrene during the wet state A sample of the system on a coated panel on a concrete flag no bigger than [300 x 300] mm. Samples must be step coated to show all the component layers including the substrate. Steps must not be smaller than 25 mm wide.

7.4.5 Contractor's Inspection and Monitoring Sheet

A sample of the Inspection and Quality Control documents for monitoring the purchases from the manufacturer and monitoring the sub-contractor

7.4.6 Dummy Trial

Before the Engineer approves the submission, trial applications shall be carried out on dummy panels at site utilising the exact processes, procedures, equipment and qualified personnel proposed in the submittal. Representatives of the coating manufacturer shall be present at the trials and monitor, correct and train if necessary and approve the trial if they are satisfied. The Contractor shall at his own expense coat as many panels as required by the Engineer until a satisfactory panel has been produced and accepted by the Engineer. The coated panel, when accepted will form the standard against which the corresponding coating in the works will be judged.

Application of the coating to the works shall not commence until the trials have been completed to the Manufacturer's and the Engineer's satisfaction.

7.4.7 Manufacturer's Responsibility

The Manufacturer shall have technical staff on the ground to train the Contractor's staff on all the processes required to achieve workmanship of the first order. The manufacturer shall ensure that he conducts random quality checks on the Contractor's work and workmanship and issue a certificate with comments if applicable and enclosing their QC worksheets.

7.4.8 Application and Site Processes

The applicator must be experienced in applying high performance coatings. He must have a seasoned and qualified crew.
The paint must be stored in the conditions recommended by the manufacturer.

The paint must be handled, processed and applied in the manner instructed by the manufacturer.
The Contractor shall diligently follow the manufacturers instructions.
The Engineer's approval must be obtained prior to applying the coating system in the works. Before approval is given the Engineer will need to be satisfied as to the following:

a) That all construction work in the immediate vicinity of the structure to be coated has been completed
b) That the whole of the structure can be coated in a continuous operation
c) That the weather conditions accord with the coating manufacturer's directions for coating application.

7.4.9 Substrate Preparation

The Contractor shall not proceed with the surface finish or making good of concrete surfaces until he has received the Engineer's permission. He shall not apply cement slurry or mortar or any other coating to the concrete surfaces from which the shuttering has been struck until the concrete has been inspected and approved by the Engineer's Representative.

The substrate must show a moisture content of less than 5% when measured with a moisture meter before the surface has been blasted, washed and dried. In addition the Contractor shall tape an unbroken polyethylene film of at least 500 gauge to the substrate and examine the underside of the film 24 hours later. There should be no signs of dampness or wetness on the surface of the concrete immediately after detachment of the polyethylene film.

Concrete surfaces to be coated shall be grit blasted using fine grit The surface shall be free of all traces of loose material, laitance, shutter oil, grease, wind blown deposits and other contaminants that could prevent the proper adhesion of, or result in adverse reaction with the protective system.

Under no circumstances shall reinforced concrete or any screed overlying reinforced concrete be acid etched.

Concrete surfaces to be protected shall be free from surface defects. The
Engineer's approval shall be obtained for any method for repairing surface defects.
An approved cementatious non-shrinking mortar shall be used for filling pockmarks
and blow holes.

Substrate surfaces must be made smooth and level over the entire surface of the areas to be coated except where design or profiles exist by design.

Areas that need repairing must be repaired with approved compatible repair materials that require submission and approval. The repaired areas must reproduce the texture of the rest of the structure. The repaired areas will require localised grit blasting after applying repair mortars. The blasted surfaces must be primed within 48 hours of blasting.

7.4.10 Quality and Workmanship

There must be no discernible colour difference in the finished work over the entire structure when viewed from a distance of approximately 5 metres in broad

daylight from different angles. The Contractor shall ensure that the entire paint used for the system is properly colour matched. All items that are not included in the coating scheme shall be masked off and protected from over spray, paint splatter, drips or spills. Terminal edges of the coated areas shall be taped to give clean lines. The site shall be cleared of rubbish and detritus waste. The Contractor's property and equipment shall be handed over in a clean and tidy state.

7.4.11 Safety

The Contractor shall conduct his work in a safe manner. He shall provide safe access and working platforms for his staff. He shall provide the necessary safe access for inspection of the work areas for the Engineer.

7.4.12 Protection of the Public and Public Property

The Contractor must take all measures to prevent causing nuisance or damage to members of the public and his property. He must put up sufficient shielding, barriers and clear signage to prevent the public from coming into contact with wet paint, over spray or paint spatter. The Contractor shall be solely responsible for any compensatory awards arising from his negligence, due to his inability to take due care or an inability to take action to obvious and anticipated damaging events.

a) Internal Surfaces for Air-Conditioned Buildings - Plastered Surfaces and Cement-Sand Renders

	System	**Film thickness (Mm DFT)**
1	Penetrating water based vinyl copolymer primer, solids approximately 25 - 30 % - brushed	<10 µ m
2	Water based filler to fill in surface defects -knifed	-
3	2-4 coats of vinyl copolymer water based topcoat till complete hiding of substrate and uniform colour - spray or roller	Total > 250 µ m

b) External Concrete and Rendered Surfaces Above Ground Level Subject to Normal Atmospheric Exposure

	System	**Film thickness (Mm DFT)**
1	A silane-siloxane penetrating primer, resin only without fillers and pigments, solids content approximately 5%, brush or roller applied.	<10 µ m
2	Water based filler to fill in surface defects -knifed	-
3	Multicoat body of UV resistant, water-based acrylic - roller or airless spray - smooth coat finish or textured as detailed in the drawings	Total > 250 µ m

c) Internal and External Concrete and Rendered Surfaces Exposed to Intermittent or Extended Periods of High Humidity but Not Subject to Extended Periods of Condensation, e.g., Bathrooms, Non-Air Conditioned Rooms, Non-Condensing Industrial Environments.

	System	Film thickness (Mm DFT)
1	A two component solvented epoxy-amine based penetrating primer, approximately 20 to 25% solids content, resin only without fillers and pigments - brush or roller applied.	<10 µ m
2	A two component solvent based epoxy filler knifed or sprayed	-
3	A multicoat body of a two component solvent based epoxy-amine coating - roller or airless spray applied	Total > 250 µ m
	A single coat of a single pack UV resisting acrylic- urethane pigmented coating - roller or airless spray applied.	> 50 µ m

d) Internal Surfaces of Concrete Subject to Extended Periods of Condensation, e.g., Closed Valve Chambers, for Water Storage Tanks

	System	Film thickness (Mm DFT)
1	A two component solvented epoxy-amine based penetrating primer, approximately 20 to 25% solids content, resin only without fillers and pigments - brush or roller applied.	<10 µ m
2	A two component solvent free based epoxy filler - knifed	-
3	Two coats of a two component solvent free epoxy-amine coating - roller or airless spray applied	Total > 500 µ m

e) External Surfaces of Concrete Outfalls

	System	Film thickness (Mm DFT)
1	A two component solvented epoxy-amine based penetrating primer, approximately 20 to 25% solids content, resin only without fillers and pigments - brush or roller applied.	<10 µ m
2	A two component solvent free based epoxy filler - knifed	-
3	Two coats of a two component solvent free epoxy-amine coating - roller or airless spray applied	Total > 500 µ m
4	A single coat of a single pack UV resisting acrylic- urethane pigmented coating - roller or airless spray applied.	> 50 µ m

f) Internal Surfaces of Wet Wells, Channels and Digestors Including Channels Subject to Erosion and Abrasion

	System	Film thickness (Mm DFT)
1	A two component solvented epoxy-amine based penetrating primer, approximately 20 to 25% solids content, resin only without fillers and pigments - brush or roller applied.	<10 µ m
2	40 % glass filled vinyl-ester coating. Entire system to be applied to coating manufacturer's specification - spray applied	> 900 µ m
3	Alternatively use preformed GRP panels mm 4 mm thick with a 0.5 mm vinyl ester facing	-

g) Insides of Highway Box Sections and Culverts

	System	Film thickness (Mm DFT)
1	Two coats of a two component solvented epoxy- amine based penetrating primer, approximately 20 to 25% solids content, resin only without fillers and pigments - brush or roller applied.	< 25 µ m
2	Or as directed by The Engineer	-

g) Surfaces of Concrete on Buildings that are to be Covered with an External Facade or Other Surfaces, such as Cable Trench Covers and Concrete Infills to DI Chamber Covers, Above Ground Level as Indicated in the Drawings

	System	Film thickness (Mm DFT)
1	Penetrating primer: Hydrocarbon solvent based rubberised bitumen - thinned 2 parts coating to 1 part hydrocarbon solvent	< 10 µ m
2	2 top coats of hydrocarbon solvent based rubberised bitumen coating without adding thinners - the first coat shall be of a different colour than the primer or second top coat	> 100 µ m
	Cautionary note: Water based bitumen emulsions shall not be used.	

7.5 COATINGS FOR STEELWORK

a) Structural Steelwork

Shop applied: 1 coat two pack zinc rich epoxy primer applied to a dry film thickness of 50 microns. SVC% not less than 53%.

1 coat of two pack epoxy high build zinc phosphate pigmented to a dry film thickness of 125 microns. SVC % not less than 56%.

Site applied: any damaged areas shall be prepared as for the shop coats and made good with original shop coats to the specified dry film thickness.

Apply overall: 1 coat of two pack polyurethane applied to a dry film thickness of 40 microns. SVC % not less than 49%

b) Steel Doors and Frames

Shop applied: 1 coat two pack zinc rich epoxy primer applied to a dry film thickness of 50 microns. SVC % not less than 53%.

1 coat of two pack epoxy high build zinc phosphate pigmented to a dry film thickness of 125 microns. SVC % not less than 56%.

Site applied: 1 coat of two pack polyurethane applied to a dry film thickness of 40 microns. SVC not less than 49%.

c) Steelwork in Contact with Water or Inside Reservoir

Shop applied: hot dip galvanizing to BS 729.

Site applied: any damaged areas shall be thoroughly cleaned of rust and surface deposits and painted with 1 coat of epoxy zinc phosphate to a minimum dry film thickness of 75 microns followed by 1 coat of epoxy micaceous iron oxide undercoat to a minimum dry film thickness of 100 microns followed by 1 coat of epoxy micaceous iron oxide to a minimum dry film thickness of 60 microns.

All coatings for the above-mentioned service shall have current potable water certificates.

7.6 COATINGS FOR TIMBER

Shop applied: 1 coat natural oil alkyd wood primer to a minimum dry film thickness of 30 microns.

Site applied: 2 coats alkyd based undercoat to a minimum dry film thickness of 40 microns per coat, followed by 1 coat alkyd decorative enamel to a minimum dry film thickness of 40 microns.

7.7 MECHANICAL AND ELECTRICAL EQUIPMENT

With the exception of stainless steel and rotating gland or bearing surfaces, all surfaces of equipment shall be protected against corrosion and erosion. Where dissimilar metals are in close proximity to each other giving rise to the possibility of electrolytic action, the mating surfaces shall be insulated.

Unless otherwise specified or required by the Engineer, or where the manufacturer's protective to equipment is of a special nature giving equal or better protection or where the material is inherently corrosion resistant the equipment shall be protected as follows:

a) Blast clean, using air that is clean, dry and free from oil or other contamination shall be to a visual standard in accordance with 180-8501-1:1988 standard 8A2.5. The type of abrasive used shall be selected to achieve a blast profile of 75 microns maximum and 25 microns minimum.

b) Fettle to remove all flash, weld spatter, sharp and rough surfaces by use of hand operated tools.

c) Clean surfaces and remove rust, scale, dirt, loose paint, etc. by use of powered hand operated wire brush or similar.

d) Degrease surface by the use of solvents that are compatible with and of the same manufacture as the paint finishes.

e) Bright parts and bearing surfaces: thoroughly polish and protect from corrosion by application of corrosion preventing lacquer or similar.

Where more than four hours has elapsed after blast cleaning, the surface shall be re-blasted before the succeeding coat is applied.

Degreasing shall be carried out when a period of more than 4 hours has been permitted to elapse since the application of the preceding coat.

Coating following blast cleaning following any stage of degreasing shall be applied within 4 hours.

Before the final finishing coat, all damaged areas of the preceding coat shall be made good by the use of a powered or hand operated wire brush. The area shall then be thoroughly cleaned and degreased with a suitable solvent.

Pipe joints (bolted) and equipment to be buried shall be protected in the following manner on Site:

a) Original finish shall be thoroughly cleaned and made good.

b) Within one hour of above one coat of appropriate primer shall be applied.

c) Immediately following priming, contours of bolted joints, etc. shall be "shaped up" using a cold applied bitumen based moulding putty packed into crevices around bolts, etc. to provide an even contour suitable for wrapping.

d) Immediately following the above the whole area shall be spirally wrapped with anti-corrosive wrap using a 26 mm minimum overlap with sufficient tension to ensure complete conformability. The wrap shall consist of a PVC carrier and bitumen based compound adhesive or similar having a compound thickness of at least 1.5 mm and a tensile strength over 10 N/mm.

e) Where the wrapping is likely to be exposed to prolonged direct sunlight either prior to or after completion of installation the whole area shall be spirally overwrapped, with a suitable adhesive tape having a thickness of not less than 0.25 mm.

7.8 PIPEWORK AND VALVES EPOXY COATING

All iron pipework in chambers and above ground and all pumping station pipework to be designed and installed by the Contractor shall be coated both internally and externally with 300 micron thick fusion bonded epoxy. The coating shall conform to the requirements of Water Industry Specification (WIS) 4-52-01 and the clause on epoxy coatings herein.

7.9 PIPES, FITTINGS AND VALVES SUPPLIED BY OTHERS

Any damage to the linings or protective coatings of pipes, fittings and valves supplied by others after the Contractor has taken delivery of the said items shall be repaired by the Contractor in accordance with the supplier's instructions.

7.10 MANHOLE COVERS AND SURFACE BOXES

After removal of all dirt, grease and concrete splashes etc, and such surface preparation as may be required, all manhole covers and surface boxes shall be painted with 2 coats of coal tar epoxy. The primer brown and the top coat black, the coal tar epoxy shall have a SVC % of not less than 83% and shall be applied at 150 micron per coat. The coal tar epoxy shall be suitable for use in tropical climates.

7.11 EPOXY COATINGS

Where epoxy coating is specified, completed fittings shall be coated on all surfaces, both internal and external, including inside bolt holes etc, with a 100% solids, thermosetting, fusion bonded, dry powder epoxy resin.

The metal surface shall be blast cleaned to ISO-8501-1 standard SA2.5 quality of surface finish, the maximum amplitude of surface roughness shall be 0.1 mm. Surfaces shall be cleaned to remove all traces of oil, grease and loose deposits, etc.

The coating process shall be commenced immediately after the blast cleaning and surface and cleaning and before the formation of visible oxidation on the metal surface.

The metal shall be pre-heated in an indirectly fired oven to a temperature not exceeding 245 degrees C. In the event of any oxidation on the surface the metal shall be cooled to ambient temperature and re-cleaned before re-commencing the coating process. The heated metal shall be immersed in abed of fluidised epoxy powder until such time as the thickness of the coating is 0.3 mm.

Alternatively, powder can be applied by spraying onto the pre-heated surface until the required and uniform thickness of coating has been achieved. The spray gun shall have sufficient capacity to maintain a uniformly dense moderate velocity spray pattern. The coating shall be applied in a uniform sweeping motion.

The coating shall be cured in accordance with the powder manufacturer's recommendations to achieve optimum physical and chemical properties.

The coating shall be tested with a calibrated thickness gauge to ensure a minimum coating thickness of 0.3 mm. Spark testing for pin holes, cracks, voids, contamination and damaged areas shall be carried out using a high voltage spark generator of 2kV. Faults shall be repaired and cured in accordance with the powder manufacturer's instructions.

On delivery to site all pipes, fittings and equipment shall be carefully inspected for handling or transit damage and shall be repaired following the manufacturer's recommended procedures.

At all times the Engineer or his Inspecting Authority shall be permitted free access to the place of coating for the purpose of examining and witnessing the coating process.

Bulk fuel tanks shall be fusion bonded epoxy painted externally. Internally the tanks shall have 3 coats of chemically resistant solvent containing two component epoxy amine adduct cured paint of MFDFT 240 micron.

END OF SECTION 7

Section 701: Polymeric Surface Coatings

Glossary of Coating Terminology

Alligatoring
A scaly pattern produced on the dried paint surface resembling an alligators skin and is usually caused by applying a coating on to a glossy unprepared substrate, coating on to coating underneath that has not been allowed to dry properly or has been softened by the fresh coat or by applying the incorrect coating system

Bleeding
Migration of substances from the substrate causing discolouration to the coating

Blister
Formation of liquid filled or hollow dome shaped bubbles caused by water vapour or expansion of air bubbles from the substrate caused by poor surface preparation, inadequacy of the coating system or applying the coating to a substrate that has not fully dried out

Bloom
Dull or foggy patches on the dried paint caused generally by poorly mixed paint or applied under high humidity or poor ventilation

Chalking
Surface deterioration of the coating polymer caused generally by UV exposure; it does not affect the performance of the paint

Checking
Patterns of short, narrow breaks in the top coats of the coating due to loss of elasticity by the coating

Chemical resistance
The ability of a coating to resist a chemical environment that is usually specified

Coating [Paint]
A film cast from a liquid or solid powdered mixture always consisting of a polymeric binder; the coating may contain a solvent or it may be solvent free; it may be opacifying when it contains pigments, translucent when it contains extenders but no pigments or it may be clear if it only contains the binder such as in a clear varnish

Coating system
Every coating is essentially a system and consists of any combination of the substrate, surfacing, primer, undercoat or body coat and top coat, each component serving specific functions

Colourfast
The ability to maintain almost its original color and not fade excessively under normal conditions of exposure

Colour retention
The ability of a paint to maintain its original color values and resist fading

Corrosion resistance
Ability of a coating system to prevent or retard metallic corrosion

Cracking
The splitting of a dry paint or varnish film, usually a result of aging or movement of the substrate

Degreaser
Solvent or compounded material used for removing oils, fats, or grease from a substrate

Dew point
The temperature at which water vapor in the air begins to condense.

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Diluent
A liquid that is added to a coating to reduce its viscosity but is not a true solvent by itself

Dry Film thickness
The thickness of paint when it is hard dry

Drying - Tack-Free
The stage of drying of a coating at which it is not sticky or tacky when touched

Dry to recoat
The stage of drying of a coating at which another coat of paint can be applied without damaging the previous coat

Dry to sand
The stage of drying of a coating at which it can be sanded without unusually clogging the sandpaper

Drying time
The stage of drying at which the coating is reasonably fully hardened to be put into service

Durability
The ability of a coating system in service to last over a specified period without failing

Efflorescence
Whitish deposits of salt found on the free exposed surfaces of concrete or masonry just above buried or submerged levels; it is caused by transport of salt solutions through the capillaries of the concrete or masonry and eventual evaporation of water at the surface leaving the salt crystals behind

Eggshell
A paint that has a luster of an eggshell, a satin-like appearance; its gloss level is usually between flat and semi gloss

Emulsion
A mixture (usually milky-white) in which one liquid is dispersed (but not dissolved) in another; it is technically not to be confused with a latex where the discontinuous phase is a solid polymer particle in water even though colloquial usage has designated it as emulsion

Enamel
enamel is a colored varnish or a high gloss coating with a reasonable degree of hardness

Fading
Loss of colour and or colour change after a period of exposure to the elements

Gloss
The ability of a surface to reflect incident light

Gloss retention
The ability of a coating to maintain its gloss under service conditions of exposure

Grinning
The surface of the substrate is partially visible through the dried coating due to poor opacity of the coating due to poor multi-coat system application, insufficient pigmentation or inadequate coating thickness

Hiding power
The ability of a dried coating film to obscure the surface over which it has been applied; it is dependent on pigment content and thickness of the dried film

Hue
A colour value that defines colour; lighter or darker variations of the same colour are of the same hue e.g. a light blue and a deep blue is of the same hue

Intercoat
A coating layer that is sandwiched between other layers of coating

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Lap
The joining area where a coating extends over an adjacent fresh coat

Latex
A fine dispersion of a solid resin in water; it is also known erroneously as an emulsion; the plural is latices

Latex coating
Water-based coating made with synthetic latices such as acrylic, vinyl acrylic, or styrene butadiene acrylic.

Marine coating system
A **c**oating system deigned to perform in a marine environment

Material safety data sheet
A document produced by the coating manufacturer providing safety and health hazard data when storing, handling and using coating products

Mildew

A black, gray or brown fungus that thrives on some coatings usually in a damp and dark atmosphere

Mildew resistance
The ability of a coating to resist mildew growth on its surface

Mildewcide
A chemical agent, often contained in a coating formulation that inhibits mildew growth on the coated surface

Mill Scale
The hard high temperature brittle oxide formed on mild steel products during ingot production, heat treatment and hot rolling processes

Moisture Resistance:
The ability of a coating to resist deterioration or failure when exposed to a highly humid environment

Mud-cracking
A manifestation of coating failure that looks like a sheet of mud that has cracked upon desiccation; usually occurs if a coating is applied too thickly beyond it recommended maximum wet film thickness

Nail head rusting
The rusting of heads of iron nails below a coated surface staining the surface coating; galvanized nails rather than uncoated nails should be used in damp environments

Non-volatile
The non evaporable portion of a coating usually consisting of pigment, binder, extenders, plasticisers and reactive diluents; it forms the entire bulk of the dried coating

Oil-based paint
Coatings made from synthetic binders that have been modified with certain natural drying such as linseed, castor, sunflower, soya, fish or tung oil; they polymerise by oxidation in air if drying oils are used or by heat provided in a baking cycle if non drying oils are used

Opacity
The ability to hide or blot out a surface by a coating

Organic
Refers generally to polymers with a carbon backbone which incidentally is the basis of life

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Peeling
The detachment of paint from the substrate or underlying coats of paint in the form of ribbons or sheets; It is usually caused by the lack of adhesion or incompatibility with the coated surface

Penetrating primer
A resin only liquid coating that is sucked below the surface of an absorbent substrate such as concrete, plaster, mortar and cementatious building boards

Permeable
Ability to transport gas or liquid through the coating film

Pigment
A finely powdered mineral or synthetic solid whose refractive index is far removed from the refractive index of the binder that surrounds it causing incident light to reflect from the surface of the pigment thus providing opacifying properties; an extender on the other hand has its refractive index closer to that of the binder causing incident light to be refracted into the extender particle and producing a translucent effect producing a non opacifying effect

Polymer
A long chain chemical substance formed from repeated joining of short chain substances [monomers] by chemical polymerisation

Preservative
A chemical used to prevent or hinder the growth of micro organisms such as bacteria, fungus, algae and protozoa in a paint formulation

Primary Colors [subtractive and additive]
In additive colour science involving light, all colours except black can be obtained by mixing three primary spectral colours red, yellow and blue; in pigment science all colours can only be obtained by mixing the three subtractive colours, cyan, magenta and yellow

Primer
The first coat applied to a bare substrate; it serves many purposes depending on the target of the formulation such as penetration into a substrate, adhesion promoter or as an anticorrosion layer for steel

Re-coating time
Interval required between the application of successive coats of paint

Reflectance
The ratio of the amount of light reflected from a surface in relation to the amount of incident light striking it

Run
Tear shaped unwanted coating flow caused by gravity from a coating drip or droplet due to poor application techniques; usually formed at holes and edges

Sagging
An unsightly and unwanted coating flow caused by gravity in the form of a recognisable sheet usually with a thickened lower wavy edge due to application of the paint beyond its recommended maximum wet film thickness for each coat

Saponification
The attack of the dried coating by alkali in the cementatious substrate usually manifested in the form of blisters, colour loss or disintegration of the coating; evidence of saponification is usually visible in months after the coating has been applied

Scrubability
The ability of a coating to resist wearing away or changing its original appearance when rubbed with a wet brush, sponge or cloth

Settlement
The gravitational drop of pigments or other solid matter in a can of liquid paint upon storage with its

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eventual accumulation in the bottom of the container; settlement can be soft which means reincorporation is fairly easy with manual stirring; it can be hard settlement due to consolidation of the solids by squeezing out the intervening binder in which case it requires mechanical stirring or shaking for homogenous reincorporation back into the coating

Sheen
A moderately low degree of gloss and image reflectance; it usually appears to be flat when viewed perpendicularly but appears to be glossy when viewed at a low angle of incidence

Silane
A short chain silicone polymer that is added to primers to improve their adhesion to damp or wet substrates

Solids
The non evaporable matter in a coating such as binder, pigment, extender, plasticisers and certain reactive diluents and that constitutes the bulk of the dried film in a coating

Solvent
A volatile liquid that solubilises the solid or liquid polymeric binder, plasticisers and diluents in a coating to form a true solution

Spatter
Droplets of coating that splash off a roller or brush during the application of a coating; often caused by wrong selection of roller nap or improper application technique

Specular gloss
The amount of incident light reflected from a coating usually measured at 20^{O},60^{O} and 85^{O} to the angle of incidenct light

Spot-prime
To apply a primer to only areas where the previous coating has been removed or stripped to the substrate

Spray
Method of application where the liquid or powdered coating is turned into a fine mist and spread on to the substrate forming a film; liquid paint can be sprayed using a pneumatic stream, an airless system the coating is put under great pressure and released through a fine orifice to atomise the liquid stream; liquid or finely powdered solid paints are passed through an electric field and electrostatically charged and attracted to the substrate held at the opposite polarity

Spreading rate
The volume of liquid coating that will cover a specific area at a given thickness

Stripping
Removing dried paint from a substrate by scraping, chemical removal or burning

Substrate
A surface upon which a coating is applied

Surfacer
Polymeric or polymer cementatious filler used to fill out hollows, pits and cavities and to form a smooth level and uniform surface in the substrate before the application of top coats.

Tack cloth
A fabric coated with a tacky polymer that is used to remove dust and fine debris from a sanded surface prior to coating

Tacky
The stage in the paint's drying process at which the film is sticky when lightly touched.

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Thinner
A volatile solvent and/or diluent used for lowering the viscosity of a coating prior to application or for washing coating soiled items for the purposes of cleaning

Topcoat
The coating intended as the final coating layer in a coating system

Touch up
Application of paint on small areas of painted surfaces to repair misses and damages

Ultraviolet Absorber
A mineral or chemical substance used as a constituent in coating formulations to absorb UV radiation and mitigate or reduce its damaging effects on the coating

Ultraviolet radiation [UV radiation]
The portion of the sun's spectrum in the far-violet region that causes damage to coatings

Undercoat
An intermediate layer of coating in a system designed to provide opacity and build up the thickness of the system and build a uniform and evenly pigmented surface to produce the best substrate for top coat applicat

Uneven gloss or sheen
Formation of patchy glossy or reflective sheen caused by poor homogenising of the coating before application, by poor quality coating or by poor surface preparation causing uneven absorption of the coating into the substrate

Value
The lightness or darkness of a color, i.e. light blue, medium blue and dark blue have different values.

Varnish
A liquid composition that is converted to a transparent solid film after application

Vehicle
The liquid part of a coating consisting of the polymer, plasticiser, solvent and diluent in which the solid components such as pigments and extenders are dispersed

Viscosity
The fluidity of a coating

Volume solids
The percent volume of the non evaporable components in a coating in relation to the total volume that includes the evaporable components

Washability
The ease with which dirt can be removed from a dried coating by wet swabbing or washing

Water based coating
Coating where the true solvent for the binder or the liquid phase in latex is water

Weather resistance
The ability of a coating to withstand the elements of weather such as rain sun wind and temperature

Wet adhesion
The ability of a dry coating film to adhere to the substrate when the substrate is wetted subsequently after application and dying of the coating

Wet edge retention time
The length of time a freshly applied coating maintains fluidity at its edges so that it can be joined without lap marks by a continuation of adjacent application of the substrate

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Wet film thickness
The thickness of a liquid film immediately after application before it begins to dry

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Section 702: Polymeric Surface Coatings - General Provisions

1. SERVICE LIFE

The service life must be at least 10 years, within which time the coating system will not crack, contain permanent stains, de-bond or cause a repair to the coating system. The service life does not include any surface repainting schedule recommended by the coating manufacturer or any damage caused by defects in the underlying substrate. The Contractor shall provide a warranty to satisfy the service life requirement. The paint manufacturer shall specify the period to first maintenance and what that maintenance should consist of.

2. COATING SYSTEMS SPECIFIED

All coating systems specified must have been designed and proven specifically for the actual usage and exposure specified. The Contractor shall not submit coating systems on the basis of undefined 'similar usage or exposure'. List of projects must show the exact coating system applied, the exposure conditions, number of years in service, the periodic maintenance carried out. Lists of projects without the qualifying data will not be acceptable.

3. VERIFICATION OF PREVIOUS USAGE

The manufacturer shall provide the contact name, address and the participating technical engineer of three projects where identical systems were applied in Oman by the nominated applicator. The Engineer reserves the right to seek directly the opinion of the previous client and in addition to visit the site to obtain verification of performance and good application.

4. MATERIALS

All coating materials shall be sourced from an approved professional paint manufacturer whose products have proven to be satisfactory in similar applications. The manufacturer shall have a competent research and development laboratory specifically for polymeric surface coatings. Further the factory shall be equipped with the appropriate equipment for manufacturing.

5. SUBMISSIONS

The Contractor shall submit the following for approval: -

5.1. Manufacturer's details

the location of the research and development laboratory
the quality system in brief,
the location of the manufacturing unit
the production quality tests performed on the paint submitted

5.2. Details of previous usage

list of works executed in Oman in which the same system has been applied successfully by the selected applicator; the list shall include types of substrate coated, the conditions of exposure; the contact name, address and the participating technical engineer of the previous client

5.3. Applicator details

a detailed method statement of the application process from substrate preparation to coating
a list of equipment and instruments that is required and possessed by the applicator
a sample of the Quality Control documents to be used on site.
all product data sheets and the manufacturer's recommendations on storage, handling, processing, application and health and safety.
a statement from the manufacturer that the system meets all the requirements of the specification.
details on how the Contractor will meet the requirements for workmanship, safety at work and safety to members of the public including details of access platforms, shields, barriers, signs and containment of paint overspray and splatter.

5.4. Samples for concrete and cementatious surfaces

A sample of the system on a coated panel on a concrete flag no bigger than [300 x 300] mm.
Samples must be step coated to show all the component layers including the substrate. Steps must not be smaller than 25 mm wide.

6. QUALIFIED COATING MANUFACTURER

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The coating system must be manufactured by a bona-fide industrial paint manufacturer with professional R & D and batch testing facilities.

7. MANUFACTURER'S RESPONSIBILITY

The coating manufacturer shall provide to the Contractor in writing the processes involved, the quality control procedures, control measurements, storage and handling of coating and ancillary products, Occupational Health and Safety requirements and procedures for the protection of members of the public. The manufacturer shall have technical staff on the ground to train the Contractor's staff in application and proper processing of his system before the coating trials are carried out. The manufacturer shall provide random quality checks on the Contractors work and workmanship and issue a certificate enclosing the quality verification worksheets.

8. SPECIALIST COATING APPLICATOR

The applicator shall be experienced in applying high performance coatings. He must have a seasoned and qualified crew The paint shall be stored, handled, processed and applied in the manner and conditions recommended by the manufacturer. The Contractor shall diligently follow the manufacturers instructions.

9. PRE-COATING APPROVAL

The Engineer's approval must be obtained prior to applying the coating system in the works. Before approval is given the Engineer will need to be satisfied that: -

the coating trials have been satisfactory
all construction work in the immediate vicinity of the structure to be coated has been completed
the whole of the structure can be coated in a continuous operation
the manufacturer's verification that the substrate preparation is adequate and of the required quality
the weather conditions are in accordance with the coating manufacturer's directions for application
the shields, barriers, signage, work platforms and other pre-coating preparations are in place

10. QUALITY AND WORKMANSHIP

There must be no discernible colour difference in the finished work over the entire structure when viewed from a distance of approximately 5 metres in broad daylight from different angles. The Contractor shall ensure that the entire paint used for the system is properly colour matched. All items that are not included in the coating scheme shall be masked off and protected from overspray, paint splatter, drips or spills. Terminal edges of the coated areas shall be taped to give clean lines. The site shall be cleared of rubbish, detritus, waste, The Contractor's property and equipment and handed over in a clean and tidy state.

11. SAFETY

The Contractor shall conduct his work in a safe manner. He shall provide safe access, work platforms and working conditions for his staff. He shall provide the necessary safe access for inspection of the work areas for the Municipal Engineer.

12. PROTECTION OF THE PUBLIC AND PUBLIC PROPERTY

The Contractor must take all measures to prevent causing nuisance or damage to members of the public and his property. He must put up sufficient shielding, barriers and clear signage to prevent the public from coming into contact with wet paint, overspray or paint spatter. The Contractor shall be solely responsible for any compensatory awards arising from his negligence, due to his inability to take due care or due to his omission or inability to take prior action to obvious and anticipated damaging events.

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Section 710: Polymeric Surface Coating Works for Concrete and Cementatious Surfaces

1. Applicable section

Muscat Municipality Construction Specification; Sections 701 and 702

2. General provisions

The work shall consist of furnishing all materials, labour and equipment and performing all operations in connection with the application of paint to all exposed concrete surfaces whether it is indicated or not in the Drawings. The colours of the paint to be applied will be selected by the Engineer. The application of the coating system shall be performed by an approved specialised applicator.

3. Coating systems for exposed concrete surfaces

3.1. For exposure to structures exposed to normal weather elements

Exposure conditions: Constant UV exposure and the elements, possible constant sea mist near shoreline, public and private environments

	Either System 710.3.1.1	**Or System 710.3.1.2**
1	A silane-siloxane penetrating primer, resin only without fillers and pigments, solids content approximately 5%, brush or roller applied. DFT less than 10 µm.	A two component solvented epoxy-amine based penetrating primer, approximately 20 to 25% solids content, resin only without fillers and pigments, brush or roller applied. DFT less than 10 µm.
2	Surfacers shall be water based single component polymer or polymer-cementatious based. Pure cementatious surfacers, mortar or grout shall not be used.	Two component epoxy-amine solvent based surfacer
3	Multicoat body of UV resistant water-based acrylic, roller or airless spray applied,minimum DFT of 200 to 250 µm.	A multicoat body of a two component epoxy-amine coating, roller or airless spray applied, 150 µm DFT minimum.
4	—	A single coat of a single pack UV resisting acrylic- urethane pigmented coating, roller or airless spray applied, minimum DFT of 30 µm.

3.2. For exterior of new buildings

Exposure conditions: 1. Exposure conditions: Constant UV exposure and the elements, possible constant sea mist near shoreline, public and private environments

	System 710.3.2.1	**System 710.3.2.2**
1	A silane-siloxane penetrating primer, resin only without fillers and pigments, solids content approximately 5%, brush or roller applied. DFT less than 10 µm.	A silane-siloxane penetrating primer, resin only without fillers and pigments, solids content approximately 5%, brush or roller applied. DFT less than 10 µm.
2	Surfacers shall be water based single component polymer or polymer-cementatious based. Pure cementatious surfacers, mortar or grout shall not be used.	Surfacers shall be water based single component polymer or polymer-cementatious based. Pure cementatious surfacers, mortar or grout shall not be used.
3	Multicoat body of UV resistant water-based acrylic, roller or airless spray applied,minimum DFT of 200 to 250 µm.	Multicoat body of UV resistant water-based modified acrylic copolymers, roller or airless spray applied, minimum DFT of 200 to 250 µm.

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	System 710.3.2.3	**System 710.3.2.4 [not used]**
1	A silane-siloxane penetrating primer, resin only without fillers and pigments, solids content approximately 5%, brush or roller applied. DFT less than 10 µm.	
2	Surfacers shall be water based single component polymer or polymer-cementatious based. Pure cementatious surfacers, mortar or grout shall not be used	
3	Multicoat body of textured UV resistant water-based modified styrene butadiene /acrylic copolymers, roller or airless spray applied, minimum DFT of 2mm.	
4	Stippled or finished to Clients requirements	

3.3. For interior of new buildings

Exposure conditions: 1. Exposure conditions: Constant UV exposure and the elements, possible constant sea mist near shoreline, public and private environments

	System 710.3.3.1	**System 710.3.3.2**
1	A silane-siloxane penetrating primer, resin only without fillers and pigments, solids content approximately 5%, brush or roller applied. DFT less than 10 µm.	A silane-siloxane penetrating primer, resin only without fillers and pigments, solids content approximately 5%, brush or roller applied. DFT less than 10 µm.
2	Surfacers shall be water based single component polymer or polymer-cementatious based. Pure cementatious surfacers, mortar or grout shall not be used.	Surfacers shall be water based single component polymer or polymer-cementatious based. Pure cementatious surfacers, mortar or grout shall not be used.
3	Multicoat body of water-based acrylic copolymers; brush, roller or airless spray applied, minimum DFT of 150µm	Multicoat body of water-based vinyl and or styrene butadiene modified acrylic copolymers; brush, roller or airless spray applied, minimum DFT 150 µm.
4	Gloss [matt or eggshell] to Clients requirements	Gloss [matt or eggshell] to Clients requirements

	System 710.3.3.3 For damp areas e.g. toilets & non air-conditioned rooms	**System 710.3.3.4 For damp areas e.g. toilets & kitchens requiring washable hygenic surfaces**
1	A silane-siloxane penetrating primer, resin only without fillers and pigments, solids content approximately 5%, brush or roller applied. DFT less than 10 µm.	A silane-siloxane penetrating primer, resin only without fillers and pigments, solids content approximately 5%, brush or roller applied. DFT less than 10 µm
2	Surfacers shall be water based single component polymer or polymer-cementatious based. Pure cementatious surfacers, mortar or grout shall not be used.	Surfacers shall be solvent based single component vinyl based. Pure cementatious surfacers, mortar or grout shall not be used.
3	Multicoat body of water-based damp and mildew resistant, acrylic/vinyl copolymers; brush, roller or airless spray applied, minimum DFT of 150µm	Vinyl primer
4	Gloss [eggshell or semi-gloss] to	Multicoat body of solvent based mildew and

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	Clients requirements	damp resistant vinyl polymers; brush, roller or airless spray applied, minimum DFT of 150µm

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5		Gloss [eggshell or gloss] to Clients requirements

3.4. For exposure above high tidal level at the seafront

Exposure conditions: Constant UV exposure and the elements, sea mist, seawater splashes, public and private environments,

	System 710.3.4.1	**And/or System 710.3.4.2**
1	A two component solvent based epoxy-amine based penetrating primer, approximately 20 to 25% solids content, resin only without fillers and pigments, brush or roller applied. DFT less than 10 µm.	A two component solvent based epoxy-amine based penetrating primer, approximately 20 to 25% solids content, resin only without fillers and pigments, brush or roller applied. DFT less than 10 µm.
2	Two component epoxy-amine solvent-free surfacer	Two component epoxy-amine solvent-free Surfacer
3	A multicoat body of a two component unmodified polyol- aliphatic urethane coating, roller or airless spray applied, 400 µm DFT minimum.	A multicoat body of a two component solventfree epoxy-amine coating, roller or airless spray applied, 400µm DFT minimum.
4	—	A single coat of a two component unmodified pigmented aliphatic isocyanate - polyol coating, roller or airless spray applied, DFT 50µm minimum.

3.5. For exposure below high tidal level at the seafront

Exposure conditions: Partial exposure at inter tidal zone to UV and the elements, partial and complete submergence in seawater, subject to fouling at inter tidal zone by marine molluscs and tube borers

	System 710.3.5.1
1	A two component solvent based epoxy-amine based penetrating primer, approximately 20 to 25% solids content, resin only without fillers and pigments, brush or roller applied. DFT less than 10 µm.
2	Two component epoxy-amine solvent-free surfacer.
3	A multicoat body of a two component solventfree epoxy-amine coating, roller or airless spray applied, 400µm DFT minimum. For below tide level the final topcoat shall be antifouling.
4	A single coat of a two component unmodified polyol- aliphatic urethane coating, roller or airless spray applied, DFT 50µm minimum.

3.6 For waterproofing hidden surfaces of concrete above ground level

Exposure conditions: ambient temperature, possible high humidity

	System 710.3.5.1
1	A penetrating primer made by thinning a solvent based oxidised bitumen or rubber-bitumen coating 50:50 with white spirits. DFT Nil.
2	2 coats of a solvent based oxidised bitumen or rubber- bitumen coating, DFT 100 minimum

4. Additional requirements for bridge concrete box sections and concrete culverts

In addition, all structural concrete surfaces such as insides of box sections and culverts as shown in the drawings, that are not to be coated with System 1 or 2, shall be completely coated using 1 or 2 coats of the penetrating primer as directed by the Engineer and to his satisfaction.

5. Coating properties

The coating system must be water and alkali resistant

The components of the system must have good adhesion to concrete and between inter-coats

Pigments used in topcoat must be resistant to substantial fading from UV light

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The colour is to be approved by the Engineer
Run down stains from mineral rich water [from condensation, water drips, rain and wash water] will occur. The topcoat must be washable. The topcoat must be resistant to acquiring permanent staining on its surface from such rundowns.

6. Coating trials

Prior to applying the system in the works, trial applications shall be carried out on concrete dummy constructed for the concrete trials or on a concrete substrate not less than 2 m^2 approved by The Engineer. The Contractor's applicator shall demonstrate at the trial the entire process using the methods and equipment for preparing the substrate and applying the coating including the associated quality control and verification. The technical representative of the coating manufacturer shall be present at the trial to verify that the surface preparation, application and the workmanship and specified properties have been properly conducted. The Contractor shall at his own expense conduct as many trials as are necessary to achieve the desired results. The approved trial coated area shall form the reference against which the coating in the works will be compared. Coating works shall not be carried out until the trials have been proved to be satisfactory and The Engineer has given permission.

7. Substrate preparation

7.1. General provisions

The Contractor shall not proceed with the surface finish or making good of concrete surfaces to be coated until he has received the Engineer's permission to do so and he shall not apply cement slurry, curing compounds, mortar or any other substances to the concrete surfaces to be coated.

The substrate must show a moisture content of less than 5% when measured with a surface moisture meter after the surface has been blasted, washed and dried. In addition, the Contractor shall tape an un-punctured [500x500] mm polyethylene film of at least 500 gauge to the substrate and examine the underside of the film 24 hours later. Signs of dampness or wetness on the surface of the concrete immediately after detachment of the polyethylene film will require the concrete to be dried out naturally and the test repeated.

Substrate surfaces must be made smooth and level where defects are visible before and after blasting. Surface defects such as pockmarks, surface air bubble cavities, fins, sharp edges, protrusions and depressions must be filled in or removed as appropriate. Areas that need repairing must be repaired with compatible repair mortars, surfacing compounds and material recommended by the coatings manufacturer. The repaired areas must reproduce the texture of the rest of the structure. The repaired areas will require grit blasting after applying cementatious repair mortars. Resinous repair compounds may not require blasting if surface coated within the recommended inter-coating period.

The surface must be grit blasted to remove surface contamination. Dune or beach sand shall not be used as a blasting medium. The blasted surface shall be power washed and dried. The prepared surfaces must be coated with the penetrating primer within 48 hours.

Surfaces to be coated and being coated must be protected from contamination from traffic, weather induced events and other sources. The Contractor shall provide a clean enclosed habitat.

7.2. Additional requirements for coating weathered surfaces

All contaminants such as dust, dirt, oil, grease and graffiti must be removed. Fungus, algae, moss, dust, dirt and debris on the surface or trapped in crevices, ledges and cracks must be removed. Where there has been evidence of mildew or fungus, the surface must be treated with an approved penetrating fungicide. Surfaces that have efflorescence must be treated and/or repaired to remove the deteriorated substrate and to remove capillary pressures that will cause distress to the coating that is to be applied. Cracks larger than 0.2 mm may require assessment by The Engineer for structural repairs otherwise they shall be V-cut at the surface to widen the opening of the crack and repaired. The surface shall be built back, if required to a smooth level uniform surface. All repair and surfacing compounds shall be approved by The Engineer.

7.3. Additional requirements for applying the same generic coating as previous

The surface must be cleaned, abraded down and prepared to specification requirements. All edges of depressions caused by the patchy removal of existing coating that may show through in the final coat must be feathered down by grinding or by the judicious use of an approved filler or surfacer. A bonding or sealing coat may be required to cause adhesion to the old coating or surface.

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7.4. Additional requirements for applying a new coating onto previously uncoated aged concrete

All surfaces must be cleaned, repaired, grit blasted, washed and prepared as required by the specification.

8. Action on insufficiencies and repair of defects

The Contractor shall make take immediate action on deficiencies in application and make good all coating defects as it arises during or after application:inclusive of items in Table 702.1 -

Table 702.1

Substrate	Application	Dried film
Uneven		
Not smooth	Poor homogenising of coating	Alligatoring
Sharp edges	Grinning	Bleeding
Poor quality grit	Sagging	Blisters
Inadequate blasting	Runs	Bloom
Contamination of substrate	Minimum DFT not achieved	Checking
Poor masking	Brush marks	Cracking
Pits	Visible lapping	Non uniform colour
Craters	Poor inter-coating time	Detachment from the substrate
Untreated efflorescence	Drips and spatter	Flaking
Poor cleaning	Improper habitat	Pinholes
Poor stripping	Improper shielding	Mud cracking
	Inadequate work platforms	Nail head rusting
	Inadequate signage	Poor opacity
	Inadequate public protection	Peeling
	Inadequate protection of work	Saponification
	Inadequate quality control	
	Inadequate record keeping	
	Inadequate measurements	

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SECTION 8

CONCRETE AND CEMENTATIOUS SURFACES – MEMBRANE WATERPROOFING FOR BURIED STRUCTURES, ROOFING AND PROTECTIVE COATINGS

8.1 MEMBRANE WATERPROOFING SYSTEM FOR BURIED CONCRETE AND CEMENTATIOUS STRUCTURES

This section deals with external torch on membrane waterproofing applied to all buried concrete and cementatious structures whether cast in situ, precast or block work.

8.1.1 Membrane Waterproofing System for Concrete and Cementatious Structures Buried above the Water Table

Other relevant clauses of the Specification shall form part of this clause where the context so requires.

8.1.2 Requirements

All materials to be incorporated into potable water installation must be tested and approved in accordance with BS 6920 "Suitability for non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water".

The Contractor shall furnish all tools, construction equipment, materials, labour and supervision to provide an effective waterproof lining or coating as specified herein.

8.1.3 Product Delivery, Storage and Handling

The Contractor shall deliver products to the job site in their original unopened containers clearly labelled with the manufacturer's name, brand designation, type and class as applicable.

The Contractor shall store products in an approved dry area with rolled goods laid flat, one pallet high, and shall protect them with soil and from exposure to the elements. Products shall be kept dry at all times.

Products shall be handled in a manner that will prevent breakage of containers and damage to products.

8.1.4 Guarantee and Warranties

In addition, the Contractor and manufacturer shall jointly guarantee the completed protective membrane/liner installation to be free from defects in workmanship and or materials for a period of 20 years from the date of acceptance of the completed installation.

In the event of a failure in the protective membrane/liner installation or if the protective membrane/line installation is proven defective in service during the warranty period, the Contractor and manufacturer shall provide, replace or repair the protective membrane/liner without any additional cost to the Employer.

8.2 MEMBRANE REQUIREMENTS

All structural concrete whether mass or reinforced placed in an excavated condition and designed to be in permanent contact with the ground and earth shall be protected by a torch-applied waterproofing membrane system with protection boards as indicated on the drawings. Self adhesive membranes shall not be used.

The membrane shall be torched on to form an impermeable layer under the structure on top of blinding concrete before constructing the structure and subsequently on the walls and other surfaces as required after construction of the structure and before backfilling. The membrane shall be laid on to a reasonably smooth concrete surface free from sharp edges and projections.

The Contractor shall ensure that no damage occurs to the waterproofing membrane during and after placing.

The waterproofing membrane shall be a minimum of 4mm torch-on, APP (atatic polypropylene) or SBS (styrene-butadiene-styrene) modified bitumen sandwiched on a polyester net. The outer surfaces of the membrane shall be covered with a polyethylene (PE) tissue.

The membrane shall have all the properties stipulated in the Table below.
(Alternative equivalent standards such as Uteac, Moat, BS and DIN standards may be used instead of the ASTM standards stipulated):

Waterproofing membrane with PE tissue on each surface		
Bituminous matrix	APP or SBS modified	
Polyester fabric weight per m^2	$\geq$ 200 g	
Minimum thickness	4 mm	
Tensile Strength Longitudinal Transverse	 ≤ 42 N/ mm^2 ≤ 48 N/ mm^2	 ASTM D638
Elongation Longitudinal Transverse	 ≤ 210 % ≤ 160 %	 ASTM D638
Tear Resistance Longitudinal Transverse	 ≤ 340 N/mm ≤ 310 N/mm	 ASTM D1004
Adhesion to primed concrete to self on torching	 ≤ 1.75 N/ mm^2 ≤ 35 N/ mm^2	 ASTM D1000 Peel Test
Puncture Resistance	≤ 220 N/65 mm	ASTM E154
Water Absorption After 24 hrs. After 35 days	 < 0.14 % < 0.95%	 ASTM D570
Environmental Resistance	To conform	ASTM D543
Moisture Vapour transmission	< 0.3 g/m^2 at 24 hrs	ASTM E96

8.3 APPLICATION BY SPECIALIST APPLICATOR

All waterproofing membranes shall be installed by a specialist applicator approved by the Engineer and applied strictly in accordance with the manufacturer's instructions and approved by the Engineer.

8.4 SURFACE PREPARATION

Concrete surfaces to be protected shall be free of all traces of loose material, laitance, shutter oil, grease, wind blown deposits and other contaminants that could prevent the proper adhesion of, or result in adverse reaction with the protective system. If the cleanliness condition of the concrete surface is observed to be poor, the Engineer shall instruct that the surface be sweep blasted with fine grit to remove the contamination. The surface shall be washed and dried after blasting.

Concrete surfaces to be protected shall be free from surface defects. The Engineer's approval shall be obtained for any method for repairing surface defects. An approved cementatious non-shrinking mortar shall be used for filling pockmarks and blow holes greater than 3 mm. Pockmarks and blowholes below 3mm need not be filled and may be left as they are for membrane waterproofing. Only cementatious repair materials shall be used. Resin containing repair materials shall not be used.

Prior to the application of the approved waterproofing system, the surface moisture of the concrete shall not exceed 5% when measured by a concrete moisture meter. A 600 x 600 mm undamaged polyethylene sheet shall be taped on to the concrete surface and left for a period of 24 hours. There shall be no sign of wetness or dampness on the covered surface. Concrete must have been left to dry for at least 20 days after the wet curing period to reach a state of acceptable dryness.

8.5 ACTIONS ON JOINTS

The actions of expansion, contraction and construction joints shall not cause the membrane to fail. This is to be achieved by taping down a de-bonding medium such as wax paper, tape or fabric at least 150 mm either side of the joint before torching the membrane. Membrane joints shall not fall within 200 mm of the concrete joints.

8.6 REDUCING THE EFFECTS OF CORNERS, ANGLES AND PROJECTIONS

Fins and unwanted projections on the surfaces shall be removed.

The Contractor shall provide all chamfers, fillets, laps and reinforcing strips at corners, angles and edges as recommended by the manufacturer. Preformed triangular fillets made from wood or plastic may be used to profile the internal corners.

8.7 PRIMING

Concrete surfaces shall then be thoroughly sealed with a thin coat of evenly applied primer. The primer shall be either as recommended by the manufacturer of the approved proprietary waterproofing product, or shall be selected to be

compatible with the waterproofing material. The primer shall be well brushed in and not allowed to pond in any depressions. The primer shall be left to dry for at least 6 hours before applying the membrane. The primed area shall be protected from wind blown dust or dust generated by site works.

8.8 TORCHING ON THE MEMBRANE

Small strips of the membrane shall be torched on to corners and internal angles if necessary using more than one layer as approved in the submittal. Putty
The membrane shall be cut to size, laid and torched on to the primed surface without causing damage to the membrane. Nails or any other items that puncture the membrane shall not be used for temporary or permanent fixings. The minimum over lap shall be 100 mm on the sides of the sheet and 150 mm at the ends. The membrane shall not terminate less than 150 mm above soil level.

8.9 PERMANENTLY EXPOSED MEMBRANE SURFACES

Bitumen membranes shall not be exposed to the atmosphere under any circumstances. Where it is necessary to bring the membrane above ground level, vacuum coated aluminised bitumen membrane shall be used for that portion of the exposed membrane or alternatively aluminium flashing shall be used to protect the exposed membrane.

Where the waterproofing terminates on the surface of a wall, aluminium flashing strips approved by the Engineer shall be installed into horizontal grooves chased into the concrete wall. The chased groove shall be filled with an approved permanently flexible building sealant designed for external use in Oman.

8.10 INSPECTION AND QUALITY ASSESSMENT

The installed membrane shall be visually inspected for pin holes and damage. Damaged and defective areas shall be sealed by torching on another layer of membrane. The membrane shall be installed such that air pockets and bubbles are not trapped between it and the concrete surface or between successive layers.

8.11 STAGE INSPECTION BY THE ENGINEER

Each stage of the waterproofing process including repairs shall be inspected by the Engineer before permitting continuance of the next stage.

8.12 PROTECTION OF THE WATERPROOFED MEMBRANE

All waterproofing installations shall have affixed to them as indicated in the drawings, protection board not less than 6 mm thick spot torched over the waterproofing membrane within 24 hours of the membrane installation. Hydrocarbon containing adhesives, organic solvents and material that will attack the bituminous waterproofing membrane shall not be used. The board may be installed butted end to end without overlapping and without gaps. In horizontal surfaces beneath asphalt pavements on bridge decks and highways, the board must be butted end to end.

The protection board shall be weather, water and rot proof. The puncture resistance shall be such that no effect is noted on the underside of the board following BS 1142 chisel test.

8.13 MEMBRANE WATERPROOFING FOR CONCRETE STRUCTURES BURIED BELOW THE WATER TABLE (STIPULATIONS IN ADDITION TO THE ABOVE MENTIONED REQUIREMENTS)

The requirements shall be the same as stipulated in this section except for the following: The membrane shall have a continuous film inside the bituminous sandwich instead of the polyester net. In the event that the continuous film membrane is not available, the installation shall be made up of two layers of 4mm membranes of the polyester net type reinforcement to provide a total membrane thickness of 8 mm excluding the thickness of the protection board.

8.14 SUBMITTAL

At least 30 days prior to installation, the Contractor shall submit for approval the following:

a) Details of each Structure to be Waterproofed
The detailed shop drawing of the structure to be waterproofed and including details of in-fills, fillets, chamfers and flashing strips if appropriate.

b) Information from the Membrane Manufacturer
- i) Identification and details of manufacturer
- ii) Technical data of the primer, membrane, filleting putty, infills and protection board.
- iii) The manufacturers product data sheet
- iv) The manufacturer's type test certificate
- v) A sample of the manufacturer's production batch test certificate
- vi) A list of projects in the Gulf where a similar system has proven to be successful under the same conditions of exposure
- vii) Small samples of each material
- viii) Small stepped sample of the system applied on a concrete flag no greater than 500 x 500 mm
- ix) The manufacturer's method statement for installation including surface preparation, priming, application of fillets and mastics and the delay between each and subsequent application
- x) Manufacturer's instructions for transporting, storage and handling
- xi) Health and safety data sheet to EU format for each material.

c) Repair and Surface Preparation Materials
- i) Identification of material providers such as cementatious repair mortars
- ii) Product data sheets
- iii) A statement from the manufacturer that the system meets all the requirements of the intended use and the specification
- iv) The manufacturer's recommendations on storage, handling, processing and application Health and safety data sheet to EU format for each material
- v) A 100 g sample of the grit to be used in sweep blasting.

d) Details of the Specialist Applicator
   i) The details of the specialist applicator and his qualification and ability and a list of works, executed in environmental conditions similar to those experienced in Oman, in which the same make of waterproof membrane was successfully used
   ii) The equipment and tools to be utilized in application
   iii) A sample of the fine grit to be used in surface blasting.

e) Contractor's QC and Monitoring Work Sheet
   A sample of the Contractors site Inspection and QC form.

f) Contractor's Dummy Demonstration
   The Contractor shall demonstrate on a dummy concrete structure with external and internal corners a sample application before approval is given.

END OF SECTION 8

SECTION 9

BUILDING TRADES

9.1 GENERAL

9.1.1 Scope

This Section covers the supply and construction of blockwork, brickwork, masonry, rendering, plastering, roofing, doors and windows, floor, wall and ceiling finishes, carpentry and joinery, ironmongery, miscellaneous metal work, cable trenches, paving, caulking and sealing and anti-termite treatment for the structures and buildings in accordance with the requirements of the Drawings and these Specifications. Other relevant clauses of the Specification shall form part of this clause where the context so requires.

9.1.2 Submittals

Shop drawings shall be submitted prior to fabrication and/or manufacture and assembly of each and every work. Shop drawings shall be based on the Drawings, Specification, and field measurements, and shall present complete information as to fabrication, installation and proper fitting with other construction.

The Engineer's approval shall be obtained for all proposed manufacturers and suppliers of all materials. Manufacturers or suppliers shall not be subsequently changed without the approval of the Engineer.

9.1.3 Coordination and Cooperation

Work of this Section shall be fully coordinated with related work of other trades. Particular attention is required for items embedded in concrete or blockwork. Roofing applicators shall be responsible for proper coordination of roofing work with other crafts where such work abuts, adjoins or is in any manner affected by roofing work.

9.2 CONCRETE BLOCKWORK, BRICKWORK AND MASONRY

9.2.1 Concrete Blocks and Calcium Silicate Bricks

All concrete blocks shall comply with BS 6073. The average compressive strength of the blocks and the lowest compressive strength of any individual block tested in accordance with BS 6073 shall not be less than the following values:

- Average of 10 blocks: 7.0N/sq mm
- Lowest individual block: 5.6N/sq mm

Blocks for external and load bearing walls, where indicated on the Drawings shall be solid blocks. Blocks for internal partition non-load bearing walls shall be lightweight hollow blocks. Solid blocks shall be provided and placed in position where fixings or supports are required.

The water absorption of the blocks shall not exceed 14 percent of the dry weight.

The blocks shall be made from a mix of 250 kg of cement to 1500 kg of fine aggregates. The fine aggregates shall comply with the grading of Table 4, BS 882. Cement and water shall be as specified in Section 5.

Precast concrete blocks shall be manufactured using an approved machine or vibrating table. Blocks shall be true in shape, even in size, square with sharp arises and free from flaws and holes. After removal from the machine the blocks shall be laid out on their pallets under cover in separate rows one block high for a minimum of 24 hours and kept wet by watering with a fine spray.

The blocks may then be removed from their pallets and shall remain under cover and be kept wet by watering for a further period of six days after which they may be stacked not more than five high until required for use. Blocks shall not be built into the Works until they are at least 21 days old.

All blocks and bricks shall be stacked by hand on approved hard standings. Blocks shall be stored in orderly stacks so arranged that they are used in the order in which they are delivered. Stacks shall be clear of standing water. Blocks and bricks shall be protected from splashing by mud or contamination by other materials. Bricks and blocks shall be stored either on pallets or by other methods to the approval of the Engineer in order to prevent absorption of moisture from the ground that may contain dissolved sulphates or other soluble salts.

Blocks shall generally be nominally 390 mm long and 190 mm high and 100 mm, 150 mm, or 200 mm thick (nominal). Blocks for the inner leaf of cavity wall may be hollow but blocks for other walls shall normally be solid. Where blocks are to be used in work to be plastered or rendered the faces shall be scored whilst the blocks are still “green” to provide a key.

Manufacturer's tests certificates shall be produced in respect of each type of concrete block employed, and the manufacturer must give a written warranty that all blocks are properly cured and dried before delivery to site. Each batch of blocks shall be marked in a distinguishing manner.

Bricks shall generally be solid with a compressive strength not less than 15N/sq mm and density not less than 1800 kg/cu m. Colour of brick shall be to the approval of Engineer.

Separate samples of each type and size of brick or block, taken at random from the load, shall be deposited with, tested and approved by the Engineer before being used and subsequent deliveries shall be up to the standard approved.

All blockwork courses laid below the original ground level shall be manufactured from sulphate resisting cement. Other concrete blocks shall be manufactured from ordinary/normal Portland cement.

9.2.2 Glass Block and Glazing

Glass block shall be 190 mm x 190 mm x 80 mm thick. They shall be bedded and jointed with 6 mm to 8 mm thick mortar using white cement and pointed. Care shall be taken to keep blocks clean and of good appearance. Where located in external walls, glass blocks shall be laid as a double leaf with cavity.

Galvanised steel support frames shall be provided for larger panels of glass block.

Installation of glass blocks shall be in accordance with DIN 4242 and the manufacturer's instructions.

All materials shall be new and of a type and quality to meet the requirements specified herein. All materials shall be delivered to the Site in original packages bearing manufacturer's labels intact.

Glass shall be of the type, quality and substance complying with BS 952, Part I Table 1.

9.2.3 Mortar

The cement, fine aggregate or sand and water shall comply with the respective requirements of British Standards stipulated herein. Cement shall be sulphate resisting type for all works below original ground level. The grading of the sand shall be in accordance with Table 4 BS 882. Imported hydrated lime shall comply with Class B Part 1 of BS 890. The use of shell lime for mortar will not be permitted.

Plasticizers for mortars shall be of an approved manufacture and comply with BS 4887 and shall be used in strict accordance with the manufacturer's instructions.

Samples of all materials to be used in the mortars shall be submitted to the Engineer for testing and approved prior to their use in the Works.

The mix proportions shall be selected from Table I of BS 5628 and tested in accordance with BS 5628 and BS 455I at weekly intervals to ensure compliance.

The mortar shall be thoroughly mixed dry until a uniform mix is obtained. Sufficient water shall then be added and the mixing continued until a homogeneous mix is obtained. Excess water shall not be present in the mix. All mortars shall be mechanically mixed but where small quantities only are required the Engineer may permit hand mixing on a clean dry wooden platform.

Mortar shall be mixed in an approved location and care shall be taken that no foreign matter enters the mix, or a loss of liquid occurs during mixing.

Mortar shall be used in the Works as soon as possible after mixing but in no case after the initial set commences. In no event shall mortar be remixed and used after the initial set has taken place and it shall be removed from the site immediately.

9.2.4 Setting-Out

The Contractor shall provide proper setting-out rods and set out on the same, all work showing openings, heights, sills and lintels, the blockwork being built to the thickness, widths and heights shown on the Drawings.

The walls shall be taken up level as far as possible, and no lift shall be greater than 1.0 m above the adjoining walls. Joining of lifts shall be made by long

steps. Corners shall be raised first and these shall be laid to a gauge rod and racked back to the main wall.

Single block walls shall be built of selected blocks to keep an even face on both sides.

9.2.5 Workmanship, Laying and Jointing

All work shall be carried out in accordance with BS 5628.

The Contractor shall provide all labour, materials, plant, scaffolding, covering and incidentals for all construction in blockwork. The Contractor shall execute and make good all necessary chases, holes, mortises, rebates and the like, built-in lintels, sills, timber and the like as required and perform all necessary attendance upon other trades and make good on completion. The Contractor shall be responsible for covering and protecting the fair finished blockwork during the progress of the works and shall clean down the whole upon completion, make good and point up and leave all perfect and to the satisfaction of the Engineer.

All concrete blocks shall be soaked with water before being used and the tops of walls left off shall be wetted before work is recommended.

Walls shall be carried up regularly without leaving any part more than 1.0 m lower than another unless the permission of the Engineer is first obtained. Work which is left at different levels shall be raked back.

The courses of blockwork shall be laid and jointed in the appropriate mortar with perfectly level horizontal joints. Each course shall be well flashed up with mortar and lined and quoins, jambs, and other angles plumbed, as the work proceeds. All walls shall be plumbed vertical. The thickness of the horizontal mortar joints shall not exceed 40 mm to every four joints.

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

Metal anchors for fixing brickwork or blockwork to concrete shall be galvanised mild steel to BS 1449, minimum tensile strength 460 N/sq mm 4.5 mm thick x 35 mm minimum width, length to suit cavity with ends turned through 90 degrees to form lugs 60 mm long.

Shot-fired nails for fixing metal anchors to concrete shall be high tensile steel nails with a minimum pull out load of 6 kN in concrete with a characteristic strength of 30 N/sq mm.

Where a blockwork wall is built up against a column, a post or an in-situ concrete wall the end void of blocks shall be filled with concrete. Metal anchors shall be fixed to the concrete and built into the blockwork at every second bed joint.

Where an internal blockwork wall is separated from a column by a cavity one void in the blockwork alongside the column shall be filled with concrete. Metal anchors shall be fixed to the concrete and built into the blockwork at every second bed joint.

Where an external blockwork wall is separated from a column by a cavity one void in the blockwork shall be filled with concrete and reinforced with one 10 mm diameter mild steel reinforcing bar to within 250 mm of the top of the wall. Metal anchors shall be fixed to the concrete and built into the blockwork at every alternate bed joint.

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

Newly laid blockwork and brickwork shall be protected from the harmful effects of sunshine, rain, drying wind, running or surface water and shocks, during the day of laying and the following day. The Contractor shall include for and provide a sufficient amount of cheap cloth material which shall be kept wet, and used for this purpose. Any work that may be damaged shall be taken out and rebuilt as directed by the Engineer. Any costs incurred in carrying out such remedial works shall be borne by the Contractor.

Pointing to external facings shall be rounded hollow as the work proceeds and that to internal facings, basements and manhole walls shall be flushed joint as work proceeds.

Holes and chases shall preferably be left in the walls where required. Embedded conduits and pipes shall be built in. Under unavoidable circumstances holes and chases may be cut out subject to the Engineer's approval and if approved by the Engineer they shall be made good to the satisfaction of the Engineer. Chasing shall be carried out by suitable mechanical tools. Continuous horizontal chasing longer than 400 mm will not be permitted. Putlog and other similar holes shall where practicable be of full brick size.

The top courses of hollow concrete blockwork walls shall be laid in solid blocks unless otherwise indicated. For any part of the walls below ground level solid blocks shall be used unless otherwise approved by the Engineer. Walls in toilets and kitchens to which fittings are to be fixed shall be made of solid blocks.

The tops of all non-loading-bearing walls and partitions shall be pinned up to the soffits of beams, or slabs above them. Walls or partitions that do not reach the soffits of beams or slabs shall have a reinforced concrete beam with a minimum depth of 250 mm over the whole wall length.

Suitable reinforced concrete horizontal and vertical stiffeners shall be provided when the blockwork panel exceeds 5.0 m in length and/or 4.0 m in height. Size and positions of such stiffeners shall be to the approval of the Engineer. Whenever an opening is made in a blockwork panel a reinforced concrete lintel and sill shall be provided at the top and bottom sides of the opening. The length of such lintels and sills shall be extended to at least 400 mm each side of the opening.

Movement joints and joint spacing shall be in accordance with BS 5628 and shall be to the approval of the Engineer.

Sealing compounds in concrete and blockwork shall be supplied by a manufacturer approved by the Engineer and shall be applied in strict accordance with the manufacturer's instructions. Where required by the Engineer, samples shall be prepared under the guidance of the supplier's technical representative for approval, prior to proceeding with the works.

Vertical joints shall be sealed with a high performance polyurethane joint sealant, gun grade. The material shall comply with U.S. Federal Specification TT-S-00227E Type II Class A, have excellent durability, resistance to ultra-violet rays, adhesion properties and high movement capability. Colours shall be to the approval of the Engineer. Similar pouring grade compounds shall be used for horizontal joints.

In areas which are exposed to possible chemical attack a pitch polyurethane elastomeric joint sealant shall be used to form a highly resilient joint.

9.2.6 Damp Proofing

Damp proofing for foundations, underfloors and on vertical faces of walls shall be mineral base bitumen damp-proof course complying with the requirements of BS 6398, or as otherwise approved.

All surfaces shall be carefully flushed up with mortar to form an even surface.

Damp-proof course shall be kept flush with the outer surface of the bricks and shall be set back to allow for pointing.

After the surface of the brickwork has been flushed up the damp-proof course shall be laid and protected from damage until the mortar is set.

Care shall be taken, especially in cold weather, to prevent cracking when unrolling and bending bitumen damp-proof course.

Bitumen damp-proof courses shall be lapped a minimum of 100 mm at joints. The joints in damp proof courses set in the base of walls and other locations to resist the upward movement of moisture by capillary action shall be clean and in close contact. Joints in bitumen damp-proof courses in parapet walls and other similar locations where the moisture penetration is downwards shall have the laps sealed with a mastic bitumen compound approved by the Engineer.

9.2.7 Lintels and Sills

Lintels and sills shall be bedded and jointed in similar mortar to that used in adjacent blockwork or brickwork. Lintels and sills shall be set flush with the wall face and shall have a rough surface to provide the key when the wall is to be plastered or rendered.

Precast concrete lintels and sills shall comply with BS 5642 and BS 5977.

9.2.8 Reinforcement of Blockwork Walls

Walls exceeding 2.5 m in height shall be reinforced for their full height by embedding expanded steel mesh in the horizontal mortar joints. Expanded steel

mesh shall conform to BS 405. The mesh size reference and frequency of horizontal mortar joints reinforced shall be as directed by the Engineer.

All walls required to act as fire/blast protection walls shall be reinforced as above unless the Contractor's design requirements call for additional or more substantial reinforcement which shall be to the Engineer's approval.

9.2.9 Protection Against Damage

Architectural features, finished surfaces and quoins shall be protected against damage during the progress of the works. Sills, jambs and heads shall be protected by basings as soon as they are built.

Freshly completed work shall be covered with waterproof sheets in locations where rain damage is likely.

Frames and other items built-in shall be fully protected by boards, sheets or other measures which are to the approval of the Engineer.

9.3 BUILDING FINISHES

9.3.1 General

The Contractor shall provide all materials, labour, equipment, tools coverings and incidentals to carry out, protect, make good, and maintain the Works to the satisfaction of the Engineer. Repairs to any damage caused by inadequate protection shall be borne by the Contractor.

The finished surfaces of floors, walls and ceilings shall be formed accurately to the dimensions shown on the Drawings or as specified. Plane surfaces shall not have a variation out of plane of more than 3 mm against a 3m long straight edge anywhere on the surface. This tolerance limit is also applicable across joints in finishes and across junctions of different types of finish.

All proprietary finishes and applications approved by the Engineer shall be applied strictly in accordance with the manufacturer's instructions.

9.3.2 Storage of Materials

All finishing materials shall be stored in a clean, dry, protected place and not unpacked until required for incorporation into the Works. Compounds to be mixed on site before application shall be stored and protected in the manner prescribed by the manufacturer and products with a limited shelf life shall be delivered to site at times compatible with the Contractor's approved construction programme and progress of the Works. Any deteriorated or damaged items shall be removed from site and replaced at the Contractor's expense.

The Contractor shall provide suitable dry-weather proof storage for materials so as to avoid contamination, pre-setting and premixing of materials. The Contractor shall ensure a complete turnover of stocks by using the materials on the site within periods not exceeding three months. Different gradings of aggregate shall be kept in separate heaps.

9.3.3 Plasterwork

a) Materials

Cement and water shall comply with the requirements of Section 5.

Sand for cement rendering shall conform to BS 1199. The sand for plastering shall be clean and shall be washed in potable water if necessary. The sand shall be sieved and graded to meet the following requirements:

i) For plaster undercoats, the grading shall be as in BS 882, Table 2, Grading Zone 2.
ii) For plaster finish coats, the grading shall be as in BS 882, Table 2, Grading Zone 3 or Grading Zone 4.

Colour additives, proprietary bonding agents (of the polyvinyl acetate emulsion type) and other admixtures shall be obtained from an approved source when called for in the contract and shall be used in accordance with the manufacturers instructions.

Expanded metal lathing (EML) shall comply with BS 1369 Type (a) Figure 1 weighing not less than 1.6 kg/sq m. EML shall be laid over all joints between blockwork/brickwork and concrete, and all chases made in the blockwork or brickwork. Laps shall be 400mm and tied with galvanised tying wire.

Nails for fixing metal lathing shall be flat head galvanized nails to BS 1202.

Staples shall be galvanized and to BS 1494.

Wire shall be 1.2mm diameter to BS 443.

Plaster stops, casing and angle beads shall be stainless steel of GRP of a type approved by the Engineer. Plaster stops, casing and angle beads shall be fixed to all comers and edges of plaster work and shall be fixed in accordance with the manufacturer's instructions.

b) Mixing

Mix proportions shall accord with this Outline Specification appropriate to the type and location of work as shown on the approved Contractors Documents or agreed with the Engineer.

c) Proprietary Products

Proprietary products shall be mixed strictly in accordance with the approved manufacturer's instructions.

d) Workmanship

All internal plastering shall follow the recommendation in BS 5492.

Plastering shall be neatly made good up to metal or wood frames and skirtings and around pipes or fittings. Angles shall be round to 5 mm radius.

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

Surfaces described as trowelled smooth shall be finished with a steel or celluloid trowel to a smooth flat surface free from trowel marks. Surfaces described as floated shall be finished with a wood or felt float to a flat surface free from trowel marks.

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

All proprietary brands of plaster or plastering materials shall be selected and applied strictly in accordance with the manufacturer's instructions regarding the different purposes and backgrounds for which they are intended. Particular attention shall be paid to the manufacturer's instructions regarding the time allowed to elapse between mixing and using.

e) Preparation and Application

i) Surfaces Generally and Key Coat

All surfaces to be plastered shall be clean and free from dust, grease, loose mortar and all traces of salts. Mortar joints in brickwork and blockwork shall be racked out to a depth of 15 mm. Smooth or greasy concrete surfaces to be plastered or rendered shall be roughened by hacking or brush hammering and these and any other surface directed by the Engineer shall be treated with an approved bonding agent to provide an adequate background key. The bonding agent shall be applied strictly in accordance with the manufacturer's instructions. Where directed for cement renderings, the bonding agent shall be added to the gauging water in the manufacturer's recommended proportions.

All surfaces to be plastered shall first be dashed with a mixture of Portland cement and sand (450 kg cement :1 cu m sand) to form a key.

ii) Moistening of Surfaces

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

iii) Junctions of Differing Surfaces

Before plastering is commenced joints between differing materials where the final surface is to be flat (other than those between the

main reinforced concrete members and the block walls) shall be reinforced. This shall apply where walls join stiffeners, concrete frames around steel doors and similar situations where cracks are likely to develop and as directed by the Engineer. The reinforcement shall consist of a strip of approved galvanised or stainless steel wire mesh (10 mm to 15 mm hexagonal mesh) 150 mm wide or of an approved expanded metal with galvanised or stainless steel nails and washers, galvanised or stainless steel staples or similar. Where shown on the Drawings, proprietary type I galvanised or stainless steel casing and angle beads shall be used. The reinforcing mesh shall be fixed at both edges by stapling, plugging, or nailing at intervals not exceeding 50 mm and as required. The reinforcement shall be fixed so that it is embedded completely in the undercoat of plaster.

Where the joint is between the main concrete elements (columns, beams, and the like) and blockwork, a groove of suitable size filled with mastic sealant shall be provided all to the approval of the Engineer.

iv) Undercoats

After preparation of the surfaces as above, the undercoat shall be applied to the required thickness between screeds laid, ruled and plumbed as necessary. When nearly set the surface of the undercoat shall be scratched as described previously. The undercoat shall be allowed to set completely and shall be cured as described below before the finish coat is applied. Where plastering is applied in one coat or where roughcast is to be applied the scratching shall be omitted.

v) Finishing Coats

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

vi) Sprayed Finishes

The sprayed finish shall be applied with an approved machine to give a finish of even texture and thickness. The sprayed finish shall be applied in four separate coats allowing time for drying between coats. Application in one continuous operation to build up a thick layer will not be permitted. The total finished thickness of the four sprayed coats shall be not less than 3 mm. The sprayed finish shall not be applied until all repair and making good to the undercoat are completed. Rainwater pipes, fittings and the like shall first be fitted, then removed during the spraying process and refitted and jointed afterwards. Any plaster which adheres to other pipes, doors, windows and the like shall be carefully removed before it has set. Curing as below shall take place after the application of the fourth coat.

vii) Curing

Plaster shall be kept moist by sprinkling with water at regular intervals for a period of at least seven days and until no powdery particles are present, to the satisfaction of the Engineer.

f) Joints

Joints shall be introduced in plastered or cement rendered surfaces over movement joints, where directed. Such joints shall be formed by inserting a pair of casing beads, as previously described, arranged one on each side of the joint, leaving a line joint in the finished work.

h) Types and Thicknesses

The type, mix and thickness of plaster for each location shall be as agreed with the Engineer. Any plastering more than 12 mm thick shall be applied in two coats. The types of plaster coats to be applied after the key coat described previously shall be in accordance with the following schedule:

Description	Mix	Thickness(mm) T = Total U = Undercoat F = Finishing Coat		Surface
		Walls	Ceiling	
Internal or external Plain Face		T 15	T 13	
Cement: Sand	1:4	U 12	U 10	Scratched
	1:4	F 3	F 3	Floated
Internal Render and Set		T 15	T 13	
Cement : Sand	1:4	F 15	F 10	Trowelled
External Render and Spray		T 15	T 13	
Cement : Sand	1:4	U 12	U 10	Floated
	1:1	F 3	F 3	Sprayed

A mortar plasticizer approved by the Engineer may be added to assist workability and application of the render.

i) Rendering and External Finishes

i) Smooth Finish

Rendering shall be applied in two coats. The sand for the first coat shall conform to Table 1 of BS 1199 and for the second coat to Table 2 of BS 1199. The wall shall be wetted before the application of the first coat, which shall be finished flat and vertical by straight edge, and scored to form a key. The second coat shall not be applied until the first coat has dried out completely. Immediately before application of the second coat, the surface of the first coat shall be wetted, and the second coat shall be finished to a smooth hard and dense surface, which is truly flat and vertical. An approved plasticizer may be used in both coats subject to the Engineer's approval.

ii) Colours of External Finishes

Colours shall be consistent throughout all areas treated with the same colour and remain fast. The colour of each area shall be as approved by the Engineer. The Contractor shall be deemed to have included in his price for executing sample panels as necessary to demonstrate to the Engineer's satisfaction the pigmentation and surface texture that will be achieved during subsequent application. Accepted sample panels will be used for comparative checking purposes during the execution of the work and shall be kept until the rendering work is completed.

9.4 FLOOR, WALL AND CEILING FINISHES

9.4.1 Materials

Portland cement, fine aggregate and water shall be as specified in Section 5. The fine aggregate shall be to Grading M or F, Table 5 BS 882.

Colour pigments shall be lime-proof and non-fading to BS 1014.

Marble chippings shall be of an approved quality in irregular pieces and be roughly cuboid in shape. Flaky pieces shall not be used. Sizes shall be as required by the Engineer.

9.4.2 Screeded Beds

Concrete floors that are required to be surfaced with screed shall have a roughened surface, produced by hacking and wire brushing. The roughened concrete floor shall be cleaned, wetted preferably overnight, the surplus water removed and 1:1 cement/sand grout brushed into the surface, keeping just ahead of the screed bed. The screeded bed shall be 60mm thick minimum and shall be well compacted and levelled with a screeding board and steel trowelled smooth. The finished surface of the screed shall be treated with an approved hardener to prevent dusting.

The screed shall be mixed in the proportions of 1:2:4 (cement, sand, gravel of 10 mm maximum size) by volume with the minimum quantity of water necessary to give a good hard smooth, steel-trowelled finish in accordance with Section 5.

Unless specified otherwise, bay sizes and joint positions shall be as agreed with the Engineer on site with due regard to the recommendations of BS 8204.

The bays shall be laid alternately in chequer-board fashion. A minimum of 24 hours shall be allowed to elapse between the laying of adjacent bays.

Each bay shall be completed in one uninterrupted process. Expanded steel mesh reinforcement shall be provided in all screeded beds.

No screed shall be allowed to bridge structural movement joints. Movement joints shall be extended through screed.

Conduits or other service pipes in floor screeds shall be limited to the minimum, but where unavoidable they shall be arranged singly so that a minimum cover of 35 mm of screed is provided over them. In such cases, a 225 mm wide strip of expanded steel mesh shall be provided as reinforcement to the screed over these pipes, or conduits. The expander steel mesh shall weight 0.5 kg/sq m and shall conform to BS 405.

All screeds shall be painted, tiled, covered with PVC or coated with an epoxy screed as indicated on the Drawings or as specified.

9.4.3 Epoxy Resin Based Floor Topping Screed

Epoxy resin based floor topping screed shall be a 3 component solvent free combination of epoxy resin and hardener filled with high crushing strength chemically inert aggregates possessing the following physical characteristics:

a) Density shall not be less than 2000 kg/cu m.
b) The compressive strength shall not be less than 70 N/sq mm in accordance with BS 6319 Part 2.
c) The flexural strength shall not be less than 25 N/sq mm in accordance with BS 6319 Part 3.
d) The tensile strength shall not be less than 12N/sq mm in accordance with BS 6319 Part 7.
e) The absorption shall not be greater than 0.12% in accordance with ASTM C413-83.
f) The slip resistance in dry/wet shall be not less than 63/55 respectively based upon test using TRRL Pendulum Tester.
g) The abrasion resistance shall have a maximum loss of 0.3 g in accordance with ASTM C944.
h) The minimum bond strength to the parent concrete floor shall exceed the minimum tensile strength of the parent concrete.
i) The minimum thickness shall be laid as 5mm and the maximum thickness shall be 12mm.

The material shall be applied by experienced applicators duly certified by the material manufacturer. All aspects of preparation, mixing, applying and subsequent finishing, shall be in full accordance with the manufacturer's instructions and recommendations.

Following completion of the application of the epoxy screed topping and approval of the same by the Engineer, the Contractor shall apply an epoxy based sealing paint over the entire area of the floor topping, which shall be fully compatible with the base screed.

9.4.4 Terrazzo Floor Tiling

Terrazzo floor tiling shall comply generally with BS 5385.

Tiles shall comply with BS 4131 with marble aggregate up to 6 mm size, colour white, ground, grouted and reground to fine grit finish, size 300 mm x 300 mm x 30 mm for internal use and 600 mm x 600 mm x 30 mm for external use. Bedding methods shall be "separating layer" for interior of buildings and "direct bedding" for exterior work.

Tiles for bath/washrooms shall have matt non-slip finish.

Skirting tiles shall be 150 mm high with rounded top and 20 mm coving to floor edge of the same construction as the tiles with preformed angles and stop ends. Separating sheet shall be 125 um (500 gauge) polythene or building paper to BS 1521, Grade A1. Expansion joint material shall be polysulphide sealant and finer. Mortar for bedding shall be cement: sand mix 1:3 of stiff plastic consistency.

Coloured grout for jointing shall be white cement : fine white sand 1 : 1 with pigment, paste-like consistency to approved colour.

All tiles shall be obtained from a single manufacturer.

Tiles shall be handled and stored to prevent damage and shall be kept in the supplier's cartons until required for laying.

A sample area of tiling, size 2 m x 2 m, including skirting shall be laid in an approved location in advance of the remainder for approval before proceeding.

Tiles shall be laid to a tolerance of not more than 3 mm under 3 m long straight edge. Before laying, the base shall be adequately true and level and free from contamination and loose areas.

Laying of tiles shall be as follows:

a) Separating Layer Method

Lay separating sheet on the clean level base with adjacent sheets lapped 100 mm. Soak tiles in water and allow to drain for 10 to 15 minutes removing an surface water, spread, level and compact cement-sand mortar bed 20 mm thick and allow any free surface water to dry. Place a neat cement slurry 2 to 3 mm thick on the backs of tiles and firmly beat down tiles into bedding to form an even surface with even joints not less than 3 mm wide.

After a minimum of 16 hours following laying, work grout well into joints so that they are completely filled, finish flush and thoroughly clean off surplus grout as the work proceeds using fine sand and cloth.

b) Direct Bedding Method

As described for "Separating Layer" method but with the exclusion of the separating sheet. Skirting tiles shall be bedded to floors and walls with cement mortar to form straight even lines and shall be grouted in the same manner and at the same time as the tiles.

Expansion joints shall be provided round the periphery of each room at not more than 7 m in each direction of tiling and at all plinths and pedestals.

Expansion joints shall be carried through the full depth of tile and bedding.

Armoured aluminium angle 50 mm x 50 mm x 6 mm to grade 6061 -T6 shall be fixed at every change in floor surfacing, the top surface being ground off flush with the floor finish.

Traffic shall not be allowed on the floor until at least 4 days after completion of laying and jointing and then only light traffic for a further 10 days.

The finished floor shall be sealed with an approved sealer of a type recommended by the tile manufacturer.

9.4.5 PVC Flooring

PVC flooring shall be flexible antistatic heavy duty PVC of minimum 3 mm thickness tiles/rolls obtained from an approved manufacturer. PVC vinyl asbestos tiles will not be accepted. The tiles shall be laid by a specialist and the jointing layout is to be approved by the Engineer. The tiles shall be laid on a flat, clean screed, in strict accordance with the manufacturer's instructions.

9.4.6 Raised Access Flooring

The raised access floor system shall be with removable load bearing panels 600 mm x 600 mm nominally supported on adjustable pedestals and stringers. Pedestals and stringers shall be of galvanised steel and shall permit snap-on connection and lateral locking of the ends of stringers.

All panels shall be total interchangeable and relockable, except cut panels. The system shall be capable of providing a close fit to all perimeters with perimeter joints with walls sealed.

Panels shall be constructed of 34 mm thick high density inert calcium sulphate core, strengthened with high mechanical resistant fibres with self-extinguishing hard plastic edging, covered and sealed with 0.05 mm. Thick aluminium foils on bottom side and finished on top with antistatic vinyl. The density of the inert materials shall be 1450 kg/cu m $\pm$ 25kg/sq m. The complete floor system shall comply with the following static loading:

a) Concentrated load: not less than 4.5 kN over 25 sq mm
b) Uniformly distributed load: not less than 18kN/sq m.

The system shall not deflect by more than 1/250 of the shortest span or 2.5 mm which ever is less. The system shall not excessively bounce or move when subjected to pedestrian and light wheeled traffic.

9.4.7 Skirtings

Internal hardwood skirting shall be made from clear, properly seasoned hardwood and the face in direct contact with plastered wall shall be painted with two coats of approved preservative before fixing. The skirting shall be 100 mm high and 20 mm thick and the outer edge shall be rounded.

Skirtings shall be fixed to the wall by plugs and brass screws and varnished to the approval of the Engineer.

Outside skirtings shall be made of the same type as the floor finish or painted plaster subject to the approval of the Engineer.

9.4.8 Ceramic Tiling

a) Wall Tiling - General

Wall tiling shall comply generally with BS 5385.

Tiling shall be glazed ceramic wall tiles complying with BS 6431 with cushion edges and spacer lugs, size 150 mm x 150 mm x 5 mm, colour white, unless otherwise specified. The top row and external angle tiles shall have rounded edges. All tiles shall be obtained from a single manufacturer.

Adhesive shall be approved premixed type as recommended by the tile manufacturer.

Grout shall be approved premixed type as recommended by the tile manufacturer.

Tiles shall be handled and stored to prevent damage and soiling and shall be kept in the supplier's cartons until required for fixing.

A sample area of tiling, size 1 m x 1 m shall be fixed in an approved location in advance of the I remainder for approval before proceeding.

b) Wall Tiling - Application

The manufacturer's recommendations for fixing shall be strictly followed for an products and materials.

The background shall be adequately true and level, free from contamination and loose areas and adequately prepared to give a good bond. Concrete and masonry backgrounds shall be thoroughly dry and shall have been exposed to air for not less than 28 days before tiles are fixed. Cement render backgrounds shall be a minimum of 14 days old, shall be firmly bonded to the background and free from dust.

Tiles shall be fixed by the ribbed adhesive thin bed method. Adhesive shall be applied to the wall as continuous float and trowelled with a notched trowel. The tiles shall be pressed on to the adhesive with a twisting/sliding action to give as far as possible a solid bed under the whole tile. Surplus adhesive shall be removed from the face of the tiles and the tiles left to set.

Tiles shall be laid to a tolerance of not more than 3 mm under a 2 m long straight edge. They shall be set out so that cut tiles are kept to a minimum and where they do occur are as large as possible. Joints shall be horizontal and vertical, with horizontal joints in adjacent walls aligning.

Grout shall be worked well into the joints so that they are completely filled, surplus grout removed with a damp cloth and the joints tooled to a smooth finish.

c) Floor Tiling - General

Floor tiling shall comply generally with BS 5385. Tiles shall comply with BS 6431 and shall be size 150 mm x 150 mm x 6.5 mm thick, colour white unless otherwise specified. Tiles shall have matt non-slip finish. The “separating layer” bedding method shall be used as detailed below. The floor shall have an overall thickness of approximately 50 mm over the structural slab.

Skirting tiles shall be 150 mm wide x 150 mm high with rounded top and 20 mm coving to floor edge of the same construction as the tiles with preformed angles and stop ends. Skirting tile joints shall align with floor tile joints and wall tile joints.

All tiles shall be obtained from a single manufacturer.

Separating sheet shall be 125 um (500 gauge) polythene perforated with 25 mm holes at 50 mm centres. Expansion joint material shall be polysulphide sealant and filler on 6 mm thick polyethylene foam filler strip.

Tiles shall be handled and stored to prevent damage and shall be kept in the supplier's cartons until required for laying.

A sample area of tiling, size 2 m x 2 m, including skirting shall be laid in an approved location in advance of the remainder for approval before proceeding.

d) Floor Tiling - Application

Tiles shall be laid to a tolerance of not more than 3 mm under 3 m long straight edge. Sudden irregularities shall not be permitted.

The base shall be adequately true and level. Before laying it shall be thoroughly dry brushed to remove all laitance, dirt and other loose material. Deposits of oil, grease and other substances incompatible with the bedding shall be removed using a suitable emulsion followed by clean water. New concrete surfaces shall be cleaned with a detergent to remove all traces of curing compounds or surface retarders.

Lay separating sheet on the clean level base with adjacent sheets lapped 100 mm.

Soak tiles in water and allow to drain for 10 to 15 minutes removing all surface water. Spread, level and thoroughly compact the cement-sand mortar bed. Within 2 hours and before the bedding sets evenly coat the back of each tile with neat cement slurry 2 to 3 mm thick and firmly beat down into the bedding to form an even surface with even joints not less than 3 mm wide, at the correct finished floor level.

After a minimum of 16 hours following laying, work grout well into joints so that they are completely filled, finish flush and thoroughly clean off surplus grout as the work proceeds using fine sand and cloth.

Expansion joints shall be provided round the periphery of each room at intervals of not more than 7 m in each direction of tiling and at all plinths and pedestals. Expansion joints shall be carried through the full depth of tile and bedding.

Armoured aluminium angle 50 mm x 50 mm x 6 mm to Grade 6061-T6 shall be fixed at every change in floor surfacing, the top surface being ground off flush with the floor finish.

Traffic shall not be allowed on the floor until at least 4 days after completion of laying and jointing and then only light traffic for a further 10 days.

9.4.9 Demountable Suspended Ceilings

Proprietary demountable ceilings shall be provided in all control, computer and office areas.

The ceiling panels shall be fabricated from 20 mm thick high-density resin-bonded glass wool with a micro-porous painted surface which shall be able to withstand wet cleaning. The panels shall be suspended a maximum of 250 mm beneath the roof slab soffit using a galvanised mild steel adjustable hanger system.

The ceiling system shall be suitable for use in humid environments and have a Class O fire resistance as defined in BS 476: Parts 6 and 7 together with a high sound absorption coefficient (Class B or above to ISO 11654). It shall have a minimum light reflectance of 70% and be suitable for use with the light fittings specified elsewhere.

No installation work shall commence until all glazing, cladding, and the like have been completed and all external openings closed in.

9.5 CARPENTRY AND JOINERY

9.5.1 General

Softwood for structural use shall comply with BS 5268 species groups SI and S2 of Tables 9 and 9A, grade 50 or equivalent.

Hardwood for structural use shall be an approved species generally complying with BS 5268-5 equivalent to grade 50 of Table 3 for bending and tension parallel to the grain.

Timber for joinery shall comply with BSEN 942:1996 Part I Appendix A for softwood and Appendix B for hardwood. Workmanship shall comply with BSEN 942: 1996.

Plywood shall comply with the requirements of BS 6566, WBP bonded type with a minimum thickness of 6 mm. Plywood face veneers shall be to BS 6566, Grade 1. Plywood adhesives shall be to BS 1203, WBP Grade. Plywood shall be obtained from an approved manufacturer to the correct thickness specified. The Contractor will not be permitted to make up the required thickness by gluing together sheets of thinner plywood.

Hardboard shall comply with BS 1142 Part 2 Type S of density normally exceeding 800 kg/cu m.

Insulating board shall comply with BS 1142 Part 3 having density not exceeding 350 kg/cu m and mean thermal conductivity not exceeding 0.058 W/m deg C.

Adhesive for joinery shall comply with BS 1204 Part 2.

Moisture content shall be:

a) Structural timber: Not more than 22% at any time but no more than 15% during gluing.

b) Joinery timber: External 20% $\pm$ 2% at any time but 17% $\pm$ 2% during manufacture

Internal 10% $\pm$ 2% at any time.

All joinery shall be framed together as soon after the commencement of the work as possible, and the workmanship shall comply with BS 1186: Part 2.

Timber work not of the quality or class specified or which is split, fractured shrunk at the joints, or shows any defect or unsoundness, lack of seasoning or bad workmanship shall be removed and put together anew, or replaced by new material.

All joinery and timber work to be painted shall be primed at the place of manufacture with an approved wood primer. The primer shall be applied by brush in an adequate and uniform coat to all surfaces including those to be bedded in.

Preservative treatment for structural carcassing timber shall be carried out by means of water-borne copper/chrome/arsenic compositions in accordance with the tropical proofing schedule of BS 2870. The same preservative shall be applied to all cross-cuts and other exposed surfaces.

Records of the preservative treatment carried out shall be maintained by the Contractor and shall be submitted to the Engineer for inspection when requested.

Trussed rafters shall be designed and constructed to comply with BS 5268. Shop drawings shall show the geometry of the trussed rafters together with the details of the design giving the structural adequacy of all joints, building in and the like. No notches shall be cut in structural timber without approval.

Fixing plugs shall be made from hardwood, fibre, plastic or other approved material.

In joinery work the surface defects known as "tearing out", "woolliness" and "chip bruising" will not be allowed.

Nails shall be steel complying with BS 1202: Part 1: 1994. Steel and brass screws shall comply with BS 1210.

Chromium plated and brass screw cups, dome headed screws, foundation bolts and nuts and coach screws shall comply with BS 1494: Part 2.

Self-tapping screws shall comply with BSEN ISO 1478:1995. Steel screws shall not be used with hardwood joinery.

Nail lengths shall be not more than the total thickness of sections to be joined less 5 mm, but otherwise not less than twice the thickness of sections through which nails are driven.

Screws lengths shall be not more than the total thickness of sections to be joined less 5 mm, but otherwise not less than 1.5 times thickness of the section through which screws are driven.

9.5.2 Timber Doors

Timber doors shall comply with BS 459 as follows: Part 1 for panelled doors, Part 2 for flush doors, Part 3 for fire check doors and Part 4 for matchboard doors. Timber doors shall comply with BS 4787 Part 1 for dimensional requirements.

Doors shall be sized to enable the removal of the largest item of furniture or equipment proposed.

Unless otherwise specified or approved the species of timber for doors shall comply with BS 1186, Part 1 Appendices A and B. No species of timber shall be used which is indicated in Appendices A and B as unsuitable without the approval of the Engineer. Unless otherwise specified hinges shall be 100 mm butt hinges, 1.5 pairs on external and 1 pair on internal doors. Hinges and screws shall be steel on softwood doors and brass on hardwood doors.

The Contractor shall provide evidence of the performance of fire-resisting doors and frames in tests carried out in accordance with BS 476, Part 8.

Panelled doors shall be constructed from hardwood and all joints shall be mortise and tenon type. Finished door thickness shall be 44 mm for external use and 35 mm for internal use.

Internal flush doors shall be semi-solid core type with hardboard or plywood facings, 35 mm finished thickness with hardwood lipping to vertical edges.

External flush doors shall be solid core type with plywood facings, 44 mm finished thickness with hardwood lipping to all edges and 60 mm x 35 mm splayed and grooved weather moulding.

Half-hour fire check flush doors shall be solid core type with plywood facings, 44 mm finished thickness. Hardwood lipping shall be provided to all edges on internal and external doors. External doors shall have plywood facing of exterior weatherproof grade and 60 mm x 35 mm splayed and grooved weather moulding. Hinges shall be the rising butt type.

One-hour fire check flush doors shall be solid core type with plywood facings, 55 mm finished thickness. Hardwood lipping shall be provided to vertical edges on internal doors and all edges on external doors. External doors shall have plywood facing of exterior grade weatherproof grade and 60 mm x 35 mm splayed and grooved weather moulding. Hinges shall be the rising butt type and an approved type automatic door closer shall be fitted.

Louvre doors and shutters shall be constructed from softwood to the type and dimensions shown on the Drawings or as specified, and shall be 35 mm finished

thickness. Doors and shutters shall be framed with mortise and tenon joints and have 48 mm x 8 mm rounded edge softwood louvre blades housed and glued into the stiles. Double leaves shall have rebated meeting stiles.

9.6 STEEL DOORS

9.6.1 General

Doors shall be sized to enable the removal of the largest item of furniture or equipment proposed.

9.6.2 Steel Doors

Doors and frames unless otherwise specified shall be made of galvanized sheet steel of minimum 1.5 mm thickness and the design and construction shall ensure stability under all practical conditions. They shall be constructed according to BS 1245 and BS 6510.

Steel profiles shall be formed by mechanical means and all joints shall be made carefully and in accordance with the best modern practice. No joints shall be permitted in the metal facing. If the steel thickness of the metal facing is less than 5mm steel reinforcement not less than 5mm thick shall be provided for the door closer.

The doors shall generally be double skin and comply with the requirements of BS 476 Part 22 for insulated steel doors with a minimum fire rating of 1 hour.

Authority of labelling/approving/listing shall be UL/FMNDS/LPC.

Steel fire doors shall be used as a barrier for openings in fire rated partitions and walls. Only labelled fire doors and frames with listed or labelled hardware shall be used to confirm the appropriate fire rating for the equipment. The door leaves shall be manufactured using welded double skins of hot dipped galvanised mild steel sheet, of minimum thickness 1.5 mm. The door leaf shall be stiffened using a steel section around the perimeter of the frame. The door shall be a minimum of 55 mm thick and filled with suitable fire resistant materials to withstand the rated fire period. The door frames shall be of double rebate profile of minimum 2 mm thick, hot dipped galvanised mild steel. The door frame and door leaf shall be one unit.

All fire doors shall be arranged to either remain in the normally closed position with a suitable self-closing device or in the normally open position with a feasible element actuated mechanism that shall close the door automatically in the event of a fire.

The entire surface area of the door leaf shall be insulated using a non-combustible insulation material to provide a minimum of 30 minutes fire rating. The insulation material shall be glued to the internal face of the double skin sheet and its perimeter frame. A fire resistant lock in an insulated lock pocket shall also be provided.

A total of three anchors shall be provided per 2.5 m height of frame with a minimum of six anchors per frame. Two part hinges with ball bearings shall be provided with a minimum of three hinges per leaf.

All doors shall be provided with the following minimum hardware and which shall also be subject to separate approval of the Engineer:

- Fire protected mortise lock, suitable to insert a profile cylinder of the master key system
- Surface mounted push bar and panic bolts exit device
- Overhead surface mounted door closer according to DIN 18263 in each door leaf
- Door knob shall be fixed to the external side of the fire protected side of the door leaf
- Handles and backing plates shall be stainless steel grade 316L
- Door stoppers shall be provided for each door leaf
- Designation labels shall be provided for all doors.

All door leaves shall be hot dipped galvanised and primed at the workshop in accordance with BS 729 and BSEN 10143. Final coats of paint for doors at Site shall be as per Section 7. The minimum thickness of galvanising shall be 48 microns.

All access doors to switch gear rooms and fire-protected rooms shall be provided with fire-resistant viewing glass window panels, which shall as a minimum be equal to the fire rating of the door assembly. All doors shall have a BS/DIN Logo label attached to indicate the rating, controlling institutions, manufacturers' name and date of production.

9.6.3 Steel Rolling Doors

Shutters shall be constructed of interlocking roll-formed galvanized steel slats to provide a curtain stiffness to withstand wind pressure of 125 kg/sq m. Galvanized steel slats shall be tight-coat galvanized with a coating of 0.40 kg/sq m of flat metal, free from flaking or peeling.

Roller shutter doors shall be procured from an approved recognised proprietary manufacturer.

Motorized doors shall be electrically operated. Electric motor 460 V, 3-phase, 60 Hz and worm reducing gears shall be separate unit coupled together and so designed and constructed that in case of failure in the electrical system the door can be operated by means of an auxiliary chaingear operating mechanism. A control lever shall be located within easy reach from the floor, which will instantly engage the auxiliary chain-gear operating mechanism. Power unit shall be self-locking and capable of holding the door in any position in case of failure of the counter balancing spring.

Motor unit shall be so designed that the motor can be completely removed without interfering with the operation of the door by the auxiliary chain-gear operator.

Shop drawings shall indicate the following minimum information:

- type, location and elevation of each door
- details of construction
- gauges of materials
- identification of surface preparation.

9.7 GLAZING

Glazing shall comply generally with BS 6262. Glass shall, unless otherwise shown, be 4 mm thick clear ordinary glazing quality complying with BS 952 except where required to be thicker in accordance with BS 6262.

Obscure glass shall be 4 mm thick complying with BS 952 Group 1.

Square pattern wired ground and polished glass shall be 6 mm thick with straight wires both ways to form 12.5 mm squares.

Solar control glass shall be formed from two panes of glass bonded together with a lamination between them of thin metallic film vacuum deposited on the inner surface of one of the panes. Solar control glass shall be of an approved type and manufacture.

Double glazing units shall be formed from two panes of 4 mm thick glass separated by a profiled 13 mm aluminium spacer with the complete periphery of the unit sealed by the application of a highly impervious moisture vapour resistant polysulphide material. The inner pane shall be clear float glass and the outer pane solar control glass. The units shall be of an approved type and manufacture.

Tempered plate glass, for use in aluminium exterior entrance ways and transoms shall be 19 mm thick "solarbronze" glass.

All glass and glazing units shall be delivered in the supplier's containers with details of glass attached. All glass and glazing units shall be of accurate size with clean undamaged edges and surfaces that are not disfigured. All glass and glazing units shall be kept dry during delivery and storage.

Putty shall be approved metal casement type of approved type and colour for metal and hardwood frames and linseed oil type complying with BS 544 for softwood frames. Rebates shall be sealed before glazing with primer for softwood frames and the finish varnish for hardwood frames.

External glazing shall be wind and watertight on completion.

Edge clearance shall be equal all round each pane, and not less than 3 mm for single glazing. Edge clearance for double glazing units shall be in accordance with the manufacturer's recommendation.

Location blocks of lead, sealed hardwood, rigid nylon or uPVC shall be used for all panes exceeding 0.2 sq m located in accordance with BS 6262, but not more than 75 mm from each corner.

Glass shall be secured in timber frames with glazier's springs or cleats at not more than 440 mm centres and in metal frames with spring clips as provided or recommended by the window manufacturer.

Back putty shall be of regular thickness not less than 2 mm. Front putty shall form a neat triangular fillet stopping 2 mm short of the sight line.

Beads and screw fixings where required shall be supplied by the window manufacturer unless otherwise specified. Hardwood beads in hardwood frames shall be fixed with brass screws and cups.

Glazing compound of approved type and manufacture shall be used for bedding and sealing bead glazing.

Distance pieces of plasticized PVC shall be of a thickness equal to the distance between the glass and rebate or bead and shall be located as follows:

- Opposite each other on each side of glass
- Not more than 300 mm apart, adjacent to fixing points of beads
- So as not to coincide with location blocks.

Painted or stuck on indicators shall not be used on solar control glass. Whitewash may be used on clear glass but must be restricted to small central areas of panes.

All glass shall be left clean inside and out free from all scratches or other blemishes on completion.

Mirrors shall be silvered 6 mm clear float glass complying with BS 952.

9.8 ALUMINIUM WINDOW FRAMES

Aluminium window frames shall be from an approved manufacturer and fabricated from H9 aluminium alloy in accordance with BS 4873, and fully weatherstripped. Surface finish shall be anodising to BS 3987 to provide an anodic coating of 25 micron average thickness over mechanical satin finish.

Fittings shall be the manufacturer's standard type and glazing shall be as specified.

Aluminium windows at high levels, if provided, shall be fitted with mechanical devices of type approved by the Engineer to allow for opening of such windows from the ground level.

Marble sills of thickness 30 mm and of approved type shall be installed under the windows.

Fly screens of non-ferrous gauze with a minimum of 120 strands per 100 mm of a type specifically manufactured for the purpose shall be provided to all opening casements. Flyscreens shall be removable for maintenance purposes.

Pre-finished surfaces shall not be allowed to rub or slide against each other and shall be well protected during transportation and storage.

To prevent damage by contaminated moisture condensation or cement or plaster splashes significant surfaces shall be protected by strippable tape or an approved transparent lacquer that weathers away naturally in service.

Before fixing two coats of bitumen solution or mastic impregnated tape shall be applied to all surfaces likely to be in contact with concrete, mortar or render.

Frames shall be fixed generally in accordance with CP 151 using fixing lugs and brackets supplied by the manufacturer.

Frames shall be pointed externally with an approved gun applied butyl or polysulphide non-setting mastic in accordance with the manufacturer's instructions.

9.9 IRONMONGERY

9.9.1 General

All ironmongery shall be of an approved type and manufacture and samples shall be presented to the Engineer for approval before ordering.

Fixing screws shall match the ironmongery and shall be of suitable sizes. On completion all ironmongery shall be adjusted as necessary, cleaned, oiled and left in perfect working order. Removable ironmongery, except hinges, shall be removed for painting and re-fixed prior to the final coat or on completion as instructed by the Engineer.

9.9.2 Hinges

All hinges shall comply with BS 7352: 1990. Hinges shall be pressed or wrought steel on softwood and cast or extruded brass on hardwood.

Hinges to timber doors shall be 100 mm butt hinges, fixed pin type.

Rising butt hinges shall be provided as agreed by the Engineer.

Hinges to timber shutters shall be parliament type with 75 mm width between legs.

9.9.3 Bolts

Bolts for doors and cupboards shall be provided as agreed by the Engineer.

All bolts shall be barrel bolts with silver anodised finish to BS 3987. All bolts shall have their own socket or plate.

Bolts for standard doors shall be 100 mm and for cupboard doors 75 mm long back plate.

Bolts for timber shutters shall be the necked type with 75 mm long back plate.

Indicator bolts for bathroom/washroom doors shall have an emergency release.

9.9.4 Padlocks

Padlocks shall be the five pin timber type in a long shackled 63 mm solid brass or bronze case with 2 keys.

9.9.5 Panic Bolts

Panic bolts shall have malleable iron or steel base with steel shoots and cross arms for cutting to exact length on site, fittings suitable for concrete floors and in the manufacturer's standard finish.

9.9.6 Lever Handles, Pull Handles, Cover Plates, Roses, Escutcheons, Kick Plates and Finger Plates

Lever handles, pull handles, cover plates, roses, escutcheons, kick plates and finger plates shall be aluminium with silver anodised finish to BS 3987 supplied to the satisfaction of the Engineer. Pull handles shall be straight bent bar type

200 mm long. Kick plate shall be 400 mm high and finger plate 150 mm x 150 mm.

9.9.7 Cabin Hooks and Eyes

Cabin hooks and eyes shall be 76 mm long with backplates for fixing, polished brass for internal use and galvanised mild steel for external use and shall be supplied where agreed by the Engineer.

9.9.8 Automatic Door Closers

Automatic door closers shall be supplied where required by the Engineer.

Automatic door closers shall be face fixing type suitable for the weight of door to which attached, hydraulically operated with steel arms and steel or aluminium body, capable of door opening to 180 degrees and having adjustable hydraulic check.

9.9.9 Fittings to Metal Doors and Windows

Fittings to metal doors and windows shall be as provided by the manufacturer to suit the range specified and included with the door or window as an integral part of the unit.

9.10 SECURITY AND SAFETY SYSTEM

The key and lock system shall be one or more Grand Master keyed systems designed and supplied by the Contractor to the approval of the Engineer. Locks shall comply with BS 5872 category B or better.

Cylinder locks shall be to a grand master key system capable of providing continuity of locking requirements and security throughout the project to the following specification:

a) Upright cylinder mortise lock with separate single cylinder bolted directly to the lock case with two machine screws, having a separate thumb turn on rose, or blanking plate, on opposite door face, also capable of being supplied with double cylinders to bolt back to back if required.

b) Bevel edge cylinder rings shall be provided to give flush face to cylinder and bolt through to thumb turn rose, opposite ring or blanking plate.

c) Deadbolts shall have 20 mm single throw and latch bolts shall have 14 mm throw and have easy action. Cylinder locking shall be mounted above lever handles.

d) Cylinder combinations, ideally 7 pin but minimum 6 pin assemblies shall be capable of providing a high level of security under grand master key requirements up to 1,500 locks, all to differ in 20 sub-suites capable of having 15 common cylinders per sub-suite in addition to other key combinations.

e) All lock facilities (lock, deadlock, night latch, emergency exit locks, sliding door locks and the like) shall be incorporated in a modular case size.

9.11 ROOF COVERING, WATER PROOFING AND INSULATION

9.11.1 General

Covering to roofs shall be the most suitable for hot and humid areas. The system shall comprise torch applied one layer proofing membrane 3 mm minimum thickness, insulation layer and finishing layer. All components of the system shall be of the best quality and shall be compatible. All roofing details shall be carefully designed to the approval of the Engineer. The waterproofing membranes and the insulating layer shall be laid by operatives experienced in this work. No materials shall be ordered before the Engineer's approval is obtained for the detailed design of the roofing system.

The Contractor shall provide 10 years warranty to guarantee the integrity of the roofing system.

9.11.2 Surface Preparation

The reinforced concrete slab shall be fully cured, cleaned and smoothly finished before the roof covering work commences.

9.11.3 Waterproofing Membrane

The waterproofing membrane shall consist of one layer of 3 mm minimum thick non woven polyester reinforced type torch applied to the approval of the Engineer. The material should not be susceptible to attack by moulds and fungi. The material should be resistant to solar radiation but notwithstanding this, the membrane shall be shielded from solar radiation at all locations including upstands. The waterproofing membrane shall normally be laid directly on top of the concrete roof/or roof screed.

The waterproofing membrane layer shall be laid at right angles to each other and strictly in accordance with the manufacturer's instructions for this work and to the approval of the Engineer.

9.11.4 Thermal Insulation Layer

A thermal insulation layer shall be formed by either lightweight concrete or extruded polystyrene rigid foam.

a) Lightweight Concrete

Lightweight concrete screeds for obtaining falls or as an insulating layer shall be of an approved type of foamed concrete. The materials shall be measured, applied and cured in accordance with the manufacturer's instructions and to the satisfaction of the Engineer. The fall to drains shall be 1:60 minimum.

Density of the finished lightweight concrete shall be 1,040 to 1,120 kg/cu m with a maximum thermal conductivity (K) value of 0.302 W/m degree C.

The lightweight concrete shall be chemically inert, stable, impermeable, inorganic.

Twenty-eight day crushing strength shall be at least 2.0N/sq mm

The screed shall be cured in accordance with Section 5 for a period of not less than seven days and during this time the screen shall not be subjected to traffic of any kind.

The lightweight screed shall be topped with a layer of cement and sand mortar (1:3 mix), well trowelled in to ensure proper adhesion and shall have a minimum finished thickness above the screed of 10 mm. The surface shall be finished flat and true.

The screeds and toppings shall be allowed to dry out thoroughly before subsequent roofing operations are carried out.

Screed and toppings shall not be laid during rain.

The thickness levels of the lightweight concrete shall be as recommended by the manufacturer and approved by the Engineer but the minimum thickness at the drains shall be 75 mm.

On top of the lightweight concrete and its topping screed, the separation layer shall be applied.

b) Polystyrene Foam

As an alternative to the lightweight concrete, polystyrene foam may be used as a thermal insulation layer. The layer shall be extruded polystyrene rigid foam or similar to the approval of the Engineer. Material thickness shall be such that the roof achieves the specified thermal conductivity but shall not be less than 40 mm. The thermal insulating layer shall be resistant to ageing and rotting, have good dimensional stability and possess a high resistance to thermal cycling.

Slopes to drains shall be adopted by means of lightweight concrete or sand/cement screed laid to falls directly on top of the reinforced concrete roof and before applying the water-proofing membrane and as specified above.

The thermal insulation layer shall normally be laid directly on top of the waterproof membrane. The material should be laid strictly in accordance with the manufacturer's instructions and to the approval of the Engineer. The thermal insulation layer shall be followed by the separation layer.

9.11.5 Separation Layer

The separation layer shall be a synthetic fibre mesh of polyester base (or other similar material) to the approval of the Engineer.

The separation layer is necessary to prevent fine particles of sand from getting under the waterproofing membrane or penetrating the joints in same. The separation layer shall be laid with minimum 300 mm laps.

The separation layer shall be laid directly on top of the thermal insulation layer and to the approval of the Engineer.

9.11.6 Protection Layer

The protection layer against solar radiation, wind uplift and buoyancy shall be hydraulically pressed concrete paving slabs of minimum thickness 40 mm and laid on top of the separation layer.

The concrete paving slabs shall be laid loose with tight joints.

9.11.7 Roofing Details

Roofing details shall be supplied by the Contractor, who shall be responsible for providing any additional details or samples as may be required by the Engineer to ensure that all comers, arises, penetrations and the like are satisfactorily waterproofed.

9.11.8 Roofing Drainage

The position, size and number of rainwater outlets shall be carefully designed. Slope to drains shall be 1:60 minimum and the drains shall be composed of reinforced concrete gargoyles with bottom outlets connected to downpipes. Downpipes shall be 150 mm diameter uPVC manufactured in accordance with BS 4576. The design, installation and testing of the roof drainage systems shall be in accordance with BS 6367.

9.12 ANTI-TERMITE TREATMENT

9.12.1 General

Before laying foundations for structures, the sides and bottom of the excavation, plinth filling and soil used for backfilling shall be sprayed with anti-termite chemical solution approved by the Engineer.

Precautions must be taken not to disturb the treated areas by re-levelling excavation or filling, as this will break the chemical barrier. If such a situation arises, the area shall be treated again to restore the chemical barrier.

The treatment shall be built-in-termite and shall be carried out by an approved specialist sub-contractor. The chemicals used shall have a certificate or approval issued by the Sultanate of Oman Public Health Department.

The specialist agency shall provide a guarantee that buildings shall be free from termite infestation for a period of 10 years.

9.12.2 Stage 1: Treatment to Foundations, and Top Course of Block Masonry at Plinth Level

After excavation for foundations and columns the bottom surface of the excavation shall be sprayed with chemical emulsion. If the excavation bottom is rock that does not retain the chemical emulsion, the top course of block walls, both external and internal, shall be sprayed soon after the blocks are laid.

9.12.3 Stage 2: Treatment to Soil under Slabs at Plinth Level

After filling and before the dry rubble or core packing, the entire surface of the fill shall be treated with a chemical emulsion. Light rodding shall be done to facilitate spraying and absorption.

9.12.4 Stage 3: Treatment of Wall and Floor Junctions

Rodding shall be carried out along the junction of plinth/basement walls and fill at 150 mm intervals and chemical emulsion sprayed so as to mix properly with the fill.

9.12.5 Stage 4: Treatment to Soil along External Wall Perimeter

After levelling and before paving or plinth protection is laid, the soil along the external wall perimeter of the building to a depth of 300 mm shall be sprayed with chemical emulsion. If necessary, rodding at 300 mm intervals shall be carried out to facilitate spraying and absorption.

9.13 STRUCTURAL STEEL WORK

Structural steel work shall comply with the requirements of Section 6.

9.14 CABLE TRENCHES

9.14.1 General

Cable trench sizes shall be standardised. Layout drawings shall be submitted for each site showing layout and size of trenches.

No trench shall cross a road. Power cables shall be placed in ducts of minimum 150 mm diameter with bell-mouthed ends. Ducts shall extend 1500 mm minimum beyond the edge of roads. Spare ducts shall be installed for likely future development.

Floors and walls of trenches shall be either precast or in-situ Grade 30 concrete of minimum 150 mm thickness, with the external surface painted with two coats of bitumastic paint.

9.14.2 External Cable Trenches

Walls and covers shall protrude at least 70 mm above site finish level and the top of the wall shall be flat with no rebate. Floors shall be sloped at 1:150 minimum slope to brick soakaways placed below the trench at low points; the volume of each soakaway shall be 2.5 cu m per 150 sq m of trench.

Covers shall be in concrete with an ASTM C 1202 permeability of less than 2000 Coulombs. All surfaces of the concrete cover shall be coated with the rubberized coating system as provided for in Section 6. Each cover weight shall be less than 55 kg. The minimum depth shall be 70 mm, with downstand ribs along each side providing a minimum overall depth of l00 mm. The sides of the cover shall overhang the wall by 15 mm and in the centre of each end there shall be a hand hole of minimum size 100 mm x 20 mm. This hole shall allow air to ventilate the trench so that heat built up in the trench shall be reduced. No gaps larger than 5 mm shall be left between adjacent covers so that the cables are always shaded. Cover slabs shall sit squarely and uniformly on the trench walls without the need for bedding or shims. Because portable equipment may be rolled over and along trenches, each cover shall be capable of resisting a 250 kg point load at mid span. The Contractor shall provide ramps up to the edge of covers in several locations, as agreed on Site, to enable wheeled equipment to mount the covers. The upper surface of covers shall have a stiff broom non-slip concrete

finish. All sharp edges shall be stoned smooth. Outer edges shall be chamfered.

Longitudinal fire separation walls and transverse fire separation walls, where required, shall be of brick or reinforced concrete.

9.14.3 Cable Trenches in Buildings

Cable trays shall be supported by approved inserts or drilled anchor bolts.

The building layout shall minimise trench lengths. Where power cables pass through a building to reach the far side, this shall generally be in a tunnel section. The Contractor shall be responsible for providing all trenches and ducts in a building, including ducts for outgoing power cables up to the site boundary and including any pulling pits required.

Where cables enter the building, all ducts/trenches shall be sealed. Fire/oil barriers shall be required to separate hazardous equipment. The ends of all ducts entering trenches shall be bell-mouthed.

Trench covers shall be as specified for chequer plate flooring in Section 6. Covers shall fit snugly around all cables.

Any beams used to support large span covers shall be removable. All metal work shall be painted as specified in Section 7.

All covers shall bed down evenly. Fully detailed fabrication drawings shall be provided for all covers.

9.15 PAVING

Pedestrian access routes between buildings and between buildings and roadways, and the like shall be designed by the Contractor and shown on the approved shop drawings.

Precast concrete paving slabs and concrete edgings shall comply with BS 7263: Part l. Slabs shall be 25 mm thick and except where cutting is necessary, 600 mm square. Edgings shall be 150 mm x 50 mm x 60 mm long square edge section as Figure 11, BS 7263: Part 1.

For radii of 12 m or less, specially cast edgings of the appropriate radius shall be used.

Bedding and backing for precast edgings shall be Grade 20 concrete.

Mortar for bedding slabs shall be l:1:6 cement:lime:sand by volume or other approved mix.

Base material shall be aggregate complying with BS 882 graded 65 mm to dust compacted with a 2.5 tonne roller to a finished thickness of 100 mm.

A sample area of paving of minimum size 3.5 m x 3.5 m shall be laid for approval by the Engineer before further work may proceed.

Slabs shall be laid on five 150 mm diameter spots of mortar not less than 25 mm thick and tamped to levels and falls. Slabs shall be laid to a regular pattern with even joints approximately 6 mm wide and any cut slabs placed on the edges of the paved area.

Jointing shall be carried out by brushing into the joints a dry cement: sand mortar mix 1:3, thoroughly damping the paving with a fine water spray and finishing the joints to a slightly dished profile.

Finished paving shall be covered with polythene sheeting for at least 3 days. No pedestrian or other traffic shall be allowed during that period.

9.16 CAULKING AND SEALING

9.16.1 General

All caulking and sealing products shall be applied in strict accordance with manufacturer's recommendations. All materials proposed for use shall be subject to approval.

9.16.2 Locations to be Caulked and Sealed

Caulking or sealing to provide a weatherproof and dustproof joint between materials of construction shall be provided as applicable, but not limited to, the following locations:

- Joints at exterior of all doors in exterior walls
- Joints at other frames in exterior walls
- Control joints
- Duct, pipe and electrical penetrations in exterior walls and as otherwise indicated or specified.

9.16.3 Caulking

Caulking shall be defined as the application of an oil-based compound designed for joints having very limited movement capability conforming to the Specification and shall be limited to interior usage.

9.16.4 Sealing

Sealing shall be defined as the application of elastomeric or rubber-based compounds designed for joints having moderate movement capability and for use where exposure to weather is indicated. Generally, sealants shall be used for all exterior work and for specific interior applications where so indicated by reference to the expected movement.

9.16.5 Application

The joints to be caulked or sealed shall be thoroughly cleaned of dust, dirt, scale, corrosion, grease or anything that might interfere with the adhesion of the sealant. Non-porous surfaces such as metal or glass shall be cleaned either mechanically or chemically when solvent is used to clean non-porous surfaces. The solvent shall be wiped off with clean cloths before it dries and re-deposits the contaminants.

If the joints are deeper than 10 mm, they shall be packed to within 10 mm of the surface with one of the joint fillers specified; the final 10 mm shall be filled with the sealing compound. The joints to be caulked or sealed shall be built up to or be cut out square down the sides so as not to be vee-shaped.

The surfaces to be caulked or sealed shall be primed with primer recommended by the manufacturer of the sealant being used in accordance with the sealant manufacturer's application instructions with respect to the various types of materials to which the sealant is to be applied.

The joint filler, the primer or any other material used in conjunction with the sealant shall be of such composition that it will not cause staining of the sealant or the material to which it is applied.

The sealant shall be applied before the final coat of paint is applied to adjacent work. The sealing compound shall be applied with a hand gun with the gun nozzle of the proper size to fit the joints. The material shall be driven in with sufficient pressure to solidly fill the joints; superficial painting of the joints with a skin bead will not be acceptable. The finish of the weather sealing on flush surfaces shall be neatly pointed flush or be tooled with a beading tool. Excess material shall be removed according to the job conditions or as directed.

The weather sealing shall be uniformly smooth, free of wrinkles, flush with adjacent surfaces and absolutely watertight. Adjacent surfaces which have been soiled by the application of the sealing compound shall be wiped clean and left neat. The work will be judged to be defective due to the sealants hardening, cracking crumbling, melting, shrinkage, leakage or running.

The weather sealing shall be guaranteed against any defect of materials or application for a period of two years after the date of the certificate of completion of the project. Any failure that may occur within this guarantee period due to defective materials or application shall be repaired or the weather sealing shall be replaced with new materials meeting these Specifications at no additional cost to the Employer.

END OF SECTION 9

SECTION 10

PLUMBING

10.1 GENERAL

10.1.1 Description

This Section covers the provision, installation and complete operation of the building plumbing, sanitary fixtures, and systems as shown on the Drawings and as specified herein.

10.1.2 Work Included in This Section

Principal items include, but are not limited to the following:

- Complete soil and waste systems from all sanitary traps to beyond building line to a point of connection shown on plans, including required trenching and backfill, including all final connections to site sewer system.
- Complete vent system from all sanitary traps to a point of termination above the roof.
- Complete roof rainwater drainage system from all rainwater roof drains to beyond buildings as shown on plans.
- Plumbing fixtures including supports, faucets, trim, rough-in, valves, piping, hangers, clean-outs, access boxes, sleeves and wall plates as indicated and/or specified.
- Final connections to all fixtures, items of equipment and site utilities.
- Submittal of shop drawings, "as built" record drawings and guarantees.

10.1.3 Explanation of Drawings

For purposes of clearness and legibility, the drawings are essentially diagrammatic, and although size and location of equipment are drawn to scale where possible, the Contractor shall make use of all data in all of the Contract Documents and shall verify this information prior to and during construction.

Scale and figure dimensions are approximate. Before proceeding with the work, the Contractor shall assume all responsibility for the fitting of his materials and equipment to other parts of the equipment and structure.

All work not shown in complete details shall be installed in conformance with accepted standard practice and manufacturer's recommendations.

Changes in location of all piping, apparatus and equipment as indicated on the drawings, shall be made to meet the architectural and structural conditions as required and as approved by the Engineer.

All items shall be installed in a manner and in locations avoiding all obstructions, preserving headroom and keeping openings and passageways clear. Changes shall be made in locations of equipment and materials which may be necessary in order to accomplish this. The drawings are essentially diagrammatic to the extent that many offsets, bends, traps, special fittings and exact locations are not indicated. Contractor shall carefully study the drawings and premises in order to determine the best methods, exact locations, route, building obstructions, etc., and shall install all apparatus and equipment in the available locations.

Work indicated on drawings, but not mentioned in Specification, or vice versa, shall be performed the same as if specifically mentioned or indicated by both. Any supplementary labour or materials required for a complete, approved, and properly operating installation shall be furnished.

10.1.4 Permits Licenses and Inspections

The Contractor shall give the proper authority all notice required by law relative to the work in his charge and shall obtain the necessary permits and pay the inspection fees if any, to the concerned authority.

All work and materials shall conform to the latest State ordinances and regulations.

10.1.5 Temporary Service

The Contractor shall furnish all water, and fuel required for the installation of the work and for the period of operation during testing of the system.

10.1.6 Site Utilities

The Contractor shall verify the available site utilities and make connections to water and sewer after ascertaining that site systems have been tested and are ready for connection, and after building systems are tested.

10.1.7 Locations and Space Requirements

All spaces, dimensions, locations, conditions, etc., required for the installation of all plumbing and related work shall be verified and full responsibility assumed. All necessary rough-in data and dimensions for all fixtures, equipment and equipment furnished under other Sections shall be obtained.

10.1.8 Ordinances and Permits

The Contractor shall comply with all applicable ordinances, anything herein or on the drawings to the contrary notwithstanding. This shall include State Health and Safety requirements as locally adopted. The Contractor shall obtain and pay for permits and licenses, give all notices, and pay all fees to complete the work. Before final acceptance of work, furnish to the Engineer "Certificates of Inspection", stating that the work has been inspected and approved by the relevant authority or written proof, in any other standard form, that the work has been approved by the relevant authority as necessary.

10.1.9 Openings

The Contractor shall cooperate with all trades in obtaining information as to openings required in walls, slabs and footings for all piping and equipment. Sleeves shall be accurately located and placed in forms before concrete is poured. Where several pipes pass through floors in close proximity, the Contractor may provide a single framed opening in lieu of individual sleeves. Framed openings shall be approved by the Engineer and shall be provided l00 mm high curbs, on all sides. The Contractor shall pay all extra costs for cutting of holes as a result of incorrect, delayed or neglected locations of sleeves or frame openings.

10.1.10 Painting

All finished painting shall be done as specified in Section 7, unless specified clearly under this Section. All apparatus and equipment, not specified otherwise, shall be provided with a shop prime coat. All insulation exposed to view shall be sized for painting, or as herein specified. All exposed ironwork, tanks, pipes, and fittings, without factory finish, including pipe hangers and rods shall be primed and painted with one coat of black asphalt varnish suitable for hot surfaces. Exposed pipe threads in bare or insulated piping shall be thoroughly cleaned and painted with two coats of metallic paint, or red lead.

10.1.11 Cooperation with Other Trades

The Contractor shall so organize work progress to harmonize with the work of all trades so that work may proceed as expeditiously as possible. The Contractor shall be responsible for the correct placing of the work and the connection thereof to the work of all related trades.

10.1.12 Protection of Finish

The Contractor shall provide adequate means for, and shall fully protect, all finished parts of materials and equipment against damage from whatever cause during the progress of the work and until final completion. All materials and equipment in storage and during construction shall be covered in such a manner that no finished surfaces will be damaged or marred and all moving parts shall be kept perfectly. clean and dry. All damage or defective work shall be replaced prior to applying for final acceptance.

I 0.1.13 Clean-Up

During the progress of the work, premises shall be kept reasonably free of the debris, waste materials and rubbish resulting from the work under this Section. Upon completion and before final acceptance of the work, all debris, temporary protective coverings, rubbish, left-over materials, tools and equipment shall be removed from the site. Exposed piping, machinery, apparatus shall be thoroughly cleaned of cement, plaster, paint and other materials, grease and oil spots removed with cleaning solvent. Surfaces shall be carefully wiped and all cracks and comers scraped clean. Chromium or nickel plated materials and equipment shall be thoroughly polished. The entire installation shall be left in a neat, clean and usable condition.

10.1.14 List of Materials and Equipment

All items of material and equipment required by this Section shall bear the approval of the Engineer prior to the start of any work. The Contractor shall submit all items requiring such approval, allowing ample time for checking and processing and shall assume all responsibility for delays incurred due to the rejected items. Submittal information covering all items shall be submitted as described in Sections 1 and 11.

10.2 MATERIALS

10.2.1 General

Materials and/or workmanship shall be of the best quality for the purpose intended, and all materials shall be new and in first class condition. Materials shall be clearly marked or stamped with the manufacturer's name and/or Stamp and rating.

10.2.2 Rainwater and Ventilating Pipes and Fittings

Rainwater down pipes and fittings shall be 150 mm diameter uPVC manufactured in accordance with BS 4576. The design, installation and testing of the roof drainage systems shall be in accordance with BS 6367.

10.2.3 Water Supply

a. Galvanized Mild Steel Pipes and Fittings

Unless otherwise stated all water supply pipework shall be galvanized mild steel tubing conforming to BS 1387 (Class C). Fittings shall galvanized malleable cast iron complying with BS 143. All pipes and fittings shall be suitable for screwing to BS 21 pipe threads.

b. Stopvalves, Gate Valves and Draining Taps

Stopvalves shall be brass to BS 1010. Draining taps shall be brass to BS 2879.

c. Cold Water Storage Cisterns

Cold water cisterns shall be galvanized mild steel to conform to BS 417 Grade A, or plastic (polyolefin or olefin copolymer) to conform to BS 4213, or approved glass reinforced plastic.

The cisterns shall be of the sizes stated and in the positions shown on the drawings and where galvanized shall be painted inside with 2 coats of non-tainting bituminous paint.

The cisterns shall be provided with a brass ball valve to conform to BS 1212 Part I with plastic or copper float conforming with BS 2456.

d. Hot Water Storage Tanks

Hot water storage tanks shall be approved, proprietary low pressure insulated tanks bossed for pipe connection and immersion heater. The immersion heaters shall be electric immersion heaters complying with the requirements of BS 3456 Section 2.21.

e. Copper Tubes

Copper tubes shall be half hard copper tube complying with BS 2871: Part I, Table X.

f. Copper Fittings

Fittings for copper tube shall comply with BS 864: Part 2 for capillary and compression Type A fittings. PTFE tape for compression joints shall comply with BS 7786.

Draining down taps shall comply with BS 2879.

Stop valves shall comply with BS 1010: Part 2 with crutch handles.

10.2.4 Internal Drainage Pipes and Fittings

The internal drainage installation shall be carried out in compliance with the relevant Bye-Laws.

a. uPVC

uPVC pipes for drainage shall conform to BS 5481 and BS 4660 and shall be installed in accordance with the manufacturer's guidelines.

1 0.2.5 Sanitary Fittings

The quality of all ceramic sanitary fittings shall comply with BS 3402 and shall be obtained from an approved manufacturer. Samples shall be submitted for approval prior to installation.

Sanitary fittings shall, unless otherwise stated be as described below:-

a. WC Suites

WC Suites shall be of white glazed fireclay and comply with BS 5503, BS EN 33, BS EN 37 and BS EN997. They shall, have "P" or "S" traps as required. 90 mm bore outlet, and two gallon capacity high or low level cast iron or glazed fireclay flushing cistern and appurtenances. W.C. seats and covers shall be solid section black plastic and shall comply with BS 1254. Connectors for WC's and cisterns shall comply with BS 5627.

Flushing cisterns and flush pipes shall comply with BS 1125. A manufacturer’s certificate shall be provided testifying that the flushing cisterns comply with BS 1125. Ball valves shall comply with BS 1212. Floats shall comply with BS EN 1561.

b. Wash Basins

Ceramic wash basins shall be white glazed fireclay size 625 mm x 450 mm overall and shall conform to BS 5506, BS EN 31 and BS EN 32. Each basin shall be provided with a 32 mm outlet with stopper, chromium plated chain and stay. Faucets shall be chrome plated, 13 mm diameter and shall comply with BS 5412: Part 1. Wastes for basins shall comply with BS 3380. Traps for basins shall be plastic and shall comply with BS 3943 with a 75mm minimum depth of seal. Pedestals shall match the basin.

c. Sinks

Sinks shall be of stainless steel to the sizes stated and shall conform to BS 1244:Part 2 Type A. Each sink shall be provided with a 40 mm chromium plated brass waste outlet with grating. A 40 mm trap shall be fixed to each sink, having a 40 mm or 75 mm deep seal as necessary. One or two 12 mm bib traps, as required, shall be fixed with extension pieces of adequate length. Sinks shall have double draining boards and fitted cabinets underneath.

d. Taps

All taps shall conform to BS 1010. Taps shall be of the following type as appropriate and, where necessary, shall be provided with extension pieces.

- Pillar taps shall be heavy-duty chromium plated brass with cross heads, 12 mm diameter for basins and sinks.
- Bib taps, unless otherwise stated, shall be 12 mm diameter heavy-duty chromium plated brass with cross heads, complete with backplate elbow or wall flange. Bib taps to stand pipes shall be 12 mm diameter unplated brass, and shall have an extended nozzle suitable for hose connection.
- Manual mixing valves shall comply with BS 1415: Part I.
- Taps shall be colour coded hot and cold.

e. Showers

Shower fittings shall comprise a 100 mm diameter adjustable chromium plated brass inclined shower head with hose and 12 mm diameter supply pipe(s) with mixing valve to control the water supply. Shower head shall be adjustable spray type connected to chromium plated supply pipe.

f. Traps

Traps shall be of the following types:

- Traps for sinks, lavatory basins and baths shall be copper, brass, or aluminium, to BS 1184, with cleaning eye. Traps to baths shall have an overflow connection.

- Traps for urinals with suspended drains shall be 75 mm diameter cast iron to BS 416, Table 14. They shall be fitted with cast iron connectors with top drilled and threaded to receive outlet from urinal.

- Traps for urinals with buried drainage shall be 75 mm diameter cast iron to BS 437. They shall be fitted with cast iron connectors with top drilled and threaded to receive outlet from urinal.

10.2.6 External Drainage

a. Sundry Materials

Excavation, concrete work, brickwork and pipework, except as specified herein, shall be as described in other sections of the Specification.

b. Gulleys and Traps

Glazed stoneware and cast iron gulleys and traps shall comply with BS 65 and BS 437 respectively.

c. Types of Drain Pipes

All soil and rainwater pipes except where under buildings or above ground, shall be vitrified clay or an approved make of uPVC pipe. All pipes under buildings shall be cast iron which shall extend for one meter beyond the building line.

d. Manhole Covers and Frames

Manhole covers and frames shall be as described in Section 3.

10.3 INSTALLATION

10.3.1 General

The plumbing installation shall be carried out to the satisfaction and in accordance with any local Acts and By-laws of the local authorities.

The plumbing installation shall generally comply with the following

- BS 6465: Part I Sanitary Appliances -Selection and Installation

- BS 6700: Water Supply

- BS 5572: Sanitary Pipework

All pipework shall be neatly executed in long lengths to avoid unnecessary jointing. Horizontal pipes shall be fixed with a slight fall to prevent airlocks and to enable the system to be easily drained down.

10.3.2 Rainwater and Ventilating Pipes and Fittings

a. Cast Iron

Cast iron downpipes and ventilating pipes shall be jointed with yarn and molten lead or approved cold caulking compound. Cast Iron pipes shall be fixed to the structure as described for external pipe.

b. Access for Cleaning Internal Rainwater Pipework

All internal rainwater pipework shall be provided with an adequate number of access plates, cleaning eyes etc. to ensure that the system is fully accessible for cleaning.

c. Wire Balloons

All outlets from gutters shall be fitted with galvanized mild steel wire balloon gratings of approved design to fit securely into the outlet.

d. Roof and Balcony Outlets

Roof outlets shall be coated cast iron of an approved type. The outlets shall be provided with a luting flange to receive the roof or balcony finish. Roof outlets shall be provided with a coated cast iron dome grating. Balcony outlets shall be provided with a coated cast iron flat grating.

Rainwater pipes and fittings shall be fixed and jointed in accordance with manufacturer's instructions. Fixing clips for pipes shall be at 1.8 mm centers. Inspection hatches shall be provided at all bends. Testing of rainwater pipes shall be carried out as specified in Clause 10.3.7.

10.3.3 Water Supply

The water supply installation shall be carried out in compliance with the local By-Laws.

a. Galvanized Mild Steel Pipes and Fittings

Jointing shall be by means of screwed joints made with white hemp and an approved non- tainting leadless jointing compound. Reducing pieces shall be provided when jointing pieces of different sizes.

All pipework shall be fixed to walls and ceilings with galvanized malleable iron brackets conforming with BS 1494 table 6(a)/7(a) with screwed backplates or tails for building in where required extended brackets shall be used which shall consist of galvanized malleable iron pipe rings as Table 13(a) with screwed galvanized mild steel rods split for building in or with screwed backplates as Table 10 (a).

Brackets shall be fixed at sufficient points on straight runs and in addition at all bends and fittings.

b. Pipe Sizing

Unless stated otherwise, the final connections to all fittings shall be 12 mm diameter. The sizes of distribution pipes from which these connections are taken shall be as follows:

Number of Fitting Served	Diameter of Distribution Pipe
2	22 mm
3, 4	28 mm
5 to 7	32 mm
8 to 12	40 mm
13 to 18	50 mm

c. Stopvalves Gate Valves and Draining Taps

An adequate number of valves and draining taps shall be provided so as to permit the various sections of the installation to be isolated and drained down. The following rules shall apply to all installations:

- A stopvalve shall be fitted to the rising main at a height of 1 meter above the point of entry into the building.
- A draining tap shall be fitted to the rising main immediately above the stopvalve.
- A stopvalve shall be provided to the rising main as close as possible to the storage cistern.
- A gatevalve shall be provided to the down supply pipes from all cold water storage cisterns, as close as possible to each cistern.
- A stopvalve shall be provided to the branch supply pipe for each range of sanitary fittings at the junction with the main down supply.
- A draining tap shall be provided at the lowest point of each branch supply pipe to enable the whole of the installation to be drained down.

d. Cold Water Storage Cisterns

Each cistern shall be fitted with a 25 mm diameter outlet for connection to wash-out pipe and a stop-tap shall be fitted to the wash-out pipe. The end of the wash-out or connector shall not project into the cistern. The wash-out pipe shall be run to a position to be determined.

e. Copper Tube

Copper tube shall be fixed clear of walls and ceilings with two piece copper spacing clips complying to BS 1494: Table 8d or with proprietary plastic pipe clips. Clips shall be at l.2m horizontally and 1.5m vertically for 15 mm dia pipes and at 1.8m and 2.4m respectively for 22 mm and 28 mm dia pipes. Capillary joints shall be neatly made with all surplus solder removed. Screw threads on compression joints shall be wrapped with PTFE tape prior to tightening.

10.3.4 Internal Drainage

The internal drainage installation shall be carried out in compliance with the local By-Laws.

a. uPVC

uPVC pipes shall be jointed by solvent welding as per manufacturers' recommendation.

b. Access for Cleaning Soil and Waste Pipework

The soil and waste system shall be fitted with sufficient access plates, or eyes, to ensure that the system is fully accessible for cleaning.

c. Wire Balloons

All soil and ventilating pipes shall be fitted at the top with a galvanized mild steel wire balloon grating of approved design to fit securely into the pipe.

d. Vent Pipes

Vent pipes passing through tiled or asphalted roofs shall have an approved proprietary flashing built-in to the roof to provide a weather-tight seal. Care shall be taken in allowing for expansion in accordance with the manufacturer's instructions.

e. Floor Gullies

Floor gullies shall be coated cast iron, with 90 mm trapped outlet and shall be fitted with a galvanized flat grating of an approved type.

f. Layout of Pipework

The positions and runs of soil, waste and water supply pipework shall be approved by the Engineer before the installation is commenced. Exposed pipework shall be set out to give a neat appearance.

g. Builders Work

All holes, chases etc. in reinforced concrete to accommodate pipework and fittings shall be formed as the structural work proceeds. No cutting into reinforced concrete will be allowed. All holes and chases in walls, floors and ceilings etc. shall be made good on completion of plumbing work and before decoration. Any damage caused to finished work shall be rectified to the satisfaction of the Engineer.

h. Painting

All exposed pipework, traps, brackets etc. shall be painted in accordance with the Painting Specification.

i. Testing

Testing of internal drainage system shall be carried out as specified in Clause 10.3.7.

10.3.5 Sanitary Fittings

Sanitary fittings shall be fixed by the Contractor, unless otherwise stated, described as follows.

a. WC Suites

The low level WC suites shall be plugged and screwed into floor. The cistern shall be fixed to the wall using concealed hangers plugged and screwed to the wall.

b. Wash Basins

One or two 12 mm pillar taps shall be fixed as required. Where one tap only is required, provide and fix one tap hole stopper to match the basin unless otherwise specified. Basins shall be fixed on two cast iron brackets plugged and screwed to wall.

c. Sinks

Unless otherwise specified sinks and draining boards shall be installed on cabinets with fitted cupboards underneath.

Where one tap only is required, a tap hole stopper to match the sink shall be provided. If not supported on a cabinet unit, the sinks shall be provided with suitable legs and bearers in cast iron or galvanized steel with painted finish.

d. Showers

The shower head shall be fixed at a height of 1800 mm above the finished floor level.

e. Testing

After completion of the works the whole of the installation shall be flushed out and tested as specified in Clause 10.3.7 and directed by the Engineer.

f. Supervision

All plumbing shall be carried out by or under the supervision of a plumber duly licensed by the local authorities.

10.3.6 External Drainage

a. uPVC Pipes and Fittings

uPVC pipes and fittings shall be jointed by the solvent welding process as recommended by the manufacturer.

b. Gulleys and Traps

Jointing of gulleys and traps shall be as described for the pipes of the same materials. Gulley gratings, unless otherwise specified shall be coated cast iron.

c. Drain Installation

All drains shall be laid in accordance with the Specification. Unless otherwise stated the drains shall be laid to gradients within the following limits:

100 mm diameter -	Maximum gradient -1 in 30 Minimum gradient -1 in 60
150 mm diameter -	Maximum gradient -1 in 50 Minimum gradient -1 in 100

d. Beds, Haunching and Surrounds

Beds, haunchings and surrounds shall be provided to drain pipes and fittings as necessary.

e. Manholes and Inspection Chambers

Manholes, circular or rectangular shall be constructed as detailed in the Specification and/or as shown on the Drawings.

f. Inspection and Testing

Close inspection shall be maintained at every stage of the drainage work to ensure that pipes and fittings are laid as specified and that the drainage system is kept clean during the work. All lengths of drain shall be thoroughly cleaned out before testing. Testing shall be carried out as specified in Clause 10.3.7.

The system shall be tested twice:

The first test shall be carried out as soon as practicable after laying (but not less than 48 hours after jointing) and before haunching or surrounding pipes and before backfilling trenches.

The second test shall be carried out on completion of the works.

The test shall be carried out, where possible to a complete section of drainage between manholes. Short branch drains shall be tested with the main drain run. Long branch drains shall be tested separately.

The Contractor shall carry out the tests in the presence of the Engineer and all necessary remedial work shall be to his satisfaction.

The drains shall be tested by water tests, which shall be carried out as detailed in the Specification.

The Contractor shall provide all labor, water, other materials and equipment required for testing and these shall be to the satisfaction of the Engineer.

10.3.7 Testing

Soil and waste pipes shall be air tested for leaks to a pressure of 38 mm water gauge, constant for three minutes, in accordance with BS 5572 Section 12.

Rainwater pipes shall be tested for leaks as above, and gutters shall be tested by filling with water to overflow level.

Testing shall be undertaken to hidden sections of pipework before they are built in.

All leaks found shall be rectified and retested.

END OF SECTION 10

SECTION 11

GENERAL MECHANICAL AND ELECTRICAL EQUIPMENT REQUIREMENTS

11.1 GENERAL

These General Mechanical and Electrical Equipment Requirements, which apply to all mechanical, electrical and instrumentation systems and equipment, are a part of each and all of the separate Sections of the Specification. The Contractor shall direct the attention of all manufacturers and suppliers of mechanical and related appurtenances for the work to the provisions of the Contract Documents and this Section and also to the extreme climatic conditions at the Site.

Climatic conditions are very severe. Dust storms are frequent. Humidity is high, maximum relative humidity is up to 100 percent and periods of high humidity are frequent.

The maximum ambient temperature to be used in design of mechanical and electrical equipment, unless otherwise specified, is 55^{o}C. Metal surfaces in direct sunlight can reach 85^{o}C.

11.2 JOB CONDITIONS

Drawings are diagrammatic and indicate the general layout of the complete Works. Locations of equipment, valves, inserts, anchors, motors, panels, pull boxes, cables, conduits, stub-ups, lighting fixtures, power and convenience outlets, and exterior lighting units are approximate. The Contractor shall conform to the Drawings as closely as possible, exercising care to secure approved headrooms and clearances, to overcome structural interference and to verify scaled dimensions, field dimensions and conditions at the place of work.

11.3 QUALITY ASSURANCE

All equipment furnished shall be of a design that has been used in similar applications and shall be demonstrated to the satisfaction of the Engineer that the quality is equal to equipment specified or made by those manufacturer's specifically named herein. The manufacturer shall have successfully designed and furnished similar sized or larger equipment for a similar application.

The Engineer may inspect equipment at the factory. The Contractor shall notify the Engineer in sufficient time so that the factory inspection can be arranged. Factory inspections will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations. Approval of equipment at the factory only allows the manufacturer to ship the equipment to the Site and does not constitute final acceptance.

Factory tests are required for equipment as specified in the detailed Specification.

11.4 ADAPTATION OF EQUIPMENT

No responsibility for alteration of a planned structure to accommodate substitute equipment will be taken by the Engineer. Equipment which requires alteration of the structures will be considered only if the Contractor assumes all responsibility for making and coordinating all necessary alterations. All revisions to structures, mechanical, electrical, or other work made necessary by such substitution shall require the approval of the Engineer and the cost of said revisions, including cost of any redesign by the Engineer, shall be made at the Contractor's expense.

After approval of the Mechanical and Electrical drawings the Contractor shall prepare and submit to the Engineer revised Drawings showing any necessary revisions to the proposed civil structures. The location, size and details of box-outs and fixings for mechanical and electrical and other equipment shall be shown on the revised Drawings and the Contractor will be responsible for providing in the civil structures the correct location and size of the box-outs and fixings shown on the approved mechanical and electrical drawings. The Contractor shall prepare at his own cost the necessary revised civil drawings and detailed structural and other design calculations and submit them to the Engineer for approval. The Contractor shall not be entitled to an Extension of Time for Completion for any delays from the preparation of such revised drawings. The Contract price shall not be increased as a result of any changes in the civil structure from that shown on the Contract Drawings, unless such changes are the result of a variation properly ordered by the Employer.

11.5 GUARANTEE AND WARRANTIES

The Contractor shall guarantee all equipment in accordance with the Conditions of the Contract. In addition to the general guarantee requirements, equipment guarantee shall cover (1) faulty or inadequate design; (2) improper assembly or erection; (3) defective workmanship or materials; and (4) leakage, breakage, or other failure. For equipment bearing a manufacturer's warranty in excess of one year, furnish a copy of the warranty to Engineer with the Employer named as beneficiary.

11.6 SUBMITTALS

Refer to Section I and to specific sections for basic submittal requirements. All layouts and shop drawings shall be to scales of 1:1, 1:2, 1:5 or multiples of ten thereof. Additional requirements for equipment are as specified hereafter.

11.6.1 Technical Data

The Contractor shall submit the following documents for all equipment in accordance with a time schedule commensurate with the construction programme. The Contractor shall note that this time schedule should be submitted to the Engineer within seven days from the commencement of the Contract, and obtain prior approval.

Submittal 1

- Detailed schedule of submittals.
- Drawing list and schedule for submittal.

Submittal 2

- Shipment schedule.
- Descriptive catalogues and manuals certified by the manufacturers.
- List of materials of construction of equipment.
- For each motor: Motor data, including the manufacturer; the minimum guaranteed efficiency and power factor at full load, 3/4 load, and 1/2 load; locked motor current in amps; full load current in amps; the motor speed in rpm; mounting details: motor housing materials; winding material; NEMA Design Letter; NEMA Code Letter; ambient temperatures including de-rating factors and maximum elevations in which motor is designated to operate continuously; service factor; NEMA insulation class; temperature rise; type of enclosure; voltage; bearing life dynamic balance. Field recorded current data shall indicate the full load current for each motor and current rating for the overload relay, each motor starter and control.

Submittal 3

- Dimensioned general layout drawings of all equipment.
- Control panel layouts.
- Single line diagrams showing final loads and cable sizes.

Submittal 4

- All remaining shop drawings.

Submittal 5

- Draft instruction manuals (in English).

11.6.2 Shop Drawings

Drawings shall be submitted to the Engineer within the time periods specified above but prior to fabrication of custom made equipment or the placing of orders for manufactured equipment and after the approval of submitted Technical Data. Shop drawings shall be submitted in complete sets indexed by Specification paragraph and Drawing number describing the various equipment items or systems. Shop drawings, data and Specification for the equipment shall include, but shall not be limited to complete fabrication, assembly, foundation, and installation drawings, together with detailed Specification and data covering performance, weight of the equipment, power drive assembly, parts, devices, wiring diagrams, anchor bolt placement and details including projections from concrete, materials of construction including shafts, bearings, impellers, castings, pump stuffing boxes and shaft guards, electric motor data including size, make, type, designation, and mounting details, detailed pipe drawings and all other accessories forming part of the equipment to be furnished.

11.6.3 Coordination of Unit Responsibilities

Refer to pertinent Sections for items of equipment to be assembled of several components under the unit responsibility of one manufacturer. To coordinate these requirements, the Contractor shall monitor and verify the unit responsibility

processes and submit the following information to the Engineer in writing on a monthly basis:

- Shipment dates of the various components to the unit responsibility manufacturers.
- Scheduled dates of factory tests by unit responsibility manufacturers.
- Scheduled shipment dates to site of unit responsibility items.

11.6.4 Submittals for Operational Demonstrations and System Validation Tests

At least 60 days before the first operational demonstration is to be performed, the Contractor shall submit a detailed and comprehensive procedure plan for performance of each operational demonstration required. Identical equipment items may be covered under one plan. An estimated date and duration for each procedure and the personnel required shall be included.

At least 60 days before the first system validation test is to be performed, the Contractor shall submit a detailed and comprehensive procedure plan for performance of each separate validation test and for each validation test that covers two or more systems. Each procedure plan shall describe and itemize the involved system including associated electrical equipment and instrumentation and control systems, and shall include evidence of an organized step-by-step procedure properly coordinating the efforts of the various trades and manufacturer's representatives involved and of the operations of the facilities. The procedure plan shall include an estimated duration and date for each procedure and the personnel required.

In addition to the information specified above, each procedure plan shall include the following information, as applicable:

- Description of temporary procedure facilities including drawings and sketches as required to fully illustrate the facilities.
- List of test materials and estimated quantities.
- List of instruments, measuring, and recording devices, and other test equipment, whether a part of the plan or furnished separately for temporary use.
- Names of supervising and inspecting manufacturers.
- Complete listing of all functional parameters to be observed and recorded.
- Recording intervals.

Samples of the forms, charts, and other materials to be used in recording demonstration and validation test results shall be submitted.

Within 10 days after completion of each procedure plan 3 copies of all recordings and results of all operational demonstration and system validation tests shall be submitted.

11.6.5 Manufacturer's Certified Reports

To the extent required under this Section, the equipment manufacturer, or his authorized representative shall submit a notarized written report with respect to his equipment certifying that (1) the equipment has been properly installed, wired, and connected under his supervision, (2) the equipment is in accurate alignment, (3) he was present when the equipment was placed in operation, (4) he has checked, inspected, and adjusted the equipment as necessary, (5) the equipment has been operated under full load conditions and operated satisfactorily, and (6) the equipment is fully covered under the terms of the guarantee.

11.6.6 Record Drawings

Record Drawings shall be submitted as detailed in Section 1.

The complete set of drawings for approval shall be submitted to the Engineer within thirty days of the commencement of Test on Completion. The Engineer's approval, or otherwise, to the drawings shall be given within thirty days of receipt of the complete drawings. The Contractor shall submit final copies of drawings within thirty days of receipt of the Engineer's approval.

Drawings shall include but not be limited to complete schematics and wiring diagrams; drawings showing all installed equipment, conduits, piping/tubing, pipes, cables and all routing and tray systems; supports and mounting details; point to point diagrams with cable wire, tube and termination numbers for instrumentation.

11.6.7 Instruction Manuals

The Contractor shall submit four sets of Instruction Manuals and Priced Parts Lists for all mechanical, electrical and instrumentation equipment to the Engineer. Two copies of the draft manual shall be delivered as specified under Clause 11.6.1. The final copies shall be provided to the Engineer within two weeks of the commencement of the Maintenance Period and shall include all revisions necessary to correct for any changes made during installation or checkout.

The manuals shall include not less than the following information for all equipment supplied:

- General introduction and overall description, purpose, functions, simplified theory of operations, etc., particularly for logic schematics.
- Specification (including equipment specification data sheets).
- Installation instructions, procedures, sequences, tolerances and precautions.
- Operational procedures.

- Shut-down procedures.
- Maintenance, calibration and repair instructions.
- Greasing and lubrication charts.
- Schematics and wiring diagrams.
- Detailed circuit operational description including programmable controller ladder diagrams.
- Parts list and spare parts recommendations.

The format of the manuals shall use drawings and pictorials to illustrate the text to the extent necessary to insure a clear, concise presentation. Manuals have been written to cover a family of similar equipment, strike out inapplicable information in a neat fashion or emphasize applicable portion by heavily weighted arrows, circles or boxes; whichever provides the clearest and neatest presentation. Where identical instruments are used in more than one control loop or subsystem, include only one instrument manual. However, an index by tag number for all instruments shall identify its location in that manual. Control loop and/or subsystem operational description shall identify the function of each instrument and its relation to the other instruments in the loop. Each manual shall be bound in a cover that indicates the equipment, panel or process area to which it applies, manufacturer's name, local address and telephone number, and year of purchase.

11.6.8 Ordinances and Regulations

Materials, equipment and workmanship shall be designed to comply with and shall be installed in accordance with the requirements of all legally constituted public authorities having jurisdiction, including Safety Orders and Fire Protection Rules and Regulations. Except that where provisions of these Specification exceed such requirements, these Specification shall govern. The Contractor shall obtain and pay for all permits, licenses and inspections that are required for the performing of his work by all laws, ordinances, rules, regulations or orders of any body lawfully empowered to make or issue same, having jurisdiction.

11.7 PRODUCT DELIVERY, STORAGE AND HANDLING

All equipment shall be boxed, crated or otherwise enclosed and protected during shipment, handling, storage and after installation until final acceptance of the equipment. Electrical materials shall be delivered in manufacturer's original cartons or containers with seals intact as applicable. Large multicomponent assemblies shall be delivered in sections that facilitate field handling and installation.

Unless designed for outdoor use, all equipment shall be kept dry, off the ground and covered from exposure to weather. Pumps, motors, electrical equipment and equipment having anti-friction or sleeve bearings shall be stored in weathertight storage facilities. Heaters in equipment shall be connected and operated until the equipment is placed in operation. The Contractor shall prevent corrosion, contamination or deterioration of stored equipment.

Equipment and materials shall be handled in accordance with manufacturer's recommendations. Large or heavy items shall only be lifted by the designated points. Padded slings and hooks shall be used for lifting to prevent damage.

All equipment shall be protected until final acceptance and all factory surfaces must be protected from impact, abrasion, discoloration and other damage. All damaged equipment must be repaired or replaced before final acceptance.

11.8 PRODUCTS

11.8.1 Materials and Workmanship

All equipment furnished shall be new and guaranteed free from defects in materials, design, and workmanship. It shall be the manufacturer's responsibility to ascertain the conditions and service under which the equipment will operate and to warrant that operation under those conditions shall be successful. All parts of the equipment shall be amply proportioned for all stresses that may occur during fabrication, erection, and intermittent or continuous operation. Equipment and materials shall be provided suitable for the service conditions and meeting standard specifications such as ANSI, ASME, A WW A, ASTM, NEMA, BS, UBC and UL.

All equipment shall be designed, fabricated, and assembled in accordance with the best modem engineering and shop practice. Individual parts shall be manufactured to standard sizes and gauges so that repair parts, furnished at any time, can be installed in the field. Corresponding parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests. Iron castings shall be tough, close-grained grey iron free from blow-holes, flaws, or excessive shrinkage and shall conform to ASTM A48-74.

11.9 LUBRICATION

11.9.1 Lubricants

The Contractor shall provide lubricants of types recommended by equipment manufacturers in quantities sufficient for consumption prior to completion, testing, and final acceptance. In addition sufficient approved lubricants for one year normal operation shall be provided.

11.9.2 Lubrication Systems

Lubrication of equipment shall insure constant presence of lubricant on all wearing surfaces. Lubricant fill and drain openings shall be readily accessible. Easy means for checking the lubricant level shall be provided. Prior to testing and/or operation, the equipment shall receive the prescribed amount and type of lubricant as required by the equipment manufacturer. Equipment lubrication systems shall be systems that require attention no more than weekly during continuous operation, shall not require attention during start-up or shut down, and shall not waste lubricants.

11.10 STRUCTURAL STEEL FABRICATIONS

Fabrication shall conform to "Code of Standard Practice for Steel Buildings and Bridges" and "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" of the AISC unless otherwise indicated or specified. Design all fabrications for dynamic and vibratory loadings. Structural steel shapes conforming to ASTM A36, A500, A501, A570, A618, or equal, as applicable shall be used. Welding shall conform to AWS D1.1 Structural Welding Code. Specified items shall be galvanized in accordance with ASTM A123, A153, or A386 as applicable; use galvanized bolts and fasteners with galvanized assemblies. All structural members shall be considered as subject to shock or vibratory loads. Unless otherwise specified, all steel which will be submerged, fully or in part, during normal operation of the equipment shall have a minimum nominal thickness of 6 mm.

11.11 EQUIPMENT BASES AND BEDPLATES

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

11.12 ANCHORS AND SLEEVES

Each equipment manufacturer shall furnish the required anchor bolts, nuts, washers, and sleeves of adequate design for securing bases and bedplates to concrete bases, all stainless steel, hot-dip galvanized or cadmium plated as specified for each item. Sleeves of at least 1-1/2 times anchor bolt diameter shall be provided. Anchor bolts shall be provided of length to allow for 40 mm of grout under baseplates and adequate anchorage into structural concrete unless otherwise shown or specified.

All anchors used in areas containing sewage or sewage gases shall be approved stainless steel. All fixing holes shall be grouted with epoxy mortar and the exposed fixing material sealed with a coal tar epoxy or GRP coating as appropriate.

11.13 SAFETY GUARDS

All the chain drives, fan blades, couplings, exposed shafts and other moving or rotating parts shall be covered on all sides with safety guards conforming to all relevant State, and local codes and regulations; conform to the most restrictive requirements. Safety guards shall be free of all sharp edges and corners. Corrosion-resistant materials at least equivalent to hot-dip galvanized steel shall be used. Safety guards shall be fabricated from 16 USS gauge, or heavier, galvanized or aluminium-clad steel or 12 mm mesh galvanized expanded metal. Guards shall be designed for easy installation and removal. Necessary supports, accessories, and fasteners shall be provided of hot-dip galvanized steel or

stainless steel. Guards in outdoor locations shall be designed to prevent entrance of rain and dripping water.

11.14 DRIVE UNITS

Drive units shall be designed with a AGMA rating and service factor suitable for 24-hours continuous duty service under operating load, constructed to preclude oil leakage around shafts. Drive unit housings shall be constructed of high grade cast iron, welded steel, or other suitable material. Thermal rating of each unit shall exceed the design load or proper cooling devices shall be provided. All drives shall be designed especially for the service for which they are to operate.

11.14.1 Motor Ratings

Drive motors shall have nameplate power rating at least equal to the theoretical brake power required to drive equipment under full load for conditions specified, including all losses in speed reducers and power transmission and shall be as specified in Section 12.

11.14.2 V-Belt Drives

Each V -belt shall be equipped with a sliding base or other suitable tension adjustment. Where motors are to be adjusted to tension the belts in a vertical direction, this shall be accomplished by four studs which are double nutted to the motor plate to raise and lower the motor plate. Hinges with a jacking screw to tension the belts shall not be used. Provide drives having a service factor of at least 1.6 at maximum torque using nameplate rating of driving motor.

11.15 GEARED POWER TRANSMISSION UNITS

Oil-lubricated totally enclosed gear reducers and increasers shall be provided.

11.15.1 Service Ratings

Each gear shall have a nameplate service power rating equal to the nameplate rating of the driving motor. Each gear shall have mechanical and thermal capacity equal to or greater than an equivalent power determined by multiplying the service power rating by the specified service factor recommended by AGMA for heavy duty service, except each set of worm gears shall have a minimum service factor of 1.20 and all other gears shall have a minimum service factor of 1.50.

11.15.2 Thermal Rating

Thermal rating for the equivalent power shall be obtained without auxiliary cooling equipment such as heat exchangers. Units shall be designed to operate continuously for the conditions specified in a location where ambient temperatures vary from 7^{o}C to 55^{o}C, and metal surfaces in direct sunlight can reach 85^{o}C. Data for any gear reducer/increaser requiring a cooling coil shall be submitted to the Engineer for approval. If a cooling coil is required, provide minimum 25 mm diameter tubing and a 25 mm solenoid supply water valve with the gear.

11.15.3 Bearings

Anti-friction bearings shall be provided throughout, designed to give minimum 20000 hours B10 life for the specified power in continuous operation consistent with acceptable modem practices for applied radial and thrust loads at the speeds involved. Provide thrust bearing rates at 1-1/2 times the maximum thrust loadings involved.

11.15.4 Gear Nameplates

Each geared power transmission unit shall be equipped with an AGMA nameplate which shows service power, actual service factor for actual mechanical or thermal rating as applicable, and AGMA gear Class I rating.

11.16 ELECTRIC MOTORS FOR MECHANICAL EQUIPMENT

Motors shall conform with applicable requirements of Section 12 and specific requirements for driven equipment.

11.17 CONTACTS

Contacts specified to be supplied as part of equipment for interlock or failure indication shall provide SPDT switches rated for 240 Vac, 50 Hz at 5 amperes resistive or 3 amperes inductive loading, terminated at screw-type barrier strips in a NEMA 4 enclosure, unless otherwise shown or specified.

11.18 GAUGES

Gauges shall be installed in the suction (where applicable) and discharge of each pump and blower. The gauges shall be 150 mm diameter and shall include a. petcock between the pump/blower and the gauge. For solids-bearing or corrosive fluids a diaphragm gauge isolator shall provided. Suction gauges shall be of the compound type and shall have a range of 760 mm of mercury to 10 m head of water. Discharge gauge ranges shall be a standard commercially available range with the maximum reading not less than 3.5 m head greater than the pump's rated shut-off pressure. Gauges shall read in metres head over their entire range.

11.19 NAME PLATES AND DATA PLATES

Provide Type 316 stainless steel nameplates of ample size with embossed or preprinted lettering, fastened to the equipment in a prominent place with corrosion-resisting pins. On nameplates, display manufacturer, serial number, date of manufacture, model number and essential operating characteristics. Inscribe data plates with specific or directed information.

11.20 PROTECTION OF FINISH

The Contractor shall provide adequate means for fully protecting all finished parts of the materials and equipment against damage from whatever cause during the progress of the work and until final completion. All materials and equipment in storage and during construction shall be protected in such a manner that no finished surfaces shall be damaged or marred and all moving parts shall be kept perfectly clean and dry. Painting shall conform to applicable requirements of

Section 7 and following requirements unless modified or otherwise specified elsewhere in this Section.

11.20.1 Factory Painting

On mechanical equipment, drives, starters, control panels and other similar self-contained or enclosed components, apply a factory primer and high-quality oil-resistant baked industrial enamel finish. Paint or otherwise protect surfaces that are inaccessible after assembly by a method that provides protection for the life of the equipment.

11.20.2 Shop Priming

Apply one or more shop coats of metal primer on surfaces to be finish painted at the site, coating thickness to protect surfaces until finished. Use primers specified for the required paint systems in Section 7. The Contractor shall submit for approval the coating systems intended for use. Shop primers for affected items of equipment shall consist of only those approved for intended protective coating system. Shop drawing submittals shall make it clearly evident that this has been coordinated.

11.20.3 Rust Prevention

Machined, polished, other ferrous surfaces, and non-ferrous surfaces that are not to be painted shall be coated with an approved rust preventive compound, and, in the case of aluminium be anodized. Structural galvanized steel and stainless steel need not be coated.

11.21 AUTOMATIC EQUIPMENT

All equipment, except centrifugal pumps, which is under automatic control, shall have a red warning label supplied and fixed alongside each access point or point of physical danger. The label shall be suitably engraved and manufactured from a non-corrodible material of an overall size not less than 200 mm x 150 mm. Unless otherwise specified or agreed by the Engineer the legend shall be in both English and Arabic as follows:

DANGER
THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED AND MAY START WITHOUT WARNING

When specified an audible warning shall sound for 15 seconds before the mechanism starts to operate. This delay shall be non-adjustable. Guards and or handrailing shall be provided to prevent accidental contact with normally accessible moving parts.

11.22 SPECIAL

11.22.1 Power Ratings

Power ratings shown for the proposed equipment are in accordance with the best information available to the Engineer. In the event equipment items proposed by

the Contractor should require motors with larger power rating than shown, it shall be the Contractor's responsibility to furnish starting equipment, feeder and branch circuits, conduits, and accessories as required to comply with the electrical code and prevent excessive voltage drop without added cost to Employer.

11.22.2 Equipment

Where equipment to be furnished is installed in an existing enclosure or adjacent to existing equipment, the Contractor shall field check the dimensions of existing equipment, location of conduits, etc., and shall familiarize himself with all existing conditions and difficulties to be encountered in performing such work.

11.23 EXECUTION

11.23.1 Coordination

The drawings show in a diagrammatic form the arrangements desired for the principal apparatus, piping, and similar appurtenances, and shall be followed as closely as possible. Proper judgement shall be exercised in carrying out the work to secure the best possible headroom and space conditions throughout, to secure neat arrangement of piping, valves, fixtures, hangers, and similar appurtenances, and to overcome local difficulties and interference of structural conditions wherever encountered.

The Contractor shall take all measurements for his work at the installation sites, verify all dimensions and conditions at the place of installation, verify subcontractor drawings and be responsible for the proper installation, within the available space of the apparatus specified and shown on the drawings and submit written details and reasons for proposed deviations from drawing and Specification and shall secure the approval of the Engineer for any variations before making any changes.

11.24 INSPECTION DURING MANUFACTURE

Employer and the Engineer shall be entitled at all reasonable times during manufacture to inspect examine and test on the Contractor's premises the materials and workmanship and performance of all Plant to be supplied under the Contract. If part of the said Plant is being manufactured on other premises, the Contractor shall obtain for Employer and/or the Engineer permission to inspect examine and test as if the said Plant were being manufactured on the Contractor's premises. Such inspection examination or testing shall not relieve the Contractor from any of his obligations under the Contract.

The Contractor shall give Employer and the Engineer written notice of the date on which and the place at which any Plant will be ready for testing as provided in the Contract and unless Employer or Engineer shall attend at the place so named within seven days after the date which the Contractor has stated in his notice the Contractor may proceed with the tests and shall forthwith forward to the Engineer duly certified copies of the test readings and graphs.

Where the Contract provides for tests on the premises of the Contractor or of any sub-contractor the Contractor except where otherwise specified shall provide free of charge such assistance labour materials electricity fuel stores apparatus and

instruments as may be requisite and as may be reasonably demanded to carry out such tests efficiently.

The Contractor shall bear the cost of any inspections of off-site manufactured components and off-site testing which Employer and/or the Engineer attend. This cost shall include, but not limited to, all travel and related subsistence for up to two persons.

Where the Contract provides for tests on the Site the Contractor except where otherwise specified shall provide at his own expense such labour materials electricity fuel stores and apparatus and instruments as may be requisite and as may be reasonably demanded to carry out such tests efficiently.

If after inspecting examining or testing any Plant the Engineer shall decide that such Plant or any part thereof is defective or not in accordance with the Contract he may reject the said Plant or part thereof by giving to the Contractor within a reasonable time notice in writing of such rejection stating therein the grounds upon which the said decision is based.

11.25 PREPARATION

Prior to installing equipment, ensure that installation areas are clean and that concrete or masonry operations are completed. Maintain the areas in broom-clean condition during installation operations

Clean, condition, and service equipment in accordance with the approved Instruction Manuals and requirements in other Sections of this Specification before installing.

11.25.1 Manufacturer's Supervision and Installation Check

Each equipment manufacturer shall furnish the services of an authorized representative especially trained and experienced in the installation of his equipment to (1) supervise the equipment installation in accordance with the approved Instruction Manual, (2) be present when the equipment is first put into operation, (3) inspect, check, adjust as necessary, and approve the installation, (4) repeat the inspection, checking, and adjusting until all trouble or defects are corrected and the equipment installation and operation are acceptable, (5) witness and supervise operational demonstrations and system validation tests to the extent specified, and (6) prepare and submit the specified Manufacturer's Certified Report. All costs for the services of manufacturers' representatives shall be included in the Contract Rates.

11.26 INSTALLATION

11.26.1 Structural Fabrications

Conform to the AISC Code and Specification references in Article "Structural Steel Fabrication."

1.26.2 Equipment

Conform to approve Instruction Manuals. Employ skilled craftsmen experienced in installation of the types of equipment specified. Use specialized tools and

equipment, such as precision machinist levels, dial indicators, gauges, and micrometers, as applicable. Produce acceptable installations free of vibration or other defects.

11.26.3 Anchor Bolts

Deliver bolts with templates or setting drawings and verify that bolts are correctly located before structural concrete is placed.

11.26.4 Base and Bedplate Grouting

Do not place grout until initial fitting and alignment of connected piping is completed. Level and align equipment on the concrete foundations using suitable steel and brass shimming, then entirely fill the space under base or bedplates with grout. Bevel exposed grout at 45 degrees angle, except round exposed grout at horizontal surfaces for drainage. Trowel or point exposed grout to a smooth dense finish and damp cure with burlap for three days. When grout is fully hardened, remove jacking screws and tighten nuts on anchor bolts. Check the installation for alignment and level, and perform approved corrective work as required to conform to the tolerances given in the applicable Instruction Manual.

11.27 TESTING

11.27.1 Field Quality Control

All costs for performing operational demonstrations and system validation tests shall be included in the Contract Rates, and no extra payment will be made to the Contractor on account of overtime, weekend, or holiday labour costs required to perform and complete the demonstrations and validation tests. Requirements specified in this Section are in addition to the demonstration and test requirements specified under other Sections of the Specification.

11.27.2 Operational Demonstrations and Systems Validation Testing

Testing shall be performed by the Contractor in accordance with the approved procedure plans to demonstrate to the Engineer's satisfaction that:

- All components of the process systems defined herein, the complete systems, and the new Plant systems are fully completed and operable.
- All units, components, systems, and the entire Plant systems operate with the efficiency, repeatability, and accuracy indicated and specified; and
- All components, systems, and the entire Plant conform to the Contract Documents and the approved shop drawings, samples, construction manuals, material lists, and other approved submittals.

11.27.3 Scope of Operational Demonstrations and Systems Validation Testing

System validation tests are required for all mechanical and electrical equipment, and systems specified including all associated and related electrical systems and control devices specified in Sections 12, 13 and instrumentation and control systems.

Works to be operationally demonstrated are defined as individual equipment items such as pumps, blowers, sand filter systems, aerators, scrapers, mixers, etc and all similar equipment items. Demonstrations shall be performed simultaneously on groups of identical equipment items and groups of items supplied by one manufacturer to the extent feasible.

Systems to be validation tested are defined as complete systems that perform a discrete process function of the Plant such as chemical systems, pumping systems, filter backwash systems, emergency power system, and similar systems. Each system shall include associated structures, tanks, piping, utilities, instrumentation and controls, and like related items. Two or more separate systems shall be validation tested simultaneously when necessary to validate an entire discrete Plant function.

Operational demonstrations and validation testing shall not commence for any equipment item or system until all related structures, piping, electrical, instrumentation, control, and like work have been installed, tested, and connected in compliance with the pertaining requirements specified elsewhere in the Specification.

Materials and electrical power for operational demonstrations and validation tests shall be furnished by the Contractor. Fresh potable water shall be used to fill tanks, wells, piping, and systems that contain water, sewage or sludge in normal operation. The specified chemicals shall be used for chemical systems but do not exceed in-service concentrations. All temporary facilities, storage, and similar facilities shall be furnished. Use procedures that conserve testing materials and avoid wastage, especially with respect to large quantities of fresh water and electrical power.

Operational demonstrations and system validation testing shall be performed under continuous inspection by the Engineer. Technical representatives of the various equipment manufacturers shall be present at the start of the operational demonstration, shall examine their equipment at least twice near the beginning and end of the validation tests, shall supervise the start-up and adjustment procedures, and shall perform all other services necessary for the manufacturer's certified reports required herein.

All defects and malfunctions disclosed by demonstrations and validation tests shall be immediately corrected using approved methods and new materials for repairs as required. Interruption time necessary for corrective work shall be added to the specified total demonstration and validation test periods.

Satisfactory completion and approval of required operational demonstrations and system validation testing is <u>one</u> of the conditions precedent to the Engineer's acceptance of the work and does not constitute final acceptance.

11.27.4 <u>Operational Demonstrations</u>

The performance of installed equipment shall be demonstrated to show that it complies with all requirements indicated and specified. Equipment items shall be operated through entire no-load to full-load range in accordance with the approved procedure plan for not less than 24 consecutive hours, unless a longer period is specified under other Sections of the Specification.

11.27.5 Commissioning and System Validation Tests

Commissioning and setting to work of the Plant may be dependent on the completion of other contacts or operation of existing works. At a date to be agreed with the Employer and the Engineer the Plant shall be commissioned with potable water and the Contractor shall supervise the working of the Plant for system validation tests and shall during that period provide all necessary engineering and technical supervision continuously to effect any adjustment that may be necessary .All equipment components of each system shall have successfully completed the required operational demonstration before the system is validation tested. Perform validation testing in accordance with the approved procedure plan.

Each system shall be tested, including standby systems, by continuous operation in "in-service" condition for not less than 168 consecutive hours, with no interruptions except for normal maintenance or corrective work. Where the "in-service" condition is an automatically controlled repeat cycle with on/off intervals, it shall be so operated.

Systems shall be operated continuously 24 hours a day under constant inspection of trained operators. System operation shall be cycled from full load to light load and back to full load each 24 hours. Variable speed equipment shall cycle through the applicable speed range at a steady rate of change. Simulated alarm and distressed operating conditions shall be induced and test controls and protective devices tested for correct operation in adjusting system functions or causing system shutdown.

Subject to Contractor's request and Engineer's approval in each case, the Contractor may simulate certain operating conditions relating to flow rates, water levels, and malfunctions. Permission for simulations will be granted only where it is unwise or impossible to obtain the conditions covered by the capability of ranges or equipment. The simulation methods shall reflect reasonable anticipated operating conditions.

The Contractor shall not be entitled for a Completion Certificate for the whole of the Works in accordance with Clause 48 of the Conditions of Contract, unless the whole of the Works has been run under the supervision of the Contractor for validation tests to the complete satisfaction of the Engineer for 168 hours without interruption and the Engineer shall have so certified in writing.

I 1.27.6 Ranges for Testing

Flow metering systems shall be tested at not less than 3 values corresponding approximately to minimum, average and maximum capacity, respectively.

Liquid level indicating systems shall be tested at not less than 5 levels corresponding approximately to low, average, normal, maximum and high alarm levels, respectively. Low-low and high-high level alarms and system reaction shall also be tested where equipment or instruments are required to react to such conditions.

Remotely controlled gates and valves shall demonstrate suitable operation both from local controls and remote controls. As a minimum, these procedures shall include full-open and full-close positioning. Each test shall be repeated not less

than 3 times for non-throttling and non-modulating valves. In addition to these minimum requirements, and subject to approval, all throttling valves and modulating valves shall be operated at not less than 3 intermediate positions and shall demonstrate the ability of each valve to hold the set position under operating conditions.

Variable speed equipment shall demonstrate accurate response to speed controlling devices and controls within the required operating ranges. Actual output shaft speeds of manually adjustable speed equipment shall be validated by measurement of shaft speeds versus speeds shown by equipment instruments.

11.27.7 Automatic Response of Equipment

Response of equipment to appropriate manual or automatic controls, or combinations of both automatic and manual controls, shall be demonstrated to be correct and accurate. Where applicable, all components shall be tested for both manual and automatic operation. Where a component performs more than one function, every function shall be validated.

Pumping equipment shall respond accurately and reliably to liquid level and flow rate signals from appurtenant basins, sumps, or wet wells. Automatic alteration and backup pump functions shall also be validated.

Chemical feed systems where so designed shall respond accurately to flow signals and feed proportionally over the ranges of process flows to be validated.

Ventilation systems and air compressors shall respond accurately, smoothly and reliably to control signals, where applicable.

Auxiliary equipment items such as automatic samplers, annunciators, alarms, and like items shall respond accurately and reliably to every condition to which they are programmed, in the manner specified.

11.27.8 Recording of Data

Neat and comprehensive records of each operational demonstration and system validation test shall be maintained by the Contractor. Each portion of the demonstration or validation procedure shall be described with all components itemized. Records shall be prepared on forms in a step-by-step fashion paralleling the approved procedure plans. Forms shall list for each condition the following:

1. Step taken;
2. Result anticipated;
3. Result obtained;
4. If incorrect, corrective action taken; and
5. Retest result;
6. Steps (4) and (5) shall be repeated until all systems operate as required.

Instruments, gauges, and other sensors and display devices forming a part of the various systems shall be employed for data acquisition to the extent applicable. The Contractor shall furnish all other instruments, gauges, recorders, and test devices as required, types conforming to the approved procedure plans.

All applicable data such as, but not limited to water and other liquid levels, flows, pressures, head differentials, duration of runs, instrument readings, chemical feed rates, voltage settings, drive speeds, motor running currents, torque, voltages, pressures, clarity, residual chlorine, and related information, as applicable, and in accordance with the approved procedure plans, shall be recorded at the start and finish of each operational demonstration and at maximum 8-hour intervals during system validation tests, unless shorter intervals are specified elsewhere.

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

11.28 INSTRUCTION OF EMPLOYER'S PERSONNEL

After the equipment has been installed, tested, adjusted and placed in satisfactory operation, the Contractor shall provide the services of manufacturer's representatives to instruct the operating personnel in the use and maintenance of the equipment. An instruction program shall be conducted for up to six plant operators designated by the Employer. The Contractor shall give the Engineer and Employer at least one month's written notice of the proposed instruction program. Instruction covering basic system operation theory, routine maintenance and repair, and "hands-on" operation of equipment shall be included. The duration of the program shall be based on the complexity of equipment involved, and the Employer's approval of instruction adequacy shall be obtained before terminating the program. Instruction periods shall be acceptable to the Employer and shall be planned in consultation with him.

11.29 COORDINATION OF DEMONSTRATION, TESTING AND INSTRUCTION REQUIREMENTS

Operational demonstrations, system validation testing, and instruction of Employer personnel may be performed simultaneously, subject to prior approval of the extent of coordination in each case.

11.30 RUNNING MAINTENANCE

The Contractor shall be responsible for operating the works and for carrying out running maintenance of the systems for three months after issue of the Completion Certificate.

11.31 IN-SERVICE CHECKS

As a part of the Work, an in-service check of each system required to be validation tested shall be performed twice during the period of the Contractor's guarantee by qualified technical representatives of the various system manufacturers, including manufacturers of equipment components within systems. Checks shall be detailed and complete, requiring not less than 8 hours at the site, and shall be performed under the observation and to the satisfaction of the Engineer. All costs for in-service checks shall be included in the Contract Rates.

11.31.1 Notification

The Engineer shall be notified in writing at least 10 days before the performance of each in-service check. The proposed dates for checking shall be changed if required by the Engineer.

11.31.2 Consultation

At the time of each in-service check, the manufacturer's technical representatives shall consult with the Engineer to review the O&M Manual and the pertinent operational and maintenance problems encountered, and shall furnish technical advice and recommendations to the Engineer.

11.31.3 Schedule

Initial in-service checks shall be performed approximately 6 months after issue of Provisional Acceptance Certificate. The second in-service check shall be performed within 30 days of the end of the Contractor's guarantee period.

11.31.4 Reports

A written report of each in-service check, signed by the appropriate manufacturer or his representative, shall be delivered to the Engineer within 10 days following the check. The report shall describe the checking procedure in detail, and shall state all advice and recommendations given to the Engineer.

END OF SECTION 11

SECTION 12

ELECTRICAL EQUIPMENT

12.1 GENERAL

12.1.1 Description

Requirements specified in Section 11 of the Specification shall also apply to this Section. The Contractor shall obtain all necessary approvals, permits and comply with all requirements of the Directorate General of Electricity.

12.1.2 Quality Assurance

Factory tests are required for all electrical equipment and assemblies which shall be performed in accordance with the codes and standards specified as applicable to the equipment.

12.1.3 Compliance with Local Requirements

All work included in this Section shall comply with the requirements of the Ministry of Housing Electricity and Water, and in particular with Oman Electrical Standard (OES) 2,4,5,6,7 and 11,21 A and B, 22 A, B and C, 23 and 31. Where the Contractor detects any conflict between the above and any requirements specified in this Section he shall bring all the relevant facts to the Engineer who will issue the necessary instructions after consulting MHEW.

12.1.4 Technical Data

Schedules of technical data for specific items of equipment are provided as necessary for equipment to be provided under specific contracts.

12.1.5 Rubber Mats

All high tension and low voltage switch boards and motor control centres rooms shall be provided with suitable insulation mats 600 mm wide to BS 921 on each accessible side of a panel. The mats shall meet local and international safety regulations and shall be approved by the Engineer.

12.1. 6 Information Sheets and Drawings

In addition to the record drawings and specification requirements in other Sections, the Contractor shall provide information sheets and drawings for each electrical panel compartment. These shall be stored in a purpose built enclosure within the individual compartment.

12.2 MATERIALS AND INSTALLATION

12.2.1 Power Supply

MHEW will supply power to the site by 415 V, 50 Hz, lines.

All LV electrical equipment shall be suitable for use in a 415 volt, 3 phase, 4 wire, 50 Hz solidly grounded system. The Contractor shall obtain the system fault level from the MHEW Directorate General of Electricity.

12.2.2 Power Supply Termination

The Contractor will be responsible for the coordinating with MHEW and making necessary arrangements for power supply connection.

12.2.3 Meters Installation

Main incoming kWh meters will be supplied and installed by MHEW.

12.2.4 MV Switchgear. MV Cables and Transformers

All MV switchgear, cables and transformers will be provided and installed by MHEW. The Contractor shall be responsible for follow-up/coordination with MHEW of all matters relating to this activity.

12.3 MOTOR CONTROL AND DISTRIBUTION SWITCH BOARDS

12.3.1 Design and Construction

Motor control and distribution switchboards shall be of all-welded construction. The switchboard frame shall be fabricated of 2 mm sheet steel pressed or rolled to shape and neatly finished and free from any joints or sharp edges. Structural members where needed shall be welded to the frame. The switchboard shall be metal clad and totally enclosed type, dust and splash proof, and self-supporting, suitable for plinth mounting.

The inside of the cubicle shall be finished matt white. Doors and panels shall be constructed of similar metal and of similar gauge to that of the frame and shall be neatly finished and free from any sharp edges. Doors shall hang from hidden hinges and be provided with lockable handles. The doors shall operate with adequate toggle action so as to latch with suitable slots at both the top and bottom of the switchboards. Latching rods shall be adequately guided by brackets. The latching rods and brackets shall be cadmium plated. Electrical switchboards shall comply with BS EN60439-1, form 4 separation, type 7 construction.

A circuit directory card shall be provided to identify each connector circuit.

All sections of the switchboard shall be of equal depth. The switchboard shall be extendable at both ends.

The boards shall not be installed to be more than 2000 mm high to the top of the board.

The first section of the switchboard shall include the main incoming switchgear and associated metering and relays. Metering shall include ammeter and voltmeter with selector switches, CT's, fuses and indicating lamps. One number phase reversal and low voltage release unit of the self-resetting type shall be provided to control the operating circuit of each pump motor starter. The unit shall drop out at 85 percent and pick up at 92.5 percent of nominal supply

voltage. The units shall have adequate damping to override transient disturbances.

The control section shall include automatic timer, duty selector switch and the instrumentation, control, indication and alarm as specified.

Distribution section shall contain MCB or MCCB for power distribution. A TPN MCB distribution board for small power and lighting shall also be incorporated, as appropriate.

The entire panel layout shall be approved by the Engineer prior to manufacture. The Contractor shall submit front of the panel layout drawing, dimensions and schematic diagram for approval with his detailed proposal.

12.3.2 Finishing of Metal Work

Metalwork shall be finished in accordance with the requirements of the Specification. The switchboards shall be touched-up to the original finish at site after erection if any part is found to be scratched or marked.

12.3.3 Busbar and Small Wiring

Busbar marking and arrangement, connections and grade of copper shall comply with BS 159 and 1433.

The switchboards shall be arranged so that all the busbars run horizontally through each Sectional length. Busbars consisting of high-conductivity tinned copper shall comprise four bars, mounted rigidly on slotted high grade Bakelite or other non-hygroscopic insulators, and capable of withstanding the system fault current which can occur at the installation. Connection from the busbars to the circuit breakers and switches shall be effected by means of copper bars and identified by means of coloured plastic sleeving or painting to indicate the phase colours.

Busbar Systems

All connections in the current carrying parts shall be made by means of bolts and lock nuts. Cables connection to busbars shall be made by means of cable lugs and bolts and lock nuts. Neutral bar shall be full size and shall be provided with an adequate number of terminals, cable lugs, bolts, etc. to suit the installation.

All small wiring shall be of adequate size which shall not be less than 4 sq mm in section and shall be PVC insulated cable fixed securely without strain by means of cleats of the compression type.

For the purpose of easy identification, suitable colour codes shall be used and ferrules or reference numbers shall be fitted at both ends of wires. No joints shall be permitted in the wiring which shall be neat and systematic and supported in such a way as shall not cause obstruction of any kind within the switchboard. Where necessary, bushes shall be provided to protect the insulation of the wiring.

12.3.4 Switchgear

12.3.4.1 General

All the switchgear required for the switchboards shall be supplied and installed with the switchboards. The arrangement of switchgear shall conform to normal practice and shall be arranged in such a way so that it is nearest to the instrument panels associated with it. Test certificates for circuit breakers, fuse switches, etc. shall be submitted to the Engineer for approval.

All switchgear shall have a mechanical interlock such that the cubicle containing the switchgear cannot be opened with the switch closed, or the switch closed with the cubicle open. The switches shall be of the MHEW approved type and of the correct rating after derating for the specified ambient temperature, and able to withstand the system fault level.

Automatic safety shutters shall be fitted to cover each three phase group of isolating contacts.

12.3.4.2 Standards

The following standards shall be complied with:

1.	BS 88	:	Cartridge Fuses
2.	BS EN 60947-2, IEC 947-2	:	Circuit Breakers
3.	BS EN 60898-2, IEC 947-2	:	Miniature Circuit Breakers
4.	BS 546	:	Electrical Outlets
5.	BS 7430	:	Code of Practice for Earthing
6.	BS EN 60529	:	Ingress Protection
7.	BS 5486	:	LV Switchgear and Control Gear

12.3.4.3 Overcurrent Protective Device Coordination

- The Contractor shall carry out and provide an overcurrent protective device coordination study as part of his material submission, as outlined below:

- Properly coordinated automatically operated protective devices shall be provided for this Contract. The overcurrent protective devices shall be coordinated for adequate continuous current and interrupting capacity to assure proper overcurrent protective devices operation under normal and fault conditions in the system.

- All overcurrent protective devices on this Contract and the first upstream device of the existing electrical system shall be coordinated so that they will perform as follows. When two or more overcurrent protective devices (including the first upstream protective device of the existing system) in series with each other experience current flow greater than their rated current, the device with the lowest rated current shall trip and/or open the circuit first and thereby prevent the higher rated devices from operating.

- The manufacturer of the overcurrent protective devices shall prepare a coordination study to verify the above stated performance requirements. The

Study shall be documented by the manufacturer and the documents shall include but not be limited to the following:

1. A composite drawing or drawings (on full size, reproducible, log-log paper) showing the entire new electrical system (including the first upstream protective device of the existing system) showing all protective device curves (including motor overloads), short circuit duties, motor starting curves and damage curves for motors, equipment and conductors. This drawing, or drawings, shall show that all protective devices are properly coordinated to perform as stated above.

2. Manufacturer's overcurrent operating curves (on full size, reproducible, log-log paper) for each overcurrent device. In the case of fuses, both minimum melt and maximum clearing time curves shall be included.

3. Reproducible copies of all project single line diagrams so marked to show short circuit duties at all switchboards and motor control centres, and which operating curve applies to each overcurrent device on the diagram (the operating curves shall also be correspondingly marked);

4. A tabulation of the short circuit duties at all switchboards and motor control centres, sizes and ratings of all overcurrent protective devices and the required settings of all of the adjustable overcurrent protective devices so that the performance requirements are met. Protective devices which have earth fault protection features are specifically required to meet this performance requirement.

5. This documented coordination Study shall be submitted for review before the overcurrent devices are supplied for the project.

6. The manufacturing facility shall be certified to the ISO -900 I series of standards from the International Standards Organization.

7. Preference will be given to one manufacturer of ACBs, MCCBs and MCBs to ensure proper coordination.

12.3.4.4 Air Circuit Breakers

- Air Circuit Breakers shall be to IEC 947-2 or BS EN 60947-2, suitable for triple pole service and shall have breaking capacity of 50 KA symmetrical for 1 second at 415 Volts.

- Air Circuit Breakers (conventional type and not moulded case circuit breaker) shall be 500 V, 50Hz, triple pole with neutral link on ratings as shown on the Drawings. They shall be air break, trip free, drawout type with mechanical and electrical ON/OFF indicators.

- All air circuit breakers shall be electrically operated by automatic motor wound spring mechanism. A standby manual operating handle shall be provided for operating the circuit breaker in case of power or motor failure.

- The air circuit breaker shall be provided with overcurrent, short circuit and earth fault protection having the following characteristics:

  1. Adjustable long time delay current setting (50%-150%) with varied tripping time.

  2. Adjustable short time delay current setting (400%-1000%) with variable tripping time.

  3. Instantaneous tripping for heavier overcurrent adjustable from 400% - 1600% of base current.

  4. Adjustable earth fault trip current setting (20%-60%) with variable tripping time.

- The circuit breaker shall have three positions on the drawout mechanism, namely service position where all main and auxiliary contacts are made, test position where main contacts are open but auxiliary contacts are closed and isolated position where all contacts are open. An indicator shall clearly show these positions and provisions shall be made for locking the breakers in any position. An ON/OFF indicator shall be provided.

- Mechanical Interlocks shall be provided to prevent withdrawing or inserting of the breaker when it is 'ON'. Any attempt to do so shall trip the breaker automatically.

- 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.

- The moving contacts comprising the main and arcing contacts shall be of the spring loaded, self-aligning type. The arc contacts shall be arranged to make before, and break after, the main contacts.

- Each ACB shall include the following components and accessories:

  1. Auxiliary Contacts
  2. Arc Chutes
  3. Folding Extension Rail
  4. Charging Handle
  5. Open and Close Pushbuttons
  6. Over Current Trip Indicator
  7. Keylock on Trip Button
  8. Spring Charge Condition Indicator
  9. Breaker Position Indicator
  10. Making Current Release
  11. Automatic Shutters for the B/B Terminal
  12. Carriage for every size of ACB exceeding 25 kg in weight
  13. Operation Counter.

- The Main Incoming Circuit Breakers shall be provided with cable boxes to suit the incoming cables from the transformers.

- Circuit breakers shall be tropicalized to operate continuously in an ambient temperature of 55°C and high relative humidity.

- Type test certificate for each size of circuit breakers and MCCBs shall be provided from an internationally recognized testing authority acceptable to the Engineer.

12.3.4.5 Moulded Case Circuit Breakers

- Breakers shall have a combination of thermal and magnetic tripping giving an inverse time delay protection against sustained overloads and instantaneous tripping under heavy overloads and short circuits.

- Breakers shall have a quick make, quick break over-centre switching mechanism that is mechanically trip free from the handle so that contacts cannot be held closed against short circuits and abnormal current-

- Tripping due to overload or short circuits shall be clearly indicated by the handle assuming a position mid-way between the manual ON and OFF position.

- Latch surfaces shall be polished.

- Poles shall be constructed to open, close and trip simultaneously.

- Ampere ratings shall be clearly visible.

- Breakers shall be completely enclosed in a moulded case to IEC 157-1A, suitable for installation inside switchboards.

- Non-interchangeable trip breakers shall have the trip unit sealed.

- Breakers with earth leakage relay protection shall be provided with shunt trips.

- Frame sizes shall be as per manufacturer's standard size and as approved by the Engineer.

- Magnetic trips shall be adjustable type for rating 200 Amp and above.

12.3.4.6 Miniature Circuit Breakers

Miniature Circuit Breakers shall be suitable for the type of load they feed. They shall be fault rated so that fuse backup protection is not required. They shall be rated in accordance with BS EN 60898. They shall include the following minimum features.

1. Magnetic and thermal trip elements
2. Trip-free mechanisms

3. Locking of facilities with detachable proprietary brackets and clearly marked ratings.
4. Trip healthy pushbuttons to test the trip circuit.

12.3.4.7 Fuses

Fuses shall be the High Breaking Capacity (HBC) type to BS 88.

Fuses shall either include a suitable fuse carrier or shall be capable of isolation. If the fuse carrier is included it shall be such that when it is being withdrawn normally or when it is completely withdrawn, the operator is completely protected, from accidental contact with any live metal of its fuse link fuse contacts and fixed contacts.

If the fuse is capable of isolation it shall be so interlocked with the switch that isolation is complete before the fuse enclosure can be opened further. The switch shall be prevented from closing while the fuse-cover is open.

12.3.4.8 Testing

All overcurrent protective devices shall be tested both at the manufacturer's works and on site. Test certificates or type test certificates shall be provided for all devices.

12.3.5 Instruments

All instruments including ammeters, voltmeters, power factor meters, kilowatt-hour meters, etc., shall be supplied and installed with the switchboards. Ammeter, voltmeters, and P.F. meters shall be 96 mm square type and flush mounted with the instrument panels. Protection fuses for the instrumentation shall also be provided within the same panel. HBC fuses shall be used for instrument wiring. kWH meters may be mounted behind glass panel within the switch boards.

Calibration terminals shall be provided for all instruments.

Selector switches for voltmeters, shall enable the reading of L-L and L-N voltages, while those for ammeters shall read the line current separately. kWH meters shall be of the pulse type suitable for monitoring management system and shall register 3 phase 4 wire unbalanced loads.

Indication lamps shall be provided as appropriate to indicate the main supply voltages and standby supplies. Neon lamps with front extract type shall be used. Coloured lenses of red, yellow and blue shall be used for identification of phases. Filament lamps shall not be used for indicators.

12.3.6 Labelling

Labelling of the switchboard shall be by means of black perspex with engraved traffolyte ivorine labels in Arabic and English. Labels shall be fixed to the switchboards by means of screw thread on the panels and screws with counter sunk heads. Warning and danger notices shall be engraved labels with red letters on white background in Arabic and English.

Each compartment door shall have a title label and each door mounted component or control shall have a function label.

Every internal component shall be identified and each circuit breaker shall be labelled with identification (MCCB or MCB type, current capacity and setting range).

Compartments with doors or covers not interlocked to an isolator shall have an external label affixed thereto as follows:

"DANGER, LIVE TERMINALS" with flash and voltage in red letters on white background in Arabic and English.

All live terminals shall be covered with 2mm thickness plastic cover.

12.3.7 Cable Entry

All cable entries to the switchboards shall be from the bottom. All the necessary glands, cable boxes, supporting brackets etc. shall be supplied and installed in the switchboards for all the incoming and outgoing cables.

Gland plates of non-corrosive metal shall be provided and positioned approximately 300 mm above floor level for reception of conduits and threaded glands. Where single core cables are to be terminated, the gland plate shall be non-magnetic.

12.3.8 Current Transformers

All current transformers required in the switchboards shall be supplied and installed. The current transformers shall have the correct ratios, output and type and class of accuracy for their function and shall comply with the relevant BS for instruments and protection transformers respectively. For remotely mounted kWh meters, CTs terminals in the switchboard shall be brought to the special terminal blocks to facilitate connection for external wiring to the meters. This terminal block shall be labelled. The secondary sides of current transformers shall be earthed.

12.3.9 Heaters

Suitable heaters shall be provided in each compartment of the switchboards to prevent condensation. The heater shall be thermostatically controlled for operation over the range 22-48 degrees C. The heater shall operate from 240 V AC supply taken within the switchboard over a control switch and fuse and controlled by "OFF-AUTO" switch. Auxiliary contacts for motor heaters shall operate in the reverse mode to the starter contactor

12.3.10 Earthing of Switchboards

A continuous bare copper strip shall be supplied and installed within the switchboards to run the full length of the structure. Terminals shall be provided for the connection to the metal cladding or armouring of all incoming and outgoing cables and to the main earth. Sizes of earth bars shall comply with BS 5486, BS 5227 and BS 7354.

12.3.11 Fuses

All fuses shall be High Breaking Capacity (HBC) type to BS 88 and one spare fuse for each fuse fitted in the panel shall be supplied, clipped adjacent to the position in which it would be in service. A complete schedule of all fuses in the panel shall be affixed in a convenient position in the panel.

Neutral links shall not be arranged in fuse holders but shall be separately bolted copper links with one link for each fuse.

12.3.12 Auxiliary Switches

Auxiliary switches for indication, protection, interlocking and supervisory purposes shall be readily accessible and enclosed in a transparent dust-proof cover.

Adequate secondary disconnection shall be included between the fixed portion of a circuit breaker and the moving portion.

Spare auxiliary contacts (two normally open and two normally closed) shall be provided on each unit and wired to suitable accessible spare terminals.

12.3.13 Indicating Lamps

All indicating lamps shall be low voltage with self-contained transformer. Bulbs shall be voltage rated higher than the transformer secondary voltage to ensure long life.

Lamps shall be well ventilated and the design shall permit removal of lamp glass and bulbs from the front of the switchboard.

Indicating lamps shall be supplied by individually fused circuits.

All pilot lamp bulbs shall be of the same voltage, regardless of transformer primary voltage.

12.3.14 Transformers

12.3.14.1 General

A. Transformers shall be oil immersed, hermetically sealed, naturally cooled, double wound, core type suitable for outdoor installation.

B. Where appropriate, transformers shall be mounted on a steel structure fixed to the concrete slab.

C. Transformers shall be manufactured and tested to comply with BS 171/IEC 76.

D. Transformer oil shall be to BS 148./IEC 291

E. The transformer manufacturer shall have quality control conforming to the relevant parts of ISO 9000.

F. Ventilation pattern shall be oil natural, air natural, ONAN.

G. The impedance voltage of the transformer shall be 6.3%.

H. The Contractor shall furnish the transformer manufacturer with the single line diagrams indicating the types and sizes of the loads connected to the transformers.

I. Changeover between HV voltage ranges shall be effected by an externally operated off-circuit switch located below the cold oil level.

12.3.14.2 Winding Connections

A. The windings shall be connected HV delta, LV star in accordance with vector group reference Dyn 11 of IEC 76.

B. The star point of the secondary windings shall be brought out through the tank and suitably terminated in a separate housing for solid earthing in addition to the neutral connection.

C. Provision shall be made for current transformers for fault protection to be mounted on both neutral and earth connections.

12.3.14.3 Tappings

A. Adjustable tappings shall be provided on the primary windings for variation from +7.5 % to -7.5 % in 2.5 % steps.

B. Tapping control shall be means of a manual, externally operated, off-circuit tapping switch complete with mechanical tap position indicator.

C. Locking facilities shall be provided for the switch such that the lock can be inserted only when the switch is in a definite tap position.

D. The tap changing selector shall be located below the oil level inside the tank and the selector operating rod shall be external outside the tank.

12.3.14.4 Construction

A. The core shall be constructed from cold rolled steel laminations manufactured to BS 6404. The laminations shall be insulated from each other by means of a suitable temperature resistant oil proof coating.

B. The winding design and construction shall provide adequately designed and located coolant flow ducts so that possible hot spots are eliminated. Windings shall be braced to withstand dynamic stress due to short circuit conditions. Full details shall be provided of arrangements for taking up or eliminating coil shrinkage during service.

C. The core and winding shall be designed so that the iron loss is at a rninin1um but the ratio of copper loss to iron loss shall be in accordance with an economic design and the manufacturer shall state the ratio used.

D. The arrangement of internal connections shall be such that the transformer core and windings may be lifted bodily from the tank without disturbing the cable boxes or insulators.

E. The transformer tanks shall be constructed from high grade steel with electrically welded seams. The structure of the tank shall enable it to be handled whilst filled with oil and shall be pressure tested to 70 kN/ sq m.

F. The transformer tank shall be mounted on a steel structure fixed to the concrete slab.

G. The tank shall incorporate lifting eyes suitable for the mass of the transformer and oil.

H. The tanks shall be provided with external cooling tubes or fins to provide natural cooling under the climatic conditions.

I. All terminals shall pass through oil tight insulating glands into respective disconnecting terminal chambers to facilitate cable testing.

J. The tanks shall be non-breathing hermetically sealed type.

K. The tank covers shall be of such construction as will prevent the accumulation of moisture and shall be bolted to a flange on the tank top to form a weatherproof seal. All gaskets shall be of synthetic rubber and cork compositions. The tank tubes and all steelworks shall be shot blasted internally and externally before painting and a rust inhibiting paint shall be applied to both external and internal surfaces before applying a final finish. The exterior shall be given an additional coat on site of a durable oil and weather resisting paint. The manufacturer’s paint system shall be submitted to the Engineer for approval.

L. The design and construction of the transformer core winding and tank shall ensure that the noise level at full load is kept to the rninin1um consistent with economic design. The tank shall be reinforced or braced where necessary to reduce the noise level.

M. The complete transformer arranged for service shall be capable of withstanding the specified impulse voltage on the HV windings.

N. All windings, winding terminals and connections shall be fully immersed in oil under all operating conditions and materials shall be suitable for this duty and not be subject to deterioration from contact with oil.

O. The windings shall be thoroughly dried out under vacuum at the manufacturer's works and shall be delivered to Site filled with oil to the normal level and ready for service.

12.3.14.5 HV and LV Terminations

A. The HV cable box shall be designed for air insulated dry type termination suitable for 3 core XLPE, double steel tape armour, PVC served, 120 sq. mm copper cables.

B. The HV cable box shall be mounted on the top of the transformer tank and bushings arranged for cables approaching horizontally.

The bushings shall be replaceable without having to open the tank cover.

The LV cable terminations shall consist of 3 phase and 1 neutral bushings mounted in an air insulated cable box suitable for receiving 8 x 240 sq mm four core XLPE SW A PVC cables.

The LV cable entry box shall also be mounted on the top of the transformer and bushings arranged for cables approaching horizontally.

The cable boxes on the transformer shall be suitable for the above HV and LV cable arrangements and shall be complete with all necessary fittings, grimp type cable lugs of specified size, compression glands, armour clamps, bonding straps, tapes, etc.

12.3.14.6 Fittings

In addition to the standard fittings as per BS 171, the transformer shall be fitted with the following:

1. Thermometer pocket for oil temperature.
2. 200 mm diameter dial type oil thermometer with maximum reading pointer and fitted with 2 sets of adjustable contacts for alarm and trip functions.
3. Rating and diagram plate (to comply with BS 171) of a durable and non-corrodible material.
4. Oil level gauge clearly visible from ground level.
5. Pressure relief valve with alarm contacts.
6. Tank filling and drain valves.
7. Separate neutral earthing terminal with independent access cover enclosed with weatherproof housing for the restricted earth fault current transformer .
8. Earthing terminal for tank.
9. Marshalling box for over-temperature and pressure alarm and trip contacts.
10. Large identification labels shall be affixed to each transformer identifying their primary circuit breaker
11. Lifting and jacking lugs.

12.3.14.7 Earthing

A. Transformers shall be connected to the earth bars installed inside the substation.

B. All metallic enclosures, tanks, fittings and accessories must be bonded together and connected to the earth bar.

C. The transformer secondary winding star point/neutral shall be connected to earth.

12.3.14.8 Installation

Transformer shall be mounted on a steel structure fixed to the concrete slab.

HV and LV cables to the transformers shall be supported on galvanized, heavy duty cable ladders.

12.3.14.9 Testing

A. Type and routine tests shall be carried out in accordance with BS 171/IEC 76.

B. Routine tests shall be carried out in accordance with BS 171, including:

1. Measurement of winding resistance
2. Voltage ratio measurement
3. Check of voltage vector relationship
4. Measurement of impedance voltage and load losses
5. Measurement of no-load loss and current
6. Insulation resistance measurement
7. Separate-source voltage with stand test
8. Induced over voltage with stand test
9. External construction inspection
10. Check of oil leakage.

All the above tests shall be carried out at the transformer manufacturer's factory. Tests 6, 9 and 10 shall be repeated on site.

C. Type Tests

1. Temperature rise test on the transformer.
2. Impulse withstand test on the transformer shall be applied on the HV winding leg only and shall be in accordance with BS 923 and BS 171.

D. Short Circuit Test

Short circuit test need not be performed if already performed on a transformer of the same rating and similar construction. Type test result shall be made available.

12.3.15 Protective Devices

The Contractor shall provide all necessary protective devices and he shall be responsible for so designing the protection that is it is entirely suitable for the equipment being protected and relates correctly to the whole supply system.

Protective devices shall comply with BS 142 and BS EN 602556.

12.3.16 Control Relays/Auxiliary Relays/Interposing Relays

Relays shall be suitable for operation on a nominal 110V AC supply or in special cases 24V AC (i.e. float switch control if necessary). Relays shall be suitable for operation at plus 10 percent and minus 25 percent of their nominal rated voltage.

They shall be of the plug-in type only, complete with plastic cover and shall be fitted with normally open/normally closed or changeover contact combinations as necessary.

The contact material shall be suitable for their specific application.

Mixed voltages must not be used on the different contacts of a particular relay. If necessary additional relays shall be used.

Coils shall be vacuum impregnated or guaranteed suitable for the local climatic conditions.

Terminations to the relay bases shall be of the front connected screw clamp type. The relay mounting panel shall be drilled and tapped to accept future spare bases.

Relays shall be secured to their bases by retaining bar or clip to prevent malfunction due to the relay being loosened in its base.

Care shall be taken to ensure that relay contacts and associated wiring are suitably fuse protected.

AC operated relays shall have a neon indicator mounted within their clear covers which shall be connected directly across the relay coil to indicate when supply is connected. These indicators shall be easily seen when the relay compartment door is opened.

Relays having different contact configurations or different coil voltages shall under no circumstances be interchangeable.

A permanent means of identification shall be affixed to both relay and base in line with the circuit diagram reference.
Where remote supply voltages are used then care shall be taken to ensure that all relays and any other equipment involved (terminals, fuses, etc.) are completely shrouded and where possible segregated. A warning label engraved in English and Arabic shall be fitted onto, or adjacent to, any such equipment. Similarly where voltages exceeding 55V to earth are employed in relay compartments or non door-interlocked sections then shrouding segregation and warning labels shall be applied.

12.3.17 Distribution Board

Distribution boards for small power and lighting shall be fed from a TPN moulded case circuit breaker and shall have outgoing MCBs (BS EN 60898 with residual current devices as specified with suitable short circuit capacity type 3).

12.3.18 Low Voltage Supply

One suitably rated SP&N moulded case circuit breaker feeding one 240/25 volt 400 VA single phase, earthed screen low voltage isolating transformer shall be incorporated in the panel to feed the low voltage socket outlets via accessible fuse and earthlink.

12.3.19 Socket Outlet

The panel shall be fitted at each end with I no.25 volt 5 amp 3 pin socket outlets of the flush mounted type with protective cover complying with BS EN 60309-2, and colour coded plugs. Each socket shall be located with its centre point 150 mm from the front face and 150 mm above the base, clearly labelled in English and Arabic with its rated voltage.

Flush type 13 amp switched socket outlets, each connected directly to a 15 amp miniature circuit breaker, shall be fitted one in each end of the panel, adjacent to the 25V socket outlets and clearly labelled.

12.3.20 Motor Control Units

The motor control units shall comply with BS EN 60947-4-1 and BS 587. The cubicles shall be easily accessible for maintenance purposes and shall be damp-proof and dust-proof. The motor starter shall be of rating to carry the full load current of its rated duty at its most severe load conditions. All starters shall be capable of at least 10 starts per hour at 100 percent full load torque. Motor starters shall be dust-proof. Motors up to and including 7.5 kW shall be started direct on line.

Each starter shall be housed in a separate compartment which shall contain the following:

- 1 no. triple pole (TP) externally operated fault making load breaking moulded case circuit breaker interlocked with the compartment door with provision for using a padlock to lock it in the OFF position and provided with suitable number of auxiliary contacts.

- Contactors selected from one of the following types:

    1. 1 no. TP contactor for switching direct-on-line (DOL) in accordance with BS EN 60947 and fitted with auxiliary contacts. The rating of contactors shall have at least 25 percent spare capacity.
    2. For auto-transformer starting there shall be provided magnetically operated starting accelerating and running contactors operating under mechanical or pneumatic timing devices. The auto-transformers shall limit the starting current to 4 times full load current (FLC) with 60 percent, 70 percent and 80 percent tappings.
    3. For slip ring rotor resistance starting there shall be provided magnetically operated starting accelerating and running contractors operating under mechanical or pneumatic timing devices.

- 1 no. TP magnetic overload relay.

- 1 no. TP thermal overload relay with double trip bar or similar offering single phase protection. The relay shall be fully adjustable but set at the optimum current setting required to give protection against a normal running overload condition. The adjustable setting range shall cover the required power output and also the percentage in hand (refer Section 12.9.3) should some or all of the additional power output be found necessary in practice.

  Documentary evidence must be produced showing the current/time characteristic of each overload at its setting (hot/cold for the thermal overload) overlaid on the motor manufacturers thermal stability time/current characteristic for comparison. Consideration must be given as to the requested method of starting (DOL, auto transformer etc.)

- 1 no. set of auxiliary relays and timers required to provide the necessary indication and control sequence.

- 1 no. set of main terminals and auxiliary tem1inals for remote controls and indications.

- 1 no. set terminals for remote lock-off stop push buttons.

- 1 no. 240/110 Volt 50 Hz double wound single phase transformer with earth screen and of suitable capacity to supply all control circuit and pilot lamp requirements. The transformer secondary shall be centre tapped and earthed via a removable bolted earth link. The transformer primary shall incorporate a suitably rated fuse and neutral link with the control and lamp circuits having separate fuse protection on each side.

- 1 no. anti-condensation heater (off when starter contactor is closed). The heater shall be separately fused.

- 1 no. set of power factor correction capacitors with protection for all drives above 9 kW.

- 1 no. adjustable thermostat to be mounted in the starting resistance cubicle and protecting the resistance from overheating by tripping the main contactors. (Resistance starting).

The following equipment shall be mounted on the door of the starter cubicle:

- 1 no. ammeter fitted with suppressed scale to read motor running and starting current with red mark to indicate full load current.

- 2 no. pilot lamps to indicate "SUPPLY ON" (Green) and "MOTOR RUNNING" (Red).

- 1 no. pilot lamp to indicate "MOTOR FAILED" (Amber).

- Pilot lamps shall comply with Section 12.3.13 having 110V transformer primary.

- 1 no. "HAND/OFF/AUTO" selector switch.

- 1 set "START/STOP" push button.
- 1 no. externally operated overload reset push button.
- 1 no. motor and cubicle heater "OFF/AUTO" control switch.
- 1 no. electronic hour counter reading to 99999 hours with LCD display, memory and battery backup with reset button.
- 1 duty label.

As remote indication of drives may be required, each starter should be designed for this purpose.

The signal for the remote indication will be taken via auxiliary contacts fitted to the isolators and contactors or relays of the individual starters.

The motors in some groups may be required to operate in a predetermined sequence and starters should include suitable auxiliary relays and contacts which can be tested and calibrated without tripping the circuit. Additional facility of checking relays while panel door is open shall be provided.

Fault indication at the relay and annunciator panels shall be included.

All starters shall contain a totally enclosed dustproof timer or the operation will be controlled by a timer in the automatic section which shall prevent pump(s) starting after a power failure until after a preset time has elapsed. The timer(s) or contacts shall be adjustable in the range 50 to 200 percent of the anticipated maximum delay which shall be taken as twice the total time required for all pumps to start and run steadily having been started consecutively. The timer(s) or contacts shall be set to give individual sequential start after a power failure with no drive starting until its predecessor has reached full steady running.

Where slip ring rotor resistance motor starters are employed the rotor resistance shall be of the metal grid type and shall limit the starting current to that specified for the size of drive.

Rotor resistance shall be mounted in floor standing units panel top units or integral panel units.

The rotor resistance may be mounted within floor standing cubicles constructed of 2 mm (minimum) thick sheet steel of welded construction. The cubicles shall be provided with adequate ventilation louvers and access to the resistance units shall be by means of a lockable, hinged front door. The cubicle shall be arranged for cabling from below.

Both the exterior and interior of the cubicle shall be stove enamelled to BS 4800 colour IBE51 and the exterior shall be provided with warning notices to indicate electrical hazard within.

Each cubicle shall be equipped with a heater which shall be continuously "on" while the associated resistance bank is de-energized.

The rotor resistance may be mounted within separate cubicles mounted on top of the control panel. . These cubicles shall be identical in construction to the control panel and dummy cubicles shall be provided as necessary to ensure uniform height of the entire control panel.

The cubicles shall be provided with adequate ventilation louvers and access to the resistance units shall be by means of a lockable, hinged front door. Cable connections to the main control panel shall be via suitable cable glands to maintain the integrity of the control panel enclosure.

Each cubicle shall be equipped with a heater which shall be continuously "on" while the associated resistance bank is de-energized.

The rotor resistance may be mounted within a cubicle within the control panel itself, provided that:

- The resistance cubicle is adequately ventilated front and rear.
- The resistance cubicle is provided with suitable cable gland entries to maintain the integrity of the control panel enclosure.
- The resistance cubicle is located so that no electrical components are mounted above it.
- The motor starter equipment is located in a separate, totally enclosed cubicle within the control panel.
- 1 no. TP wound magnetic overload relay fully adjustable but set at the actual current setting required to trip under a stalled motor condition within the maximum time that the motor characteristic permits this condition to exist.

The manufacturer or supplier shall submit the final proposed control wiring and layout to the Engineer for approval before proceeding to manufacture or take delivery of the motor control boards. Motor control boards equipped with wrong or inadequate facilities to suit requirements at site will be rejected and corrected at no additional cost to the Employer.

12.3.21 Test Certificates for Motor Control Boards

Each motor control board shall carry separate test certificates from the manufacturer. These certificates shall be submitted to MHEW at the time of application for power connection or testing of the installation.

12.3.22 Cable Connections

All incoming cables to the motor control board shall be connected to the individual circuit breaker or isolator of each motor control unit. The circuit breaker or isolator shall isolate completely the incoming supply to the unit for the motor and shall not affect the adjacent units in the control board in any way.

All outgoing cables shall be connected through links or connectors rigidly mounted and insulated to the cable supporting frames. All cable terminations shall be labelled.

12.3.23 Spare Parts for Motor Control Board

Spare parts shall be provided as recommended by the manufacturer and as specified.

12.3.24 Control Components

All components used in each control unit shall be uniformly and systematically installed and labelled. Parts of similar function shall be 100 percent interchangeable. Control relays shall all be interchangeable where possible and shall be the 'plug-in type. All the control components including the motor and control fuses, contactors etc. shall be accessible from the front. The cover to the control components shall be hinged.

12.4 CONDUIT

12.4.1 General

uPVC conduit shall be used below roadways and at permanent free standing equipment. Flexible plastic conduit (liquid tight where necessary) may be used for connection between stubs and equipment terminal outlets, if such flexible connections are protected from mechanical damage.

Where subject to moisture or exposed to weather, steel conduit shall not be jointed together, fittings for conduit which are of different metals that are subject to electrolytic interaction shall not be used.

Galvanized steel conduit shall be used for exterior installation of wiring. The conduits shall be of electrical grade i.e., without internal burrs and zinc grains to save wires from abrasion during pulling operation.

Pipe joint compound shall be provided to make up conduit joints in earth, concrete, masonry, or where exposed on exterior.

12.4.2 Products

Conduit shall be provided in conformance with the following specification.

- Rigid steel conduit shall be smooth surfaced heavy wall mild steel tube, of uniform thickness and temper, machine threaded at each end and protected inside and out with hot dip galvanizing, sherardizing or equivalent process. It shall comply with BS 4568 and BS 31.

- Flexible metallic liquid tight conduit shall be interlocking single strip, steel construction, hot dip galvanized inside and out, after fabrication and encased in a liquid tight neoprene or equivalent outer jacket over the flexible steel core and shall comply with BS 731: Part 1.

- Field bends shall be made with conduit hickey. Minimum bending radius of conduit shall be not less than ten times diameter for conduit and not less than twenty times diameter for primary conduit.

12.4.3 Execution

Non-metallic conduit systems shall not be used without written permission of the Engineer. Conduit shall be run on the surface or sunk as specified and be neatly arranged and ways shall be provided for additional conduits at all distribution boards. The sizes of conduits used shall be determined by the number of cables to be drawn in as scheduled in the IEE Regulations or as specified for a particular position, but in no case shall conduit less than 20 mm diameter be used.

Sunk and concealed conduit systems shall support fittings independently of any false ceiling.

All conduits shall be installed in an approved manner and arranged with adequate ventilation and drainage. Where practicable all bends or sets shall be formed in the conduit itself. The Contractor shall ensure that conduit draw-in boxes and junction boxes are of sufficient capacity to allow all cables to be installed shall comply with the recommendations detailed in the IEE Regulations.

The whole of the conduit system shall be completely swabbed through to remove any loose matter or dirt before cables are drawn in. Where conduits connect to switch boxes, draw-in boxes, and the like, the conduits must have a machined faced socket screwed on to the end which when tightened is flush with the outside of the box. The conduit is then to be secured to the apparatus by means of a hexagon smooth bore brass bush screwed from the inside of the apparatus into the conduit socket in order to make a sound and tight mechanical joint.

Surface run conduits shall be supported at intervals in accordance with the following schedules:

Size	Interval
20 mm	1.2 m
25 mm	2.0 m
32 mm	2.5 m

Where bends and sets occur in the conduit run the conduit shall be securely fastened at a distance of 225 mm either side of the diversions.

All bends and sets shall be formed in the conduit itself. Factory made bends shall not be installed without the written permission of the Engineer. The radius of a bend shall not be less than that given in the IEE Regulations.

Standard junction boxes, or adaptable boxes, shall be provided at all junctions and at sharp changes of direction to any special positions where they are called for by the Engineer on Site. Steel or malleable cast iron inspection couplers may be used in long runs to facilitate drawing in cables.

Particular care must be taken to ensure that no water is allowed to enter conduit at any time and all conduits shall be arranged with adequate ventilation and drainage. Inaccessible junction boxes will not be allowed.

Only continuous lengths of buried conduit shall be installed between boxes, no joint boxes shall be allowed in the floor screeds. Conduits crossing expansion joints shall be fitted with couplings of approved manufacture with an earthing clip

at each side of the coupling connected by the correct size of tinned copper stranded wire.

The ends of conduits laid or set in formwork prior to concreting shall be temporarily sealed off with a coupler and a solid brass plug.

Fixing to surfaces of walls shall be by means of spacer bar saddles securely fixed by screws. Where conduits are concealed or laid in structural floors they shall be held in position with substantial fixings of make and pattern to be approved by the Engineer.

Conduit shall be of the screwed pattern and galvanized by the hot dip process. All conduit fittings not carrying accessories shall be supplied with flat covers fixed in position with round head brass screws and gaskets.

Adaptable boxes shall be constructed of minimum 3 mm sheet steel or best quality cast iron, finished as previously detailed for conduit boxes and sized to prevent the undue packing of cables in them.

Weatherproof boxes and accessories shall be used outdoors.

Conduit shall be installed such as to permit complete rewiring without the need to remove false ceilings or carry out builders work.

No one conduit serving single phase socket outlets lighting points and switches shall contain more than one phase.

Wiring shall be carried out on the looping-in system and no joints other than at looping-in points will be allowed.

Where the conduit system terminates at any equipment requiring a non-rigid connection a flexible conduit shall be installed of the PVC or PVC sheathed metallic type, fully watertight with purpose made connection adaptors.

Each flexible connection shall include not less than 400 mm length of flexible conduit and a separate earth conductor shall be run within the conduit connected to the earth terminals in the equipment and the fixed conduit run. The flexible conduit shall not be used as an earth continuity conductor.

12.5 DISTRIBUTION SYSTEM

12.5.1 General

The distribution system consists of XLPE cables, PVC/SW A/PVC cable, PVC/PVC, PVC insulated, MICC cables and special cables for particular application and all installation materials to form a complete installation, shall be supplied, installed, connected and tested. All cables shall be 600/1000 V grade with copper conductors.

The Contractor shall ensure that each cable is of sufficient rating for its normal and fault conditions. To assess the rating and cross section required for each cable the following factors shall be considered:

- Fault level.

- Conditions of ambient temperature relevant to method of laying.
- Voltage drop
- Voltage drop in motor circuits due to starting.
- Overcurrent settings of circuit breakers.
- Disposition of cabling whether in air ducts or grounds.

Cable ratings shall be calculated in accordance with Electrical Research Association Publication ERA 69-30 or IEE wiring regulation.

The Contractor shall submit details of the cable sizes using actual parameters (including actual cable lengths) for the Engineer's approval before ordering.

The Contractor shall be responsible for measuring the length of cable required.

Each cable shall be supplied in a suitable length and be continuous through its run. Through joints will not be permitted without written permission from the Engineer.

12.5.2 Cable Routes

Medium voltage, low voltage and control cables shall be separated from each other by adequate spacing or installed in independent conduit/duct.

12.5.3 PVC Armoured PVC Insulated Cables

PVC armoured PVC insulated cable conductor of suitable sizes and manufactured to BS 6360 and PVC insulation to BS 6004, BS 6746 and BS 6746C, as applicable. Only PVC cables bearing the manufacturer's name shall be used.

XLPE armoured cable shall comply with BS 5467.

12.5.4 Conductors

Conductors shall be completely installed and connected. Apply wire lubricant to ease the pulling of conductors in conduits. Recommended pulling tensions shall not be exceeded. Splice and terminal connections shall be made tight with spring and compression connectors. The connectors shall be crimped with a tool that provides uniform and tight connections. Connectors shall be sized as specified in this Section. All the required wiring interconnections shall be included.

12.5.5 Insulation

All connections shall be insulated as required with tight wraps of plastic tape. Insulation putty shall be applied to fill irregularities and voids in splices. High and medium voltage cable splices shall be completed as instructed by the cable manufacturer.

12.5.6 Insulated Colour Codes

Insulation colours shall be in accordance with Table 51B of the Latest Edition of the IEE Regulations for the Electrical Equipment of Buildings.

12.5.7 Installation of Cables

For the purpose of this paragraph of the Specification, installation of cables shall include the following:

- Measuring, marking off and cutting of all cables to length before installation or laying.
- Temporary sealing, protection and support of cables being installed or laid, and testing of cables for insulation before jointing or termination.
- Preparation of all necessary materials for the placement, support or carriage for all cable runs. These shall include earth trenches, sleeve, ducts, cable trays, trunking, racks, clamps, saddles, etc.
- Where cables pass through foundation walls or other underground structures, the necessary ducts or openings shall be provided in advance for the same. However, should it become necessary to cut holes in existing foundations or structures the electrical contractor shall determine their location and obtain approval of the Engineer before cutting is done.
- Sealing of cables in ducts, sleeves or trenches to prevent ingress of water to plant room, manholes or switchroom.
- Testing of cable insulation, phasing and continuity.

12.5.8 Jointing of Cables

Cable sealing and jointing shall be in accordance with the best current practice. Cables with metal sheaths or armouring shall be terminated or jointed with metal sheaths or armouring solidly bonded to the metal joints or terminal boxes to provide a low resistance path under fault conditions.

12.5.9 Cable Pulling

Cable pulling shall be by manual means and sufficient wooden roller support shall be provided over the bottom of the trench to prevent damage. Cable guides shall be used for pulling cables round a bend.

12.5.10 Installation of XLPE Cables

The jointing of XLPE cables shall be carried out by a certified cable jointer of the relevant type. The jointer shall provide evidence to the Engineer that he has the necessary experience for the work.

Terminal sealing of cable may be by compound in cable boxes or by heat shrink kits. In any case, the termination shall be completed moisture proof. All cable ends must be flame warmed thoroughly to ensure that all moisture is driven off the dielectrics before proceeding to joint or terminate the cable. Wherever the XLPE cable is cut for installation, the ends must be sealed immediately by means of a lead cap and wiped to the sheath for air tightness, unless jointing or termination is done immediately.

Bending radius for the XLPE cable shall be in accordance with IEC 502.

All cables shall be terminated on cable sockets of correct size and cutting of copper strands of the conductor to suit undersized sockets shall not be permitted.

All cable entries through sleeves, ducts, floor or wall shall be sealed by tar, epoxy-resin or other water repellent compound suitable for the aggressive conditions pertaining. Cable through floors or slabs shall be sleeved through a short section of PVC or steel pipe and suitably bushed to prevent abrasion to the cable.

All the cable sheaths shall be bonded by copper earth bonding leads of appropriate size and connected to main earth distribution bars at the switchboards or transformers.

12.5.11 Installation of PVC SWA PVC Cables

Jointing and terminating of PVC steel wire armoured cable shall be done by experienced jointers who shall provide evidence to the Engineer that they possess the relevant experience for the work. At terminal sealing boxes, cable cores shall be brought through unbroken terminals and the cores shall be seated rigidly within the cast resin.

Straight joints are not encouraged in this work but when proved to be inevitable, due to changes or other unforeseen circumstances, this may be allowed only by written approval of the Engineer. Straight joints buried underground shall be compound filled and totally watertight. The steel armouring shall be made electrically continuous in such joint and the effective resistance shall be as low as possible. Where necessary, external earthing bond may be added.

Termination shall be by means of glands of the compression type to BS 6121, complete with terminating boxes. The glands shall provide a perfect grip on the steel armouring on termination.

12.5.12 Cable Trenching

The cable routes are shown on the Drawings. The exact location may be adjusted on the written approval of the Engineer. The cable route shall be as straight as possible.

Excavation of trenches for the cables shall be at least 700 mm deep measured from the finished ground level of the site. The Contractor shall be responsible for the establishment of this level at site and shall arrange to excavate and lay the distribution cables at the appropriate time, such that his cables will not be disturbed when installed. Any damage to the cable after installation shall be the sole responsibility of the Contractor and he shall make good the damage at his own cost. Trench width shall be adequate for cable spacing of 75 mm minimum (medium voltage).

12.5.13 Cable Protection

Before cables are laid, sand to a depth of 75 mm shall be placed in the bottom of the trench. Another 75 mm deep layer of sand shall be placed over the installed cables. At road crossings and other places where cables enter pipe sleeves an

adequate bed of sand shall be provided, so that the cables do not slack and get damaged by pipe ends after back filling.

12.5.14 Cable Covers and Markers

Cable covers shall be concrete slabs of appropriate size and 50 mm thick and laid above the top layer of sand so as to give direct protection to buried cable against damage from earth pressure. For identification of the cable route, cable markers shall be installed over the route, particularly at the points of change of direction and at the joints, if any. For long straight runs, markers shall be installed at appropriate intervals.

12.5.15 Backfilling and Reinstatement

After laying the cable covers, the trench shall be backfilled with selected loose soil, free from stones or other hard materials. The layer of refill shall be firmly compacted to the same finished level as the prevailing ground level.

12.5.16 Cable Trays and Supports

Cable trays shall be made of heavy duty, return flanged, perforated, hot dipped galvanized steel of not less than 1.6 mm thickness, with upturned flanges on both sides and with PVC coating. Tray width shall be as appropriate to accommodate all the cables in the same run. Cable supports shall be steel brackets fixed to ceiling, wall or slab in the manner as approved by the Engineer. Cable support spacing shall be 1 m to 1.5 m.

All hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cable they are supporting, non-ferrous, and so treated as to withstand site conditions without corroding.

12.6 LIGHTING AND SMALL POWER INSTALLATION

12.6.1 Layout Drawings

The general layout for all the lighting fittings, general purpose power outlets, exhaust fans, etc. is shown on the Drawings. The positions are given as a guide to indicate approximate locations only. The exact positions for ceiling fittings in false ceilings shall comply with the ceiling grid liners and panels. Other positions shall be verified with the Engineer at site.

12.6.2 Lighting Fittings

The types of light fittings for the work are shown on the Drawings. The Contractor shall be responsible for the supply and installation of all the various types of lighting fittings. Lighting fittings shall be complete with control gear, high frequency electronic starters, to minimize/prevent stroboscopic effect, power factor correcting capacitor, tubes, lamps, shades, reflector, etc.

The Contractor shall be responsible for the replacement of all the consumable components of the fittings within the warranty period.

Each surface mounted lighting fitting shall terminate at a standard junction box having entries to conduit and shall include connectors of adequate capacity and size for the connection of the number of wires at that point.

Each fitting mounted on a suspended ceiling shall have the standard mounting brackets or clips for the type of ceiling in question. The fittings shall include the necessary connectors and heat resistant cable for connection between the fittings and the terminal box. All suspended fittings shall be suitable for servicing and maintenance from the underside of the fittings. Fittings installed directly to the underside of a non-fireproof ceiling shall be provided with a 12 mm ventilation gap between the fittings and the ceiling.

All lighting fittings shall be provided with an earthing terminal which shall be connected to the earth continuity lead of the final sub-circuit. Fittings for external use shall be weatherproof and suitable for tropical environment.

Standard fluorescent lighting fittings shall have two suspension or fixing points.

The point box suspensions and other parts of the lighting fittings shall be erected at times to suit the program for building work and painting. The glassware diffusers, shades, lamps and tubes shall not be fitted until all building work and painting is complete.

All fittings shall be left clean inside and outside, and ready for use. All fluorescent fittings shall be suitable for instant start.

All fluorescent tubes shall be energy saving type and of an approved manufacture and standard white. They shall be suitable for the lighting fittings in which they are installed and of the correct voltage. Diffusers on fluorescent fittings shall be polycarbonate, unless otherwise specified elsewhere.

All incandescent lamps shall be of an approved manufacture with metal coil filaments, gas filled and pearl in all standard sizes, with standard caps to suit the fittings in which they are installed.

The Contractor shall supply and install all lamps for the entire lighting fitting installation and shall replace all burned out lamps through to the end of the Defects Liability Period.

Lighting fittings shall be protection class IP 56 for indoor use and IP 65 for outdoor use, unless otherwise specified, and shall be suitable for continuous operation at 55 degrees C ambient temperature. Lighting fittings for emergency lighting systems shall comply with BS 5266.

12.6.3 Wiring Devices

Receptacles and switches shall be specification grade heavy duty and be provided in galvanized steel boxes with covers. Unless otherwise indicated, the device colour shall be ivory for all flush duplex receptacles and local switches, and their coverplates.

12.6.4 Switches

Sub-circuit switches, unless otherwise stated, shall be single-pole quick make and break type, with solid silver alloy contacts and totally enclosed switch action for flush or surface mounting, as required, and shall be suitable for indoor and outdoor use.

The switches shall be housed in standard galvanized conduit boxes complete with conduit knockouts. The switches may be single or multi gang as required. Switches in mechanical plant rooms shall be metal clad type and suitable for flush or surface mounting, as required.

Switches for external use shall be waterproof, metal-clad galvanized type.

Switches shall be rated at 5A or 15A depending on the connected load on the final sub-circuit. For inductive loads, switch rating shall be twice the steady current of the loads.

12.6.5 13/20 Amp Socket Outlets

Switched socket outlets shall be to BS 1363 single pole 13/20 A, 3 pins, switched shuttered outlets and shall be flush mounted type. Switches shall be quick make and break type with solid silver alloy contacts totally enclosed switch action. Socket outlets shall be flush mounted in galvanized steel boxes to BS 3676 and 1363 with conduit knockouts.

They shall be of metal-clad type with matt chrome finished cover plates and shall be flush mounted unless fitted to non-decoratively finished walls or pillars where surface mounting will be accepted.

13/20 A socket outlets shall be mounted at 300 mm above finished floor level or 1.5 m above floor level in places where they are intended for use above counter or work bench.

Each 13/20 A socket outlet shall be complete with an ivory finish moulded plug to BS 1363 complete with colour coded fuse to BS 1362. Plugs shall be supplied complete with fuse and handed to the Engineer on the issue of the practical completion certificate of the installation.

12.6.6 Contactors

The contactors for the control of the group of lights in the final sub-circuit shall be three pole with silver alloy contacts with capacity for two times the rating of the steady current in the circuit. Coils shall be suitable for continuous rating without overheating or damage or noise and shall operate on 240 V AC, 50 Hz capable of remote control switch which may be 1 way, 2 way or intermediate.

Contactors shall be capable of being serviced or replaced from the front of the switchboard or distribution boards.

12.6.7 Low Voltage Supplies

Where low voltage supplies are required for illumination and power supplies (hand lamps installation liable to flooding, portable hand tools, etc.) they shall be

obtained from an auxiliary transformer wall mounted for permanent installation. Wall mounted units shall be supplied complete with any necessary brackets and fixtures.

Units shall be of the non-inherently short circuit proof type and shall have primary and secondary fuses mounted in an accessible position.

12.6.8 Installation Materials

All wiring, conduits, conduit boxes, draw-in boxes, junction boxes, saddles, brackets, etc., required for the completion of the sub-circuit installation and wiring shall be included in this work.

Generally, PVC insulated copper conductors of minimum size 4 sq mm shall be used for the wiring of lighting and general purpose outlets and in concealed conduits.

12.6.9 Conduits

All conduits and fittings etc., run exposed in false ceiling, and in any other areas as directed by the Engineer, shall be in galvanized steel.

Conduits cast in slab, or floor, shall be fixed securely to prevent movement and the joints shall be securely wrapped with tape where necessary to prevent them from coming loose or allowing ingress of concrete during casting. Any defects in the conduit installation shall be made good by the Contractor at his own cost.

Surface conduit in false ceiling or other areas where exposure is permitted shall be galvanized steel with fittings and accessories of similar materials. Conduit saddles shall be spaced at 1 m apart for sizes below 25 mm diameter. For bigger sizes, saddles may be 1.5 apart. Saddles shall be fixed by screw in rawl plugs in drilled holes.

Conduit run shall be as straight as practicable and shall either be vertical or horizontal. Diagonal runs are not permitted. Draw-in boxes shall be added for runs of more than 2 bends or for straight run of more than 9 m span. Conduit sizes shall be adequate for the number and sizes of the cables being installed in the conduit. Minimum conduit size to be used shall be 20 mm. Number of cables in each conduit shall comply with Table 51B of the Latest Edition of the IEE Regulation for the Electrical Equipment of Buildings.

Conduits ends shall be carefully plugged to prevent ingress of concrete during casting. Termination of steel conduit in steel boxes shall be by means of threaded conduit joint and brass-made bush. Conduit ends shall be filed free of burrs before termination. Conduit ends shall be carefully plugged to prevent ingress of foreign particles. All metal conduits shall be made electrically continuous. Metal flexible conduits shall not be used as earth continuity lead.

12.6.10 Cable Trunking

Where cable runs are too numerous for conduit system, cable trunking may be used. Cable trunking shall be made from galvanized steel sheet and shall be of the following grades:

Sizes	Grade
100 mm x 100 mm	1.2 mm
150 mm x 150 mm	1.6 mm
Larger	2.0 mm

Cable trunking shall be complete with flanged outlets, blank ends, reducers, bushes, bends, tees, four way boxes and fitting adaptors. The cable trunking shall be complete with cable retainer and covers of the same grade of material. The cover shall be fixed by self-tapping screws. Cable trunking shall be fitted facing downwards to facilitate cable installation. The trunking shall be supported by brackets if suspended or directly to the soffit of slab or floors by screw in rawl plugs in drilled holes. Trunking sizes shall be such that a cable occupation factor of 0.45 shall not be exceeded.

The cable trunking shall be provided with a bare copper conductor of 6 sq mm and shall be bonded to the trunking at regular intervals, especially at the joints. Low voltage wiring such as fire alarm cables, telephone cables etc., shall not be included in the alarm cable trunking for the purpose of lighting and power installation.

Cable trunking shall be colour code finished with two coats of bright orange.

12.6.11 Wiring System

The wiring of all final sub-circuits from distribution boards to their respective fittings or lighting and power points shall be in 240/440 V grade PVC insulated copper conductor.

Wiring for lighting and power points shall be separate throughout the installation, except in the case of cable trunking. All cable sizes shall be capable of carrying the full load current of all their respective circuits continuously without overheating or undue voltage drop which shall not exceed 2.5 percent of the nominal supply voltage at the supply terminal. Minimum cable size for lighting or other low volt wiring shall be 4 sq mm minimum, 2.5 sq mm for earthing wires and 1.5 sq mm for control wiring. Special control wiring and screened cables shall be as recommended by system suppliers.

For 13A ring main, the cable shall be a continuous loop for both the neutral and the phase wire from the distribution boards. Cable shall not be cut at the sockets. For all other wiring, no joints shall be allowed in the wiring run except at the switch or fittings. Neutral wire shall not be drawn to any switch point.

A minimum length of 250 mm tails shall be left on all cables at outlet positions for connection of the lighting fittings or other apparatus fed by the outlet.

Wiring code shall be in accordance with the Latest Edition of IEE Regulations for Electrical Equipment for Buildings. The switched wire shall in all cases be red coded.

Incorrect wiring code will be rejected and the Contractor shall be responsible for replacement of any part of the wiring rejected by the Engineer for non-compliance with the Specification.

12.7 EARTHING SYSTEM

12.7.1 Earthing System

The earthing system shall cover each and every building in the Works consisting of a main earth at the switchboard room and localized earths where necessary .Where the cable sheath and armour is used as the earth return path then it shall be established that the resistance is less than 1 ohm. All these earths shall be bonded together. The metal sheaths or armour shall not be used as earth continuity or earthing lead. All metallic parts including pumps, trays, ladders, etc. shall be earthed using suitable size earthing cable with PVC/G sheath.

The earthing system shall comply with the latest standards and industrial codes, as well as the requirements of the MHEW Directorate General of Electricity.

12.7.2 Earth Electrodes

The earth electrode system shall consist of two electrode beds or nests independently arranged and each comprising a system of vertically mounted rods. Leads from each electrode shall be brought to concrete disconnection chambers to enable each electrode to be disconnected for testing purposes. Each electrode shall be capable of providing an effective earth within the limits specified. The earth pit containing the earth rods shall be of the preformed type with concrete inspection covers. The electrodes shall solid copper rods driven into the open ground at spacing no less than 30 meters apart. The electrodes shall be bonded together and the aggregate earth resistance so formed shall be less than 1 ohm.

12.7.3 Copper Earthing Lead and Bonding

The bonding of the electrodes and the copper earthing leads shall be copper conductor with nominal cross-sectional area of not less than 70 sq mm with PVC yellow/green sheath. The bonding shall be by means of non-corrosive metal clamps or by brazing.

12.7.4 Earth Electrode Inspection and Test Point

All inspections and test points of the earth electrodes shall be boxed up with brick and cement mortar with a removable slab cover. The positions of these earth electrodes shall be permanently labelled with the words.

"**Safety Electrical Earth. Do Not Remove**"

12.7.5 Telephone Earth

Telephone earth shall be either by means of steel cored rods or G.I. pipes but shall be isolated from the general earth. The earthing lead shall be bonded to the MDF. The earth resistance shall be 1 ohm or less.

The size of the earthing lead shall be not less than 10 sq mm.

All the earthing for the positive pole of any PABX and other low voltage equipment shall be taken from the telephone earth. This earth shall be kept isolated from the electrical earth.

12.7.6 Lightning Protection

Lightning air terminals, and ground conductors for lightning air terminals, shall be provided as per BS 6651 and shall be 25 mm diameter G.I. (air termination rod) 0.2 meter long with top spike. Roof conductors and down conductors shall be of copper conductor size 50 mm sq.

Air termination rods (lightning finials) shall be securely anchored and welded. Down conductors shall be run along the outer surface of the wall or column of the building. Down conductors shall be as short as possible, protected, and directly connected to earth pit. Anchoring bolts shall be used to hold roof conductors and down conductors in firm position. Also lightning finials welded to channel shall be anchored in such a way to keep in firm position. Lightning conductor connectors shall be provided for conductor splice connections and conductor terminal connections. The connectors shall be heavy duty, cast metal, and shall have hex-head screws in the bodies and holes in the tongues for bolts. Handrail and other metal structures in the vicinity of the lightning protection system, if any, shall be bonded to the system.

12.8 TESTING

12.8.1 Test at Manufacturer's Works

All tests or inspection shall be in accordance with the relevant ISO, British/USA or such other standards as approved by the Engineer.

All tests or inspection at the manufacturer's works shall be accompanied with test or inspection certificates showing all the relevant information and details relating to the test or inspection. Four copies of Test Certificates signed by the manufacturer's representative shall be submitted to the Engineer on or prior to the despatch of equipment to site.

12.8.2 Installation Inspection

During installation, or when the Contractor is satisfied that the work is in satisfactory working order, he shall arrange with the Engineer to carry out tests on or inspection of the installation or completed work. If any part or equipment is found to be not in accordance with the Specification or relevant Standards, such defect shall be put right by the Contractor to the satisfaction of the Engineer and at no extra cost to the Employer and retested if necessary.

12.8.3 Test Inspection by Power Supply Authority

Prior to the completion of the work, the Contractor shall arrange with the MHEW Directorate General of Electricity for the inspection, testing, reading of meters etc. to obtain clearance for the connection of power to the plant or equipment.

12.8.4 Attendance During Testing

For all the tests and inspection as aforementioned, the Contractor shall provide the necessary tools, labour and skilled technicians as and when required during the period of test and inspections.

All tests or inspections shall be conducted in the presence of the Engineer. Test results shall be obtained and recorded and submitted in quadruplicate to the Engineer. Any results showing variation from the manufacturer's test results shall be rectified to the satisfaction of the Engineer and at no extra cost to the Employer.

12.8.5 Standard Tests at Site

The following are the tests required to be carried out and recorded.

- Earth electrodes impedance and earthing system.
- Insulation resistance test.
- Continuity tests.
- Operation and system tests such as sequence interlock, etc.
- Operation of protective gear circuit test by simulation of check sensitivity and stability.
- Phase rotation list.
- Polarity test to ensure that single switches are installed in the live conductor and not in the neutral conductor .
- Test for ring main circuits.
- Insulation resistance test to earth and between conductors before and after connection of fittings.
- Insulation resistance test on all equipment apparatus installed, before and after connecting such equipment to the supply circuit.
- Earth continuity test for each final sub-circuit and the completed installation to ensure that earth fault loop impedance is such as to satisfy the requirements of the Latest Edition of the IEE Regulations for the Electrical Equipment.

The electrical equipment shall not be deemed complete until satisfactory completion of the tests mentioned above and presentation of the record of such tests to the Engineer.

12.9 INDUCTION MOTORS

12.9.1 Description

This Section outlines the electrical requirements for squirrel-cage and wound-rotor induction motors.

12.9.2 Power Wiring

The wiring shall be complete, and include all motor connections.

12.9.3 General

All motors shall be suitable for operation on a 415 volts 50 Hz 3 phase supply.

All motors shall be capable of starting 10 times per hour. The stalled motor current shall not exceed 6 times full load current.

The motors shall be commercially silent in operation and run free from vibration and the rotors shall be perfectly balanced both statically and dynamically and shall be tested and adjusted for dynamic balance in an approved manner.

The motors shall be fitted with anti-condensation heaters of a size to maintain the temperature of the windings 5 degrees C above ambient. Each heater shall be provided with a switch and automatic control to disconnect it when its motor is in operation.

Terminal boxes shall be provided with glands suitable for XLPE or PVC armoured cable. The motor stool base, where appropriate, shall be drilled at the manufacturer's works vertically below the terminal box gland for the passage of the cables and the edges of the hole slightly countersunk or the hole bushed.

Arrangements shall be made with the manufacturer so that the Engineer may witness motor tests, if so desired.

The motors shall run in ball and/or roller bearings and the weight of the motor shall be carried by thrust bearings incorporated in the motor body.

The efficiency and power factor of the motors shall be high over a wide range of load conditions and the motors shall be designed manufactured and tested in accordance with BS 4999 and BS 5000 (or BS 2048 and BS 5000 in the case of small horsepower motors) for continuously rated industrial electric motors with Class 'F' insulation but limited to Class 'B' temperature rise. The maximum continuous rating (MCR) of each motor shall be as set out in Table below, unless otherwise specified, and shall be rated and designed to suit the local climatic conditions.

MCR RATINGS

Application	Up to 75 kW drive	Above 75 kW drive
All motors	10 percent above that required under all conditions of operation	5 percent above that required under all conditions of operation
Compressors	25 percent above max. duty requirements	12.5 percent above max duty requirements

Note: The reserve power requirement shall be added to the calculated power prior to any other adjustments, e.g. high ambient temperatures at Site.

Motors shall be selected from the following to satisfy the Contractor's performance requirement and comply with the requirements of the MHEW Directorate General of Electricity.

- Motors up to 7.5 kW shall be squirrel cage suitable for DOL starting having a starting current not greater than 6 x full load current (FLC).

- Motors between 7.5 kW and 37.5 kW may be the following:

    1. Squirrel cage rotor with auto transformer starting having starting current limited to 4 x FLC and tappings to suit torque requirements.
    2. Double cage rotor with DOL or auto transformer starting having starting current limited to 4 x FLC and tappings to suit torque requirements.
    3. Slip ring wound rotor with rotor resistance starting with starting current limited to 4 x FLC.

4. Soft start starter.

- Motors over 37.5 kW shall be one of the following:

1. Double cage rotor with transformer starting having stating limited to 2.5 x FLC and tappings to suit torque requirements.
2. Slip ring wound rotor with rotor resistance starting with starting current limited to 2.5 x FLC.
3. Soft start starter.

Centrifugal pumps on unscreened sewage will give at least 100 percent full load torque on starting and, therefore, only squirrel cage rotor machines utilizing direct-on-line (DOL) starting or slip ring wound rotor machine with rotor resistance starting will be acceptable for these drives.

Terminal boxes shall be cast iron, over-sized, diagonally split, and rotatable in 90 degree steps. Provide a gasket between the box and motor frame, and attach the box to the motor frame with high strength zinc plated and chromated steel bolts and cap screws.

12.9.4 Finish

The casing shall be coated with a red-oxide zinc-chromate primer, and finished with a corrosion resistant epoxy coating.

12.9.5 Nameplates

Provide stainless steel nameplates of ample size with clear numerals and letters. Nameplates shall indicate the manufacturer, serial number, model number, type, power, phase, Hertz, volts, design, full load amperes, locked rotor code letter, service factor, speed, insulation class, temperature rating and other essential data. Nameplate data shall be complete in English. Nameplate shall be secured to the motor frame with corrosion resisting pins in accessible locations.

12.9.6 Grounding

Lugs shall be provided in all motor terminal boxes for grounding.

12.9.7 Minimum Requirements

Motors shall have Class "F" insulation. Temperature rise by resistance shall not exceed the Class "B" insulation system unless otherwise indicated. The motors shall be sized so that the brake power does not exceed 90 percent of the full load nameplate power, unless otherwise specified elsewhere. The motor must be able to accelerate the driven machine from zero to top speed at 90 percent of rated voltage without overheating.

12.9.8 Enclosures

Enclosures for induction motors shall be approved for the installations and as indicated. The enclosure types shall be as outlined in the specific equipment Specification, or be of one of the following as indicated. The equipment shall have the manufacturer’s corrosion resistant finish.

- IP54 for general purpose drives.
- IP55 for indoor pumps and machines
- IP56 for outdoor use of machines subject to splashing or washing down.
- IP68 for submersible machines.

12.9.9 Temperature Rise

Temperature rise above the temperature of the cooling medium, for each of the various parts of the motor, shall not exceed the values specified by the motor manufacturer.

12.9.10 Construction of Motors 180 kW and Smaller

Motors 180 kW and smaller shall include cast iron housing and end brackets. The terminal box shall be cast metal with gaskets between the box and housing, and between the box and cover. The box shall have a threaded conduit entrance. Ventilating fans shall be non-corroding. Vertical motors shall be provided with aluminium canopy caps. A condensate drain hole shall be furnished in each end bracket on horizontal motors and a single drain hole in the lower bracket of vertical motors.

12.9.11 Bearing

Provide bearings that are designed to give 3 years B-10 life for the conditions specified in continuous operation, with proportions, mountings, and adjustments consistent with best modem practices for all applied radial and thrust loads at specified speeds. Design thrust bearings in vertical motors to carry up or down thrust that pump may impose during starting or operation at any capacity, including shutdown. The bearings shall be anti-friction and the bearing chamber shall be coated with a rust inhibiting grease or oil. End brackets shall include lube fill and relief plugs or fittings which allow re-lubricating while the motor is running.

1. Ball Bearings
   The ball bearings shall be double shielded, grease or oil lubricated except for belted service frames where roller bearings shall be furnished. Provide motor/bearing protection with internal shaft flingers or inner bearing caps.

2. Grease Lubricated Motors
   Include fittings for periodic lubrication service, except on motors specifically designed and equipped with factory-sealed bearings.

3. Oil Lubricated Bearing Housing
   Equip with a reservoir of sufficient depth to provide space for settling of foreign matter, drain plug accessible from motor exterior, and a visual oil level indicator.

4. Sleeve Bearings
   Equip with proper oil rings. Wicks or packings are not acceptable. A sight glass for each bearing shall be provided, with the proper oil level range marked by the manufacturer to prevent overheating.

5. Couplings on Horizontal Ball Bearing Motors
   Construct to absorb total axial movement and thermal expansion of motor and driven equipment shafts.

6. Couplings for Sleeve Bearing Motors
   Couplings shall be of a type which avoids the transfer of thrust loads that would cause the rotating thrust bearing surface to bear against the sleeve bearing thrust collar.

12.9.12 Dynamic Balance

Dynamic balance of motor built in frame size 143 and larger shall be 0.025 mm total amplitude or peak to peak displacement.

12.9.13 Motors 50 kW through 180 kW

Motors 50 kW through 180 kW shall also include two sets of temperature detecting devices, approved by the Engineer, shall be embedded in the windings. One device shall have normally open contacts to actuate an alarm when the temperature rise exceeds 90 degrees C when operating in specified ambient temperature. Also, one device shall have normally closed contacts to open the motor controller holding coil when the temperature reaches 105 degrees C when operating in the specified ambient temperature.

12.9.14 Installation

Provide all equipment and wiring installation, including connections as indicated, specified and required. Assure proper fits for all equipment and materials in the spaces as shown on the Drawings. The following shall be provided and/or carried out:

- Provide power, control, alarm, and grounding installations for all motors as indicated and required.
- Check the connections and provide correct rotation for all motors.
- Record the full load current to each motor, and the overload relay rating in each motor starter for the certified data submittal.
- Provide the wiring for heaters in the motor frames and the required controls to de-energize the heater when the motor operates.
- Provide the required wiring for all control equipment that shall be furnished and installed under other Sections of the Specification.
- Install the control stations on steel stanchions and building structures near the motors, or as shown on the Drawings.

12.10 FACTORY TESTS

- All Motors 50 kW and Larger shall be given complete tests including:

1. No load running current.
2. Locked rotor current.
3. Full load heat run.
4. High potential test.
5. Winding resistance.
6. Bearing inspection.

7. Locked and idle saturation curves.
8. Service factor heat run.
9. Percent slip.
10. Breakdown torque.
11. Locked rotor torque.
12. Efficiency at full, 3/4, and 1/2 load.
13. Power factor at full, 3/4, and 1/2 load.
14. Balanced to total amplitude.
15. Noise test (where applicable).
16. Wound-rotor type, secondary volts at collector rings.

Tests (except locked rotor current) shall be made at full voltage and rated frequency.

- All Motors Smaller than 50 kW shall be given standard commercial tests.

12.11 FIELD CHECKS

- Motor Installations shall be complete and correct.
- Operating Tests shall be performed to observe that motors start, run and stop satisfactorily.
- Field Damaged Factory Finish on equipment shall be touched-up with paint that is equal in quality and colour to the original factory finish.

12.12 POWER FACTOR CORRECTION CAPACITORS

12.12.1 Scope

This Specification covers the technical requirements of shunt capacitors required for power factor correction of individual motor feeders. The power factor shall be improved to a minimum of 0.93 lagging on each machine larger than 9 kW. A 3-phase capacitor shall be provided and located within each respective starter in the Motor Control Centre.

12.12.2 Codes and Standards

Unless otherwise specified, shunt capacitors and their associated components shall conform to BS 1650.

12.12.3 Performance and Characteristics

Capacitors shall be capable of satisfactory operation for the application, duty and requirements as indicated in this Specification.

Capacitors shall be designed to withstand safely, without any injury or damage, the highest system voltage (rms) specified.

The size of capacitor shall be selected to correct the power factor of the motor at its duty point, but should not exceed the magnetizing kVAR of the motor even if a lower corrected power factor results.

12.12.4 Construction

The capacitors shall be of the oil or synthetic oil immersed type with paper or paper and plastic film dielectric in an oil-tight steel tank complete with discharge resistances. A metal enclosed terminal box shall be provided with cable entry sealing facilities. Polychlorinated biphenyls or askarels are not acceptable impregnants.

12.12.5 Capacitor Connections

The capacitor shall be connected after the line contactor but before the motor protection overloads and ammeter such that the motor current only is indicated. All capacitors shall have a set of 3 protection fuses.

Central automatic power factor correction shall be provided, where shown on drawings. The central system shall consist of bank of capacitors with a minimum size of 25 kVAR. It shall have an electronic sensor which connects the first stage capacitor only if the resultant of the power factor correction shall not exceed the magnetizing kVAR of the motor/motors connected to the supply, even if a lower corrected power factor results. Power factor correction capacitors/panel supplier shall submit proof of this to the Engineer, for approval.

12.13 OUTDOOR LIGHTING

12.13.1 Scope

Outdoor lighting shall involve the supply and installation of street lighting and area lighting lamp posts, 3-phase underground distribution cables, high pressure sodium and mercury vapour lamp fittings and the relevant control and distribution boards as shown on the Drawings. All outdoor lights supplied shall be controlled by photo cell/timer unit with manual override facilities.

12.13 .2 Lamp Posts

Street lighting lamp posts shall be 10 m long with 50 mm mast arm, 5^{o} tilt complete with 250 watt lamp, base, base plates and cable box with fuses, and shall be fabricated from Class B galvanized iron pipes to approved designs for mounting as shown on the Drawings. All formings, joints and mounting brackets shall be welded. Base plates of suitable thickness shall be welded. A 10 mm diameter drain hole shall be provided at the centre of the base plate. All welding shall be filled continuous and built up in layers free of any impurity. Welding of stiffeners shall be on both sides for the full length of the stiffener. All sharp edges on the stiffeners shall be filed and smoothed off.

12.13.3 Painting of Lamp Posts

Lamp posts shall be painted externally with 2 coats of aluminium paint. All internal metal surfaces, including the stump within the cable connecting box, shall be painted with red lead, or other approved anti-corrosion paint.

12.13. 4 Installation of Underground Conduits and Handholes

The general layout for the conduits and the approximate positions of the handholes and/or related manholes shall be clearly shown on the Contractor's

submittal. Conduits shall be uPVC and shall be laid straight between handholes, at 600 mm depth and on the centreline of the handholes.

12.13.5 Installation of Lamp Posts

Lamp posts shall be installed as shown on the Drawings.

12.13.6 Wiring and Cabling (Directly Buried Armoured Cables)

Distribution cabling to the lamps from the distribution and control board shall be in 4 core XLPE/SWA/PVC insulated and PVC sheathed copper conductor. No joints will be permitted between handholes. Lamps on similar circuits shall be wired by looping-out principle with the looping within the lamp post terminal boxes. Suitably sized connectors shall be done without cutting the conductors. Wiring to the lamp control gear shall be as follows:

- Live wire in red PVC insulated copper
- Neutral in black PVC insulated copper
- Earth in green PVC insulated copper.

The live conductor for each fitting shall be wired through a 3 A or 10 A (as required) cartridge fuse complete with fuse carrier and base. Neutral and earth conductor may be connected directly to the connector of the incoming cable loop of the respective pole. Pole distribution cables may be in PVC insulated copper conductor in single core with red PVC for live, black PVC for neutral and green/ yellow PVC for earth.

All posts shall be earthed according to IEE Wiring Regulations using cable armoured for this purpose.

12.13. 7 Distribution and Control Boards

The Distribution and Control Boards for the compound lighting shall have 3-phase supplies, with each lamp circuit controlled by 24 hour timer/photo cell controller with override manual switch at the location of the DB. All control switches for the lighting circuits shall be permanently and legibly labelled. Control switches shall be mounted on one common board located in the panel.

12.14 WEATHERPROOF ENCLOSURES

12.14.1 General

Airconditioned weatherproof enclosures, rated in accordance with IEC 529 to IP66, shall be provided for all electrical, control, instrumentation, etc., equipment which is to be used externally.

12.14.2 Construction

1. They shall be suitable for the prevailing climatic conditions and shall be of robust vandal proof construction. All instrumentation and control cubicles, kiosks etc. designed for use outside shall be manufactured having walls of double skinned, resin bonded fibreglass, with a totally encapsulated infill of rigid weather and "boil" proof plywood to BS 1203 between the two skins .

2. The laminate material shall have flame retardant characteristics in compliance with BS 476 Part 7 Class 2, and shall retain "stability, integrity and insulation" for 30 min. when tested in accordance with BS 476. An indicative fire test report shall be provided by the manufacturer
3. Colour impregnated gel coats backed by coloured resin shall be used to ensure maintenance free and "colour fast" finishes, light grey in colour unless otherwise specified.
4. The roof section shall have a totally encapsulated fill of end grain balsa instead of plywood. The end grain balsa shall have a minimum thickness of 18 mm.
5. If required by the internal components, encapsulated thermal insulation shall be included.

12.14.3 Doors

The cabinet shall have a single door, or two or more hinged non-overlapping doors, fitted with a double locking bar, with a waterproof lever handle and cylindrical lock. Doors shall have an all round channel recessed gasket of non-fatigue, oil and age resistant material. Hinges shall be strong, smooth action and of stainless steel, and shall allow the door to be easily removed. Doors shall be fitted with a suitable fixing bar to hold it in the open position and prevent it opening too far. These shall be strong enough to restrain the door in windy conditions without damage.

All door catches and locks shall latch onto stainless steel reinforced surfaces. The door sill shall be protected by a non-corroding alloy material.

Door-mounted meters and transparent windows shall be of tinted toughened glass, which shall be protected from harmful direct sunshine by orientation or other approved means.

12.14.4 Backplate

The cabinet shall have an easily removable rear mounting plate on moulded spacers.

All internal equipment shall be mounted on supports built into the fibreglass structure. Fixing bolts through the skin will not be accepted.

The kiosks shall be floor mounted, suitable for bolting down to a concrete base.

12.14.5 Ventilation

Ventilation via louvers with efficient sand traps and vermin screens shall be provided where necessary.

12.14.6 Lighting

Enclosures shall be provided with internal fluorescent lights and thermostatically controlled anti-condensation heaters. An external bulkhead light shall also be provided.

END OF SECTION 12

SECTION 13

MECHANICAL EQUIPMENT

13.1 GENERAL

13.1.1 Description

Requirements specified in Sections 11 and 12 of the Specification also apply to the mechanical equipment specified herein.

13 .1.2 Technical Data

Schedules of technical data for specific items of equipment are given elsewhere as necessary for the equipment to be provided under specific contracts.

13.2 AIR CONDITIONING

13.2.1 General

Compressor units for split and window A.C. units shall be guaranteed for 5 years and one spare compressor shall be provided for each type in each building.

13.2.1.1 Description

All equipment, appurtenances and auxiliaries shall be provided for the air conditioning systems. All compressors, condensing coils, fins, tubing, controls, cabinets, covers and all other appurtenances used in or on air conditioning units and accessories that are not located in a protected indoor area shall be rated for corrosive duty. All air conditioning units located inside a building in a clean dry atmosphere may be provided with a cabinet of painted galvanized steel or other approved material, as per the Specifications, but the above requirements shall apply for all other components.

Drainage from the air conditioning systems shall be discharged to an appropriate location.

13.2.1.2 Quality Assurance

The equipment and materials to be furnished shall be new and of first quality. The complete system shall be by one approved supplier having unit responsibility for the operation of all equipment. Units shall be rated in accordance with ARI Standards 440 and 590, latest edition. Units construction shall be designed to conform to ANSI B9.1 Safety Code, NEC and ASME applicable codes. Units shall have National Electrical Inspection Agency (UL or ETL) approvals.

Each coil shall be factory tested for leakage at 2410 kPa air pressure with coil submerged in water. Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation. All equipment wiring shall comply with NEC requirements.

13.2.1.3 Coatings

All coils and associated pipework will be factory coated with Technicoat 10-1 phenolic coating applied strictly in accordance with the recommendations of Technicoat, Inc.

13.2.1.4 Installation and Start Up

The systems shall be free from objectionable noise and vibration. The maximum noise level shall be not greater than NC 50.

The Contractor shall arrange to have the manufacturer or supplier of the equipment furnished under this Clause, provide the services of competent factory-trained personnel to supervise the installation and initial operation. Installation and erection of all assemblies and components shall be in accordance with the details indicated on the approved shop drawings and the printed instructions of the manufacturer.

13.2.2 Window Type Air Conditioning Units

Each unit shall be completely packaged and all components shall be contained within the unit casing.

Each unit shall include the following:

- Refrigerant compressor having high Energy Efficiency Ratio (EER)
- Air-cooled condenser coil
- Condenser fans(s)
- Evaporator cooling coil
- Supply air fan
- Inlet filters
- Integral control panel

The compressor shall be of the rotary/reciprocating; fully hermetic pressure lubricated type and provided with internal motor winding temperature protection. It shall operate on R-22 refrigerant and shall be internally sound isolated with internal discharge gas muffler and spring mountings.

The evaporator coils and the air-cooled condenser coils shall be of copper tube with aluminium plate fins. The fins shall be of special design that does not allow water to collect between the fins and water should drain off quickly.

The supply air fan shall be double inlet, forward curve centrifugal type with steel shaft mounted in life-lubricated bearings.

The condenser fan(s) shall be vertical or horizontal mounted propeller type, direct coupled, to the driving motor. The unit shall be resiliently mounted and all bearings shall be life-lubricated.

Filters shall be of the dry fabric washable and shall be "One touch lever" operation type which can be removed without opening the front panel. All internal refrigerant piping shall be made of copper tube with joints fusion bonded using high temperature solder.

Each complete unit shall be provided with auto louvers for uniform distribution of cool air and shall be suitable for single phase, 240V 50 Hz power supply. Cabinets shall be of compact construction fitted internally with 25 mm thick neoprene-covered fibreglass insulation or equal. The units shall be totally tropicalised and guaranteed for trouble free operation at an ambient temperature of 55 degrees C.

Fan motors shall be factory installed having resiliently mounted sleeve bearings and built in overload protection.

The operating specification shall be as follows:

Cooling capacity	:	6000 K. Cal/hr
EER	:	8.0
Current	:	10.4 Amps
Air Flow	:	1050 cu m/hr
Moisture Removal	:	3.7 litre/hr

The Contractor shall provide hard wood subframes for each opening of the unit and finished with miranti architraves and G.R.C. enclosure of approved pattern.

13.2.3 Split Air Conditioning Units

Split system AC units shall be provided complete with housekeeping pads for outdoor units, vibration isolators, mounting brackets and bolts, supports for indoor units, refrigeration and condensate drain piping and controls. The units shall be mounted and secured to the building structure. Industrial units shall be provided in working areas and office type units in the office areas.

13.2.3.1 Cabinet

Cabinets shall be constructed of heavy gauge hot dipped galvanized steel. Indoor coil section of the cabinet shall be lined with fibreglass insulation. Indoor coil drain pan shall be constructed of heavy gauge galvanized steel with a galvanized or PVC pipe drain and from drainage outlet furnished in the outdoor coil section of the base.

13.2.3.2 Refrigeration System

Complete factory sealed refrigeration system shall be provided, consisting of compressor, outdoor coil and fan, indoor coil and blower, hi-capacity drier, suction and discharge line service gauge ports, high pressure switch (manual reset), low pressure switch (automatic reset), suction line accumulator, check valve, solid-state defrost control, with by-pass controls for low temperature areas, low temperature control, refrigerant lines connections and a full operating charge of refrigerant.

13.2.3.3 Compressor and Control Compartment

Compressor shall be hermetically sealed, suction cooled, overload protected and equipped with internal pressure relief valve and shall be internally protected from excessive current and temperature. Crankcase heater shall be furnished as standard equipment. Running gear shall be spring mounted within the sealed can and the compressor shall be installed on resilient rubber mounts in the unit.

13.2.3.4 Indoor and Outdoor Coils

Indoor and outdoor coils shall be constructed of aluminium fins machine fitted to copper tubes and tested under pressure to insure leakproof construction.

13.2.3.5 Indoor Blower

Each blower shall be statically and dynamically balanced, internally vibration isolated with neoprene mounts.

13.2.3.6 Cleanable Air Filter

25mm frame filters with washable or vacuum cleanable polyurethane shall be provided. Contractor shall provide one set of spare filters for each indoor unit.

13.2.3.7 Flow Control Valve

Factory installed check valve by passing tubing to permit full refrigerant flow during cooling cycle shall be provided.

13.2.3.8 Test

Units shall be tested and rated according to ARI Standard 240 conditions and Certified under the ARI Certification program. In addition, units shall be sound tested to ARI Standard 270 conditions. Units shall carry the ARI certification seal. Units and components within shall be bounded for grounding to meet safety standards for servicing required by UL and NEC.

13.2.3.9 Vibration Isolation

Outdoor units shall have spring and neoprene vibration isolators, secured by a cadmium bolt isolator to roof and units with 6 mm deflection under load, unless internally isolated. In this case provide neoprene pads of 10 mm thickness between the unit and mounting platform or housekeeping pads.

13.2.3.10 Electrical Work

Electrical work shall be carried out in accordance with Section 12.

13.2.3.11 Overhead Suspended Equipment

Where equipment is indicated or specified to be hung from ceiling or roof construction, the Contractor shall provide all necessary hanger rods in the size and quantity required by the equipment, and all necessary supplemental structural steel sections, securely fastened to the building construction.

13.2.3.12 Wall Mounted Equipment and Duct Supports

Where equipment or duct supports are indicated or specified to be wall-mounted, the Contractor shall provide all necessary brackets, constructed of structural steel shapes and securely anchored into the building construction. Structural steel construction shall conform to Section 6.

13.2.3.13 Refrigeration and Condensate Drain Piping

Provide refrigeration copper tubing for interconnecting piping between indoor and outdoor units. The sizes of refrigerant liquid and suction lines shall be as recommended by AC unit manufacturer having connection sizes matching the unit connections. Refrigeration tubing shall have continuous thermal insulation closed-cell type of minimum thickness 15 mm designed for temperature-range-20 degrees C to 100 degrees C. Condensate drain piping shall be PVC draining each indoor unit cooling coil.

13.2.3.14 Controls

Each AC unit shall be controlled by a single stage, cooling only, room thermostat. The thermostat shall be line voltage 240V single phase, 50 Hz, of range 15 degrees C to 55 degrees C, differential 2 degrees C fixed having electrical rating matching that of AC unit requirements for controls.

13.3 LIFTING EQUIPMENT

13.3.1 General

A. This Section specifies the requirements for the design, manufacture, construction, installation, testing and commissioning of hoists, monorails, bridge cranes trolley assemblies and davits.

B. Lifting equipment shall be provided as required for maintenance purposes in the Workshop. The design shall ensure safe access is provided for the operation of the lifting equipment. Davits will be used to lift submersible pump sets and other equipment from wells. Lifting equipment shall be supplied with all the necessary hooks, spacers, clamps, harnesses, slings, D links and eye bolts to lift any of the installed plant.

C. Hoist monorails, bridge cranes, davits and ‘A’ frames shall include all equipment, appurtenances and auxiliaries to make the lifting equipment fully operational and capable of performing under the specified load conditions.

D. Lifting systems, including hoists, as far as feasible, shall use the standard components of one manufacturer to simplify maintenance.

E. Nameplates shall be permanently attached to the monorail hoist and bridge crane hoist assemblies. The lifting capacity shall be stencilled in tonnes on each side and shall be clearly legible from the working level.

F. Warning signs shall be provided to the approval of the Engineer and affixed to the bottom lift blocks or pendant controllers.

13.3.2 Design Conditions and Construction

A. The Contractor shall submit complete structural calculations for cranes, monorails and davits, as required by BS 2537 and BS 2853.

B. The Contractor shall submit shop drawings with layout drawings that clearly show the lifting height of the equipment and clearances in relation to other equipment and structures.

C. Cranes and lifting equipment shall be suitable for indoor or outdoor installation, as shown and designated. The high ambient temperature in which lifting equipment and particularly cranes may be required to operate shall be taken into consideration, particularly with respect to the electrical load ratings of motors, switchgear, resistors, cables and wiring, as well as mechanical heat sources such as brakes, bearings and gearing. Due allowance shall be made for possibly higher temperatures than the maximum recorded shade temperature near the roofs of buildings, if the lifting equipment is mounted in a building, or for the effect of direct sunlight if mounted externally.

D. Design of travelling monorail hoist and bridge crane hoists and incidental accessories shall be based upon the use of a factor of safety of 5, structural beams shall have a factor of safety of 2 with capacity load on all mechanical parts of the system. The factors of safety shall be based upon the ultimate strength of the material used. The equipment shall be of ratings and sizes designated in the Particular Specifications.

E. Lifting equipment shall be rated for the load of the heaviest installed item of plant, and designed such that one man can operate it without difficulty.

D. Hooks and load chains shall reach to the floor of the lowest level.

E. Lifting equipment installations shall comply with BS 5744 and BS 7121.

13.3.3 Davits

A. Davits and sockets shall be fabricated from fully welded mild steel, to BS 7668, BS 7613, BS EN 10155, BS EN 10013, galvanised and protected in accordance with BS 729.

B. Davits too heavy to manhandle shall consist of a davit arm, with removable pillar, and rotating removable jib arm.

C. Davits shall have a roller thrust bearing swivel for the upright pillar, with a locking mechanism.

D. Sockets shall be cast-in, unless bolted sockets are specified, or it is not possible to fix cast-in sockets. A rubber socket plug with a stainless steel chain shall be provided to prevent ingress of undesirable materials when the davit is not in use.

13.3.4 Monorail Travelling Hoists

A. Each hoist shall comprise a manually operated geared travelling pulley block complete with steel runway beams, “A” frame supports where specified and all accessories including slings and spreaders.

B. Pulley blocks may be manually operated up to a height of 6 to 8 m. Above 8 m electric hoists shall be provided. Stops shall be provided on all monorails and rails

C. The runway beams shall be designed, tested and certified in accordance with BS 2853.

D. The blocks shall run on the lower flange of the runway beam and shall be of the spur geared close haul type.

E. The blocks shall be complete with a geared travelling trolley and shall be capable of being easily removed from the trolley without the necessity for dismantling. The operating chain for the longitudinal motion of the trolley shall extend to within 600 mm of the floor.

F. Load chain collection boxes shall be provided.

G. Monorail systems shall not be used for loads exceeding 2000 kg.

13.3.5 Cranes

A. Cranes shall comprise end carriages and bridge units to be bolted together on site, during erection.

B. Cranes shall be single girder or double girder as designated.

C. All exposed moving parts of the drive mechanisms shall be fitted with safety guards wherever possible.

D. The bridge girders, end carriages and crab structures of the crane shall be designed and constructed in accordance with all the relevant requirements of BS 466 and BS 2573. With the crane operating under maximum service load, the stress in any operating component shall not exceed the permissible values stipulated in Part 1 of BS 2573. The crane manufacturer shall supply all the information required in Appendix B of BS 466.

E. The main bridge girders shall be plate or box girder designed as compound beams with the rails for the crab track secured on the top flange.

F. End Carriage

1. both end carriages of electrically operated cranes shall be powered either by a duplicate geared motor drive, or by a single motor unit and a lay-shaft system. Longitudinal and cross traverse motions shall be provided on the crane such that the operation is speedy without impairing safety in working. The hook and load chain shall be such that the hook will reach to the lowest floor level.

2. The runner wheels shall be of cast steel, with double flanges, mounted on roller bearings, or fitted with phosphor-bronze bushes running on hardened steel axles.

G. Crab Unit(s)

1. the crab frame shall be in accordance with BS 466 and shall provide a strong rigid framework for the hoist and cross-travel machinery mounted thereon. The placement and layout of mechanical and electrical items shall facilitate easy inspection, service and maintenance of the motors, reduction gearing and braking system
2. the runner wheels shall be of cast steel with double flanges and mounted on roller bearings. Gearing shall be of totally enclosed type with machine cut gears. Bearings shall be ball or roller.

H. Endstops of resilient or spring type buffers shall be provided on all runway/cross beams and crane rails. Where carriages are equipped with electric travel the end stops shall be provided with limit switches at the end of each direction of travel.

I. Crane rails shall comply with BS 449 and BS EN 10155. The line of the rails shall not vary by more than 3 mm, horizontally and vertically, throughout the whole length of travel. Whenever possible, rails shall be one piece. Where rails are to be jointed this shall be by electrical induction welding.

J. Access Platforms and Ladders

1. safe means of access shall be provided for examination and maintenance of the crane or other equipment only accessible from the crane. Guards shall be fitted where possible under the crab and long travel motor and gearbox assembly to prevent persons on the ground being endangered by falling objects during maintenance.

2. all ladders, platforms and access ways shall comply with Section 8. Open mesh flooring shall not be used. Access ways shall be not less than 800mm wide. The platforms and access ways shall be securely fenced with double tiered guard rails and steel ‘toe boards’ or ‘kicking plates’.

K. Jacking points and tie downs shall be provided for both bridge and crab.

13.3.6 Manually Operated Chain Blocks

A. The hoisting wheel shall be grooved and pocketed to receive the load chain. The load chain shall be stainless steel chain Grade 80 to BS 3114.

B. Hand chains shall be to Grade 30 BS 6405 or better.

C. Chain guides shall be provided to ensure effective guidance of the load chain into the load chain wheel pockets. A stripper shall be provided to ensure effective disengagement of the load chain from the load chain wheel.

D. The idler wheel scores shall be so shaped as to avoid twisting the chain as it passes round. The pitch diameter of the idler wheels shall not be less than 16 times the size of the chain, unless they are so shaped as to avoid a

bending action on the link.

E. The load chain anchorage, associated fittings and framework at the slack end shall be rated at 2.5 times the maximum tension in the load chain when the working load limit is being lifted. Any link used for connecting the load chain to a terminal fitting shall be of the material specified for the chain and heat treated to provide mechanical properties and strength equivalent to those of the load chain.

F. The hook shall be made from high grade forged stainless steel complying with BS 2903 'C' type and provided with a safety catch. The hook shall be supported on a ball thrust bearing to allow free swivelling under full loads.

G. The sheaves of the hook block shall be guarded to prevent a hand or fingers being trapped.

H. The crab hoisting gear shall be such that one man is capable of easily raising the maximum load.

I. A galvanised mild steel chain collecting box shall be incorporated.

J. A reliable and effective braking and locking arrangement shall be provided.

K. Lifting blocks supplied for lifting equipment shall be of stainless steel and shall include the facility for obtaining a fresh lift on the equipment lifting chains at 1 m intervals.

13.3.7 Electrically Operated Rope Lifting Hoist

A. All hoists above a height of 8 m shall be electrically operated.

B. The hoist rope drum shall be of high quality cast iron with left and right hand spiral grooves to accommodate the hoist rope in one layer. As far as possible, the drive gearing shall be fixed directly to the rope drum to obviate high torsional stress in the drum shaft. The rope shall be securely clamped to the drum.

C. The hoist drum shall incorporate a wire rope rewind system and guides to prevent the hoist rope skipping and damaging the lay.

D. The hoist braking system shall be of the automatic electro-mechanical fail safe type which, when the current is cut off or fails will automatically arrest the motion and hold at rest any load up to and including the rated load. The system shall safely control the lowering of the same load form the highest to the lowest point of lift and shall not allow any slippage of the suspended load to occur when the 'Raise' motion is initiated.

E. The hoist rope shall be a flexible wire rope specially designed for usage with cranes and in accordance with BS 302, with a safety factor of not less than six times the maximum tension induced by the safe working load.

F. The crane hook shall be of high grade forged steel trapezoidal section in accordance with BS 2903, 'C' type. The hook shall be supported on a ball thrust bearing to allow free swivelling under full loads and shall also be fitted

with a safety catch. The safe working load shall be marked in the hook in accordance with BS 2903.

G. The sheaves of the hook block shall be guarded to prevent a hand or fingers from being trapped between the sheaves and the in-running rope.

H. A limit switch shall be fitted to prevent over hoisting. This shall be self-resetting, closing automatically when the hoist motor is put in reverse.

I. Brakes shall be well protected from oil and grease leakage or spillage, and from adverse effects of atmospheric condensation or dust. A simple and easily accessible means of carrying out adjustment for wear of the shoes or linings shall be provided for all brakes.

J. Automatic brakes, operating when the drive motor stops shall be supplied for the long and cross travel motions.

13.3.8 Materials

Steel used for the fabrication of the lifting equipment shall comply with BS 449, BS 7613, BS 7668, BS EN 10113, BS EN 10155 and BS EN 10210 as applicable. Welding procedures shall comply with BS EN 287 and BS EN 288

13.3.9 Electrical Components

A. Motors

Motors shall be rated for 150 starts per hour (Duty type S7) for not less than one hour with a shaft output power at least 15% greater than the maximum power which will be required for operation and testing of the crane in the ambient temperature specified, at the maximum rated load.

B. Control Gear

1. A triple pole isolating switch with HRC fuses shall be provided at ground level for each lifting assembly. This switch shall be lockable in the 'OFF' position only and shall be provided with a Yale type lock and three keys. The switch shall have a label marked 'CRANE ISOLATING SWITCH'
2. Starters and controllers for the crane motors shall be designed and constructed in accordance with the requirements of BS 466, BS 4941, BS EN 60947. All control circuits shall operate at 110 volts
3. Mechanically and electrically interlocked reversing contactors shall be provided for each motion including speed control of the hoist. Accelerating contactors shall cut out the rotor circuit resistance of the motor in steps with suitable delays. Contacts shall be adjustable and renewable
4. controller and resistors shall be rated such that temperatures do not exceed the limits specified in BS 4941 during operation of the crane under maximum temperature conditions. Starting resistors shall have not less than a 'ten minute' rating. Speed control resistors shall be one hour rated
5. Control gear and cabling shall be suitable for 'inching' i.e. many repeated small movements at both creep and normal speed, in any direction of motion
6. Starters and controllers shall be housed in well constructed sheet steel

panel cabinets of not less than 2mm thick, sprayed and painted with an anti-condensation paint. The enclosures shall be protected against dust and damp to classifications IP 54. Starting resistors shall be mounted in a ventilated section of each control cubicle. The resistors shall all be fitted with terminal bars. The control cubicles shall be provided with lockable hinged access doors, also interlocked with the main isolating switch.

C. Controls

1. Long-travel, cross-travel and slow and normal speed hoist motions of each crane shall all be controlled from the lowest level by a pendant push button station. The controls shall operate on a low voltage system supplied by a double wound isolating transformer. Both primary and secondary sides of the transformer shall have HRC fuse protection. One pole of the secondary winding shall be effectively earthed
2. Push button controls shall be of the pendant type with 'hold-on' type push buttons automatically returning to the 'off' state on release of the button. Push buttons shall be provided for 'SLOW UP', SLOW DOWN' 'NORMAL UP', 'NORMAL DOWN', 'LEFT', 'RIGHT', 'FORWARD' AND 'REVERSE'. A larger size red 'Emergency Stop' button shall initiate tripping of the control gear main circuit breaker and automatic application of the brakes on all motions. Reclosure of the main circuit breaker shall be initiated by a separate 'Reset' button also on the pendant. The pendant shall be oil tight polyethylene, totally enclosed to IP65, shockproof, and shall be suspended from the crab unit. The voltage at the pendant shall not exceed 55 volts to earth
3. Limit switches shall be provided for all motors at the end of each direction of travel
4. Infrared or radio remote control shall be provided, where specified, or if necessary for safe operation of the crane. Two battery packs with battery charger, sensors, sensor connecting cables with clips, receiver and decoder shall be provided. Adequate sensors shall be provided at each level (minimum three) to ensure continuous control in all zones of operation. If radio control is used then approval shall be obtained by the Contractor for the frequencies used.

D. Cables wiring and earthing

1. An insulated conductor system shall be provided for electrically powered cranes supply. The insulated conducted system shall be of the type where each phase is individually insulated and supported on a metal support. The type where all conductors are contained within a single extruded or moulded insulation will not be permitted. A 'festoon' insulated cable system shall be provided for the cross-travel supply.
2. Wiring and earthing of the cranes shall conform to BS 466. Cables and wiring shall be of 600/1,000 volt grade PVC insulated cables in accordance with BS 6231 and BS 6346. Wherever possible, the cables shall be run in screwed heavy gauge galvanised steel conduit. All cable ends shall be clearly labelled with identification of the appropriate terminals.
3. The selection installation and testing of cables and wiring shall be in accordance with BS 7671 except that maximum current ratings shall be raised by a factor of 1.4 times the rating for continuous duty obtained (after applying all necessary de-rating factors for high ambient temperature, grouping and disposition form of installation, etc). The up-

rating factor of 1.4 is based on the one hour motors specified for crane operation

4. The crane structure, tracks, motor frames and metal cases of all electrical equipment, including metal conduit and cable guards, shall be earthed in accordance with BS7671.

13.3.10 Factory Inspection and Testing

A. The Contractor shall secure from the lifting equipment manufacturer certification that the following inspections and tests have been conducted on each crane or hoist system at the factory, and submit to the Engineer prior to shipment.

B. Cranes shall be inspected and tested in accordance with the requirements of BS 466 with the difference that the "Tests on Purchaser's Premises" (Clause 54) shall also be carried out in the manufacturer's works and witnessed by the Engineer.

C. The works tests shall include overload tests during which a 25 percent overload shall be lifted by the hoist at the middle of the crane span and sustained under full control whilst it is moved up and down at both normal and creep hoist speeds. Whilst still under overload the crab unit of each crane shall be operated from end to end of its travel and in both directions.

D. The mechanism and controls for the long travel motions shall be tested under light running conditions without moving the crane.

E. Tests on manually operated cranes and hoists shall comply with the above insofar as they are applicable.

13.3.11 Installation

Lifting equipment shall be installed in accordance with the requirements and instructions of the manufacturer. If specified in the Particular Specification, the lifting equipment manufacturer shall provide a representative to supervise the installation and testing.

13.3.12 Field Testing

After erection cranes and hoists shall be inspected, tested and certification provided by a qualified independent crane testing specialist in accordance with the requirements of Clause 54 of BS 466 and the tests witnessed by the Engineer. Hand cranes shall be similarly tested.

13.3.13 Spare Parts, Lubricants and Tools

Two years supply of spare parts and lubricants shall be supplied for each lifting device supplied. All special tools required for normal service and maintenance shall be provided.

13.4 NOT USED

13.5 VENTILATION SYSTEMS

13.5.1 Roof Mounted Exhaust Fans

The fans shall be of high quality glass fibre and shall be totally enclosed type with ball bearing motors manufactured to BS 5000 part 11 and with Class F insulation. The fan bearings shall be sealed during motor assembly. The fan impellers shall be of glass fibre reinforced polypropylene blades and aluminium hub. It shall have curb base. The air movement shall be 2.54 cu m/sec with shutters. The fan motor shall be of 220/250 V AC single phase and 50 Hz. The fan shall be designed to operate within the temperature range from 10°C to 55°C. The starter for fan motor shall be incorporated with thermal overload protection.

13.5.2 Wall Mounted Exhaust Fans

Exhaust fans shall be single phase 240 V AC suitable for continuous operation. Fan shall be wall mounted and shall have anti-vibration mounting frame. Fan blades and motor casing, guards and frame shall be painted with anti-corrosive paint. Motor bearing and seals shall be of the silent operation type and shall be sealed for life requiring little or no maintenance.

13.6 FIRE DETECTION AND ALARM SYSTEM

13.6.1 General

Fire alarm systems shall be installed with all conduits, wires and accessories as a zoned electrically supervised system. It shall be used for early detection and warning in case of fire.

The system shall consist of the necessary number of heat or smoke detectors for automatic alarm initiating. Also manual break glass push units will be provided at suitable locations.

The fire alarm control panel shall be installed at control room, whereas fire alarm repeater panel shall be at guard duty room. The fire alarm control and repeater panels shall give audible and visible alarm indicating the area from where the alarm is initiated. The fire alarm sounder siren may be silenced by pressing the silence button on the fire alarm control panel.

Contractor shall supply layout plan of fire alarm and detection system, showing location of detectors with fire and alarm zones.

13.6.2 Manual Fire Alarm Stations

Manual break glass station shall be die-cast, painted bright red with white or black lettering in English and shall be designed for surface semi-flush.

The manual station shall be operated by pulling down on the lever. When operated, the lever shall remain down with the alarm contacts closed until the station is reset.

An additional set of contacts shall provide a means of annunciation. The manual station shall be reset by opening the front. The station shall close only after the switch is reset. The manual station shall be tested by opening the station and operating on toggle switch. A glass rod in the station front will indicate which station has been operated and the glass rod must be replaced when the station is reset.

13.6.3 Fire Alarm Sounder

Fire alarm sounder shall have a minimum noise level of 100 dB(A) at a distance of 3 m and shall be different in sound from other hors and bells installed in the are for other purposes.

13.6.4 Automatic Fire Detectors

Automatic Detectors shall be of the fixed temperature, infrared rate-of-rise, or ionization type. The detector circuit shall be fully supervised to indicate the alarm or trouble signal upon malfunction. The detector assembly shall be for surface ceiling mounting, attached to a standard 100 mm outlet box.

Detectors shall in general be connected in groups to the central fire alarm panel. The number of detectors installed on any one line shall be limited as recommended by the manufacturer.

The ionization detector shall function on the ionization chamber principle. The detector head shall have no moving parts. It shall be possible to check or adjust the sensitivity of each individual head to satisfy the local conditions.

13.6.5 Fire Alarm Control Panel

Fire alarm control panel shall receive alarms and activate equipment in control room.

13.6.6 Cabling

Cables shall be provided according to IEC recommendations.

13.6.7 Audible Signal Module

Provide audible signal devices per circuit. The wiring for the audible signals up to and including the individual circuit shall be supervised both against an open circuit and a short circuit fault conditions. Either fault condition shall immediately cause all trouble signals to sound without causing the signal breaker to open while the panel is in the normal supervisory state.

An individual zone amber trouble LED shall be provided for each signal circuit to indicate the location of any faults in the wiring to the audible signals or signal circuit breaker open condition.

13.6.8 Master Power Supply Module

Provision of 24 V DC power for all system supervisory and control functions is required. A red "power-on" indication on the panel for each separate source of AC input power shall be present.

13.6.9 Trouble Indication

A yellow trouble LED and distinctive audible signal shall operate when any of the specified supervised trouble conditions exist. The audible portion of the trouble signal shall be silenced with a "trouble-silence" push button.

The trouble signal and indication shall automatically reset to normal when a trouble condition is corrected. To eliminate any confusion, all visual and audible trouble signals shall remain off during the progress of a true alarm. Terminals shall be provided for connection of remote, trouble lamps and audible signals.

13.6.10 Ground Detection

A ground fault on any external conductor which would adversely affect the system operation shall sound a trouble signal and illuminate a yellow "ground fault" indication on the panel.

13.6.11 Stand-by Power Supply

Battery charger module shall be an integral part of the alarm panel and shall provide a constant trickle charge to maintain the emergency power supply at peak reserve power.

Stand-by nickel cadmium battery shall be mounted in the cabinet. Batteries shall have sufficient ampere hour capacity to operate the system under normal supervisory conditions with the AC power disconnected for 24 hours and reserve power for sounding the alarm bells at the end of this period for at least 5 minutes.

END OF SECTION 13

SECTION 14

LABORATORY EQUIPMENT AND FITTINGS

14.1 GENERAL

14.1.1 Requirements

The work included in this Section comprises design, supply, installation, inspection, testing at site and commissioning of the laboratory including all specified equipment, instruments, glassware, chemicals, books, furniture and fittings, services and spares, all to an approved programme, supply, installation, inspection, testing at site and commissioning of the laboratory including all equipment, instruments, glassware, chemicals, books, furniture and fittings, services and spares.

14.1.2 Work to be Performed

A fully furnished laboratory is to be provided with the capacity to undertake the chemical and physical examination and testing of water in order that the performance of the water system can be adequately monitored.

The design shall be in accordance with best modern practice and shall facilitate inspection, cleaning, routine maintenance, and repair to ensure satisfactory operation under all service conditions. The laboratory or any part may be a standard design provided that this is generally in accordance with the Specification.

Whenever provisional ratings and quantities are stated in the Contract Documents, the figures quoted are for guidance only. The Contractor shall be responsible for establishing the correct final ratings and quantities to meet the requirements of the Specification.

The Contractor shall employ a specialist in laboratory design in the planning and design of layouts for the laboratory. The Contractor shall submit detailed drawings of the laboratory design and layout for the Employer's approval prior to placement of orders for furniture, fittings or equipment. The drawings shall coordinate all equipment and fittings and shall include details of benches, furniture, air handling (including extraction), electrical wiring and sockets, lighting, plumbing, drainage and all other laboratory services.

The Contractor shall ensure that the laboratory is safe in use, and that the duties of those who design, manufacture, import, or supply any part of the equipment and fittings in connection therewith are fulfilled in respect of any safety regulations imposed by law or by any authorised body empowered to make such regulations.

The Laboratory shall be fully equipped to undertake chemical analysis and laboratory testing of water with particular reference to the tests listed below and the analytical methods given in “Standard Methods for the Examination of Water and Wastewater” latest edition published by APHA, AWWA, WEF or the UK Standing Committee of Analysts, “Methods for the Examination of Waters and

Associated Materials", HMSO, London. The Contractor shall also allow for such other test as will be required for his proposed plant and processes, etc.

The laboratory equipment and instruments shall be supplied only by a specialised company and the Contractor shall provide details of the experience of the specialised company. All equipment and instruments shall be fully installed by the Contractor under the supervision of the supplier or his authorised agent and shall be demonstrated as being in proper operating condition to the satisfaction of the Engineer and SDO's Chemist.

Any equipment requiring power shall be 240 V AC.

The laboratory equipment and instruments to be provided are as follows:

Item	Description	Unit	Qty
1	Oven: Bench type with thermostatic control 40-200 deg C	Nr	1
2	Vacuum Pump: Up to 1 bar vacuum complete with direct connected motor, gauges, regulators, filters, switches and hose connections	Nr	2
3	Filtration Apparatus: Filtration funnel with 0.45 micron filters	Nr	2
4	Dessicator, vacuum with 140 mm plate	Nr	1
5	Meter, pH: General purpose for measurements in pH and mv in the standard and expanded modes with digital display, electrode holder and rod, range: pH 0-14, mV +/- 1999, min. accuracy: +/- 0.02, mV +/- 1.	Nr	1
6	Electrode, reference for pH meter	Nr	1
7	Electrode pH, for pH meter, range 0-14	Nr	1
8	Fluoride electrode	Nr	1
9	Chlorine Residual Electrode	Nr	1
10	Conductivity Bridge: Direct reading in ohms or mhos with range of 2 to 2,500,000 ohms	Nr	1
11	Conductivity Cell: Dipping type, Pyrex with K = 1.0	Nr	1
12	Spectrophotometer: Range at least 365 to 880 nm; bandwidth not more than 4 nm; concentric spectrometer optical system with wavelength accuracy ± 1 nm; photometric range ± 0.001 to 3.2 Abs; photometric accuracy ± 0.005 Abs from 0.0 to 0.5 Abs; ± 1% from 0.5 to 2.0 Abs; selectable momentary and constant on operational modes; readout modes: transmittance, absorbance, concentration, pH, mV, and temperature, plus optional wavelength scan and time course graphs; RS-232 output and parallel printer output, 10 to 40 ºC, 85% relative humidity and non-condensing operating environment; -2.00 to 19.99 pH range; selectable 0.001, 0.01, 0.1 pH resolution; -2000 to 2000 mV range; meter accuracy ± 1 mV or ± 0.05% of mV reading, whichever is greater; temperature probe range -10 to 110 ºC; temperature probe accuracy ± 1.0 ºC; and battery backup.	Nr	1
13	Hot Plate Stirrer: Magnetic, white ceramic top, stirring range 250-1000 rpm, adjustable in 5 degree increments up to 540 degrees C, hot surface alert safety warning light when plate is over 50 degrees C.	Nr	2

Item	Description	Unit	Qty
14	Analytical Balance: Macro-student type with 0 - 160 g capacity, digital readout to 0.1 mg and pre-weighing over full 160 g range	Nr	1
15	Turbidity Meter: Standard Laboratory Model; direct reading over range; accuracy of turbidity ± 2% of reading ± NTU from 0 to 1000 NTU, ± 5% of reading from 1000 to 40000 NTU, and ± 10% of reading from 4000 to 10,000 NTU;LED display; RS 232 interface.	Nr	1
16	Fume Hood 1200(W) x 750(D) x 450(H) mm with exhaust fan and ducting	Nr	1
17	Safety Shower Station: Drench shower overhead rose, fixed to wall, with pull rod operation.	Nr	1
18	Eye Wash Station: Wall mounted, pedal operated, including mirror and shelf, with standard eye wash bottle and eye dropper mounted on support, and two refill eye wash bottles each 500 ml with sterile solution.	Nr	1
19	Refrigerator: Laboratory quality, with adjustable temperature control and minimum capacity of 0.5 cu m	Nr	2
20	Filtration, reverse osmosis unit	Nr	1
21	Safety vented goggles: polycarbonate fog-free lens with lens with superior impact protection, wide field of vision, full-face flange for comfortable wear.	Nr	4
22	Beakers: Borocilicate glass, low form, with graduation and spout, and conform to ISO 3819:		
22.1	Capacity 1000 ml	Nr	2
22.2	Capacity 500 ml	Nr	4
22.3	Capacity 100 ml	Nr	4
23	Graduated Cylinder: Measuring, glass with spout and glass foot, with amber colour graduation, Class A		
23.1	1000 ml, subdivision 10.0	Nr	2
23.2	500 ml, subdivision 5.0	Nr	4
23.3	100 ml, subdivision 1.0	Nr	4
24	1,000 ml vacuum flask	Nr	2
25	Pipettes: Graduated, borosilicate glass, calibrated for delivery from zero:		
25.1	Capacity 10 ml	Nr	4
25.2	Capacity 5 ml	Nr	4
25.3	Capacity 2 ml	Nr	4
25.4	Capacity 1 ml	Nr	4
26	Pipettes Rinser: Polyethylene, up to 460 mm long with automatic fill/drain repeat siphoning cycle	Nr	1
27	Pipette stand: Hardwood, for holding up to 10 minimum horizontally	Nr	2
28	Burettes: Class A with glass stopcock and burette holder, capacity 50 ml	Nr	5
29	Crucibles (assorted sizes)	Nr	10
30	Supply reagents for 12 month's use for chemical and physical tests *	Item	

* Assume the following numbers of analyses/ year:	
Total Dissolved Solids, mg/L	204
Calcium Hardness as $CaCO_3$	204
Magnesium Hardness as $CaCO_3$	204
Total Hardness as $CaCO_3$	204
Total Alkalinity as $CaCO_3$	204
Carbonate as $CaCO_3$	204
Bicarbonate as HCO_3	204
Calcium (Ca), mg/L	204
Magnesium (Mg), mg/L	204
Sodium (Na), mg/L	204
Potassium (K), mg/L	204
Sulphate (SO_4), mg/L	204
Chloride (Cl), mg/L	204
Nitrate (NO_3), mg/L	204
Electrical Conductivity (mS/cm)	204
PH	204
Chlorine Residual, mg/L	204
Fluoride, mg/L	204

14.1.3 Safety Requirements

The Contractor shall ensure that the laboratory is safe in use, and that the duties of those who design, manufacture, import, or supply any part of the equipment and fittings in connection therewith are fulfilled in respect of any safety regulations imposed by law or by any authorised body empowered to make such regulations.

Safety instructions relevant to the operation of the Plant shall be included in the Instruction Manual, and on any permanent labels fixed to the Plant.

Leakage and pressure tests shall be carried out on all pipework that is to be built in. These tests shall be carried out after erection. The Contractor shall ensure that the pipework is suitably anchored and supported to sustain the test pressure. The Contractor shall inform the Engineer when these tests are to be carried out and all tests shall be witnessed and subject to the Engineer's approval.

Workmanship and the general finish shall be of first-class commercial quality, in accordance with the best instrument technology practice. Labels in compliance with BS5378 and BS5499 shall be provided to warn of dangerous or potentially dangerous circumstances or substances. Inscriptions or graphic symbols on warning labels shall be black on a yellow background as detailed in BS5378. Instruction labels shall be provided where safety procedures are essential to protect operating and maintenance personnel from hazardous or potentially hazardous conditions, for example, requiring the wearing of protective clothing. These obligation signs shall have inscriptions or graphic symbols in white on a blue background as detailed in BS5378.

14.1.4 Submittals

The following manufacturer's data shall be provided:

1. Published data, or manufacturer's letter, clearly indicating that each product to be furnished complies with these Specifications and is recommended for the application shown.

2. Complete instructions for handling, storage, installation and protection of each product.

3. Operation manuals and service manuals for every item.

14.2 PRODUCTS

14.2.1 General

The products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, may be acceptable subject to the Engineer's approval.

Each area in the laboratory shall have sufficient enclosed storage space for all materials and glassware in frequent or regular use. Storage space shall be provided in the laboratory store for appropriate stocks of materials and spare parts. Secure storage shall be provided for inflammable or otherwise hazardous materials.

Laboratory equipment listed shall generally consist of standard products. Catalogues or commercial pamphlets describing each major item shall be provided by the Contractor together with details of laboratory furnishings and services.

Materials used in the construction of laboratory furnishings and fittings shall be the best of their respective kinds and shall be selected for their specific applications. Methods of construction shall be of proven design.

The laboratory floor shall be able to withstand heavy traffic as well as stationary loads. The surface shall be non-slip, seamless, resistant to chemical attack and easy to clean.

Air handling shall be provided throughout the laboratory area with allowance being made for fume extraction within the laboratory.

The laboratory shall have natural light with a minimum average intensity of 500 lumen/sq m at working level for artificial light throughout the laboratory. Direct sunlight shall be avoided for all benches.

Sectional units shall be designed and constructed to develop maximum strength and rigidity. Each sectional unit shall be completely fabricated ready for placement in the laboratory assembly and shall be a complete integral rigid unit in itself to permit relocation at any subsequent time. Under-bench components located on the laboratory floor shall be equipped with levelling devices, easily adjustable from within the units, to compensate for any unevenness in the

laboratory floor. Above-bench units shall include draining and equipment racking and shelving of various kinds. Shelving shall be of a width appropriate for its purpose and shall be restricted so that only single line capacity is available when used for carrying chemical reagent bottles, glassware or items needing careful handling, in the main laboratory rooms.

Sectional units shall be constructed of timber with timber under-framing. Both sides of the sectional units shall be surface impregnated with epoxy or equivalent chemical resistant resin.

Materials for the construction of bench tops shall be appropriate for their use. Bench tops for supporting sensitive instruments shall be rigid and have a surface that is hard and stable and easily cleaned. Bench tops for balances shall be made of marble and provided with anti-vibration supports.

Bench tops shall be of epoxy resin (or material of equivalent durability and chemical resistance) to enable easy maintenance of surface cleanliness.

Bench tops intended for applications where protection from heat is necessary shall be of a suitable fire-resistant material of low thermal expansion.

Units shall be supplied complete and ready for installation from an approved laboratory supplier.

Fume cupboards shall be confined working bench spaces equipped with services and provided with an efficient means of removing objectionable fumes. Fume cupboards shall be provided with an efficient extraction system designed to give a face velocity of not less than 0.5m/s. The framing shall be a one-piece interior lining moulded from epoxy or polyester resin reinforced with fibreglass and epoxy-coated steel exterior. The vertical sash shall be tempered safety glass of about 6 mm thick, counter-balanced for fingertip control. Airfoil below the sash shall be epoxy-coated. Epoxy resin work surface with sink unit, remote control service fittings and flow indicator shall be provided. One fume cupboards of about 1800(W) x 800(D) x 1500(H) mm with chemical storage base cabinets for organic solvents, corrosive chemicals, acid and alkaline shall be provided.

One fume hood of approximate dimensions 1200(W) x 750(D) x 450(H) mm with an exhaust fan shall be provided. Ducting for extraction systems shall be of suitable material chosen to give the best resistance to the chemical and physical conditions to which they will be subjected such as polypropylene, rigid PVC or moulded glass fibre laminate. The extraction system shall be designed to draw air through the cupboard at such a rate that with the window fully open the velocity of air entering the cupboard shall not be less than 0.5 m/s.

Service pipework shall be located as far as possible behind the sectional units and shall be readily identifiable for purposes of inspection and repair. Pipes shall be colour coded in accordance with BS 1710 or ISO/R 509.

Work sinks shall be of glazed fireclay or approved alternative inert material, fitted beneath the bench top, this being cut to overhang the sink and throated on the underside to provide a water break. A sampling sink shall be of stainless steel and drain boards constructed of 1.5 mm thick stainless steel as an integral assembly.

Waste systems shall be supplied in "Vulcathene" or similar high density polyethylene. All sinks shall be fitted with suitable anti-siphon bottle traps, with removable bases.

Balance tables shall be floor mounted, anti-vibration, marble topped to provide a firm mounting for the analytical balance. They shall consist of a worktop of at least 80 mm thickness mounted on 2 side members and a centre member through rubber anti-vibration pads. The side and centre members shall be at least 80 mm in thickness and a minimum of 450 mm apart to form a kneehole for the operator. The table top shall be at a height of approximately 750 mm above floor level. The working surface dimensions of the table shall be a minimum of 1500 mm x 600 mm.

14.3 EXECUTION

14.3.1 Conditions of Surfaces

The Contractor shall examine substrata, adjoining construction, and conditions under which the Work is to be installed and the work shall not proceed until unsatisfactory conditions have been corrected.

14.3.2 Installation

All carpentry shall be in accordance with Section 9 as appropriate.

All plumbing shall be in accordance with Section 10.

All mechanical and electrical installations shall be in accordance with the Sections 11, 12 and 13.

14.3.3 Protection

All finished work shall be protected so that it will be without damage at the time of completion of the Works. Damaged or soiled items, surfaces, panels, etc. shall be removed and replaced to the satisfaction of the Engineer.

END OF SECTION 14

SECTION 15

WORKSHOP EQUIPMENT

15.1 GENERAL

15.1.1 Requirements

The Contractor shall provide for the Employer's use the equipment, parts, tools and other materials as specified in this section. The equipment, materials and tools to be procured shall be new and of first quality as approved by the Engineer.

The equipment shall be supplied only by a specialised company and the Contractor shall provide details of the experience of the specialised company. All equipment shall be fully installed by the Contractor under the supervision of the supplier or his authorised agent and shall be demonstrated as being in proper operating condition to the satisfaction of the Engineer.

The procured items shall be tested for performance before acceptance by the Engineer. The Contractor shall also be fully responsible for storage of such items until the completion of the Contract.

15.1.2 Submittals

The following manufacturer's data shall be provided:

1. Published data, or manufacturer's letter, clearly indicating that each product to be furnished complies with these Specifications and is recommended for the application shown.

2. Complete instructions for handling, storage, installation and protection of each product.

3. Operation manuals and service manuals for every item.

15.2 PRODUCTS

15.2.1 General

The products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, may be acceptable subject to the Engineer's approval.

15.2.2 Equipment to be Provided

Any equipment requiring power shall be 240 V AC.

The workshop equipment to be provided is as follows:

Item	Description	Unit	Qty
Metal Working Equipment			
1	Radial Drill: Capable of drilling plates and beams and large equipment, drill sizes up to 50mm diameter, and can be used as a vertical boring machine.	Nr	1
2	Magnetic Drill: Portable type, fixes (by magnet) to work piece in the field for heavy drilling, drill sizes up to 25 mm diameter.	Nr	1
3	Lathe - Long Bed: 4 m long, 600 mm radial swing at the chuck end, 300mm bed swing, capable of machining shafts on pumps, mixers, fans, and the like, and for machining same after metal spraying. Capable of manufacturing journal bearings for slow revolving equipment. Lathe shall be provided with the following attachments: a) Grinding Attachment, which can be used for fine surface finishes on pump and motor shaft repairs. b) Metal Spray Attachment, which can be used to build up worn shafts and other metal items.	Nr	1
4	Lathe - Short (Model Makers): Capable of repair and manufacture of small equipment such as instruments, small pumps and air compressors.	Nr	1
5	Pedestal Grinder - Medium Duty: Capable of welding preparation work on steel, cleaning and rough shaping of metals.	Nr	1
6	Pedestal Grinder - Light Duty: Capable of grinding and sharpening of hand tools and drill pieces.	Nr	1
7	Surface Grinder - Flat: Capable of grinding fine flat surface finish on base plates and equipment bases.	Nr	1
8	Anvil: Capable of preparing and roughly shaping steel items.	Nr	1
9	Surface Plate: Capable of checking the surface flatness and alignment of pumps, frames / base plates and shafts.	Nr	1
Electrical and Instrumentation Equipment			
10	Pedestal Grinder - Light Duty: Capable of finishing small items and sharpening tools.	Nr	1
11	Soldering Tools - Capable of fixing cable lugs and other non-ferrous items.	Nr	1
12	1000V & 2000V Meggar: Capable of breakdown testing of cable and motor windings insulation.	Nr	1
13	AVO Meter: Capable of continuity and circuit testing.	Nr	1
14	Hand Tools for General Electrician, including cable crimps, trepanning set, wire strippers, insulated pliers, centre punch, files, spanners, micrometer, callipers, steel ruler, thickness gauges, etc.	Set	2
Woodworking Equipment			
15	Woodworking Hand Tools including hammer, flat chisel, cross-cut chisel, screw drivers, divider, vice, clamps, etc.	Set	1
Paint Shop Equipment			
16	Equipment for Small Paint Shop: Capable of surface preparation and painting of repaired equipment especially items below water level and areas of high corrosion.	Set	1

Item	Description	Unit	Qty
Miscellaneous Equipment			
17	Air Compressor and Air System Ring-main: For supply ring for hand tools and blow cleaning.	Nr	1
18	Emergency Mobile Generator: Capable of driving small pumps, welding machines and emergency hand lights.	Nr	1
19	Mobile Lifting Equipment: Hand operated, capable of moving smaller items in workshop and in limited space.	Nr	1
Tools and Equipment Stores			
20	Lifting Equipment: Chains, wire strops, belts, shackles and lifting eyes for up to 500kgs.	Set	1
21	Ladder: Extension type up to 7 m, aluminium material.	Nr	2
22	Hand Tools for all machinery provided	Set	1
23	Coil rewinding tools	Set	1
24	Hydraulic pressing machine for fixing and removing bearings and pulleys	Nr	1
25	Power jack hammer, medium capacity	Nr	1
26	Electric pipe cutter for DI pipes up to 800 mm diameter	Nr	1
27	Shovel	Nr	3
28	Fire Extinguisher: Dry type to ROP requirements	Nr	2
29	Safety goggles	Nr	3
30	Safety Boots: Size to suit SDO Water Department	Nr	3
31	Safety Gloves: Size to suit SDO Water Department	Nr	6

15.3 EXECUTION

15.3.1 General

Each instrumentation item shall be checked by the Contractor upon receipt for compliance with purchase specifications, damage, shortage and shortage of components. Items shall be repaired, replaced or the vendor notified of non-conformance as instructed by the Engineer.

15.3.2 Testing and Commissioning

All equipment shall be tested and commissioned by the Contractor prior to final inspection and acceptance by the Engineer.

15.3.3 Protection

All finished work shall be protected so that it will be without damage at the time of completion of the Works. Damaged or soiled equipment shall be removed and replaced to the satisfaction of the Engineer.

END OF SECTION 15