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Council for Development and Reconstruction

THE GREEN AGRI-FOOD TRANSFORMATION FOR ECONOMIC RECOVERY PROJECT (GATE)

COMPLEMENTARY WORKS FOR THE EXPANSION OF THE SEWAGE COLLECTION NETWORK TO CONNECT TO THE ZAHLE WASTEWATER TREATMENT PLANT AND AITANIT WASTEWATER TREATMENT PLANT

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VOLUME 2 – TECHNICAL SPECIFICATIONS

PART 2 – TECHNICAL SPECIFICATIONS RELEVANT TO THE AITANIT WORKS

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Volume 2

Technical Specifications

Division 1

General Specifications

Part 1

General Requirements

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101 GENERAL REQUIREMENTS

101.1 GENERAL REQUIREMENTS AND PARTICULAR SPECIFICATION

These General Requirements shall form an integral part of the General Specifications. In addition to these General Requirements, the Contract contains a Particular Specification, to supplement and/or modify the General Specification as may be necessary in each particular case.

The provisions of the Particular Specification for any specific section or number of sections shall prevail over those of the General Specification. Whenever the term "Specification" without further qualification is used in the Contract Documents, it shall mean this General Specification together with the Particular Specification.

101.2 REQUIREMENTS OF SPECIFICATION

The Contractor shall fulfil all requirements and obligations of all clauses of the Specification applicable to the construction work involved in the Contract. Neither the following clauses of this Specification nor the Bill of Quantities shall limit the obligations of the Contractor under the accompanying Conditions of Contract. Where items are not included in the Bill of Quantities for any such requirements or obligations the cost of such requirements or obligations shall be deemed to be spread over all the items of the Bill of Quantities unless otherwise stated.

101.3 ISO 9000 CERTIFICATION

Imported manufactured products and equipment shall comply with their relevant international standards. The quality assurance of all imported goods shall be granted the ISO 9000 certification.

Locally manufactured products and equipment shall comply with US or Western European Standards. ISO 9000 certification for locally manufactured goods is not essential however these goods shall be subject to the approval of the Engineer.

101.4 DRAWINGS, RECORDS AND DOCUMENTS

101.4.1 Drawings

All works shall be performed in accordance with the drawings furnished with the Contract documents and any such additional drawings as may be issued by the Engineer from time to time during the progress of the work or any drawing furnished by the Contractor and approved by the Engineer. Additional drawings (if any) will be furnished to the Contractor in due time so as to enable him to perform the work shown thereon in its proper sequence and for any

advance planning that may be necessary for the efficient performance of such work. The Engineer will decide in each instance whether additional drawings are required for advance planning of the works and determine the time required for same.

In all cases, detailed shop drawings for all components of the Works shall be prepared by the contractor, after the approval of all related equipment items. The design and the shop drawings shall be submitted to the Engineer who shall within 21 days approve, reject or ask the Contractor to revise or modify such documents and resubmit them for approval. All these documents shall be approved by the Engineer prior to commencement of the work. The structural design will be in accordance to the recommendations based on soil investigations.

101.4.2 Records and "As-built" Drawings

The Contractor shall prepare, and keep up to date a complete set of "as-built" records of the executed Works, showing the exact "as-built" locations, sizes and details of the Works as executed, with cross-references to relevant specifications, schedules of particulars and data sheets. These records shall be stored electronically using computer aided design (CAD) and Geographic Information System (GIS) software which is compatible with the systems used by the Employer. Copies of all records shall be kept at site for the purpose of preparing and updating the "as-built" documents and drawings. The Contractor shall obtain the consent of the Engineer as to the referencing system and other pertinent details of the as-built drawings.

Three hard copies, size A3, and one soft copy shall be submitted to the Engineer for approval within 4 weeks after the completion of sections or the whole of the Works. The Works shall not be considered to be completed for the purposes of taking over (Clause 10 of the General Conditions) until the relevant "as-built drawings have been submitted by the Contractor and approved by the Engineer.

Unless specific items are included in the bill of Quantities, the cost of preparing the shop drawings, "as-built" Drawings and Records shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.4.3 Ownership of Drawings and Documents

The Drawings and documents are issued to the Contractor for the purpose of the execution of the Works under the Contract and shall remain the property of the Employer to whom they are to be returned by the Contractor after completion of the work, as a precondition for the issue of the Certificate of Completion.

101.5 BOREHOLE INFORMATION

The Contractor shall satisfy himself as to the nature of the strata underlying the sites of the works. He may carry out at his own expense borings, tests and investigations as he may consider necessary and utilize the information thus gained for the preparation of his tender.

Any subsoil information and test results provided by the Employer shall be given to the Contractor for his preliminary information only. Such information shall not relieve the Contractor in any way of his obligation to inspect the sites and of his sole responsibility for carrying out the works as specified and required by the Engineer and at the rates set out in the Bill of Quantities. No claims for additional payment and/or extensions of time shall be entertained in respect of data furnished to the Contractor by the Employer or the Engineer.

101.6 METEOROLOGICAL AND HYDROLOGICAL CONDITIONS

The Contractor's attention is directed to the meteorological and hydrological conditions prevailing in the project area and its vicinity. In his planning of the work and in his unit rates, the Contractor shall take these factors into account. No increase in prices and/or extension of time shall be granted due to rains, floods and/or other adverse climatic conditions in the project area and along the roads to it.

For information, the climatic conditions in Lebanon can be summarized as follows:

	Temperature (deg C°)						Relative humidity					
	Coastal zones		Mountanious zones		Bekaa Valley		Coastal zones		Mountanious zones		Bekaa Valley	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Summer	20	35	15	25	10	35	65	85	50	60	40	65
Winter	7	15	-5	10	-1	15	60	75	55	75	55	80

101.7 BILL OF QUANTITIES

101.7.1 Rates and Prices

The rates and prices inserted by the Contractor in the Bill of Quantities are to be the full and inclusive value of the work described. They are to cover all costs, expenses and general risks which may be involved, together with all liabilities and obligations set forth or implied in the Specification and other documents on which the Tender is based. They must include all plant, tools, materials, transport of men and materials, insurance and labour of every description. They must also take into account the conditions referred to in the general Conditions, and include time lost due to weather, payment of guaranteed minimum and holidays with pay. The cost of any travelling time subsistence and incentives such as overtime etc. must be included in the rates and prices. Where any special risks, liabilities and obligations, mentioned above or otherwise, cannot be dealt within the rates, then the price thereof is to be separately stated in items provided for the purpose or added by the Tenderer.

Any item left un-priced shall be held to have had its cost included in the unit rates for other items of work.

101.7.2 Provisional Items and Quantities

Care shall be taken to distinguish between "Provisional items" which represent work they may not be required, and "Provisional Quantities" which represent work that will be required but the quantity of which cannot be closely estimated when preparing the Bill of Quantities and details of which will be given on site.

101.7.3 Methods of Measurement and Payment

The methods of measurement and payment for each trade are normally specified in the General Specification, provided that where a different method of measurement is indicated in the Bill of Quantities or specified in the Particular Specification, the Bill of Quantities and the Particular Specification, in that order, take precedence over the General Specification.

Where no method of measurement is specified in any of the foregoing documents, the work will be measured in accordance with the latest edition of the Standard Method of Measurement of Civil Engineering Quantities, published by the Institution of Civil Engineers of London, U.K.

101.8 UNITS

In this Specification, on the Drawings and in the Bill of Quantities the S.I. (Systeme International d'Unites) metric system of dimensioning has been employed.

Where dimensions are given in metric units for materials which are only available in Imperial dimensions, the Contractor may, subject to his obtaining prior approval of the Engineer, substitute suitable sizes of materials as are available in the Imperial system. Such approval shall not unreasonably be withheld, provided that there is no difficulty in making interface connections with any other parts of the Works.

101.9 STANDARDS

For convenience and in order to establish the necessary standards of quality, reference has been made in the Contract Documents, to specifications issued by International Standards. Such specifications shall be defined and referred to hereinafter as "Standard Specifications" and shall be the latest editions of such Standard Specifications issued prior to the issue of Tender Documents together with such additions and amendments to such editions as may have been issued prior to the same date. Subject to the approval of the Engineer, any other internationally accepted Standard which specifies an equal quality of work may be used.

In reference to Standard Specifications, the following abbreviations have been employed:

B.S.	British Standard
A.S.T.M.	American Society for Testing Materials
D.I.N.	Deutsche Industrie Normen
I.S.O.	International Organization for Standardisation
A.A.S.H.T.O.	American Association of State Highway and Transport Officials
A.W.W.A.	American Water Works Association
N.F.	Normes Française
AFNOR	Association Française de Normalisation

101.10 SURVEY AND SETTING OUT

101.10.1 Engineer's Benchmarks and Survey Markers

Prior to the commencement of the work, the Contractor will receive from the Engineer a number of benchmarks and survey markers on the Site. Before starting any work, the Contractor shall check the alignment and levels of the benchmarks and markers in the presence of the Engineer's Representative and shall correct any error or mis-alignment which may be discovered during such checking with the consent of the Engineer's Representative. Thereafter, the Contractor shall establish from these corrected benchmarks and markers all levels and lines necessary for the performance of the work.

The Contractor shall be responsible for the preservation of the benchmarks and markers during

the entire period of construction, and shall at his own cost repair or replace any of them that may be damaged, destroyed, or removed by any cause whatsoever.

101.10.2 Setting Out

The Contractor shall appoint and employ the necessary qualified and experienced staff to set out the work accurately and shall establish and locate all lines and levels and be responsible for the correct location of all works.

Whether or not directed by the Engineer's Representative, the Contractor shall take such levels and dimensions as may be required prior to disturbance of the ground for the purpose of measurement and these shall be agreed between the Contractor and the Engineer's Representative in writing before any of the surface is disturbed or covered up.

The Contractor shall establish parallel survey lines or other points of reference at a safe distance, permitting the re-establishment of lines and points, wherever the original lines and points must inevitably be destroyed or removed during the progress of work.

101.10.3 Surveying for Measurement of Earthwork

All intermediate and final surveying necessary for the establishment of quantities of excavation and earthfill will be done by the Contractor, who shall establish elevation points and prepare cross-sections sufficient to permit an accurate calculation of the quantities of earthwork. The Contractor shall notify the Engineer's Representative at least three days in advance of his intention to perform such measurements. The cross-sections prepared by the Contractor and approved by the Engineer's Representative shall be basis for the measurement and payment of earthworks.

101.10.4 Payment

Unless specific items are included in the Bill of Quantities, the cost of all surveying, modifications to drawings, setting out, and measuring to be done by the Contractor and all other expenses incurred by him in complying with the requirements of this section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.11 PROGRAMME OF WORKS AND PROGRESS REPORTS

The time allocated for the performance and completion of all works under this Contract shall be as stated in Volume 1 of Contract Documents.

The Contractor shall submit to the Engineer, before commencing work on site, a fully detailed programme showing the order or procedure and method by which he proposes to carry out the construction and completion of the Works, and particularly of the organisation and staff proposed to direct and administer the performance of the Contract.

The information to be supplied to the Engineer shall also include drawings showing the general arrangement of his temporary offices, camps, storage sheds, building and access roads, and details of Construction Plant and Temporary Works proposed.

The Contractor when preparing his programme shall take due account of the time required for the delivery of materials.
The Engineer will check the proposed programme and will return same to the Contractor within 14 days of its receipt with his approval or comments and requirements for changes (if any). The Contractor shall make all requested corrections and changes not later than 7 days after having received the Engineer's comments. The programme as finally agreed to and approved by the Engineer will serve as the only basis for the carrying out of the Works.

After the commencement of each and any part of the Contract, the Contractor shall forward to the Engineer in triplicate, for each calendar month, a progress report and a chart showing the approved programme, the work completed to date and the progress made during the month. Such monthly progress reports and charts shall be submitted by the Contractor to the Engineer or his Representative not later than the 6th day of the month following that to which the report and chart refer.

101.12 WORK SITES

101.12.1 Right of Way and Sites of Works

The Employer will provide all the necessary rights of way, lands and sites on which the Works are to be carried out and will designate the access roads to the sites which the Contractor will be permitted to use.

In no case shall the Contractor occupy lands, right-of-ways or way-leaves without the previous written permission of the Engineer.

101.12.2 Contractor's Work Area

The location of the Contractor's work area, i.e. the area or areas where the Contractor may set up his offices, stores, workshops, yards for mechanical plant, etc., and transport depots, shall be agreed beforehand with the Engineer and shall be such as to avoid obstruction and nuisance to the public. The Contractor shall provide, within his work area, a Site Office for the use of his agent where written instructions from the Engineer may be delivered.

The Contractor shall make his own arrangements for and pay all costs incurred in the use of such areas of land as he may require for work areas for the purpose of the Contract.

101.12.3 Access and Construction Roads

The Contractor shall at his own expense construct and maintain within the right of way any temporary access roads and construction roads on the work sites that he deems necessary for the proper performance of the works, but the routes of such temporary roads and the method of their construction shall be subject to the Engineer's approval.

The Contractor will be permitted the use of existing roads on the Site provided that such use is co-ordinated with other users.

The Contractor will be permitted to use public roads as access roads to the Works only after having obtained permission in writing from the relevant Authorities and from the Engineer. The Contractor shall strictly adhere to all requirements and conditions prescribed by the relevant Authorities and set out in Clauses 29 and 30 of the Conditions of Contract.
The cost of preparation and maintenance of all access and construction roads and all costs incurred in complying with the requirements of this subsection shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.12.4 Existing Services

The Contractor shall make himself acquainted with the position of all existing works and services inter alia roads, sewers, stormwater drains, cables for electricity and the telephone lines, telephone and lighting poles, and water mains, before any excavation is commenced.

The Contractor will be held responsible for damage caused in the course of the execution of the Works to such existing works and services and shall indemnify the Employer, the Engineer and their agents against any claims arising from such damage (including consequential damages). Any damage caused must be made good at the Contractor's own expense.

Where the works required the crossing of existing roads, railways, fuel pipelines and services, the Contractor shall obtain the prior permission of and shall make all necessary arrangements with the relevant authorities and/or owners of said utilities and shall obtain their consent to the time and manner of execution of all work connected with such crossings.

When crossing a road in public use the Contractor shall either leave half the width of the road free for traffic or shall construct a bypass, as may be required by the road authority. The length, width and shape of any such bypass and the mode of its construction shall be as directed by the Engineer, but shall at all times permit for the passage of traffic using the main road. The Contractor shall put up warning and traffic signs, and shall employ flagmen to direct the traffic and shall mark the road crossings and put up lights from sunset to sunrise.

The Engineer's Representative may order the Contractor to repair bypasses, strengthen any temporary structures, put up additional signs or lights and generally improve the arrangements as he may deem necessary, and the Contractor shall forthwith comply with such orders. Regardless of whether or not the Engineer's Representative orders any such repairs of improvements, the Contractor shall remain solely responsible for the proper performance of all

work in connection with the erection, maintenance and subsequent removal of all temporary structures required under this Clause, to the complete satisfaction of the Engineer.

Where the Works cross existing pipes, sewers, drains, channels, telephone or power lines and cables, the Contractor shall be responsible for the preservation of all such utilities in a good and serviceable condition during the execution of the Works and shall see to it that any damage done to any of the services be immediately repaired. Inasfar as necessary, the Contractor shall construct temporary bypasses for such pipes, channels and cables and restore them to their original position after the work at the junction or crossing has been completed.

The Contractor shall construct all bypasses and do all repairs to roads, pipes, channels and cables in accordance with the requirements of the proper authorities and/or the owners thereof or shall bear the expenses of all such work done by them.

Existing access to lands, property and all other facilities shall be maintained by the Contractor during the continuance of the Works to the Engineer's satisfaction.
Where work is being carried out in the vicinity of overhead power lines the Contractor shall take special measures to ensure that all persons working in such areas are aware of the relatively large distance that high voltage electricity can "short" to earth when cranes or other large masses of steel are in the vicinity of power lines and that adequate safety precautions are being taken. The Contractor shall ensure that none of his employees commits any act which will cause damage from, or to, overhead power lines.

Unless specific items are included in the Bill of Quantities, the cost of all works required under this section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.13 WATER AND POWER FOR USE IN THE WORKS

The Contractor shall be solely responsible for the location, procurement and maintenance of water supplies adequate in quality and quantity to meet his obligations under the Contract.

The Contractor shall be responsible for the supply of all electric power to meet his obligations under the Contract and for the distribution thereof.

All costs associated with the supply of water and power shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.14 BUILDING REGULATIONS

All buildings erected by the Contractor upon the Site and Work Area shall comply with all Laws and local By-laws insofar as they are applicable.

101.15 WORKS IN THE DRY

All parts of the Works are to be carried out in the dry, and shall be kept free at all times from surface or groundwater from whatever source it may come to the satisfaction of the Engineer. Keeping the Works dry shall include all pumping and diversion of water that may be necessary in carrying out the Works, also provision and filling-in of sump holes, installation and operation of drains, pumps, well points etc., in a manner and with equipment and materials satisfactory to the Engineer.

The Contractor shall, at his own expense, make such provision for the discharge of any water from the Works as shall be satisfactory to the Engineer and to any person having rights over the lands or watercourses over or down which such water is discharged. He shall hold the Employer indemnified against any claim that may be made through non-compliance with this section. In the event of any interference with existing land or road drains due to the construction of the Works or to the dumping of spoil, etc., within or without the limit of the Works, the Contractor shall take immediately steps to restore the drainage to the satisfaction of the Engineer and the Owners, occupiers, or Authority concerned.

Unless specific items are included in the Bill of Quantities, the cost of keeping the Works dry as specified in this section, shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.16 WATCHING, FENCING AND LIGHTING

The Contractor shall employ competent watchmen and guard the Works by day and night.

From the time that any portion of the Works shall be commenced, until the end of the works, the Contractor shall be responsible for protecting the public and his workmen from anything dangerous to persons or property and for the safe and easy passage of pedestrian, animal and vehicular traffic.

Any excavation, material dumps, soil dumps or other obstructions likely to cause injury to any person or thing shall be suitably fenced off and at night protected by red warning lights. The Contractor shall, at his own expense, and immediately upon completion of any part of the Works, fill up all holes and trenches, and level all mounds and heaps of earth which have been excavated or made in connection with the Works. The Contractor shall be responsible for the payment of all costs, charges, damages and expenses incurred or sustained on account or in consequence of any accident which may happen by reason of holes and trenches being dug and left or placed in improper locations.

Fencing shall consist of at least three 15 mm diameter hemp ropes or 4 mm diameter wires, or more, if required, stretched tightly between poles, standards, etc., securely planted in solid ground, well clear of the excavation and enclosing the spoil from the excavation. The poles, standards, etc., shall not be more than 15 m apart. If circumstances require it, they shall be placed closer and the ropes or wires shall be stretched tight, approximately 0.40 m, 0.80 m and 1.20m, respectively, above the ground.

Banks of spoil of suitable height and form may be accepted by the Engineer in lieu of fencing.

Fences and spoil banks shall be clearly marked at the ends, all corners and along the length at intervals of not more than 15 m, by means of white lime-washed boards, discs, stones or oil drums during the day and by red lamps kept burning at night. Markers shall be freshly lime-washed at regular intervals to ensure that they are white and clean.

The Contractor shall detail a man to trim and fill the lamps during the day and they shall be lit at least one half hour before sunset and not extinguished until at least one half hour after sunrise.

If a road is closed, or partly closed, to traffic, temporary traffic signs and barricades shall be erected by the Contractor, to the satisfaction of the Engineer and the Police, to give proper warning to traffic and to the public. Road signs shall be not less than 1.20 m x 0.80 m in size, surmounted by a red circle. Lettering shall be black, on a yellow ground and shall incorporate reflective material. The signs shall be adequately illuminated at night. The Contractor shall be solely responsible for the proper control of all traffic.

The cost of watching, fencing and lighting and all other costs incurred in complying with the requirements of this section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.17 PRESERVATION OF TREES

No trees shall be cut down without prior permission of the Engineer who will limit the removal of trees to the minimum necessary to accommodate the Permanent Works.

If trees are cut down or damaged by the Contractor or his employees and without approval, then the Contractor shall replace such trees at his own expense with trees of not less than two years of age obtained from a reputable nursery and of species to be approved by the Engineer. The Contractor shall plant, water and ensure that the replacement trees are properly established all at his own expense.

All costs incurred in complying with the requirements of this section shall be deemed to be included by the Contractor in his unit rates for the various items on the Bill of Quantities and shall not be paid for separately.

101.18 WORKS EXECUTED BY THE EMPLOYER OR BY OTHER CONTRACTORS

The Employer reserves the right to execute on the Site works not included under this Contract and to employ for this purpose either his own employees or another Contractor whose contract may be either a sub-contract under this Contract, or an entirely separate Contract. The Contractor shall ensure that neither his own operations nor trespass by his employees shall interfere with the operations of the Employer or his Contractor employed on such Works and

the same obligations shall be imposed on the Employer or other Contractor in respect of work being executed under this Contract.

101.19 MATERIALS

101.19.1 General

All materials shall be of the best quality throughout. Materials delivered to the Works shall be equal in all respects to the samples approved by the Engineer. The methods of stocking, mixing, transporting, fixing, placing and applying all materials shall be in compliance with the specifications and to the approval of the Engineer, who shall be kept advised of any change of plan. Materials failing to comply with the Specifications shall be immediately removed from the Works, at the Contractor's expense.

All goods and materials used in the execution of the Contract shall comply in all respects with ISO 9000 Standards or other equivalent standards approved by the Engineer.

101.19.2 Approval of Materials

Before entering into any sub-contract for the supply of any material or goods, the Contractor shall obtain the Engineer's approval in writing of the manufacturers and/or suppliers from whom he proposes to obtain such materials or goods. If requested, the Contractor shall submit to the Engineer samples of such materials and shall have them tested in approved laboratories. Such tests shall be carried out at least seven days prior to the inclusion of such materials in the Works. The cost of all samples and tests shall be borne by the Contractor.

Should the Engineer, at any time, be dissatisfied with such material or goods or with the methods of production or operation carried out at the manufacturer's or supplier's works or place of business, he shall be empowered to cancel his previously given approval of such supplier and to specify any other supplier whom he may choose for the supply of such material or goods. The Contractor shall then obtain such said material or goods from such other supplier and shall bear any additional costs thereof.

Materials which, in the opinion of the Engineer, do not comply with the Specification, shall be classified as rejected materials and shall be cut out and removed from the Works and replaced as directed by the Engineer, at the Contractor's own expense.

101.19.3 Alternative Materials

Where brand names or products of a specific manufacturer are specified in the Contract, the Contractor may, subject to the Engineer's approval (which shall not be unreasonably withheld) supply alternative materials, having similar characteristics and showing performance and quality at least equal to those specified.

Whenever the Contractor wishes to propose an alternative material he shall submit detailed information concerning the type of material and/or product, the Vendor's name, drawings if required, test certificate, etc. If the alternative material is not approved by the Engineer, the Contractor shall supply the material originally specified in the Contract.

If the price of the approved alternative material is in excess of the material specified in the Contract, the Contractor shall not be entitled to extra payment over the rates in the Bill of Quantities.

101.19.4 Supply by Contractor

Pursuant to Clause 36 of the Conditions of Contract, all materials required in the Works, except as otherwise provided for in the Contract, shall be supplied by the Contractor and the cost thereof shall be included by the Contractor in his rates in the Bill of Quantities.

The Contractor's Tender shall be construed as an undertaking that all the materials and equipment to be provided by the Contractor are in his possession, or readily available and will be delivered to the Site in accordance with the Time Schedule.

101.20 MAINTENANCE OF WORKS

During the period of maintenance the Contractor shall maintain the Works and make all repairs, as defined in clauses 49 and 50 of the Conditions of Contract.

After the commencement of the Period of Maintenance, the Contractor shall do nothing which might endanger the safety of the Public and he shall carry out all instructions of the Engineer or other duly authorised person or authority in this regard. Throughout the Period of Maintenance the Contractor shall notify the Engineer what work or operations it is intended to be carried out on the Site and he shall carry out any instruction which the Engineer may give as to times and manner of working so that any inconvenience to the Public is kept to a minimum.

The Engineer will give the Contractor due notice of his intention to carry out any inspections during the Period of Maintenance and the Contractor shall upon receipt of such notice arrange for a responsible representative to be present at the times and dates named by the Engineer. This representative shall render all necessary assistance and take note of all matters and things to which his attention is directed by the Engineer.

101.21 WORKS LOG BOOK

The Engineer's Representative will keep a Works Log Book on the Site.

To assist the Engineer's Representative in keeping the Log Book, the Contractor shall supply daily to him full details in writing on the following:

1. The number of workmen of the various trades and grades employed in carrying out the Works.
2. Quantities of the various materials brought to or removed from the Site.
3. Quantities of the materials incorporated by the Contractor in the Works.
4. Constructional Plants and Contractor's equipment brought to and removed from the Site.
5. The use of Constructional Plant in the Performance of the Works.
6. Other details as requested by the Engineer's Representative.

The Engineer's Representative may, if he so desires, use the above data to conduct the Log Book. However, such data shall not bind the Employer or the Engineer in any manner whatsoever.

The Log Book will be signed by the Engineer's Representative, and a signed copy of the daily entries will be handed to the Contractor or his authorized representative, who within 48 hours from the receipt of said copy, may object to any of the entries therein by written notice to the Engineer's Representative. Such objections by the Contractor shall be recorded in the Log Book. If the Contractor or his authorized representative has not made any such objection within 48 hours as aforesaid, he shall be deemed to have confirmed the correctness of the data entered in the Log Book.

The Contractor may enter in the Log Book his remarks regarding the performance of the Works. However, such remarks shall not bind the Employer or the Engineer.

Entries in the Log Book, except those to which the Contractor has objected in writing as described above, shall serve as evidence between the parties as to facts included therein; however, they shall not in themselves from the basis for a demand for any payment under the Contract.

101.22 RESIDENT ENGINEER'S OFFICE

101.22.1 Construction

The Contractor shall, within 4 weeks of the issuance the order to commence of works, hand over to the Engineer a fully completed, furnished and equipped Engineer's office. The Contractor shall provide suitable temporary office space for the Engineer until the office is completed.

All facilities provided for the Engineer and/or Employer's staff shall be provided upon issuance the order to commence of works and shall remain available until the end of the defects liability period or until such earlier time as the Engineer may instruct.

The Contractor shall provide prefabricated portable or demountable offices or other as may be approved by the Engineer for the sole use of the Engineer and his staff, comprising:

2 offices size of each approximately 4 m x 4 m
1 meeting room for 10 people
1 secretary's room of approximate size 4 m x 4 m
1 pantry
2 toilets

1 store
1 multiple purpose room
Entrance area with space for desk
Car sheds for 5 cars.

Offices are to be of proprietary manufacture, with hard-wearing, easy-clean surfaces and robust and secure fittings. Submit full details to the Engineer for approval before delivery to the Site and erection.

101.22.2 Furnishings

Each office shall contain:
2 desks with lockable drawers and swivel chairs
2 lockable steel filing cabinets
2 office chairs
1 drawing hanger for 10 sets
2 shelves
2 pin boards
2 waste paper baskets.
1 reference table

CONFERENCE ROOM FURNITURE AND EQUIPMENT
1 conference table for 10 people
10 chairs
2 pin boa

2 shelves
2 waste baskets
1 reference
table.

KITCHEN FURNITURE AND EQUIPMENT

1 refrigerator 14 cu. ft. capacity
1 water filter and 20 liters water cooler/hot/cold
2 electric boiling rings
1 stainless steel sink and drainer
1 heat resistant worktop
1 set of storage cupboards
1 set of crockery and cutlery for each member of the staff
1 large waste basket with cover.

and all necessary consumables for the making of beverages for the duration of the contract

LAVATORY FURNITURE AND EQUIPMENT

1 w.c. suite
1 toilet roll holder
1 wash hand basin
1 mirror
1 paper towel holder
1 soap dispenser
1 waste basket with cover.

and all necessary consumables.

and, in addition, the following shall be provided:

1 secretary's desk and swivel chair
2 large lockable sheet filing cabinets
2 reference tables
6 office chairs
6 calculators
1 photocopying machine similar to FT500 I with duplex, sorter and document feeder + consumables + all photocopying papers pin boards, shelves and waste paper baskets.
2 computers (each as defined in computer section) + all consumables with all stationary and offices supplies.
1 digital camera (Min. capacity 4GB, Canon or equivalent) with necessary accessories for downloading photos to PC.

SERVICES: The Contractor shall provide and maintain the following minimum services:

- heating and air-conditioning
- electric lighting and power
- water supply
- drainage system
- fire fighting appliances
- cleaning facilities and general attendance including all personal.
- All bills and charges related to the services shall be paid by the Contractor.

TELEPHONES: The Contractor shall provide a three separate telephone connection (one cellular) and one regular phone line and one dedicated Facsimile service for the representative's offices, with PABX, extensions and telephone set for each office, secretary and conference room and shall pay all charges.

COMPUTER The Contractor shall provide on-site for the use of the Engineer:
- Intel I 7, 3.2 GHz minimum, 8.0 Giga byte of Ram, 500 Giga byte hard disk capacity, video local bus, video graphic adaptor 256 MB VGA.
- 56 x CD drive (Read/Write)
- 16 x DVD drive (Read/Write).
- 101 key English-Arabic Keyboard.
- SVGA Flat, non-interlaced, low power, low radiation 19" rotating color monitor.
- One parallel port
- Two serial ports
- USB ports
- One Mouse port
- Key lock
- Optical Mouse
- The necessary supplies throughout the Contract.
- License for latest version of "Windows 7 and Microsoft Office 2007", "AutoCAD", and "Primavera".
- Colour Laser Jet printer with A4 and A3 papers (total No. 2).
- Parallel / USB cable for printer.
- UPS for all above equipment with minimum 2 hours backup batteries
- Computer table & chair to accommodate computer, monitor, keyboard and printer
- Antistatic dust covers for all above equipment
- The necessary supplies throughout the Contract.
- Internet and E-mail service.

At the end of the project all the above equipment shall remain the property of the Contractor.

101.22.3 Miscellaneous Facilities and Services

The Resident Engineer's office shall be cleaned daily and provided with clean towels (every other day), soap, glasses and at all times with a fresh and adequate supply of drinking water. The cost of these services shall be paid for by the Contractor.

The Contractor shall be responsible for the security of all plans, papers, books, instruments from theft or fire during the continuance of the Contract and his insurance policies shall cover the office of the Resident Engineer.

The Contractor shall provide a complete set of all ASTM, AASHTO, BS EN and other Standards, Materials Manuals and Codes of Practice referred to in this Contract, or relevant thereto, shall be provided to the Engineer by the end of the mobilization period.

The Contractor shall provide all ladders, access lighting facilities and assistance etc. required by the Engineer to inspect any part of the Works.

The Contractor shall provide for the use of the Engineer when required by the Engineer, one total station surveying equipment, all of approved type and make, complete with accessories and all instruments, tapes, staffs, poles, pegs, stagings, moulds, templates, profiles, and all

other requisites for checking and setting out and measurement of the Work. The Contractor shall also provide, when required by the Engineer, the services of two experienced chainmen.

101.22.4 Maintenance and Removal

The Contractor shall fully maintain the Resident Engineer's office throughout the Contract Period and effect all repairs, painting etc. required during that period.

At the end of the Contract, the office with all its furnishings and facilities will revert to the Contractor who, upon receiving the Engineer's instructions to do so, shall dismantle the office and remove it, leaving the Site neat and tidy to the Engineer's satisfaction.

101.22.5 Payment

Unless specific items are provided in the Bill of Quantities, the cost of the use by the Engineer and his staff of the office, its furnishings and all facilities and the cost of their maintenance etc., all as specified in this Section, shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

101.23 DAYWORKS

When Dayworks are authorized by the Engineer all equipment, labour and materials shall be paid for at the rates listed in the Schedule of Dayworks in the Bill of Quantities.

All major materials for Dayworks authorized by the Engineer but not included in the Schedule of Dayworks shall be paid for on a Prime Cost basis. The Contractor shall be paid on the basis of paid invoices showing cost of materials less any discount, paid receipts for transportation and handling charges and paid receipts for insurance on materials and delivery of materials. Before authorizing the use of materials in Dayworks the Engineer may require the Contractor to supply estimates of the costs of the materials.

The Contractor shall be compensated for his expenses, overhead, labour and profit involved in procuring and delivering the materials by an amount equal to a percentage of the actual cost of the Prime Cost Sum.

101.24 WATER SAMPLES AND ANALYSES

101.24.1 Procedure

Water samples shall be out from the well. For the physico-chemical analyses, it is advisable to take a minimum of 2 liters of water. Whereas for the dosage of heavy metals and trace elements, it is necessary to take a minimum of 5 liters of water. Water will be sampled according to the indications of the laboratory and/or of the Engineer, in one or several small polyethylene flasks, with an eventual adjunction of certain substances.

The Contractor will install a regulating valve on the upper part of the pipe. The regulating valve will be fixed at a minimum height of 0.50 m above the ground. The flask in which water is sampled will be rinsed 3 times with pumped water before being filled. Each flask will be hermetically sealed and carefully labeled.

Water samples for bacteriological analyses will be taken in sterilized flasks of 250 to 500 ml. The regulating valve should be imperatively previously sterilized. Sampling flasks should not be exposed to direct sunlight and kept at a temperature of + 4 °C, before being transported to the laboratory within a maximum delay of 24 hours.

Physico-chemical and bacteriological analyses should be carried out by a laboratory approved by the Engineer.

101.24.2 Water analyses

Water analyses will be carried out and defined according to the French regulation method (decree N° 89.3 of January 3, 1989).

The required analyses are defined in accordance with:

- The origin of water: Ground or surface
- The treatment performed (if any)
- The sampling point.

At each well head, a sample of raw water will be taken to undergo a complete analysis. According to the sampling point:

- First analysis before starting works: Type P2P - C3 + B3
- Second analysis upon completion of works: Type P1 - C2 + B2.

101.24.3 Essential elements, measurements and criteria for each type of analysis (Tables 1, 2 and 3).

Table 1: **Bacteriological analysis**

BACTERIOLOGICAL ANALYSES		
Limited (B1)	Summary (B2)	Completed (B3)
Thermoduric coliforms. Fecal streptococci	Thermoduric coliforms. Fecal streptococci. Count of aerobic bacteria revivable at 22 °C et 37 °C.	Thermoduric coliforms. Fecal streptococci. Coliforms. Count of anaerobic bacteria revivable at 22 °C et 37 °C. Spores of sulfite-reducing anaerobic bacteria.

Table 2: **Standard analyses defined in accordance with the sampling point.**

Site	Source		Production				Distribution	
	At point of withdrawal, treatment performed (R)		After treatment and prior to discharge, or at the point of withdrawal if no treatment is performed (P)				In network (D)	
	(R.P.)	(R.S.)	(P1)	(P2)		(P3)	(D1)	(D2)
Origin of the water	Ground water	Surface water	Ground water and surface water	Ground water (P2P)	Surface water (P2S)	Ground water and surface water	Ground water and surface water	Ground water and surface water
Standard Analyses	B1 - - - - C3 - -	B1 - - - - C3 C4a C4c	- - B3 - C2 - - -	- - - - - C3 - -	- - - - - C3 C4a -	- - - - - - C4a C4c	- B2 - C1 - - - -	- - - - C2 - - C4b

Table 3: **Types of physico-chemical analyses**

PHYSICO-CHEMICAL ANALYSES						
-	Limited physico-chemical analyses (C1)	Summary physico-chemical analyses (C2)	Complete physico-chemical analyses (C3)	Specific physico-chemical analyses (C4)		
				C4a	C4b	C4c
Organoleptic parameters	- Appearance (qualitative): odour, taste, colour - Turbidity	- Appearance (qualitative): odour, taste, colour - Turbidity	- Appearance (quantitative): odour, taste, colour - Turbidity			
Physico-chemical parameters Natural structure of the water	- pH - Conductivity	- Temperature - pH - Conductivity - Nitrates - 3 of the following parameters: nitrates, ammonium, chlorides, sulfates, permangante value,, methyl orange alkalinity or total hardness.	- Temperature - pH - Conductivity - Chlorides - Sulphates - Silica - Calcium - Magnesium - Sodium - Potassium - Aluminium - DS - Dissolved oxygen - Free carbon dioxide (marble test) or calculation of carbonate balance - Carbonates - Hydrogen-carbonates.			
Parameters concerning undesirable substances	- Residual chlorine or any other parameter relating to the disinfection treatment	- Residual chlorine or any other parameter relating to the disinfection treatment	- Nitrates -Nitrites - Ammonium - Permanganate value, hot, in acid medium - Hydrogen sulphide - Iron - Copper - Zinc - Manganese - Phosphorus - Fluorine - Residual chlorine or any other parameter relating to the disinfection treatment.	- Kjeldahl nitrogen. - Dissolved hydro-carbons - Surface agents - Phenol index	- Iron - Copper - Zinc.	
Parameters concerning toxic substances					-Cadmium - Lead - PAH	- Arsenic - Cyanides -Chromium - Mercury - Selenium.
Other parameters						- Pesticides - Volatile

101.24.4 Interpretation of analyses (Potability)

The results will be compared to the values set by:

- EEC directives/No/ 80/779/EEC-Official Journal of the European Communities, August 30, 1980. This directive groups together 62 admissible value parameters (guide level and maximum admissible concentration).

- WHO recommendations (Geneva 1986). Grouping parameters into five categories.

- French regulations (Decree No. 89.3-Official Journal of January 3, 1989). This decree groups analyses types and tables of admissible physico-chemical and bacteriological parameters relating to the definition of water potability.

These analyses will be given to the administration for the interpretation of data and the follow up.

101.24.5 Interpretation of analyses (corrosion)

During its transportation or use, water may cause various changes to the materials with which it is in contact. The most frequent deterioration is metal corrosion.

- Effects of aeration conditions (O_2H):
  - Corrosion in a non aerated place: corrosion caused by hydrogen
  - Corrosion in an aerated place: corrosion caused by oxygen.

The iron-water equilibrium potential in the absence of oxygen, and the oxygen and hydrogen electrodes equilibrium potentials will be controlled according to the pH value of the water.

- Effects of the mineralization influence (T.D.S.-T.A.C.)
  - The global mineralization of water increases its conductivity and decreases its resistance to corrosion. In particular, the concentration of chloride shall be verified (RYZNAR index).

- Effect of temperature variation

In conclusion, the approved laboratory should confirm, according to total mineralization and pH, the action of water and temperature on the different metals.

Volume 2

Technical Specifications

Division 1

General Specifications

Part 2

Civil Works

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201 EARTHWORKS

201.1 GENERAL

201.1.1 Scope

Earthworks under this Specification include excavation and backfill for pipelines, excavation for ponds and open canals, excavation and backfill for structures, excavation from borrow areas, construction of embankments, compacted fill and surfaces and other earthworks and works related thereto, as required in the Works.

201.1.2 Classification of Excavation

Unless specific items for Rock Excavation are included in the Bill of Quantities, earthwork will not be classified in accordance with the hardness of the excavated material and all excavation will be deemed to consist of Common Excavation, as defined hereafter, regardless of the actual hardness of the excavated material.

Where excavation is classified according to hardness of excavated materials, the following definitions shall apply:

- Rock excavation shall include hard and solid rock that cannot be broken up by mechanical excavating equipment, including a heavy tractor equipped with a rooter, but which necessitates the use of pneumatic tools or blasting for its loosening and removal. Rock excavation shall also include detached boulders exceeding one half of a cubic metre in volume.

- Common excavation shall include all material other than rock as defined above and also detached boulders less than one half of a cubic metre in volume.

No material, except the aforesaid, will be defined as rock and classified as such for the purpose of payment, whether actually loosened by blasting, pneumatic tools or otherwise.

The decision as to the classification of any excavation into “rock” or “common” shall be at the sole discretion of the Engineer’s Representative, subject only to Clause 2 of the General Conditions of Contract.

Where specific items for Rock Excavation are included in the Bill of Quantities, the Contractor shall not be entitled to be paid for excavation in rock unless, at the time the excavation is open and visible, the Contractor shall give notice in writing to the Engineer’s Representative that he claims to be paid for excavation in rock. After giving such notice the Contractor shall not fill in the excavation or otherwise prevent it from being inspected by the Engineer’s Representative for the purpose of classification and determination of payline in respect of same.

201.1.3 Natural Ground Levels

The natural ground levels, as marked on the Drawings, shall form the basis of measurement for payment for excavation, fill and all other works where the site levels have bearing and no field surveys will be made. Natural ground levels at intermediate points shall be checked on the field

by the Contractor.

The Contractor shall check the natural ground levels before the commencement of earthworks, and such checking shall be made by the Contractor at his own expense, in the presence of the Engineer. The results, approvals in writing by the Engineer, shall thereafter prevail.

The cost of checking natural ground levels shall be borne by the Contractor alone, whether checking is carried out at the Engineer's request or at the Contractor's own request. No allowance will be made for normal bulking or shrinking of the soil and the Contractor shall make allowance for this in his rates.

201.1.4 Dewatering, Supporting and Fencing of Excavations

The Contractor shall, during the whole period of construction, keep the work area and all excavations dry and protected from the influx of water from any source whatsoever (rain and seepage water, water from surface and subsurface streams, groundwater, etc.) and shall provide and operate all pipes, pumps, well points and other apparatus and materials and all labour required for this purpose.

The Contractor shall, throughout the period of construction, prevent structures and/or pipelines from flotation either by keeping the work area dry or by temporarily filling the structure and/or pipeline with water, all as approved by the Engineer.

The provisions that the Contractor shall make for the discharge of any water from the Site of the Works shall be satisfactory to the Engineer and to any persons or authorities having rights over the lands through which such water is discharged. The Contractor shall keep the Employer indemnified against any claim or damage that may be caused by non-compliance with the requirements.

The sides of excavations shall be supported whenever necessary or directed by the Engineer's Representative by means of timber, steel or other type of struts, walling, boards, sheeting or any other approved system. No support work shall be removed without the approval of the Engineer.

Every precaution shall be taken by the Contractor against slips, falls, or subsidence in the excavations, but if any slips, falls, or subsidence should occur the Contractor must at once make good the same including all surface restoration and reinstatement, all at his own cost. Should any such fall, slip or subsidence disturb or weaken any foundation or support to the Works or to any adjacent structure or facility, or create empty spaces and gaps near the new works, the Contractor shall carry out such additional works as the Engineer may require in consequence thereof, such as filling the gaps so caused with concrete or other suitable material as the Engineer may direct, all at the Contractor's own expense.

Steel sheet piling may be used by the Contractor in his supporting, bracing and dewatering operations, as specified above, of his own choice or at the direction of the Engineer, or where shown on the Drawings as a permanent part of a structure. The sizes and types of sheet piles

used for temporary supporting and bracing shall be determined by the Contractor but will be subject to the Engineer's approval. Where sheet piles form a permanent part of a structure, their sizes and types shall be as shown on the Drawings or as directed by the Engineer.

The Contractor shall take all the necessary precautions during the excavation to protect his workmen and the publics. This may include, but shall not be limited to the supporting of the sides of the excavations, fencing the areas, providing warning lights and providing watchmen.

The Contractor shall be entirely responsible for the proper dewatering, supporting, fencing, lighting, watching, etc. of excavations, trenches and pits and shall not be relieved of his responsibilities under the Contract even though no objection has been raised by the Engineer to the conditions of the work.

Unless specific items are included in the Bill of Quantities, the cost of dewatering, supporting, bracing and timbering (including steel sheet piles), fencing, lighting, watching, etc. of excavations, trenches and pits and any extra earthworks and labour, materials and apparatus required for them shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

201.1.5 Use of Explosives

The Contractor shall use explosives only with the written express permission of the Engineer's Representative and all blasting shall be carried out by properly licensed and qualified workmen under experienced supervision. When using explosives, the Contractor shall abide by and conform to all the Laws pertaining to the purchase, transportation, storage and handling of explosives and shall obtain all required licences from and make all necessary arrangements with the relevant authorities prior to commencing blasting operations.

When blasting operations are in progress, all precautions shall be taken to protect all persons and livestock, the Works, and any other property from injury or damage.

The Engineer's Representative shall have the power to regulate, restrict or prohibit blasting if in his opinion it is necessary to do so for the safety of persons or property, or to safeguard the foundations or sides of the excavation, and the Contractor shall have no claim against the Employer in respect of such regulations or prohibitions. Explosives shall not be used within 20 metres or any other distance as the Engineer's Representative may direct, of concrete in permanent structures.

Notwithstanding anything said in this Sub-Section, the Contractor shall be held solely and entirely responsible for any injuries to persons and livestock and damage to public or private property.

201.1.6 Programme and Methods of Work

In addition to the information furnished by the Contractor with his Tender, the Contractor shall, after award of Contract but no later than two weeks prior to commencement of Works,

submit for the Engineer's approval detailed proposed methods of excavating, transporting and placing earthfill material, watering and compacting and any subsequent modifications thereof, together with a detailed list of quantities and type of plant to be used for all these operations. Amendments shall be made by the Contractor in accordance with any instructions issued by the Engineer before commencement of works and from time to time.

201.1.7 Excavated Materials - Handling and Disposal

As far as practicable and as determined by the Engineer's Representative, all suitable materials from excavations shall be used in the permanent construction required under the Contract.

The Contractor's operations in excavations shall be such as to yield the maximum of suitable materials for construction purposes, and shall be subject to the approval of the Engineer's Representative. Where practicable, and as determined by the Engineer's Representative, suitable materials shall be excavated separately from those considered unsuitable, and the suitable materials shall be segregated by loads during the excavation operations and shall be placed in the designated final locations either directly from the excavation, or shall be placed in temporary stockpiles for later placing in the designated locations, all as directed by the Engineer's Representative.

Excavated materials that are considered unsuitable or are in excess of those required for permanent construction, shall be removed from the Site. The Contractor shall be entirely responsible for the removal of all surplus excavated material from the Site to such disposal areas as he shall have obtained at his own cost and responsibility and shall keep the Employer indemnified against any claims, charges or proceedings arising out of the transportation and disposal of such surplus excavated material.

Spoil heaps shall be located where they will not interfere with the progress of the Works, or with the flow of water in natural streams or drainage courses, and where they will neither detract from the appearance of the completed project and environment, nor interfere with access to the structures. Spoil heaps shall be levelled and trimmed to reasonable regular lines, as determined by the Engineer's Representative.

The cost of complying with all requirements of this Sub-Section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

201.1.8 Earthworks in Urban Areas

When working in urban areas, under heavy traffic conditions (pedestrian and/or vehicular), the Contractor shall pay particular attention to all safety measures necessary to avoid accidents resulting from open trenches, construction materials and/or equipment stored in the streets, etc. without adequate protection. The Contractor shall arrange temporary crossovers to all open excavations. The Contractor shall co-ordinate his work with the traffic police, public transport companies and municipal authorities and make proper and adequate traffic and safety arrangements for the duration of the Works. The Contractor shall take into account the restrictive urban and specific local conditions and shall make due allowance in his rates in respect thereof as no claim arising from this clause or contingency will be either admitted, entertained or considered.

When excavating trenches along city streets, the storage of excavated material along the trench may be impossible or prohibited by the authorities. In such cases the Contractor shall remove the excavated materials to areas of his own choice and at his own responsibility and shall bring such materials back when required for backfill or shall import instead other suitable material for backfill from some other source. The entire cost of such removal and return or replacement of backfill material irrespective of the hauling distance shall be included by the Contractor in his unit rates for trench excavation and shall not be paid for separately.

201.1.9 Restoration of Waterways and Pipelines

The Contractor shall clean out and restore to their original condition all waterways or pipelines which may have been cut by the excavation or in any way damaged or silted up as a result of his operations.

Unless specific items are provided in the Bill of Quantities the cost of all additional work involved in crossing under or cutting through any waterways and pipelines and reinstating to their original condition shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

201.1.10 Restoration of Surfaces

The Contractor shall be responsible for the temporary and permanent restoration of all surfaces of roads, fields, paths, gardens, verges etc. whether public or private which are affected by his operations.

Temporary restoration shall be carried out immediately after the excavations have been refilled by returning the excavated material to the position from which it was removed and adding such suitable materials as may be required and consolidating the various materials as the work proceeds in order to provide a surface that is adequate for the purpose that the original surface fulfilled. Temporary surfaces shall be maintained in a condition satisfactory to the Engineer and responsible Authority until the permanent reinstatement is made.

The Contractor shall be responsible for the permanent reinstatement of all surfaces already described including asphalt surfaced public roads as specified in Section 201.3.11.

Should, at any time, any trench become dangerous, the Engineer will be at liberty to call upon the Contractor to restore it to a proper condition at three hours notice and, should the

Contractor fail to carry out the work, have it done at the Contractor's expense.

The Contractor shall include in his rates for all materials and labour which he may have to employ in reinstating the trenches and surfaces to the satisfaction of the responsible Authority concerned.

Restoration shall be deemed to be included by the Contractor in his various unit rates for earthworks and shall not be paid for separately, except where specific items have been provided in the Bill of Quantities.

201.1.11 Equipment for Earthworks

Generally, equipment for earthworks, shall be of a modern type and of a design suited for each specific purpose. Only equipment and machinery approved by the Engineer shall be used in the Works.

Grading equipment shall be of any type of earthmoving equipment the Contractor may desire or has at his disposal, provided the equipment is in a satisfactory condition and of such capacity that the programme can be maintained. The Contractor shall furnish, operate and maintain such equipment as is necessary to control uniform layers, section and smoothness of grade for compaction and drainage.

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

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

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

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

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

201.2 CLEARING AND STRIPPING

201.2.1 Clearing

The areas upon which new construction is to take place, the rights-of-way along which pipelines are to be laid and all other such areas as may be designated by the Engineer and/or

indicated on drawings as required for auxiliary purposes, (site offices and workshops, transport and machinery yards, borrow pits, stockpile sites, etc.), shall be cleared of all vegetation, shrubs and small and large trees, together with their roots, and from all other foreign and deleterious matter that may affect and interfere with the progress of the Works.

Trees and shrubs shall be cut or burnt down under strict control to ground level, the roots grubbed up to a depth of not less than 1.0m and removed from the area. All other scrub, vegetation, rubbish, etc., shall be cleared or burnt down to ground level and removed from the area to any distance.

All trees shall remain the property of the Employer and the Contractor shall collect these trees and store them until required by the Employer. All trees near to and about the Works except such as are to be removed, shall be carefully protected from damage by the Contractor during the period of maintenance and no trees shall be removed without the prior consent of the Engineer.

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

Unless otherwise specified in the Contract, clearing shall be measured by square meters. The unit rate shall include for all operations required under this Sub-Section, including removal of trees (see also Sub-Section 201.2.2 hereafter).

No clearing shall be carried out without prior written approval of the Engineer's Representative and only such areas approved or ordered to be cleared shall be measured and paid for.

201.2.2 Removal of Trees

Clearing as defined in Sub-Section 201.2.1 shall include the removal of small and of large trees. Trees of a girth of 40 cms. or less when measured at a height of 1.0m above ground shall be classified as small trees. Trees of a girth exceeding 40 cms when measured at a height of 1.0m above ground shall be classified as large trees and shall be removed only at the express order of the Engineer's Representative.

The removal of large trees, except where a specific item is provided in the Bill of Quantities, and the removal of small trees will be deemed to be included in Clearing and will not be paid for separately.

Where a specific item is included in the Bill of Quantities for the removal of large trees, they will be measured for payment by number.

201.2.3 Stripping

Areas on which compacted fill is to be placed and areas of excavations from which material for fill is to be extracted, including borrow areas, shall be stripped of top soil containing organic or otherwise deleterious and objectionable matter to a depth of at least 15 cm. or to such greater depth as may be determined by the Engineer. The stripped soil shall be stored in separate dumps for subsequent re-use in covering the slopes of embankments or the borrow areas after

excavation therein has been finished, or shall be otherwise disposed of as directed. Under no circumstances shall such stripped material be used as compacted fill.

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

Stripping shall be measured in cubic metres, computed by multiplying the area stripped by the depth of stripping. The unit rate shall include for all excavation, stacking-re-spreading and running excess to spoil.

No stripping shall be carried out without prior written approval of the Engineer's Representative and only such areas approved or ordered to be stripped shall be measured and paid for.

Unless otherwise specified, stripping of borrow areas shall not be measured for payment and the cost of such stripping shall be deemed to be included by the Contractor in his unit rates for earthwork in the Bill of Quantities.

201.3 EXCAVATION AND BACKFILL FOR PIPELINES

201.3.1 Surface Excavation to Reduce Levels

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

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

Surface excavation shall be measured in cubic metres according to the dimensions, lines and levels shown on the Drawings or directed by the Engineer. The unit rate shall include also for hauling the excavated material to fill areas, at any distance, and spreading them in layers of thickness not exceeding 20 cm. after compaction and disposal of the surplus material, all in accordance with the Drawings or as directed by the Engineer.

201.3.2 Trench Excavation for Pipelines

Pipe trenches shall be excavated to the typical cross-sections shown on the Drawings, and in no case shall the trench width up to the level specified exceed that shown on the Drawings. The Contractor shall ensure that at any point the width of the pipe trench is sufficient to permit the pipeline to be laid, jointed, bedded/surrounded and backfilling to be placed and compacted around the pipeline to the Engineer's satisfaction.

The trench invert shall, at any location, be at the proper level and trench width of the proper dimensions to allow for sand and/or concrete bedding or surrounds as shown on the Drawings and directed by the Engineer. Where pipes are laid directly on the bottom of the trench, the latter shall be straight and even so as to provide a good support for the pipe over its entire

length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its coating.

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

The length of trench to be kept open at one time shall be determined by the Engineer and shall in no case be exceeded. Should there by any danger that trenches may erode, then sections shall be left unexcavated for as long as possible and the laying and backfilling of pipelines shall follow excavation as soon as possible.

The excavated material shall be placed alongside the trench in such a manner as not to interfere with the work and to prevent its falling into same.

Should any part of a trench be excavated, in error, deeper than required, the extra depth shall be filled up with concrete, solely at the Contractor's expense.

Trench formations shall be in undisturbed ground. Where in the opinion of the Engineer, the formation is unsuitable for bearing, extra excavation shall be carried out under the direction of the Engineer and the level made up again with sound soil material carefully compacted or with concrete. This work shall be paid for by the Employer provided that the unsuitability of the formation is not due to the method of working of the Contractor, in which case the Contractor shall carry out the work at his own expense.

Trench walls excavated in rock shall be as nearly vertical as possible, and the Contractor shall consolidate the walls wherever they have been loosened by blasting or other reasons, and shall remove all loosened material. If rock occurs at a level higher than the required level of the trench bottom, the clearance between the pipe and the trench sides and bottom shall, where in rock, be made to the dimensions shown on the Drawings or directed by the Engineer, to allow for sand or concrete bedding or surround.

In confined areas, where the passage of excavating equipment is impossible, or where the Engineer's Representative deems the use of such equipment impracticable or undesirable for any reason whatsoever, trench excavation shall be done by hand. All requirements specified above shall apply to trench excavation by hand. No extra payment shall be made for works in confined areas. All excavation, whether in confined or unconfined areas, shall be paid for at uniform rates as specified hereafter.

If, in the opinion of the Engineer, there is undue delay in testing the pipelines; removing surplus material; general tidying up of areas where pipes have been laid; partial restoration of maintenance of surfaces; or similar operations, then the Engineer may order that no further

trenches shall be opened until the outstanding work has been carried out to his satisfaction and the Contractor shall have no ground for a claim against the Employer on this account.

No work will be started on the laying of pipes or bedding in any section of trench, until the trench formation of that particular section has been approved by the Engineer.

Once the pipeline section has been tested and the bedding and surround approved by the Engineer, the trenches shall be backfilled by layers as specified hereafter. Each layer shall be separately compacted and any subsidence resulting from insufficient compaction shall be the Contractor's liability and he shall forthwith add the necessary extra material which shall then be thoroughly compacted.

Unless otherwise specified, items for trench excavation shall apply to all kinds of soil, including rock, and the excavation will be measured for payment in linear metres measured along the centreline of the pipeline, classified by pipe diameter and for each section by average depth to invert of pipes. The average depth of a section shall be the average between adjacent manholes or as directed by the Engineer's Representative. The cost of trench excavation shall be deemed to include for excavation, drilling and blasting, to the required width and depth to underside of pipe barrel, finishing the trench bottom as specified, digging boreholes where required, removing excavated material and storing it alongside the trench for backfilling whenever permitted, removal of material that may result from land slides, removal of loosened earth or rock, removal and disposal of all excess spoil to any distance, timbering and dewatering as and where required if no specific items have been provided in the Bill of Quantities.

201.3.3 General Backfill

The excavated material or selected material which can be classified as suitable for backfilling shall be in accordance with the requirements of Section 201.5.

Where necessary, excavated material shall be sieved or sorted to remove large stones, rocks, or other particles which, in the opinion of the Engineer's Representative, may impede compaction.

201.3.4 Type A Fill

Type A fill shall be good hard well graded material screened and crushed as necessary to lie within the grading envelope given in Table 1.1. The material shall have a CBR greater than 25%.

The liquid limit should not be more than 25% and the plasticity index should not exceed 6%.

The minimum value of the sand equivalent should be 50%. The maximum value of abrasion test should be 40%.

Table 1.1: Grading Envelope for Type A Fill

Sieve Size	% by Mass Passing
75 mm	100
37.5 mm	85 - 100
10 mm	45 - 100
5 mm	20 - 65
600 microns	8 - 45
75 microns	0 -20

201.3.5 Type B Fill

Type B fill shall be clean hard fill free from deleterious material and free from stones greater than 150mm in size. The material shall have a CBR greater than 15%. The liquid limit should not be more than 40% and the plasticity index should not exceed 10%.

201.3.6 Hardcore

Hardcore shall consist of broken stone or other suitable hard material. It shall be free from clay, dust or other deleterious matter, shall not contain pieces exceeding 100mm and not more than 5% of the material shall pass through a 20mm sieve.

201.3.7 Beddings and Surrounds - Sand and Granular Material

(a) Sand Bedding and Surrounds for Concrete, A.C. and Metal Pipes -

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

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

Sand beddings and surrounds at any depth shall be measured in linear metres of trench in which surround has been placed, classified by diameter of pipe. The unit rates inserted in the Bill of Quantities for surrounds shall include the additional excavation in trench bottom, supplying the necessary materials, spreading, levelling and compacting the materials.

(b) Granular Material Beddings and Surrounds for P.V.C. and G.R.P. Pipes

All P.V.C. and G.R.P. pipes shall be laid in suitable granular material bedding or surround. Suitable bedding and surround material shall be broken stone or gravel from 3/8" (9.5 mm) to 3/16" (4.8 mm) size, sand (as specified in Section 201.3.7(a)) or other material having a compaction factor not exceeding 0.1. The compaction factor shall be obtained by the following test:

Equipment

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

Method

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

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

Measure from the top of the cylinder to the surface of the compacted material. This distance divided by the height of the cylinder (255 mm) is referred to as the Compaction Factor.

Interpretation of Values

Compaction Factor	Suitability for Use
0.1 or less	Material suitable
Over 0.1	Material unsuitable

For each batch of material, three (3) Compaction Factor tests shall be made and the average value used. Material sufficient for the surround of two hundred linear metres of pipe shall be considered to comprise one batch.

The granular material bedding and surround shall be wetted and thoroughly hand-tamped in layers not exceeding 15 cm in thickness after compaction. Special care shall be taken to obtain proper compaction under and around the pipe.

Granular material beddings and surrounds for pipes, at any depth, shall be measured for payment in linear metres of pipe, classified by diameter. The rates shall include additional excavation in trench bottom, supplying the necessary material, spreading, levelling, compacting and carrying out Compaction Factor tests.

201.3.8 Beddings and Surrounds - Concrete

Where required, pipes shall be bedded on or surrounded by concrete, to the dimensions, lines and levels shown on the Drawings or determined by the Engineer. All concrete used for bedding and surround of pipelines shall comply, in all respects, with the provisions of Division 202 hereafter. Plain concrete and reinforced concrete shall be of Grade C20P.

Pipes shall be supported and jointed at the correct level, clear of the trench bottom upon two blocks of precast concrete of suitable height, each supporting one end of the pipe. Concrete shall then be poured and rammed beneath and around the pipes in one operation and finished off to the level and dimensions shown on the drawings.

The precast blocks shall first be properly set on the trench bottom and boned to the correct position and level. The pipes shall then be laid on the blocks and properly centred, socketed and finally brought to the correct gradient by the application of wooden wedges one on each side of the pipe and between the pipe and the concrete blocks. These wedges shall remain left-in whilst the pipes are jointed and tested, as herein specified and during the pouring of the concrete beneath and around the pipes. Where the concrete while being poured would otherwise cause the pipes to float, pipes shall be effectively anchored to prevent such flotation.

The Contractor may, according to his own choice, pour concrete either with or without forms. Whatever the Contractor chooses; the concrete for payments shall be measured as per

Drawings and no extras shall be paid for dimensions in excess of those required according to the Drawings.

Concrete beddings and surrounds shall be measured for payment in linear metres, classified according to diameter of pipe and according to type of bedding and surround. The rates shall be valid for any depth and shall include all additional excavation in trench bottom, concrete, reinforcement, formwork, materials, labour, etc.

201.3.9 Backfilling of Pipe Trenches

Backfilling of pipe trenches (except at joints) shall be done as soon as practicable after the pipes have been satisfactorily laid in position and jointed and in no case shall more than five pipe lengths be left uncovered after laying. Where shown on Drawings, the first stage of the backfill, up to 30 cm above the crown of the pipe, shall consist of selected material. Selected material shall be granular, free from stones, rubbish, clay and organic matter. It shall be free-draining and readily compactable. This backfill shall be spread in layers not exceeding 15 cm in thickness after compaction, and compacted at least to 92% of modified A.A.S.H.T.O. density as defined in Part 2 Section 201.7.

The remainder of the pipe trench (from 30 cm above the crown of the pipe to the sub-base coarse of the road or to the top of the trench) shall be backfilled, after the completion of testing, by one of the following methods:

(a) Where the pipeline crosses or runs underneath roads or pavements, backfilling shall be of type B, type A will be used when directed by the Engineer or shown on the Drawings, and shall be placed in layers not exceeding 15 cm after compaction, wetted as necessary and compacted at least 90% of modified A.A.S.H.T.O. and the last 60 cm below the road sub-base course shall be compacted at least 95% of modified A.A.S.H.T.O. density as defined in Section 201.7.

(b) In open areas, where the requirements of para. (a) do not apply, the second stage backfill may be done with excavated material dumped into the trench by means of a bulldozer or similar equipment, provided that the fill material does not contain any large stones, that the trench is completely filled without leaving any voids, and the fill is finished with a neat mound raised to about 30 cm above the trench edges to allow for future subsidence.

All joints and other accessories shall be left uncovered until after the pipeline shall have passed any pressure or leakage tests that may be prescribed by the Specification.

Where the backfill cover over the pipes is less than 70 cm, the travel of the tracks or wheels of heavy equipment thereon will be strictly prohibited, and the Contractor shall use suitable small compactor, and shall be responsible for any damage caused to the pipe by non-compliance with this requirement.

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

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

The Contractor shall make arrangements for sites for tipping the spoil and shall include in his rates for excavation the cost of haulage and tipping of spoil and all expenses in connection with the obtaining of suitable backfilling material.

Backfilling of pipe trenches will be measured for payment in linear metres along the centreline of the pipeline, classified by pipe diameter and for each section by average depth to the top of surrounds material which is placed to 30 cm above the top of the pipe. The average depth of a section shall be the average between adjacent manholes in case of gravity pipelines, and the average between adjacent stations in case of pressure pipelines. The cost of trench backfilling shall be deemed to include supplying of material and compaction in layers not exceeding 15 cm after compaction.

201.3.10 Cased Borings

Where shown on the Drawings or instructed by the Engineer, pipes shall be installed in casings inserted into horizontal borings across embankments at existing installations or in road crossings. The casing pipe shall be of sufficient strength to withstand the forces acting on it during insertion in the bore and the external pressure of the earth, and shall have a nominal diameter as shown on Drawings but at least 6" larger than that of the line pipe. Where the soil is sufficiently cohesive and stable, the casing may be pushed into a bore previously drilled through the embankment to a diameter slightly larger (by 2-3 cm) than the external diameter of the casing. Where the nature of the soil does not permit such a procedure, the casing shall be jacked through the embankment or under the road with simultaneous drilling and removing the material from the interior of the casing pipe. In both cases, the casing pipe may be inserted in successive sections welded to each other as the work proceeds. The Contractor shall choose the most suitable and efficient method for drilling and casing and shall submit the procedure proposed by him for the Engineer's approval. Drilling and casing shall be done at the exact locations and to the lines and grades shown on the drawings or determined by the Engineer. After the casing has been installed in position and approved by the Engineer, the line pipe shall be installed therein. To protect the line pipe and especially its coating against abrasion and other injury or damage during installation and thereafter, the Contractor shall use specially designed spacers of timber or plastic or shall produce such spacers. The distances between spacers of either kind shall not exceed 3.00 m. After the line pipe has been installed in its final position, the annular space at each end of the casing shall be filled with a mixture of bitumen and sand to seal off the interior of the casing against the entry of water, mud, small animals,

vermin and other foreign bodies.

Cased borings shall be measured, separately for each diameter of casing, in linear metres by the actual length of cased boring through embankment as approved by the Engineer.

The unit rates for cased borings shall include: open-cut excavation and preparation of work area at both ends of boring, drilling through embankment, supply of casing pipe, welding of casing pipe sections, inserting of casing pipe in bore, installation line pipe in casings, supply and placing of spacers and sealing of openings at the ends, supply, transport and removal from Site of boring equipment and backfill of open-cut excavation connected with boring.

201.3.11 Road Reinstatement

a) Cutting into Paved Areas

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

MAXIMUM WIDTH OF THE TRENCHES AT THE TOP IN PAVED AREAS (IN m)

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

(*)O.D = Outer diameter of pipe barrel.

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

Cutting into paved areas will be measured for payment in linear metres of cut pavement.

b) Reinstatement of Surfaces

All surfaces whether public or private which are affected by the Works shall be reinstated in two stages, the first stage shall be carried-out in the first instance, and when the ground has consolidated fully the Contractor shall proceed with the second stage at the order of the Engineer.

First stage and second stage reinstatement of all surfaces, affected by the operations of the Contractor shall be carried out and maintained to the satisfaction of the Engineer and the responsible authority or owner.

First stage reinstatement shall be carried out immediately the trenches are backfilled.

Second stage reinstatement shall not be carried out until the ground has consolidated completely. The Contractor shall inform the Engineer before carrying out this work. In the event of further settlement occurring after the completion of the second stage reinstatement the Contractor shall forthwith make good the reinstatement to the approval of the Engineer or responsible authority.

For the purposes of first and second stage reinstatement in bitumen and surfaced roads the surface width of trenches shall be increased by recutting 15cm on each side of the trench for a depth of 8 cm to provide a solid abutment for the surfacing material.

Reinstatement of surfaced roads shall be carried out to the approval of the relevant authority.

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

Trenches in open ground shall be reinstated to the condition in which the ground was before excavation was commenced. The final surface of the trench shall be flush with the surrounding ground.

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

If at any time any reinstatement deteriorates the Contractor, shall restore it to a proper condition immediately.

Should the Contractor not remedy the defect to the Engineer's satisfaction forthwith any remedial work considered necessary may be undertaken by the Employer and/or the responsible authority at the Contractor's expense.

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

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

The trenches shall be refilled and rammed solid as specified in the Contract and shall not be topped up above the original surface level to allow for settlement.

If any trench becomes dangerous the Engineer may call upon the Contractor for its reinstatement at three hours' notice and failing this to have the work done by others at the Contractor's expense.

c) Safety of Excavation in Roads

Where the surface of the road (other than that which lies immediately above the trench) is damaged either by the concentration of traffic caused by an open trench, by subsidence or other causes arising from the operations of the Contractor, he shall permanently reinstate the whole of the surface so damaged to its original condition.

The Contractor shall ensure that trenches and reinstatement are maintained in a safe condition and shall take immediate action to remedy any deterioration which renders the works unsafe. If in the opinion of the Engineer any excavation or reinstatement is in a dangerous condition the Contractor shall immediately remedy the defect. Should the Contractor fail to carry at the reinstatement promptly the work may be carried out by others at the Contractor's expense.

d) First Stage Reinstatement

In all paved roads the trenches shall be refilled and compacted to the underside of the sub-base layer of the road at 48 cm below the road finished level.

A sub-base layer of 20 cm thick shall then be laid consisting of approved free draining granular material conforming to section 218.1.3 requirements.

A base layer of 20 cm thick shall then be laid consisting of approved crushed limestone material conforming to section 218.1.3 requirements.

Prior to application of the first stage reinstatement the surface of the road foundation shall be cleared of all dust, debris and other deleterious matter and shall then be primed with one application of prime coat MC-70 or similar approved. All joints with adjacent road surfacing shall be cut straight and vertical and primed.

The road surfacing of the first stage consists of 5 cm thick of finished asphalted concrete layer.

The surface shall be maintained with the end of the period of Maintenance or until instructions are given for the final reinstatement to be carried out.

f) Reinstatement of unmade roads

In all unmade roads the trenches shall be refilled and compacted as specified in the Contract to within 15 cm of the surface.

The trench shall be surfaced with 15 cm compacted thickness of base layer material as specified above.

The surface shall be maintained until the end of the Period of Maintenance and shall not be topped up above the level of the original surface to allow for settlement.

e) Second Stage Reinstatement

Second and final reinstatement consists of a wearing course of 4 cm compacted thickness of 14 mm nominal size dense wearing course macadam. The laying and finishing of the coated macadam shall be carried out so as to achieve a dense, smooth and even surface using a roller of not less than 12 tonnes mass.

201.4 EXCAVATION FOR PONDS AND CANALS

Excavation for ponds and canals shall be carried out and finished to the lines, grades and dimensions shown on the Drawings and to the tolerances specified hereafter.

Excavated material shall be used for earthfill in embankments and in other locations, as shown on Drawings, except for material rejected by the Engineer as unsuitable, which shall be run to spoil. Under this Section, suitable material shall be excavated, moved to fill areas, dumped and spread, as specified. The Engineer shall be entitled to designate the earthfill where individual loads of material shall be deposited.

The Contractor shall take all necessary precautions to prevent excavation beyond and below the lines and levels indicated on Drawings. Any damage to the work due to the Contractor's

operations, including shattering of the material beyond the required depths and lines, shall be made good by the Contractor at his own expense. Any and all excess excavation for the

convenience of the Contractor or any overexcavation performed by the Contractor for any purpose or reason, except as may be directed by the Engineer in writing, shall be at the expense of the Contractor. Where required to complete the work, all excess excavation and overexcavation shall be refilled, consolidated and made good with materials provided by the Contractor at his own expense, as directed by the Engineer's Representative.

Unless otherwise specified, items for excavation for ponds and canals shall equally apply to all kinds of soil, including rock, and excavation shall be measured by cubic metres of excavated material, to the lines and levels shown on the Drawings or as directed by the Engineer. The unit rate shall include for excavation, drilling and blasting, stacking, hauling excavated material in fill areas, and disposal of spoil material, all as specified in this Section.

201.5 EXCAVATION AND BACKFILL FOR STRUCTURES

All excavation for structures shall be carried out to the dimensions, lines and grades shown on the Drawings or directed by the Engineer.

Excavations on or against which concrete or compacted fill is to be placed, shall be clean and free from stones, clods, debris and other loose material. Where the bottom of an excavation does not provide a solid basis for casting concrete, it shall be consolidated by tamping and/or watering as necessary until the required density is obtained.

Any overexcavation in the bottom of the structure shall be cleaned and backfilled with concrete or selected backfill compacted to the density of the adjacent natural soil. Overexcavation in rock shall be backfilled with the concrete of the structure or with dry stone pack, as directed by the Engineer. Any and all excess excavation for the convenience of the Contractor for any purpose or reason, except as may be directed by the Engineer in writing, and all refilling of such overexcavation as specified, shall be at the expense of the Contractor.

Where possible, concrete foundations and blocks shall be cast against the undisturbed sides of the excavation. Where overexcavation beyond the lines of the structure is unavoidable due to the nature of the ground, because of the shape of the structure or for any other reason, the space between the structure and the faces of the excavation shall be backfilled to the original ground level (whether natural or reduced) as specified hereafter for backfilling.

Excavated material, to the extent that it is required and suitable, shall be put aside for use in backfill. Surplus excavated material shall be either used for backfill in other locations on the site, or shall be otherwise disposed. Wherever required, the Contractor shall obtain suitable material for compacted backfill from borrow areas.

Backfill shall be carried out to the lines and grades shown on the Drawings. The backfill material shall be placed in horizontal layers not exceeding 15 cm in thickness after compaction. The backfill material shall completely and firmly fill the spaces between the excavation lines and the structure without leaving any voids, and shall be compacted to the density of the adjacent natural earth. The sides and bottom of the excavation shall be moistened before

backfilling and so shall the backfill material, in order to obtain the moisture content necessary for the required compaction. Every layer shall be compacted by pneumatic tampers approved by the Engineer.

Unless otherwise specified, items for excavation and backfill for structures shall equally apply

to all kinds of soil, including rock.

Excavation shall be measured by cubic metres to the neat lines and dimensions of the structures, as shown on the Drawings or described in the Specification, with no allowance whatsoever so actual side-slopes, working space, etc. The unit rates for excavation shall include for excavation, drilling and blasting, stacking, hauling of excavated material to any distance, spreading and compacting and running surplus to spoil.

Backfill will be measured for payment by cubic metres, and the unit rates for backfill shall include for supplying of material, spreading and compaction of material in layers not exceeding 15 cm after compaction.

201.6 EXCAVATION FROM BORROW AREAS

Wherever required or directed by the Engineer, the Contractor shall obtain suitable material for compacted fill from borrow areas. Such suitable borrow material shall be excavated, moved to fill areas and spared as specified. The locations and boundaries of the borrow areas as well as the depths and slopes of excavation therein shall be as determined or approved by the Engineer's Representative. Before commencing to extract filling material from any borrow area, the Contractor shall strip its surface as specified in Sub-Section 201.2.3 above and shall also remove therefrom all material which is, in the Engineer's opinion, unsuitable for filling. The surface of the borrow shall be left in a reasonably smooth and even condition, as approved by the Engineer's Representative.

No excess borrow material shall be brought to fill areas. Unnecessary material shall be rejected and dumped and shall not be measured for payment.

Measurement for payment of excavation in borrow areas shall be made only for excavation of borrow material actually used as fill, to the lines and dimensions prescribed by the Engineer's Representative. Measurement shall be by cubic metres and the unit rate shall include for stripping (which shall not be measured and paid for) and for removing unsuitable material, hauling to fill areas at any distance. All materials from borrow pits placed in embankments and compacted backfill will again be included for payment under the applicable rates of the Bills of Quantities for compacting such earthwork. Provided always that the cost of borrowed material has not been specified to be included in those relevant pay items for which the same borrowed material is to be supplied.

201.7 EMBANKMENTS AND COMPACTED FILL

201.7.1 General

Wherever the term "embankment" is employed it shall also mean "compacted fill", unless the distinction between those two terms is clearly emphasized.

Embankments shall be constructed to the lines and grades shown on the Drawings. Where grassing is required, a compacted fill embankment shall be constructed up to the underside of the layer of top soil, as shown on the Drawings.

No brush, roots, sod, or other perishable or unsuitable materials shall be placed in the embankments. The suitability of each part of the foundation for placing embankment materials thereon and of all materials for use in embankment construction will be determined by the Engineer. The Contractor shall maintain the embankment in an approved manner until the final completion and handing over of all the Works.

The embankment operations shall be so conducted and the various soil strata shall be placed so as to produce a soil structure as shown on the typical cross sections, or as directed by the Engineer. The slopes of the division lines between zones and/or portions of the embankment are tentative and shall be subject to variation, at any time prior to or during construction, and the Contractor shall be entitled to no additional allowance above the unit rates in the Bill of Quantities, by reason of such variations. The embankment for each portion shall be maintained approximately level throughout the entire length of each layer from abutment to abutment. All openings through the embankment required for construction purposes shall be subject to approval, and such openings shall be constructed so that the slope of the bonding surface between embankment in place and embankment to be placed is not steeper than 1:4. The bonding surface of the embankment in place shall be prepared as provided for embankment foundations.

The Contractor shall be responsible for the stability of all embankments made under the contract and shall replace any portion which, in the opinion of the Engineer, has become displaced due to carelessness or negligence on the part of the Contractor.

Where excess spoil, or other material for which compaction is not specified, is dumped and spread, the Contractor shall route his equipment, both when loaded and when empty, to travel over the entire area of the above mentioned material. No payment will be made for this operation, and its cost shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities.

When the state of the weather is such that it would adversely affect the placing of fill, all embanking shall be stopped. In particular, embanking work will not be permitted during rain nor for such time afterwards as the Engineer may judge to be necessary to allow the upper layers in the embankment to dry to their correct moisture content as directed by the Engineer.

At all times during dry weather, whether embanking is taking place or not, the surface of the embankment is to be watered everywhere as directed by the Engineer, or protected to his satisfaction to prevent undue cracking of the surface. Watering is to be done by means of tankers, sprinklers or other methods approved by the Engineer.

Any material not complying with the specified density or moisture content shall be replaced in the embankment at the Contractor's own expense notwithstanding the fact that it may be overlaid by more recently placed material.

201.7.2 Preparation of Foundation

No material shall be placed in any section of the embankment until the foundation for that section has been suitably prepared and approved by the Engineer's Representative.

All excavation made for test pits or other subsurface investigations, and all other existing cavities found within the area to be covered with earthfill which extend below the established lines of excavations for the embankment foundations shall be filled with compacted earthfill. The foundation for earthfill, where in clayey soil, shall be scarified, wetted and compacted as specified for the earthfill to be placed thereon. Where the foundation is granular material it shall be compacted by vibrating rollers to a depth of not less than 30 cm to the same density as specified by the overlaying earthfill. Surfaces upon or against which the earthfill portions of the embankment are to be placed shall be cleaned of all loose and objectionable materials in an approved manner by hand-work or other effective means immediately prior to placing the first layer of earthfill. The surfaces of each portion of the foundation, immediately prior to placing the earthfill, shall have all water removed from depressions and shall be properly moistened and sufficiently clean to obtain a suitable bond with the earthfill. Where compaction of fill is to be started, or continued after the previous layer has been in place for over 6 hours, the area shall be harrowed to a depth of 20 cms, wetted and compacted to the required degree of compaction.

201.7.3 Compaction Control

Compaction shall be controlled by field density and field moisture tests, or by such other tests as prescribed by the Engineer.

The densities of the compacted earth materials shall be defined as follows:

(a) Modified A.A.S.H.T.O. Density shall mean the maximum dry density obtained from the compaction test in accordance with the A.A.S.H.T.O.-T-180-61 (method D) test or the (identical) A.S.T.M.-D-1557 (method D) test.

(b) Relative Density shall be defined by the following formula (in accordance with the U.S. Bureau of Reclamation Earth Manual Designation E-12):

$$D_d = \frac{Y_d \text{ max } (Y_d - Y_d \text{ min})}{Y_d (Y_d \text{ max} - Y_d \text{ min})} \times 100$$

where

D_d = Relative density
$Y_d$max = greatest dry density obtained by laboratory

$Y_d$min = least dry density obtained by laboratory
Y_d = the dry density at which the soil is to be placed or the inplace dry density

The field density of compacted material in place shall be determined by the A.A.S.H.T.O.-T-191-61 method or by the identical A.S.T.M.-D-1556-64 method. Field moisture content shall be determined by the A.S.T.M.-D-2216-63-T method.

Samples of all fill materials, both before and during placement, shall be taken for testing at frequent intervals. The following tests shall be performed:

(a) Tests to determine the maximum dry density and the optimum moisture content. The number of samples for these tests shall be as determined by the Engineer but not less than one sample per 1,000 m^3 of fill shall be taken.

(b) Field density tests. The number of samples for these tests shall be as determined by the Engineer, but not less than one sample per 1,000 m^3 of compacted fill or one sample per day, whichever is larger.

For the performance of all the above-mentioned tests, the Contractor shall provide a fully-equipped field laboratory and the necessary trained personnel for sampling and testing, all subject to the Engineer's prior approval. All costs for providing the field laboratory and the necessary personnel and for sampling, testing, transportation, etc., shall be deemed to be included by the Contractor in his unit rates for the various items of earthworks in the Bill of Quantities and shall not be paid for separately.

201.7.4 Placing and Compacting - General

Embankment materials shall be deposited in horizontal layers over the entire width of the embankment and compacted to the required densities as shown on the Drawings or as specified.

Embankments shall be formed of satisfactory materials. The thickness of each layer shall not exceed the thickness shown on the Drawings or as specified. In the construction of embankments, starting layers shall be placed in the deepest portion of the fill, and as placement progresses, layers shall be constructed approximately parallel to the finished grade line.

The material in the layers shall be brought to the optimum moisture content before rolling is started to obtain the prescribed compaction. Wetting or drying of the material and manipulation to secure a uniform moisture content throughout the layer shall be required. Should the material be too wet to permit proper compaction or rolling, all work on all portions of the embankments thus affected shall be delayed until the material has dried to the required moisture content. Sprinkling shall be done with sprinkling wagons, pressure distributors, or other approved equipment that will sufficiently distribute the water. Sufficient equipment to apply the required water shall be available at all times.

The optimum moisture content shall be determined by the Engineer and the actual content shall not vary from the required one by more than plus 4 or minus 2 percent. This optimum

moisture content, determined by the Engineer as required for compaction purposes, shall be uniform throughout each layer of the earth-fill prior to and during the compacting.

The distribution of materials shall be such that the compacted fill be homogeneous and free from lenses, pockets streaks or other imperfections.

The number of successive passes of the compacting equipment over each and every point in any layer shall be not less than six (6). The overlapping of two adjacent passes shall be not less than 30 cm. The Engineer's Representative shall have the right to test every layer. However, the Contractor shall not be permitted to start work on the successive layers without

the Engineer's Representative's permission, irrespective of whether tests have been made or not.

Where due to small width of required fill or any other reason, compaction of material in horizontal layers by sheeps foot rollers or pneumatic rollers will in the Engineer's opinion be impracticable, the Engineer may permit the use of other equipment and procedures such as compaction by mechanical tampers or spreading the material in small quantities in layers parallel to the slope and compacting same by cylindrical rollers applied along the slopes, or otherwise. Compaction shall be carried out to the Engineer's satisfaction and to the specified density.

After compaction has been completed as specified, all surfaces and slopes shall be trimmed and smoothed to accuracy specified hereafter. The cost of such trimming and smoothing shall be deemed to be included in the various rates for construction of embankments.

201.7.5 Compaction of Clayey and Silty Materials

Clayey and silty materials shall be deposited in horizontal layers of thickness not exceeding 15 cm, after compaction. The excavating and placing operations shall be such that the materials when compacted will be blended sufficiently to secure the best practicable degree of compaction, impermeability and stability. Prior to and during compaction, the materials shall have the optimum moisture content as determined by the Engineer, and the moisture content shall be uniform throughout each layer.

Insofar as practicable, as determined by the Engineer's Representative, moistering of the material shall be performed at the site of excavation, but if necessary shall be supplemented by sprinkling at the Site. Should the actual moisture content not be within the limits prescribed in Subsection 201.7.4 above, compacting operations shall not proceed until the layer has been brought to optimum moisture content, whether by wetting or scarifying and drying. No additional payment shall be made on account of any operation by the Contractor in drying or wetting the materials or on account of delays occasioned thereby.

When the filling material has been conditioned as specified, it shall be compacted by tamping with sheeps foot rollers having staggered and uniformly spaced knobs and of sufficient weight for proper compaction, by tyre rollers, by hand or power tampers, or by other compacting equipment approved by the Engineer. When tamping rollers are used, the tamping knobs and cleaner bars shall be properly maintained and the space between the tamping feet shall be kept

clear of anything which may impair the effectiveness of the roller. Unless otherwise specified, the dry density of the soil fraction in the compacted material shall not be less than 92 percent of the Modified A.A.S.H.T.O. Density as defined in Subsection 201.7.3 above.

201.7.6 Compaction of Cohesionless Free-Draining Materials

Cohesionless free-draining materials, such as sand and gravel, shall be deposited in horizontal layers of not more than 15 cm if compacted by tampers or rollers, not more than 30 cm if by treads of crawler-type tractors, surface vibrators or similar equipment and not more than the penetrating depth of the vibrator if compacted by internal vibrators.

Unless otherwise specified, the relative density of the compacted materials, as defined in Subsection 201.7.3 above, shall be not less than 70 percent.

201.7.7 Compaction of Intermediate Soil Types

Unless otherwise specified, in borderline cases between clayey and silty soils and those that fall under the definition of cohesionless free-draining materials, the density shall be either 92 percent of the Modified A.A.S.H.T.O. Density or 70 percent relative density, whichever value is the higher.

201.7.8 Pipelines and Structures in Embankments and in Compacted Fill

Where pipelines are to be laid in embankments or in compacted fill, the embankment or fill will first be constructed to the lines and levels shown on the Drawings, to a height of 1.5 m above the crown of the pipe or to the top of the embankment or fill. After the embankment or fill have been constructed to the height specified above, the Contractor shall excavate in the compacted fill a trench to the Typical Trench Cross Sections; shall lay, joint, etc., the pipes in it; shall backfill the trench, as specified, to the top of the embankment and shall complete all other operations of constructing and covering the pipeline. After all the above operations have been completed, the Contractor shall resume, where necessary, the construction of the embankment or fill and its compaction.

Where steel pipes are to be laid in compacted embankments, the work shall be carried out as specified above, except that the embankment shall be completed to a level of 50 cm above the crown of the pipes.

Where structures, such as manholes, chambers, channels, etc., are to be constructed in compacted embankments or fill, the embankment or fill will first be completed to the lines and levels shown on the Drawings. The required excavation for the structures shall then be made and the structures constructed in it. After the completion and testing of such structures, the excavation shall be backfilled and compacted to the specified density.

201.7.9 Methods of Measurement and Payment

The supply of fill material, including its hauling and spreading and running of surplus to spoil, shall not be paid for separately and shall be deemed to be included in the relevant pay items for excavation, whether from borrow areas or form excavations for pipelines, structures, etc.

Compaction of Embankments shall be paid for separately and measured by cubic metres of the volume of compacted fill in place. No payment shall be made for additional material required to be added due to Settlement, and the Contractor shall make due allowance for this in his rates. The unit rate shall include wetting and compacting and the performance of all field and laboratory tests as specified. The unit rate shall also cover all additional costs of scarifying, harrowing, etc., where and when needed and trimming and smoothing of surfaces.

No additional payment shall be made in case of stockpiling of excavated materials and later rehandling of such material if directed by the Engineer in order to produce the specified embankment structure and the cost thereof shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

201.8 TOLERANCES OF FINISHED EARTHWORKS

All earthworks shall be finished to the dimensions and elevations shown on the Drawings. Unless otherwise specified, the following variations shall be acceptable:

(a) Embankment width - not more than 20 cm over the specified widths and not more than 10 cm less than the specified widths. Embankment elevations - not more than 5 cm.

(b) Elevations of bottoms of ponds - no more than 5 cm.

(c) Channel invert elevations - not more than 3 cm, provided a continuous slope is maintained in the direction of flow so as to prevent the formation of puddles on bottom of channel.

(d) Irregularities in surfaces of all earthworks - not more than 1.5 cm when checked by a straight edge.

201.9 SOIL INVESTIGATIONS

The Contractor shall carry out soil investigations according to BS 1377 (Methods of test for soil for civil engineering purposes) at the stations, buildings, reservoirs and water towers construction site, whenever he is requested to do so by the Contract and as directed by the Engineer's Representative. These investigations shall comprise various boreholes (according to the nature of the soil) as well as reports determining the specifications of the layers, the bearing capacity of the soil, the nature of foundations and the retaining structures if needed.

201.9.1 Borings

According to the nature of the soil or rocks, one of the three following borings shall be carried out:

a) Alluvial soils

(loose soils or slightly to fairly consistent)

Borings shall be:

- Either, penetrometric borings performed by a penetrometer ≥ 100 KN, static-dynamic with a measurement of the cone resistance and the lateral friction.
- or, core-borings ∅ ≥ 76 mm performed with core samplings and in-situ-SPT. The number of borings is conditional upon the area of the structures, and shall be carried out at the rate of one boring for every 200 m^2, with a minimum of two borings. Depths shall be conditional upon the nature of the soil and the loads, and shall be fixed according to each site but shall not, in principle, exceed 15m.

In case underground water was found at a slight depth, a piezometer shall be installed. Moreover, in some cases, a trench shall be dug with a mechanical shovel down to 1 to 2 m beneath the aquifer and a permeability test performed by pumping shall be carried out (watertable drawdown and recovery).

b) Calcarous rocks

Destructive soil investigation shall be carried out with a measurement of the rate of drilling progress and the pressure exerted on the bit. These borings aim at locating the fractures and fissures in rocks, since these fissures and not the hardness of the rocky matrix limit the bearing capacity of the foundations. Borings shall reach 5 m beneath the level of the foundation.

The number of borings shall be conditional upon the surface of the structures and shall be carried out at the rate of one boring every 100m^2, with a minimum of five borings. In case borings show cavities or considerable cracks, supplementary and closely distributed borings shall be carried out after the beginning of earthworks.

In case groundwater was found, a piezometer shall be installed.

c) Extremely consolidated soils or very soft rocks (Sandstone, marl, clay)

Continuous core samplings shall be performed with a double core-driller. The diameters of borings shall be 76mm as a minimum.

A representative sample of each layer and boring shall be taken from the core-samples and shall undergo unconfined compression tests. Some samples shall eventually undergo free swelling tests.

The number of borings shall be conditional upon the surface of the structures, and shall be carried out at the rate of one boring every 200 m^2, with a minimum of two borings.

The depths shall be conditional upon the nature of the soil and the loads, and shall be fixed according to each site, but shall not in principle, exceed 15m.

In case underground water was found, a piezometer shall be installed.

201.9.2 Report

After carrying out borings and taking measurements, a report shall be drawn. It shall treat of the following issues:

- Opening and stability of excavations and the drainage methods.
- Treatment of the foundations soil, if need be.
- The permissible constraint exerted on the soil, in terms of the nature of foundations and differential settlements.
- Special recommendations concerning problems such as drainage, etc...

201.9.3 Methods of Measurement and Payment

The soil investigation shall be measured for payment by linear metre of borehole depth, the unit rate shall include mobilisation and demobilisation of equipment, labor, boreholes, tests, report, etc...

202 CONCRETE WORKS

202.1 STANDARDS, GRADES, COMPOSITION AND TYPES

202.1.1 General

This division describes the quality of materials and workmanship of concrete and reinforced concrete works cast in situ in all parts of structures below or above ground in all site locations.

The Specification shall apply to concrete prepared on site as well as ready mixed concrete and small precast concrete elements. Generally, it is based on CP 110 Part I 1972 and on BS 4881, 5328 and 5337.

In case of discrepancy or contradiction, the requirements of this Specification shall rule over any standard.

202.1.2 Standards and Codes

The current ruling Standards and Codes of Practice, detailed below, are made by reference part of this Specification.

BS	12	Portland Cement (ordinary and rapid hardening)
BS	146	Portland - Blastfurnace Cement
BS	410, 1796	Test Sieves and Test Sieving
BS	882, 1201	Aggregates from Natural Sources
BS	1305	Batch Type Concrete Mixers
BS	1370	Low Heat Portland Cement
BS	1881	Methods of Testing Concrete
BS	1926	Ready-Mixed Concrete
BS	3148	Tests for Water for Making Concrete
	4027	Sulphate Resisting Portland Cement
BS	4251	Truck Type Concrete Mixers
BS	4449	Hot Rolled Steel Bars for the Reinforcement of Concrete
BS	4461	Cold Worked Steel Bars for the Reinforcement of Concrete
BS	4466	Bending Dimensions and Scheduling of Bars for the Reinforcement of Concrete (Plain round mild steel or high yield steel)
BS	4482	Hard Drawn Mild Steel Wire for the Reinforcement of Concrete
BS	4483	Steel Fabric for the Reinforcement of Concrete
BS	5075	Concrete Admixtures
BS	5135	Metal Arc Welding of Carbon and Carbon-Manganese Steels
BS	5328	Methods for Specifying Concrete Part 1 to Part 4
PD	6440	Accuracy in Building
BS	6588	Portland Pulverised - Fuel Ash cement
BS	8007	Design of Concrete Structures for Retaining Aqueous Liquids
BS	8102	Protection of Structures against Water from the Ground
BS	8110	CP 110 Part 1 and Part 2

	Structural use of Concrete
ASTM Standard C309	Liquid Membrane Forming Compound for Curing Concrete
ASTM Standard C260	Air Entraining Admixtures for Concrete

In case of discrepancy or contradiction, the requirements of this Specification shall overrule any standard.

202.1.3 Classification and Composition

Concrete of all grades shall consist of coarse and fine aggregate, cement, water and additives. Generally, the grades of concrete shall be detailed as described in the following table. However, other grades may be required in the Particular Specification.

Table 2.1 Concrete grades and Classifications

Grade/Class of Concrete Per B.S. 5328	Characteristic Compressive Strength (Kg/cm^2)	Minimum Cement Content (Kg per m^3) of Ready Concrete	Characteristic Use
C 7P	70	150	Lean Concrete
C10P	100	200	Non-Reinforced
C15P	150	200	Concrete
C20P	200	280	
C25P	250	280	Reinforced
C30P	300	280	Concrete
C40P	400	300*	Prestressed
C50P	500	300*	Concrete and
C60P	600	300*	Concrete for Special Purposes

* For prestressed concrete the following maximum cement contents shall not be exceeded:

Grade C40P - 375 kg per 1.0 m^3
Grade C50P, C60P - 450 kg per 1.0 m^3

The relationship between grade of the concrete and its characteristic strength shall be as given in BS 5328. The grade of concrete to be used in particular locations shall be as given in Table 2.2 unless noted otherwise on the Drawings.

Table 2.2 Concrete strength requirements

Location	Maximum Coarse Aggregate Size (mm)	Grade of Concrete (BS 5328)
Blinding Concrete - General Structures - Liquid Structures	 20 or 40 20	 C15P C20P
Blinding concrete - Sulphate Condition	 20	 C25P
Substructures thickness less than 400 mm	20	C25D
Substructures, walls and slabs more than 400 mm	20	C25D
Superstructures normal concrete	20	C25D
Liquid retaining structures	20	C35D
Fine concrete	10	C25D
Precast concrete	10 or 20	C30D

In the above table suffix P means a prescribed mix, D means a designed mix and A means a design mix complying with the requirements of BS 8007.

The specific grades of concrete to be employed in the different structures or parts of structures shall be as shown on the Drawings or indicated in the Specification Bill of Quantities. The quantity of cement in the ready concrete shall in no case be less than the minimum quantities detailed in the above table.

The Contractor shall have trial mixes for the various structures designed by an approved laboratory. The mixes shall be designed with the objective of producing concrete having suitable workability, density, impermeability and required strength.

Proportions shall be determined in accordance with the "Design of Normal Concrete Mixes" published by the United Kingdom Department of The Environment and obtainable from:

Building Research Establishment and Bookshop
Garston
Watford
WD2 7JR
ENGLAND

or other approved methods, for the requirements set out in this Specifications.

The amount of water used in the concrete shall be changed as required to secure concrete of the proper consistency and to adjust for any variation in the moisture content or grading of the aggregates as they enter the mixer. Addition of water to compensate for stiffening of the concrete before placing will not be permitted. The mix to be used in every part of the Work shall be subject to the Engineer's approval and the Engineer shall have the right to demand the mix proportions and water-cement ratio to be changed during the progress of the work if in his

opinion such changes shall be necessary to secure the required quality of the concrete as detailed above.

The mix proportions shall be selected to ensure that the workability of the fresh concrete is suitable for the conditions of handling and placing, having regard to the structural element being constructed, the disposition of reinforcement, and taking full account of the environment to which it will be subjected.

The minimum cement contents and maximum water/cement ratios of designed mixes shall be as given in Table 2.3. In the event of sulphate exposure precautions requiring lower cement content than those required for normal conditions the latter requirements shall prevail.

Table 2.3 Minimum cement contents
Normal Conditions

Type of Structural Element	Exposure Conditions (BS 8110)	Minimum Cement Content (kg/m^3) Maximum Aggregate Six			Maximum Water/Cement Ratio
		40 mm	20 mm	10 mm	
Liquid Retaining Structures, Shafts and Tunnel Linings	Severe	295	325	356	0.55
All Foundations and Buried Structures	Moderate	270	300	340	0.60
Building Super-Structure	Moderate	270	300	340	0.60

Additional requirements when exposed to sulphate conditions (all structural concrete)

Concentration of Sulphates		Type of Cement	Minimum Cement Content (kg/m3) Maximum Aggregate Size			Maximum Water/Cement Ratio
In Soil (Total SO_3)	In Ground Water Parts per 100,000		40mm	20mm	10mm	
< 0.2	< 30	OPC	NORMAL CONDITIONS			
0.2 - 0.5	30 - 120	OPC SRPC	300 250	330 280	370 320	0.50 0.55
0.5 - 1.0	120 - 250	OPC SRPC	Not Permitted 300	330	370	- 0.50
1.0 - 2.0	250 - 500	OPC SRPC	Not Permitted 340	370	410	- 0.45
> 2.0	> 500	SRPC	Ditto but with protective coating			0.45

202.1.4 Types of Concrete

a) Ready-Mixed Concrete

The use of ready-mixed concrete will be permitted provided the production, transportation, sampling and testing of the ready-mixed concrete shall conform to the requirements of B.S. 1926 and that the concrete meets the requirements of this Specification as to strength, cement content, impermeability and other properties. The methods and equipment used and the speed required for transporting concrete shall be such that concrete having the required composition

and consistency will be delivered into the work, without objectionable segregation, loss of slump, and delay.

The Contractor shall notify the Engineer of the supplier from whom he intends to purchase the ready-mixed concrete and shall obtain the Engineer's approval in writing of such supplier. Prior to the commencement of concrete production, the Engineer shall be given notice to enable him to check the composition and cement content of the concrete about to be produced at the supplier's plant. However, the Engineer's approval of the supplier and his inspection of the concrete production shall not relieve the Contractor of his sole responsibility for the quality concrete, and the Contractor shall make good any damage and shall indemnify the Employer against losses caused by concrete not meeting the requirements of the Specification. The Engineer may at any time and at his own discretion prohibit the use of any ready-mixed concrete which in his opinion does not meet the requirements of the Specification, and in such an event the Contractor shall discontinue the use of such ready-mixed concrete and shall at no extra cost to the Employer supply concrete mixed on the site, or ready-mixed concrete from another source meeting the Engineer's approval.

b) Lean, Blinding and Cyclopean concrete

Concrete shall be proportioned to 200 kg of cement per 1 m^3.

Stones for cyclopean concrete shall be wetted and cleaned from any deleterious matter prior to batching. Stones with a maximum size of 20 cm and covered with concrete shall be added to fresh concrete.

The proportion of concrete shall not be less than 60% of the total volume. Stones shall not be in contact with one another, nor with the formworks or trenches sides. The minimum distance between two stones or between one stone and the side of the formwork is 5 cm. Aggregates shall not form honeycombing in the surface of concrete. Should such defect be found after the removal of formworks, the concerned parts shall be demolished and cast anew at the expense of the Contractor. Cyclopean concrete surfaces shall be thoroughly finished. The location of these types of concrete shall be indicated on the drawings. In all cases the Engineer must give his written approval for concreting.

c) Porous Concrete

Porous concrete is made of single-core coarse aggregates and practically no-fines. It produces a low slump and has a low water/cement ratio; just enough cement is used to bind the aggregates into a mass resembling popcorn. The ratio of aggregate to cement shall be 8:1 by volume or 10:1 by mass.

It is characterized by 20% to 35% of voids, and a high permeability allowing a free water flow.

Porous concrete will be used in hydraulic structures where drainage is desired. It is also used to allow the recharge of groundwater by water penetration through concrete.
To maintain the required permeability properties, concrete surfaces should not be stopped nor sealed. No finishing work even with a trowel shall be required. The compressive strength of the various mix proportions vary from 3.5 to 27.5 Mpa. Drainage velocity ranges between 100 and 900 liters/mn/m^2.

The concrete shall be mixed by machine or by hand to a uniform color and consistency before placing. The quantity of water used shall not exceed that required to coat all of the aggregate particles without forming excess grout.

d) Shotcrete concrete

Shotcrete concrete shall be mortar or concrete conveyed through a hose and pneumatically applied using either the dry mix process or the wet mix process.

The dry mix process shall consist of thoroughly mixing a proportional combination of dry fine aggregate and portland cement; conveying the mixture through a delivery hose to a special nozzle where water is added and mixed with the other materials immediately prior to its discharge from the nozzle. The wet mix process shall consist of premixing by mechanical methods a proportional combination of portland cement, aggregate, and water required to produce mortar or concrete; conveying the mortar or concrete through the delivery hose to the special nozzle where additional compressed air is added at the nozzle prior to discharge.

Shotcrete proportions shall be selected that allow suitable placement procedures using the delivery equipment selected and shall result in finished in place hardened shotcrete meeting the required strength.

The surfaces on which shotcrete is to be placed shall be finely graded to the lines and grades shown on the drawings. The surfaces shall be thoroughly compacted and shall be uniformly moistened so that water will not be drawn from the freshly placed shotcrete.

e) Chuted concrete

Chuted concrete is a plain concrete to which is added at the end of mixing a superplasticizer giving it a flowing consistency (slump at Abram's cone test = 20 to 24 cm). This concrete is especially used for heavily reinforced reservoirs or those having complex shapes. However, the following precautions should be taken:

- Check beforehand the efficiency of the superplasticizer (plasticity modification, effect on strength, duration,...)
- Mix concrete as close as possible to its final position, since this type is more prone to segregation than plain concrete.
- Use resistant formworks because chuted concrete transmits pressures (height of concrete in formworks) better than plain concrete (reduced internal friction).

f) Fibre concrete

General

Fibre concrete contain appropriate quantities of metallic fibres as to form a composite and homogeneous mixture and shall be designed according to British Standard.

The main characteristics of metallic fibre concrete are:

- Strong cohesion which gives a high strength to shocks.
- Important ductility with small cracks (< 8mm) which reduces construction cracks.
- Resistance to rupture.

Materials

Metallic fibres are machined directly from the steel slab. They are triangular, twisted, curved and have a smooth side and a rough side.

Fibres shall be stored in a dry place.

The percentage of fibres shall vary between 20 and 40 kg per cubic meter of concrete.

Cement shall be chosen according to BS 12.

Granular materials shall comply with BS 882.

Sand shall be graded 0 to 3mm or 0 to 5mm and contain 15% of fines (≤ 0.315mm). Grading shall be continuous as far as practicable with a maximum grain size of 25mm.

The water shall comply with BS 3148.

Addition of water on site shall not be permitted.

The admixtures permitted to be used with fibre concrete are:

Super Plasticizer
Super Plasticizer are used to increase the workability of fibre concrete, at the time of placing without addition of water.

Plasticizers-water reducers
They are used to increase the plasticity of concrete (especially pumped concrete) at a constant quantity.

Prior to adding fibres, concrete shall have an ultimate bending-tensile strength equal to 3.4 MPa, in order to allow the good anchoring and performance of fibre.

Concrete fluidity shall be measured by the Abram's cone (slump test).

Fibres decrease greatly the workability of concrete. Therefore, fluidizers shall be added directly on site in the truck mixer in order to facilitate placing while the water/cement ratio is kept constant.

Two types of concrete may be used:

1) Chuted concrete

This is the best solution.
Slump:

a) Prior to adding fluidizers : 4 to 6 cm
b) After adding fluidizers : 15 to 18 cm
c) After adding fluidizers and fibres: 10 to 14 cm

Chuted concrete allows to decrease the quantity of water ($0.4 \leq W/C \leq 0.5$), and, therefore, develops good mechanical resistances and ensures a considerable workability.

Fluidizers shall be added on site.

2) Plasticized concrete

Slump:
a) Prior to adding fibres : 9 to 12 cm
b) After adding fibres : 6 to 8 cm

Plasticized concrete requires no addition of water on site. Given its low workability, it is difficult to place this type of concrete.

The performance of metallic fibre concrete is measured by the ultimate tensile bending strength test after 28 days. The average common performances are tabulated hereunder:

Proportion	20 kg/m^3	25 kg/m^3	30 kg/m^3	35 kg/m^3	40 kg/m^3
Performance MPa (maximum stress)	4	4.5	4.9	5.2	5.5

Placing

Fibres shall be mixed directly with concreted without forming "urchins".

No "dosing-untangling" device shall be needed.

Placing shall be done:

- either, in the truck mixer on site, with an additional mixing of 6mm at 14 r.p.m.
- or, at concrete factory with aggregates or, at the end with an additional mixing of 4mm.
- or, in the concrete mixer on site, with an additional mixing of 6mm.

The concrete should be adequately consolidated. The vibration method is conditional upon the type of concrete.

- Chuted concrete requires almost no vibration. It is placed by means of vibrating rulers or even without any external vibration (eveness is controlled by a laser level).

Chuted concrete allows concreting large surfaces without any construction joints.

- Plasticized concrete or admixtures free concrete shall be consolidated by means of a vibrating ruler.

In the event of fair-faced concrete surfaces, fibres shall be properly integrated in concrete though adequate mechanical or manual troweling.

No particular precautions are required for other traditional finishings (sprinkling, incorporated or added finish). A curing product shall be applied to the finished surface of concrete slab to prevent rapid desiccation.

Should surfaces be painted, concrete may be cured by sprinkling with water.

Joints shall be formed in fibre concrete. However, given the plasticity and coherence of this type of concrete, it is preferable to place it continuously and, then, form contraction joints by sawing.
Joints are formed each 8m x 8m outdoors or in non covered surfaces (at the time of execution) or each 10m x 10m, and even 12m x 12m indoors. In the latter case, the proportion of fibres shall be 30 kg/m^3).

1. Construction joints
   They shall be either keyed or dowelled, with or without angle iron. However, chuted concrete allows the concreting of large surfaces without needing to form construction joints.

2. Contraction joints
   Joints are sawn over ¼ of the thickness minimum.

3. Separation joints
   Joints shall be formed around hard zones: stringers, footings, columns.

4. Expansion joints
   Expansion joints shall be avoided, as far as practicable, in covered slabs where no major temperature variations are observed.

Design of concrete pavement

According to each case, the Engineer shall determine the sizing of works.

- Westergaard modulus of subgrade reaction
- Exact definition and location of applied loads.

The maximum strengths used for calculation of concrete are conditional upon the proportion of reinforcing fibres and tabulated hereunder:

Proportion	20 kg/m^3	25 kg/m^3	30 kg/m^3	35 kg/m^3	40 kg/m^3
Allowable σ (MPa)	2.8	3.2	3.5	3.7	3.9

Controls

The user of metallic fibre concrete shall establish a self-control procedure concerning the following:

1) Taking over of support ground

The user shall take over the foundation ground in order to make sure that the slab is homogeneous and true to the adopted assumptions.

(Westergaard modules > 30 MPa/m = 3 bar/cm)

A membrane may be placed to prevent contamination with fine particles especially in silty soils or saturated with water.

It may be necessary to insert a polyethylene sheet (150 microns minimum thick) between the foundation ground and the slab to:

a) separate the slab from the foundation ground and facilitate sliding
b) avoid infiltration of water or laitance into the foundation ground.
c) avoid rising of underground water

2) Concrete quality

The user shall check the composition of concrete at the time of manufacture in the batching-mixing plant or when delivered on site, and make sure that grading curves are consistent with the present technical specifications document.

The user shall check the workability of the various types of concrete mentioned above through a slump test prior to and after placing of fibres.

According to the placement method, the user shall carry out a self control on the quantity of used fibres with regard to the volume of placed concrete, and verify that concrete is free of "urchins".

3) Mechanical strengths

Verifications shall be performed according to "the Professional Rules for Pavement Works". The user shall namely verify:

- Quality of plain concrete (tensile bending strength ≥ 3.4 MPa)
- Mechanical strength of concrete; the performances level defined above being checked out.
- Tests shall be carried out on prismatic samples 4cm x 14cm x 56cm

- Such verifications shall be carried out:

- at the concrete factory during the self control. The proportion of added fibres shall be determined on the delivery notes.
- and, on site, by the Contractor, prior to placing concrete as per the Technical Specifications.

Workmanship

The works shall be carried out by the Contractor. The Contractor shall comply with the technical specifications and the Special Specifications provided by the manufacturer.

The pavement slab shall not be used before:

48 hours after placing concrete for light pedestrian traffic
7 days after placing concrete for light traffic
28 days after placing concrete for normal traffic.

All workmanship details shall be in accordance with the requirements of all concrete sections mentioned in these specifications.

202.2 MATERIALS FOR CONCRETE -

202.2.1 Cement

Cement shall comply with one of the following sub-Clauses (i) to (iv) below:

(i) BS 12 (Ordinary and rapid-hardening Portland cement).

(ii) BS 146 (Portland-blastfurnace cement).

(iii) BS 4027 (Sulphate resisting Portland cement).

(iv) BS 6588 (Portland pulverised-fuel ash cement) provided that sub-Clause (vii) below is complied with.

(v) A mixture of BS 12 (Portland cement) and BS 3892: Part 1 (Pulverised-fuel ash for use in structural concrete) provided that the amount of pulverised-fuel ash is not less than 15% nor more than 35% by weight of the total cement and sub-Clause (vii) below is complied with.

(vi) A mixture of BS 12 (Portland cement) and BS 6699 (Ground granulated blastfurnace slag for use with Portland cement) provided that the amount of slag is not more than 65% by weight of the total cement.

(vii) The pulverised-fuel ash used shall have a maximum colour index of 6 (Colour Comparator disc reference No. 296570) when measured using the Lovibond Colour Comparator system as recommended in BS 3892: Part 1 Appendix H, Clause H8.

The Concrete Cement used for Concrete Structure in contact with wastewater shall be Sulphate resisting Portland Cement and in accordance with BS 4027.

Consignments of any cement shall be used in the order in which they are received. Any cement stored on the site over three months may be rejected by the Engineer. Should the quality of the cement be adversely affected by dampness or any other cause the cement shall be removed from the site.

Each shipment of cement shall be stored so that it may readily be distinguished from other shipments. The cement shall be free form lumps and shall be otherwise undamaged when used in concrete.

Sacked cement shall be delivered to the Site in the sound original bags of the manufacturer and shall be stored in a watertight and weatherproof shed on a floor raised at least 15 cm from the ground. Stacking cement bags to excessive heights they may cause damage to cement or is otherwise undesirable, as determined by the Engineer, will not be permitted.

Bulk cement shall be stored in weatherproof bins or silos to be approved by the Engineer. The bins shall be emptied and cleaned at reasonable intervals as directed by the Engineer.

The quality of each consignment of cement shall be verified by manufacturers' certificates showing the results of tests, as per B.S. 12, appropriate for cement to be used in tropical climates. Where the Engineer so orders, the Contractor shall perform at his own cost additional tests on samples selected by the Engineer, all in accordance with B.S.12.

202.2.2 Water

The water used for mixing concrete shall be of potable quality, free form harmful materials such as clay, loam, acids or trade effluent. River water may be used after its suitability is ascertained beyond doubt by tests according to B.S. 3148. Periodic tests shall be carried out to keep a continuous check on the suitability of such water. The source of the water shall be subject to the Engineer's approval.

202.2.3 Admixtures

Usually the water proof concrete specifications are written aiming to achieve a watertight concrete structures.
But practically the concrete can sometime be very difficult to place.

If agreed by the Engineer, the contractor will be permitted to use concrete with more plastic consistency helping to produce a smoother and denser floor and wall finishes requirements.

In heavy reinforced structures, a good and long workability is also important.

It is impossible to meet the water/cement ration > 0.5 and a good workability requirements at the same time unless concrete admixtures are used.

Contractor may use admixtures and shall use if required by the Engineer admixtures such as:

- Retarder
- Accelerator
- Plasticizer or super plasticizer
- air entraining agent
- water proofing admixtures
- Fluid admixtures
- Anti freeze admixtures

Plasticizer and super plasticizer gives good workability and correct consistency (even for pumped concrete with extended working times) to enable the concrete to be compacted as fully as possible in as short a time as possible with a high reduction in the water/cement ratio.

Retarder

- By the use of suitable retarder the Contractor must obtain that the start of the setting process be delayed from a few hours to a day or more.
- This will permit to fresh concrete to be transported, poured and vibrated over longer periods of time.
- The controlled retardation of the initial set, must not be in no way slow down the subsequent hardening process.

- The period of time during which the concrete can still be vibrated is known as the retardation time.
- The choice of retarder dosage will be made by referring to the dosage chart of the furnisher, preliminary trials may be asked by the Engineer to acertain the correct dosage for planned retardation.
- Dosage can varies with the type of structure (foundation slab or walls...) and with temperature (ambient air and/or concrete) the Contractor must consult with the Engineer to either avoid construction joints (cold joints) or to work out a concreting schedule where entire mass of concrete is required to set simultaneously.

Water proofing concrete admixture

A concrete admixture in liquid or powder form can be used by the Contractor as highly efficient water proofing principal agent with a secondary function as plasticizer.

The dosage will correspond to % of the weight of cement.

The admixture must be compatible with the type of cement.

The admixture will be dispensed directly into the mixing water (liquid admixture) prior to its addition to the aggregates /or/ added directly to the dry mixed aggregates.

Other Admixtures

The Contractor will relate to the technical specifications of the admixtures Supplier. Admixtures that contain chlorine will be forbidden.

Admixtures used shall be furnished by the Contractor and the cost of the materials and all costs incidental to their use shall be deemed to be included by the Contractor in his unit rates for concrete and shall not be paid for separately.

202.2.4 Aggregates

Fine and coarse aggregates shall be as defined by and be of the quality and nature required by BS 882 and BS 1201 whichever is applicable. In addition they shall be chemically inert to alkali reaction.

Prior to acceptance of an aggregate as inert to alkali reaction the report of a qualified geologist, appointed by the Engineer on the suitability or otherwise of materials shall be obtained following examination of all types of material that the proposed sources will yield during the course of the contract. The Engineer may require that samples be taken from boreholes and for large contracts or contracts extending over a long period then more than one report is to be obtained.

Aggregates shall conform to the requirements of the "Acceptance Standards" of Table 2.4.

Table 2.4 Sampling, Testing and Acceptance Standards

Materials	Test	Site Sampling	Testing	Accepted Standards	Remarks
1	2	3	4	5	6
CEMENT	Ordinary Portland Rapid Hardening Sulphate Resisting		 BS 4550	BS 12 BS 12 BS 4027	Manufacturer's Test Certificates
AGGREGATES	Description and Classification		BS 812 Section 2	BS 882	Whichever is applicable
	Particle size	BS 812 Sec.1	BS 812 Sec.3	BS 882	)
	Particle Shape	BS 812 Sec.1	Visual & BS 812 Sec.3		)) Mix Design
	Sp. Gravity	BS 812 Sec.1	BS 812 Sec.3		) Requirements
	Density	BS 812 Sec.1	BS 812 Sec.3		)
	Voids	BS 812 Sec.1	BS 812 Sec.4		)
	Absorption	BS 812 Sec.1	BS 812 Sec.4	BS 8007 CI. 6.2.2.	See Freeze-thaw Test in this Table
	Organic Impurities	BS 812 Sec.5			
	Moisture Content	BS 812 Sec.5			For adjustment of added water for concrete making
	Mechanical Properties	BS 812 Sec.6	BS 882		Ten per cent fines value
WATER	Suitability	BS 3148	BS 3148	BS 2138	Not required for potable water
CONCRETE	Compacting Factor	BS 1881	BS 1881 Pt 103		)) Workability Test
	Slump	Pt 101	BS 1881 Pt 102		))
	Crushing		BS 1881	BS 5328, BS 8110	Cube test
	Water Absorption		BS 1881 Pt 122	BS 340 Para 19 (b)	Precast concrete CI. 3.8
	Freeze-thaw	BS 1881			Durability test for aggregate not complying with moisture absorption requirements of BS 5337 CI, 21.2
	Electrolytic Efflorescence				As required for salt containing aggregate or saline water
	Cores	BS 1881 Pt 6 BS 1881	BS 1881 Pt 6 BS 1881	BS 1881 Pt 120 with strength specified on drawings	
ADMIXES with cement	Compatibility by Laboratory	As required			Tests to be carried out by independent Laboratory as required.

(a) General:
Aggregates for concrete shall be fine aggregate and coarse aggregate and shall be supplied by the contractor from approved sources, but the approval of any source by the Engineer shall not be construed as approval of all materials taken from that source, and the Contractor will be held responsible for the specified quality of all materials used in the work and for their being equal to the approved samples.

The Engineer, at the Contractor's expense, will test the aggregates and the Contractor shall provide such facilities as may be necessary for procuring representative test samples. The Contractor shall submit, for preliminary tests and approval, representative samples of 100 kg each of fine aggregate and of each size of coarse aggregate proposed for use in the work at least 30 days before the aggregates are required for use.

Should the Engineer reject any sample furnished by the Contractor, the Contractor shall immediately supply a sample or samples from some other source until all samples are approved by the Engineer.

Those samples which have been finally approved by the Engineer as meeting the requirements of the Specification shall be kept on the Site until the completion of all

concrete work and all aggregates brought to the Site shall be compared with such approved samples.

Any aggregate rejected by the Engineer shall be immediately removed from the Site, unless the Engineer shall permit its use after undergoing further treatment by washing and or screening in order to bring it up to standard.

The aggregates shall be brought to the Site in separate loads, each containing aggregates of one size. The aggregates shall be stored in such a way as to prevent aggregates of different sizes from being mixed together in storage. Aggregates mixed either in transport or on Site will be rejected.

(b) Fine Aggregate:
Fine aggregate for concrete shall be natural sand (but not beach sand) or a mixture of natural sand and fine crushed stone. It shall meet the requirements of B.S. 882 and its grading shall be within the limits of one of grading zones 1, 2 or 3 given in Table 2 of B.S.882. In addition, it shall have a specific gravity of not less than 2.5, shall not contain more than 5 percent by volume of shells or shell fragments. The fine aggregate delivered to the batching plant shall have a uniform and stable moisture content.

When necessary, or when required by the Engineer, all fine aggregate shall be washed in clean water, before being incorporated in the Works.

(c) Coarse Aggregate:
The coarse aggregate for concrete shall be natural gravel or crushed stone. It shall consist of hard, dense, durable uncoated rock fragments and shall meet the requirements of B.S. 882.

Coarse aggregate for reinforced concrete shall be either graded aggregate or made up of a number of single size aggregates, with the largest particles not exceeding the following sizes:

(a) 40mm, or
(b) 1/3 of the smallest thickness of concrete members, or
(c) 3/4 of the smallest space between reinforcement bars, whichever is the smallest.

Coarse aggregate for non-reinforced concrete may contain particles up to 3”

The grading of coarse shall lie within the limits given in Table 1 of B.S. 882. The exact sizes of the coarse aggregate and the grading to be used shall be determined as part of the mix design in accordance with Subsection 202.1.3.
All aggregates shall be approved by the Engineer.

202.3 BATCHING AND MIXING

202.3.1 Batching

The Contractor shall provide equipment and shall maintain and operate the equipment as required to accurately determine and control the amount of each separate ingredient entering the concrete. For concrete Class C20P and higher, the amounts of sand, bulk cement and each size of coarse aggregate entering each batch of concrete shall be determined by weighing, and the amount of water shall be determined by weighing or volumetric measurement. Where sacked

cement is used, the amount of cement entering the mixture shall be determined on the basis of integral sacks of cement and the use of cement from torn bags shall not be permitted.

For concrete Class C15P and lower, the Engineer may permit volumetric measurement of aggregates.

All weighing equipment shall be subject to the Engineer's approval. An accuracy to within 0.4 percent of the scale capacity will be satisfactory, and the equipment shall be capable of ready adjustment for compensating for the varying weight of any moisture contained in the aggregates and for effecting changes in concrete mix proportions. The Contractor shall make such adjustments, repairs, or replacements as may be necessary to meet the specified requirements for accuracy of measurement. Each dial, indicator and other measuring device shall be in full view of the operator.

Where batching by volume is permitted by the Engineer, only precisely dimensioned gauge boxes approved by the Engineer shall be used for the sand and different sizes of aggregates. After filling the box the aggregate shall be struck off level with the brim. Sand shall be poured or shovelled into the gauge boxes without compacting. All gauge boxes shall bear marks in red oil paint showing the kind and size of aggregate for which each box is to be used. No boxes similar in shape and appearance but different in volume from the approved gauge boxes shall be kept on the Site.

202.3.2 Mixing

The materials shall, unless otherwise directed by the Engineer, be mixed in approved mechanical batch mixers. In each case, the number and capacity of mixers employed shall be sufficient for the concreting operations being undertaken, shall allow for sufficient reserve capacity at all times and shall be subject to the approval of the Engineer.

The mixing shall continue until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall the mixing be for less than 2 minutes after all the ingredients are in the mixer. Water shall be added prior to, during and following the mixer-charging operations. Overmixing requiring the addition of water to preserve the required concrete consistency will not be permitted.

No dry material shall be introduced into a mixer until all material from the previous batch has been removed and the interior of the mixing drum has been cleaned of encrustations of concrete or mortar. Remixing of concrete or the addition of water to a mixture that has already begun to set or that is otherwise unsuitable for casting shall not be permitted and such concrete shall be wasted. When a concrete mixer has been out of use for more than 20 minutes, or when the type of cement is changed, the mixer shall be thoroughly cleaned before a fresh batch of concrete is made in it.

The Engineer may in exceptional cases permit hand mixing of lean and other non-reinforced concrete. No hand mixing shall be done unless authorised in writing by the Engineer. The batches in hand mixing shall not exceed 1/6 of a cu.m. Hand mixed concrete shall not be used until the mixing of the whole batch has been completed and the concrete is of uniform colour and consistency. Hand mixing shall be done twice on dry aggregate, and at least twice wet, on a clean and even surface, which will prevent the loss of water during mixing. The water added shall be measured in order to prevent the use of an excessive quantity of water.

When mixing by hand, the quantity of cement shall be increased by 10% above that specified above in Section 202.3.

202.4 PLACING AND CURING

202.4.1 Preparations for Placing

No concrete shall be placed until the Engineer has approved the formwork and reinforcement. The Contractor shall give at least 48 hours notice to the Engineer of the times he proposes to concrete and no concreting shall take place unless either the Engineer or his Representative is present.

Concrete shall be placed only in the presence of the Engineer or his duly authorized Representative, unless written permission has been given by the Engineer to place concrete without himself being present or represented. The Contractor shall give the Engineer not less than 48 hours notice before the day on which he intends to commence placement of concrete in any structure or substantial part thereof.

No concrete shall be placed until all reinforcement, formwork, parts to be embedded, and preparation of surfaces involved in the placing have been approved.

All surfaces of forms and embedded materials shall be clean and free from dried mortar which may have encrusted them from previously placed concrete.

All surfaces of foundations and areas upon or against which concrete is to be placed shall be free from standing water (except for concrete required to be placed under water), mud, debris, oil, objectionable coatings and loose, semi-detached or unsound fragments. Absorptive surfaces shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete. On surfaces of rock upon or against which concrete is to be placed, a 2 cm layer of 1:3 cement mortar shall be spread immediately prior to placing concrete and shall be well worked into the surface with the aid of brushes. Care shall be taken that the mortar does

in no case set before concrete is placed on it. The cost of such mortar and its spreading shall be deemed to be included in the rates for concrete.

202.4.2 Transporting and Placing

The methods and equipment used and the speed required for transporting concrete shall be such that concrete having the required composition and constancy will be delivered into the work, without objectionable segregation, loss of slump, and delay. Except as otherwise specified for ready-mixed concrete, the time elapsed between the first wetting of concrete ingredients and the completion of placing the concrete in the work shall in no instance exceed 30 minutes. Retempering of concrete will not be permitted. Any concrete which has become so stiff that proper placing cannot be assured shall be wasted.

Concrete shall be deposited as far as practicable directly in its final position and shall not be placed in a manner permitting or causing segregation. The Contractor shall provide suitable openings in the formwork and/or drop chutes and baffles to confirm and control the falling of concrete, and to limit its free drop to a maximum of 1.50 meters.

Except as intersected by joints, all formed concrete shall be placed in continuous approximately horizontal layers, the depths of which shall not exceed 60 cm, in such a manner that no layer of concrete will begin setting before the next layer is placed on top of it. In no case shall the delay between the placing of any two adjacent layers be such that the vibrating unit will not readily penetrate of its own weight the concrete placed before the delay.

Concreting shall be carried out continuously between and up to joints, the position and arrangement of which shall be predetermined and no interruption of placing other than at these joints will be permitted. To this end, the Contractor shall take all necessary measures, such as preparing a sufficient stock of materials, stand-by equipment, shift-work, lighting for night-work, etc.

In the event of unavoidable stoppage in positions not predetermined, the concrete shall be terminated on horizontal planes and against vertical surfaces and construction joints shall be prepared according to Subsection 202.5.1. Where required the Contractor shall also provide keyways, dowels, and/or waterstops to ensure a perfect bond and/or watertightness at the joint.

Where the concrete abuts against earth or any other material liable to become loose, the greatest possible care shall be taken to avoid falls or run of such or other materials upon the surface of the concrete, and if any such falls or runs occur the surface of the work soiled thereby shall be removed until a new and clean surface shall have been obtained, and all spaces left by such falls or runs beyond the prescribed dimensions of the work, or caused by the negligence or for the convenience of the Contractor, shall be built up with concrete at the dimensions of the work, or caused by the negligence or for the convenience of the Contractor, shall be built up with concrete at the discretion of the Engineer, and the additional cost so incurred shall be held to be included in the Contractor's rates in the Bill of Quantities for work within the original Contract limits.

No concrete shall be placed in water, except with the written permission of the Engineer, and the method of depositing the concrete shall be subject to his approval. Concrete shall not be placed in running water and shall not be subjected to the action of running water until after the concrete has hardened.

Surfaces of rock upon or against which concrete is to be placed, shall be prepared and cleaned as specified and placing of concrete shall be carried out as detailed below for construction joints.

No concrete shall be placed when the ambient temperature at the time of placing and/or 2 hours thereafter is expected to be below 4°C. The temperature of the concrete when being placed shall not exceed 32°C.

In hot weather when the temperature of the concrete is liable, in the opinion of the Engineer, to rise above 32°C, the Contractor shall, at his own expense, employ effective means, to the satisfaction of the Engineer, for reducing the temperature in the mix, such as sprinkling of water on the aggregate, protection of the water lines from the sun, painting of mixers and water tanks with light-reflecting paint and/or placing them in shadow, or by adding crushed ice to the water in a proportion not exceeding 50% of the water. The addition of ice will be permitted only if it has been proved to the satisfaction of the Engineer's Representative that all other means for the reduction of temperature are insufficient.

1) Hot weather concreting

Heat accelerates the hydration reaction of cements, thus it increases the heat of hydration and accordingly, shrinkage and cracks are likely to occur. It is necessary to abide by the following measures:

a) Use concrete as compact as possible.
b) Use cement of low heat of hydration.
c) Reduce the cement dosage as far as practicable according to the requested characteristics of concrete.
d) Use a water reducing plasticizer in order to reduce the quantity of mixing water (0.5 to 0.75 in weight of cement).
e) Use a setting retarder which increases the heat of hydration time.
f) Cool concrete constituents. This is an expensive method, but gives the best results.
g) moisturize the hardened concrete on which fresh concrete shall be placed in order to avoid loss of water.
h) Cover the structures after concreting, in order to prevent water evaporation from fresh concrete.
i) Use Antisol-E which protects concrete from desiccation (suppress the use of damp coverings, watering, etc...).

2) Cold weather concreting

When concreting in cold weather, and in order to prevent having a frozen and porous concrete, plasticizers and water reducing admixtures shall be used to reduce the

quantity of mixing water, while preserving the workability of fresh concrete at an acceptable degree.

Low temperature slows down the reaction of hydration of cement and therefore, delays formworks removal. The following precautions shall be taken:

a) Use a quick setting cement
b) Increase the C/W ration (plasticizer - water reducer)
c) Heat the materials (water + aggregates). However, the temperature of concrete shall not exceed 30°C.
d) Use isolating formworks (wood, panels coated with expanded polystyrene, etc..)
e) Protect fresh concrete with thick dry covers.
f) Heat concrete eventually (hot formworks).
g) Use antifrost products (1% in weight of cement).

No concrete shall be placed when the ambient temperature is -0°C.

Placing concrete at a temperature below + 5°C is allowed provided that the above mentioned precautions are respected and upon the prior approval of the Engineer.

3) Concreting under water

When fresh concrete is to be placed under a water in motion (currents, waves,...) adequate measures shall be taken to prevent the washing out of concrete and carrying away of mortar.

Concrete shall be conveyed via a tight chute avoiding the contact of concrete with water and placed inside an underwater formwork. In this way, only the upper section of concrete shall be wasted out and it is removed once hardened by a pneumatic drill.

While concreting, the Contractor shall control the height of concrete at the bottom of the formwork and in the chute as well as the length of chute entering in the poured concrete mass in order to prevent any sudden depositing of concrete which might cause water intrusion and stoppage of work. Throughout concreting works, the chute shall be raised progressively.

4) Concreting under sea water

Sea water has two major effects on works:

a) Dynamic effect of waves
b) corrosive effect of salt on concrete and reinforcing bars.

Structures shall be oversized and designed to have high strength. Massive elements shall be concreted. Thin walls and frail beams are to be avoided. A thick sufficient cover of a compact concrete shall be provided around reinforcement in such a way as to ensure waterproofness and avoid capillary attraction.

The cover shall be at least equal to 4 cm, and may be increased if this minimum distance cannot be ensured in all points. Concrete shall be richly batched with a minimum cement proportion of $c \geq \frac{700}{\sqrt[5]{D}}$

Sulfate in sea water reacts with tricalcic aluminate in cement and form Candlot salt which attacks concrete. Therefore, a sea water concrete containing a high proportion of clinker cement shall be used in lieu of Portland cement.

Sharp arises and peaks which are attacked easily by sea water shall be bevelled and their angles rounded off. While placing, segregation and excess water which increase porosity and contraction shall be avoided. A plasticized concrete shall be preferably used provided it does not have a too high slump and can be adequately consolidated by a proper vibration.

The external surface of concrete shall not receive any further treatment like roughening, sandblasting, washing... As far as practicable, concreting shall not be interrupted. Should stoppages be unavoidable, the surfaces of joints shall be rendered with an epoxy based mortar or Thiokol.

The cost of all work described in this Subsection shall be deemed to be included by the Contractor in his unit rates for the various items of concrete work in the Bill of Quantities and shall not be paid for separately. The Contractor shall not be entitled to any additional payment over the rates bid for concrete by reason of any limitations in the placing and concreting required in this Subsection.

202.4.3 Consolidation of Concrete (Vibration)

Each layer of concrete shall be consolidated to the maximum practicable density, so that it is free from pockets of coarse aggregate and closes snugly against all surfaces of forms and embedded materials.

Concrete Class C15P and less may be consolidated by spading, hand-tamping, or by mechanical vibration as described below. All concrete Class C20P and higher shall be consolidated by power-driven immersion ("needle") type vibrators having a frequency of not less than 9000 oscillations per minute. The vibrators shall be inserted into the concrete at intervals not exceeding 50 cm and shall be allowed to penetrate and revibrate the concrete in the upper portion of the underlying layer.

On slabs not exceeding 25 cm in thickness the use of flat surface tamping vibrators with a frequency of not less than 5000 oscillations per minute will be permitted, provided that it is supplemented by immersion vibrators adjacent to the forms and to concentrations of reinforcement bars.

On walls not exceeding 20 cm in thickness external vibrators, fixed to the forms, will be permitted. External vibrators shall be raised in lifts as the filling of the forms proceeds each lift being not more than the height of concrete visibly affected by the vibration. They shall be

placed horizontally, at distances not greater apart than the radius through which the concrete is visibly affected.

The types, sizes and numbers of vibrators shall be subject to the approval of the Engineer.

At least one stand-by unit of each vibrator type and ample spare parts for all types employed shall be available on Site during placing of concrete to ensure continuous placing with no stoppage due to breakdowns.

The vibrators shall be applied in each position for as long as required for the concrete to become uniformly plastic and shall be withdrawn as soon as water appears on the surface. Systematic spacing of insertion of the vibrators in the concrete shall be established to ensure that no concrete remains unvibrated. Care shall be exercised to avoid contact of the vibrating heads with the surfaces of the forms and the reinforcing bars or other embedded material. The vibration shall everywhere be supplemented by hand spading. Vibration shall never be used to cause concrete to flow in a lateral direction, as this will lead to segregation.

The cost of all consolidation shall be deemed to be included in the Contractor's rates for concrete.

202.4.4 Finishing of Concrete Surfaces

Formed concrete surfaces, i.e. surfaces cast against forms, shall receive the required smoothness and texture by the use of appropriate forms as specified under Section 202.10. After removal of forms and the specified curing all fins and offsets caused by misaligned or defective form boarding shall be removed. Tie wires shall be cut back to at least 15 mm below the concrete surface and the resulting depressions as well as the holes left after the removal of tie rod fasteners shall be filled with non-shrinking cement mortar and finished flush with the surrounding areas.

Where the concrete surfaces will be permanently exposed to view, the ground and filled areas shall have the same colour, texture and degree of smoothness as the surrounding concrete surfaces. Honeycombed areas and other major defects in concrete shall be repaired as specified in Section 202.7 hereinafter, and the repaired areas given the required finish.

Unformed concrete surfaces that are to be covered shall require no other finishing than sufficient levelling and screeding to produce an even uniform surface. Unformed concrete surfaces that are to remain permanently exposed shall be given a floated surface, unless a trowelled finish as described below is required. Floated finish shall consist of levelling and screeding to even and uniform surfaces followed by floating without the addition of any topping as soon as the screeded surface has stiffened sufficiently. Floating shall be done to the minimum required to produce a surface that is free from screed marks and is uniform in texture. The finish shall be given a final touch-up with a wooden float at an appropriate time after completion of the initial floating.

Trowel finish shall be applied to uniformed concrete surfaces that will be in contact with liquids and elsewhere as shown on the Drawings or ordered by the Engineer. When the surface

screeded and floated as described above has hardened sufficiently to prevent excess of fine material to be drawn to the surface, steel trowelling shall be started. Steel trowelling shall be performed with firm pressure, such as will flatten the sandy texture of the floated surface and produce a dense uniform surface, free from blemishes and trowel marks. Where required, trowelling shall be done with the addition of a certain amount of cement as specified in the Particular Specification or Bill of Quantities.

Unless otherwise specified or shown on the Drawings, all exterior angles shall be chamfered to the approval of the Engineer. The cost of Floated Finish, Trowel Finish and Chamfers shall be deemed to be included in the unit rates for concrete work and shall not be paid for separately.

202.4.5 Curing of Concrete

From casting until the end of the specified minimum curing period, the concrete shall be kept constantly moist and adequately protected against damage due to fluctuation in surface temperatures. Immediately after casting, the exposed surface of the concrete shall be covered to prevent drying and to minimize temperature variations, until the commencement of curing at an age of not more than 20 hours. Curing of formed surfaces shall commence as soon as the formwork is removed. During curing the concrete shall be kept suitably moist by:

1. Direct application of water at ambient temperature, e.g. by spray or by ponding, or,
2. Covering with absorptive material, e.g. sand or hessian, kept constantly damp. Ventilation of any gap between the material and the concrete should be prevented so as to maintain nearsaturated conditions in the air within the gap, or
3. When specifically permitted in writing by the Engineer, by sealing the surface of the concrete, before it has lost any of its original water by evaporation, by means of a sealing membrane which will effectively prevent any loss of water from the concrete. The sealing compound shall be white-pigmented and shall conform to Standard Specification for Liquid Membrane forming Compound for Curing Concrete, ASTM Designation C309 latest edition, or to another standard acceptable to the Engineer. The type and make of sealing compound and its form of application and use shall be subject to the approval of the Engineer. Membrane curing shall not be used on surfaces upon or against which concrete is to be cast or which are to be plastered or painted.

The cost of curing shall be deemed to be included by the Contractor in his unit rates for concrete and shall not be paid for separately.

202.5 CONTRACTION AND EXPANSION JOINTS

202.5.1 Contraction Joints

The position of construction joints will be as specified in the drawings by the designer. If there is a need on site to revise any specified position /or/ to have additional construction joints the proposed positions should be agreed with the Engineer.

Full structural continuity must be assumed in design at a construction joint. Reinforcement will be fully continuous across the joint, and the concrete is taken to be as nearly monolithic as possible.

The concrete at the joints should be bonded with the one subsequently placed against it, without provision for relative movement between the two.

Concrete should not be allowed to run to a feather edge, and vertical joints should be formed against a stop end. Particular care should be taken when framing the joint.

The surface of the first pour should be roughened to increase the bond strength and to provide aggregate interlock.

With horizontal joints, the joint surface should be roughened without disturbing the coarse aggregate particles, by spraying the joint surface approximately 2h to 4h after the concrete is placed, with a fine spray water and/or brushing with stiff brush.

Vertical joints can be treated similarly, if the use of a retarder on the top is authorised, to enable the joint surface to be treated after the stop end has been removed.

If the joint surface is not roughened until the concrete has hardened, the larger aggregate particles near the surface should be exposed by sand blasting or by applying a scaling hammer or other mechanical advice.

Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against the old one. It may need to be dampened prior to the new concrete being placed, to prevent excessive loss of mix water into it by absorption.

Particular care should be taken in placing of new concrete close to the joint to ensure that it has adequate fines content and is fully compacted and dense.

N.B. When instructed by the Engineer in designing construction joints for retaining aqueous liquids it is necessary to incorporate waterstops in properly constructed joints.

Construction joints shall be formed only in the positions shown in the drawings or indicated by the Engineer and concreting shall be carried out continuously between and up to joints.

All intersections of construction joints, permanently exposed, shall be made absolutely straight and level or plumb and matching with adjacent members.

Construction joint shall be formed at right angles to the axis of the member concerned, by the insertion of rigid stopping-off forms in the case of horizontal or inclined members.
The upper surface of lifts of concrete in walls and columns shall be horizontal.
The surface of the stopping-off form /or/ the horizontal surface shall be indented to produce a key the old and new work.

The face of the horizontal joints brushed and roughened shall be rendered with a 1.0 to 1.5 cm thick layer of cement-sand mortar having the same relative proportions of cement and sand (without coarse aggregate) and the same water-cement ratio as the concrete to be placed upon it, and the new concrete shall then be laid immediately upon it and thoroughly punned in.

Where joints will be permanently visible, the mortar shall be kept back at least 25mm from the exposed face.

In the case of vertical joint the face shall be rendered with a coat of neat cement placed immediately before each fresh lift of new concrete.

NB : No Day Joints /or/ Stopping-off joints will be permitted in water retaining structures. Pouring operations shall be continuous between joints as shown in the drawings.

The Contractor shall have sufficient materials and standby equipment to meet these requirements.

Where due to accident or breakdown it is impossible to continue concreting, the Engineer /or/ his Representative shall be immediately notified and his verbal instructions which shall be confirmed in writing as soon as possible, regarding either the making of a construction joint /or/ the taking out of new concrete back to the last construction joints, shall be complied with immediately.

Construction joints in wall

Where the wall is designed to be monolithic with the base slab, a kicker should be cast at the same time as, and integrally with the slab.

The height of the kicker should be at least 75mm to enable the next lift of formwork to fit tightly and to avoid leakage of cement grout from the newly deposited concreted.

The joint in this position will be a construction joint, and although it is recommended that wall panels are cast in one lift, any necessary extra horizontal joints will be construction joints when approved by the Engineer on site.

Circular Structures retaining liquid

One of the predominant forces from the liquid pressure is horizontal hoop tension (circular tension). For structural design purposes the horizontal reinforcement should be completely continuous at vertical joints.

A central waterstop should be used together with sealing compounds on both faces, whether or not any attempt is made to achieve concrete continuity.

Joints in roof

Roof slab when designed as flat slab has generally all interior joints treated as construction joints so that the slab is structurally monolithic and early thermal effects and subsequent temperature effects should be considered.

If the roof is connected monolithically to the wall the subsequent temperature effects may be disregarded.

If provision is made by means of sliding joints for movement between the roof and walls, correspondence of joints in roof and walls is not to be considered eventually.

Temporary open sections in rectangular tank

When structural continuity is required in the final structure (wall of a rectangular tank) the amount of reinforcement required to control early thermal effects may be reduced by the use of temporary open sections by the contractor after obtaining the agreement of the Engineer for such operation.

The width of the open section between adjacent panels should be no greater than 1000mm.

Properly formed construction joints should be provided at each end of the temporary open section with the longitudinal reinforcement from each adjacent panel, lapping in this area.

Sufficient time should be allowed for all the early thermal movement to take place before the open section is infilled by the Contractor.

The surface of the concrete first placed at a contraction joint shall be coated, before the concrete on the other side of the joint is placed, with an approved bituminous paint or with a sealing compound as specified in Subsection 202.4.5 . Where a water stop is inserted in the contraction joint, great care should be taken to prevent any paint or sealing compound from coming into contact with the half of the waterstop width protruding from the first-placed concrete. Any paint or sealing compound which will come into contact with the waterstop shall be immediately cleaned off.

202.5.2 Expansion Joints

For concrete structures retaining aqueous liquid, all eventual expansion joints are designed to accommodate repeated movement of the structure without loss of liquid.

The joint is designed to suit the characteristics of the material available and should also provide for the exclusion of grit and debris that would prevent the closing of the joint.

Detailing of places where the joint changes direction /or/ intersects with another joint should be uncomplicated.

The expansion joint:

At an expansion joint the Contractor shall provide a complete discontinuity in both reinforcement and concrete.

An initial gap should be provided between adjoining parts of the structure to accommodate the expansion /or/contraction of the structure.

Waterstop, joint fillers and joint sealing compounds are essential.

The Joint Filler

An elastic joint filler material cut in sheets of the thickness specified and/or shown on the drawings, shall be:

- either placed in the forms before the first placed concrete is cast.
- or, may be attached to the first placed concrete surface means approved by the Engineer.

The elastic filler materials shall be of a quality approved by the Engineer and shall conform to US Federal Specification H-H-F-341a, or to a similar approved standard.

Where the exposed sides of the joint are filled with an elastic joint sealant approved by the Engineer, sheets of foamed polystyrene may be substituted for the above described elastic filler.

The sheet of filler material, shall be cut to fit the entire contact surfaces of the complete side of the joint.

Where a waterstop is installed in the joint, the filler materials shall be placed on both sides of the waterstop so as to fit snugly about the bulb of the waterstop.

Except where a groove for joint sealant is to be formed, the edges of the filler materials shall be placed flush with the finished surface of the concrete /or/ the bottom of the chamfers.

Joints in the filler shall be made tight so that mortar from the concrete will not seep through to the opposite concrete surface.

N.B.: Joint sealing compound cannot be expected to provide a liquid-tight seal for more than a proportion of the life of the structure and waterstops should always be provided in movement joints by the Contractor and installation must follow the recommendations of the manufacturer.

202.5.3 Elastic Joint Sealant

Where shown in the Drawings, the groove formed on the exposed side of contraction or expansion joints shall be filled with an elastic joint sealant meeting the requirements of ASTM Designation D-1850. The joint sealant is supplied in two components, base and accelerator,

which are mixed together only immediately before use. Flow type sealant shall be used on horizontal or nearly horizontal surfaces, and heavy type on inclined and vertical surfaces. If required by the manufacturer, a suitable primer shall be applied on the joint surfaces prior to the filling of the groove and the time elapsing between the application of the primer and the placing of the joint sealant shall not exceed the maximum prescribed by the manufacturer. Care shall be taken that the mixed compound is used before the expiry of its pot-life as indicated by the manufacturer.

Prior to the application of the primer (if any) and the placing of the joint sealant, the groove

shall be thoroughly cleaned, flushed with a jet of water and finally cleaned and dried with compressed air. The joint sealant shall be placed immediately after mixing of the two components, by means of a caulking gun so as to fill the joint groove completely and tightly, without leaving any depressions, voids or air bubbles. The joint filling shall be finished neatly and flush with the concrete surfaces by means of a spatula or similar tool.

202.5.4 Payment for Joints

Unless specific items are included in the Bill of Quantities, the cost of all work and materials for making construction, contraction and expansion joints shall be deemed to be included in the rates for the concrete work and shall not be paid for separately.

202.6 TOLERANCES FOR CONCRETE STRUCTURES

The maximum permitted variation from the design dimension shown on the Drawings or ordered by the Engineer shall be as follows :

1. Variation from the plumb :	
a- In the lines and surfaces of columns, piers, walls and arises	In any storey or 5 m maximum ..... 10 mm 15 m or more ..... 25 mm
b- For exposed corner columns, construction-joint grooves, and other conspicuous	1/2 of the above amount
2. Variation from the level or from the grades indicated on the Drawings :	
a- In floor and beam soffits	In 3 m ..... 5 mm In any bay or 5 m maximum ... 10 mm In 10 m or more ..... 20 mm
b- For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines	..... 1/2 of the above amount
3. Variation of the building lines from established position in plan and related position of columns, walls and partitions	In any bay or 5 m maximum .... 5 mm In 10 m or more ..... 20 mm Plus ..... 10 mm
4. Variation in the size and location of sleeves, floor openings and wall openings	10 mm
5. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls	Minus ..... 5 mm Plus ..... 5 mm

6. Footings :

a- Variation of dimensions on plan	Minus ..... 10 mm
b- Misplacement or eccentricity	2 percent of the footing width in the direction of misplacement but not more than ..... 50 mm
c- Reduction in thickness	Minus ..... 5 percent of specified thickness but not more than ..... 50 mm

202.7 REPAIR OF CONCRETE

202.7.1 General

Repair of concrete where permitted by the Engineer shall be performed. The Contractor shall correct all imperfections on the concrete to the satisfaction of the Engineer.

202.7.2 Concrete Repairs in "Rehabilitation Works"

Many factors can lead to defects in old concrete structures which will manifest themselves sooner /or/ later depending on the agressivity of the environment.

The visible manifestation of the defects is commonly referred to a damage.

– A defect exists where a structure, member, or building material is permanently subjected to stresses or aggressive conditions which exceed its load bearing capacity or resistance.

– The damage is the consequence of that defect and normally manifests itself at the surface of the concrete, it may however lie concealed beneath the undisturbed surface of the concrete.

The Contractor is invited not to simply repair the damage because this does not by itself suffice to eradicate the defect which caused it.

Precautions must therefore be taken by the Contractor to prevent a recurrence of damage caused by the same defect.

In most cases this is achieved by treating the surface of the concrete with an additional form of protective treatment: Repair protection: is the formula for successful remedial actions.

The Contractor must visit all the site and for each structure:

– Identify the various stress factors that can cause damage to concrete structure.
– Give guidance in the diagnosis and assessment of such damage.
– Suggest "method of treatment" aiming to eradicate the primary cause or defect.

The Contractor must obtain full agreement from the Engineer for each of these steps.

The Contractor must obtain also previous approval from the Engineer for:

- The products.
- The remedial treatment of concrete.

N.B.: Repairs systems designed to render concrete and reinforced concrete impermeable to water, in existing water retaining structure may be used by the Contractor applying these same procedures.

The main zones to be assessed by the diagnosis can be resumed to:

1) Corrosion of steel reinforcement:
   a) Carbonation
   b) Infiltration of harmful substances.
   c) Thickness of concrete cover to the steel reinforcement

2) Mechanical influences on concrete:
   a) Abrasion

3) Chemical influences:
   a) Erosion by dissolution of the material.
   b) Disruption caused by internal expansion

4) Physical influences.

5) etc..

a) Objectives and Options of the remedial work

The basic objectives of any remedial work may be defined ideally as the reinstatement of the structure to its original condition and the prevention of future damage arising form the same cause.

Reinstatement means the eradication of damage both visible and invisible and the restoration of the affected member to its original section by making good with new concrete or patching mortar.

Prevention means eradicating the defect by strengthening the affected member, protecting the surface of the concrete and the steel reinforcement or eliminating the stresses that are causing the damage.

The Contractor must minimise the total cost of concrete repairs by:

- Starting the remedial treatment at the earliest possible opportunity.
- Making a correct assessment of the extent of the remedial work required.

A close cooperation with the Site Engineer will facilitate the Contractor options and will minimise the total cost involved.

b) Diagnosis and Analysis of Damage

The first requirement for a lasting repair is to establish the cause and extent of the damage. Unless the cause of damage is known, it is not possible to eradicate the defect.

By establishing the precise extent of the damage the Engineer and the Contractor are in a position to assess the need and urgency for repairs.

The analysis must determine:
- the rusting steel reinforcement zones,
- the depth of carbonation,
- the presence of harmful substances,
- the thickness of the concrete cover,
- the damage to concrete surface,
- the cracking,
- etc...

c) Repairs and Reinstatements

The basic operations involved in repairing concrete damage by the Contractor are as follows:

1) Preparing the concrete substrate by:
- Testing the surface of the concrete,
- Preparing the subshate by:
- Sand blasting
- Torching

- Grinding, scabbing
- Steam cleaning
- Water pressure jetting
- Acid etching.
- etc...

d) Protecting the steel reinforcement against corrosion

- Derusting of steel reinforcement,
- Preparation of the surface (wire brush, sand blast..)
- Anti-corrosion coating.

e) Patching or resurfacing

- Small areas will be patched,
- Large surfaces will be resurfaced by special non Shrinkable mortar application or by grouting.

f) Crack repairs

Cracks may be treated by:
- filling by injection, or
- impregnating and sealing them with the same material.

g) Protecting concrete against further damage

Concrete can be directly protected against further damage by eradicating the original cause of the damage; however this is rarely accomplished without difficulties, and:
- Protective coating can be applied to the surface of the concrete (preventive action)
- Additional reinforcement can be added to the structure.

202.7.3 Concrete Repairs in News Concrete Works

Any concrete which in the opinion of the Engineer fails to comply entirely with this specification shall be declared defective and shall be cut out, removed from the site and replaced, and any steelwork reinforcement or other material damaged by the cutting and shall be replaced, all at the Contractor expansion.

The Contractor will submit to the Engineer, details of his proposal for rectifying the defects, and shall comply with the Engineer's instructions, regarding the procedure of carrying out the work.

Notwithstanding the Engineer approval, should the remedial work prove unsatisfactory, the Contractor shall make good the work and bear the whole cost occasioned by the defective work.

Immediately after the forms have been removed, all fins and projections and all timber works at joints shall be removed and rubbed smooth with a carborandum block.

All holes and honeycombing in the surface shall be cleaned out and roughened up to give a good key. These holes shall then be filled with 1:2 cement/sand mortar and after it has thoroughly hardened, the surface shall be rubbed down with a carborandum stone to an even finish.

Concrete filling shall be used for holes extending entirely through the concrete, for holes in which no reinforcement is encountered, and which are greater than 0.20 m^2 and deeper than 10 cm and for holes with reinforcement concrete which are in area greater than 0.05 m^2 and which extend beyond reinforcement.

Plastering of smooth concrete surfaces will not be permitted.

All mortar and concrete filling must be non shrinkable and shall be kept constantly moist and protected from drying due to surface temperature and natural ventilation.

All materials, procedures and operations used in the repair of concrete shall be subject to the Engineer direction. All fillings shall be bonded tightly to the surface of the holes and shall be sound and free from shrinkage cracks and drummy areas after the fillings have been cured and dried.

All repairs of concrete executed by the Contractor shall be deemed to be included in the unit rates for concrete work in the Bill of Quantities and shall not be paid separately.

202.8 TESTING OF CONCRETE

202.8.1 General

Prior to the commencement of work, trial mixes shall be prepared and preliminary tests for workability, compressive strength and impermeability (where required) will be made at an authorized laboratory. The results of these tests will be used in specifying the mix design to be used by the Contractor. During the progress of work, daily slump tests will be made to ensure that the concrete is dense and of an adequate workability.

With the commencement of concrete placement and on each day concreting, samples shall be taken for testing for compressive strength at the ages and frequencies as prescribed hereafter. Where required, samples shall be taken for impermeability tests. The Engineer shall determine the elements from which concrete samples shall be taken for testing.

202.8.2 Slump Tests

The slump measured in accordance with B.S. 1881 shall not exceed 5 cm in concrete for foundations and horizontal or inclined slabs and shall not exceed 10 cm in other parts of the

structures, unless otherwise specified or directed by the Engineer. Slump tests shall be made as directed by the Engineer.

202.8.3 Compressive Strength Tests

For testing the compressive strength of concrete, samples of fresh concrete shall be taken and used for preparing test cubes. The cubes shall be tested for compressive strength after 7 days and 28 days. The dimensions of the cubes and the methods of sampling and testing shall be in accordance with B.S. 1881. The cubes shall be marked and dispatched to the laboratory according to the instructions of the Engineer and at such intervals as may be specified by him.

Unless otherwise specified or directed by the Engineer, at least three samples shall be taken from different batches on the same day of casting. Out of every sample, at least two test cubes shall be prepared for testing at 7 and 28 days, respectively. The number of samples taken from hardened concrete which for any reason was not taken while the concrete was fresh or of which the strength obtained did not meet the requirements, and taking and testing of such samples shall be in accordance with B.S. 1881.

The average strength of the cubes or more tested at each age may be taken as the works cube strength of the concrete. This works cube strength may be accepted as complying with the specified requirement for works cube strength, if none of the compressive strengths of any of the cubes is below the specified works cube strength, or if the average strength is not less than the specified works cube strength and the strength of the weakest cube is not less than that listed in the following table. The table details the required cube strengths of work cubes and trial mixes for the various grades of concrete.

Compressive Strength Requirements (for all types of Concrete)

Grade	Characteristics compressive strength (kg/cm²)	Cube strength at 28 days (kg/cm²) **		
		Works cubes *		Trial mixes *
		Average	Weakest Cube	Average
C10	100	133	85	
C15	150	200	128	215
C20	200	275	170	315
C25	250	325	213	365
C30	300	375	255	415
C40	400	475	340	515
C50	500	575	425	615

* Strength requirements may be adjusted in accordance with CP110, if and as detailed in the Particular Specification.

** Concrete may be provisionally accepted on the basis of the days' cube strength, provided the average strength is at least 70% of the required 28 days strength and provided 28 days' cubes will be tested and will meet the requirements.

If for any part of a structure the works cube strength does not reach the required values at the age of 28 days, or if the concrete has hardened and samples have not been taken while the concrete was still fresh, the Engineer may permit the cutting of at least six cylinders out of the same part of the structure, and the cylinders shall be tested in accordance with the requirements of B.S. 1881. The concrete shall be deemed to comply with the specification if its strength, as deduced from the cylinder tests, meets the compressive strength requirements detailed in the above table and the results of the previous samples shall not be taken into account. Should the concrete also fail to meet the requirements in the testing of the cylinders as above, all the concrete from which the samples have been tested will be considered defective. In such a case, the Engineer may at his own sole discretion, order the carrying out of additional tests by any method he may deem fit, and if such additional tests show the concrete meeting the requirements he may accept it. Should the concrete not meet the strength requirements in the test of samples as above, or in the additional tests that the Engineer may have permitted, then it shall be dealt with according to one of the following two methods, chosen at the sole discretion of the Engineer.

(a) The Contractor shall demolish and re-construct the part of the structure made of the defective concrete.

(b) The Engineer will accept the defective concrete but reduce its price as defined hereinafter. This provision shall apply only to concrete in which the average compressive strength of the samples taken is not less than the Characteristic Compressive Strength listed in the table. In such an event, the Engineer may accept the concrete, but reduce 2% of the unit rate per cubic meter of the defective concrete for every kg/cm² of the difference between the required strength and the average strength. (For example: C130 concrete was required. The strengths of all samples were above 255 kg/cm² but the average strength of the samples was 367.5 kg/cm² instead of 375 kg/cm². In this case the Engineer may, at his sole discretion, accept the concrete and reduce its unit rate by 15%).

Concrete that has not met the requirements as stated above and concrete that the average compressive strength of the samples of which is below the nominal strength shall be rejected in every case. The part of the structure made of the rejected concrete shall be demolished and re-

built by the Contractor at his own cost.

202.8.4 Impermeability Tests

Where required on the Drawings or the Specification, or where directed by the Engineer, the concrete shall be tested for impermeability. Samples for the impermeability tests shall be in the form of 20x12 cm plates and shall be prepared, cured and tested in accordance with DIN 1048. Unless otherwise stated in the Particular Specification or elsewhere in the Contract, the requirement for impermeability shall be that, when a water pressure of 2 kg/cm² is applied to one side of the test specimen, no moisture shall appear on the other side.

202.8.5 Payment for Tests

The costs of sampling and performing the tests in accordance with this Section, including all labour, equipment, transportation and ancillary works, shall be deemed to be included by the Contractor in his unit rates for concrete and shall not be paid for separately, unless specific items for testing are included in the Bill of Quantities.

202.9 STEEL REINFORCEMENT

202.9.1 General

Reinforcement steel for concrete shall meet the requirements of the relevant British Standards listed in Subsection 202.1.2 of this Specification.

The Contractor shall supply the Engineer with certificates from the makers of the steel showing that it has complied under test with the appropriate Standard Specification, stating the process of manufacture and if required the chemical analysis, and such test sheets shall be forwarded to the Engineer one week before the dispatch of such steel to the Works.

The steel shall be stored off the ground and kept scrupulously clean and free from loose mill scale, loose rust, oil and grease or other harmful matter. Any bar adversely affected by storage or for any other reason shall be cleaned or removed from the Site and replaced by the Contractor at his own expense.

202.9.2 Bar Schedules

Where reinforcement bar schedules are shown on the Drawings to assist the Contractor in preparing and placing the steel reinforcement, the Contractor shall carefully check such bar schedules for compliance with the structural drawings and shall correct the bar schedules as necessary. Where no bar schedules are incorporated in the Drawings, the Contractor shall

prepare such schedules at his own cost and responsibility. In any case, the Contractor will be solely responsible for the correct preparation and placing of steel reinforcement in accordance with the Drawings. Any bars bent and prepared according to incorrect schedules, and not suitable for placing in the structure will be rejected and will not be paid for.

202.9.3 Bending Reinforcement

All bending shall be done cold, by an approved bending machine, in a manner that will not injure the material. Welded joints shall not be permitted in any bar. Only experienced steel benders, to the approval of the Engineer, shall be employed in bending. All bending shall be in accordance with British Standard 4466. The internal radius of all cranks and bends shall be at least three times the diameter of the bar. Heating of mild steel bars only to facilitate bending, especially of large diameter bars, will be permitted, provided the temperature of the steel does not exceed 850°C (cherry-red heat) and provided further that the cooling rate is low and uniform (normal still-air cooling). Quenching of hot-bent bars in water will not be permitted. Reinforcement bars depending on cold working for their strength, such as cold drawn or twisted bars shall not be bent hot.

202.9.4 Placing Reinforcement

The number, size, form and position of all steel bars, ties, links etc.. shall be in exact accordance with the Drawings and in the placing and fixing the function of each bar shall be borne in mind.

The greatest care shall be taken to ensure that the steel is laid out correctly in accordance with the Drawings and fixed rigidly within the forms. Sufficient temporary ties of annealed iron wire shall be provided to prevent any displacement before or during the placing of concrete and to ensure that the specified amount of cover is everywhere maintained. Concrete shall be rammed firmly with spatulas around the steel and compacted against it and against the shuttering.

No pieces of metal or blocks or wood shall be used on the bottom surface or against the sides of formwork to keep the reinforcing bars in position. For this purpose specially prepared precast concrete blocks shall be used of a thickness equal to the concrete cover specified hereafter. The use of plastic spacers is also accepted.

Unless otherwise shown on the Drawings or directed by the Engineer, the cover reinforcement, including cover stirrups and distribution bars, shall be at least equal to the diameter of the principal reinforcement bars plus

- at least 1 cm in the case of solid interior slabs, or
- at least 1.5 cm in all other cases, or
- at least 1 cm in addition to the above in the case of elements exposed to climatic influences.

In any case, all parts of a structure in direct contact with the earth or water shall have at least 3 cm cover over reinforcement, including stirrups and distribution bars.

The minimum cover stipulated above shall be increased, if necessary, up to 5 cm wherever a structure is particularly liable to danger of corrosion or abrasion, and up to 8 cm where concrete is placed directly against earth, without formwork.

Bars, generally, shall be of the required lengths and the lapping of main bars will not be permitted, except as indicated on the Drawings. Where bars are required or permitted to be lapped, the parts along the lap shall have a clear space between them equal to 1cm or the diameter of the bar, whichever is the greater. The minimum length of overlap will be 40 times the diameter of the bars for hooked bars and at least 60 times the bar diameter for bars without

hooks. Laps of adjacent parallel reinforcement bars shall be staggered. Ends of ties shall be cut back 1.5 cm from face and covered with mortar. Fabric reinforcement shall be lapped at least 40 diameters or two squares, whichever is the greater.

All laps of bars are to be tied tightly with six laps of 1.5 mm annealed iron wire at intervals of ten diameters of the bars. All crossings of steel are to be secured with three laps of wire. Splicing of bars by butt welding will be permitted, provided that the resulting joint is not inferior in strength to the rest of the bars. Bars depending for their strength on cold drawing or twisting shall not be spliced by welding. Crossings of steel bars may be secured by tack welding instead of tie-wires, provided that burning or other damage to steel at tack-welds is prevented. All welds shall be done in a thoroughly workmanlike manner by qualified welders either by the oxy-acetylene method to BS 693 or by the metal arc method to BS 5135. Splices of bars having a diameter of 26 mm and more shall be done by butt-welding only.

The Contractor shall not pour any concrete before the Engineer has inspected and approved the placement of reinforcement. Such approval shall, however, not affect the Contractor's responsibility for the correctness of the reinforcement in accordance with the Drawings, reinforcement schedules, Specifications and/or directions given by the Engineer.

202.10 FORMWORK

202.10.1 General

The Contractor shall design, supply and fix all necessary formwork, together with its attendant scaffolding, timbering, shoring, strutting, etc.., required for the placing of the concrete.

The Contractor will be permitted to use timber boarding as formwork or forms lined with plywood, hardboard of approved manufacture or steel sheets. Where timber boarding is used, the formwork surfaces coming in contact with wet concrete shall be made of properly seasoned timber. Full size plywood or hardboard sheets shall be used except where otherwise required or where smaller pieces will cover the entire area. Forms shall be so placed that markings shall be symmetrical.

All formwork shall be of sufficient strength to resist movement of men or equipment and the pressure of the wet concrete while it is being placed and vibrated, without distortion. Where plywood, hardboard or steel lining is used, particular care shall be taken to ensure that the forms are adequately braced and stiffened.

The formwork for successive vertical lifts must make such perfect contact with concrete in the preceding lift that there shall be no excrescences, bulges, tears or other outward signs of faulty junction. The formwork must be constructed so that there shall be no leaked of mortar. Whenever it is unavoidable, the Contractor shall prevent leakage of any kind through open joints by means of suitable caulking.

The repeated use of forms of all descriptions will be at the discretion of the Engineer, who will require the forms to be reconditioned or surfaced from time to time. After repeated use, the old forms will be replaced with new ones at the direction of the Engineer.

All exposed concrete shall have the external angles chamfered 20 mm or as directed by means of moulding strips fixed to the formwork. Interior angles on such surfaces and edges at formed

joints will not require bevelling unless requirement for bevelling is indicated on the Drawings.

The height of all erected at any one time shall be subject to the approval of the Engineer.

The surface of the forms shall be free from encrustation of mortar, grout, or other foreign material. Before the form panels or boards are erected in place, the surfaces of the forms shall be oiled with an approved commercial form oil that will effectively prevent sticking and will not stain the concrete surfaces.

202.10.2 Types of Forms

The surfaces of formwork to give a desired finish of formed concrete will be classified as follows :

(a) Unwrought Formwork of unwrought timber will be permitted in formwork for concrete surfaces or portions thereof which will receive plaster or other facing, or which will be covered up below ground level.

(b) Wrought Formwork (for Smooth Internal and External Surfaces) made of new plywood or new steel sheets or timberboarding planed on both sides to equal thickness, shall be used on all exposed concrete surfaces except where plaster or another facing or fairface concrete are provided for. The formwork shall ensure that a regular and smooth finish is obtained, free of excessive bulges, irregularities or unsightly markings or defects of any kind.

(c) Fair-face Concrete Formwork shall be employed where shown on the Drawings, required in the Specification or directed by the Engineer. This type of formwork shall include use of new plywood or new steel sheets equal thickness, joined by torque and groove joints in parallel and vertical or horizontal alignment, arranged so as to achieve concrete surfaces of the textures and patterns required.

Where the surfaces formed in wrought or fair-face formwork are defective, the Engineer may order repairs to be made in accordance with Section 202.7 above and, if large surfaces should be found honeycombed or otherwise impaired, he may order all such surfaces to be plastered with cement plaster. Repairs to fair-face concrete, where required, shall be made in accordance

with Section 202.7 above, but if in the Engineer's opinion such repairs would be insufficient to restore the external appearance of the surface, he shall order surfaces destroyed and cast anew.

The cost of all above-mentioned repairs to concrete surfaces, including application of cement plaster, and re-casting shall be deemed to be included in the unit rates for concrete work in the Bill of Quantities and shall not be paid for separately.

202.10.3 Form Ties

Embedded metal rods or sleeves used for holding forms shall remain embedded and shall terminate not less than 2½ cm from the face of the concrete. Embedded wire ties for holding forms will not be permitted in concrete walls which are to come into contact with liquids or where the concrete surfaces through which the ties would extend will be permanently exposed. Wire ties may be used for concrete walls to be plastered, stone faced or covered with earth. Wire ties shall be cut back at least 1.5 cm from the face of the concrete. The holes left in the concrete surfaces after cutting back of wire ties and removal of fasteners or holding rods or sleeves, and the insides of sleeves where sleeves are used, shall be completely filled with an approved non-shrinking mortar, and the mortar shall be finished flush with the concrete surfaces. This operation will be carefully carried out. The hole formed by the cutting process will be thoroughly cleaned and wetted before filling. Time mortar will be of damp, not wet, consistency. The patch will be properly towelled smooth to match the surrounding concrete surfaces and shall be thoroughly cured by keeping it moist continuously for at least three days. After the patch has hardened, the Engineer may require the patch and the adjacent concrete surface to be ground down smooth. Any patches that are loose or hollow on completion must be re-done. Water stop tie rods shall be used for liquid retaining structures.

All costs for complying with the requirements of this Subsection shall be deemed to be included in the unit rates for formwork and shall not be paid for separately.

202.10.4 Embedded Metal Parts

Parts of metal work, such as fixtures for wall brackets, hooks and similar parts that are to be embedded in the concrete shall be attached to the forms in their proper position prior to placing of concrete.

All costs for and in connection with the installation of metal parts shall be deemed to be included in the unit rates for formwork and for concrete and shall not be paid for separately, except where specific items shall be included in the Bill of Quantities.

202.10.5 Striking of Forms

To facilitate satisfactory progress with the specified curing and to permit earliest practicable repair of surface imperfections, forms shall be struck as soon as the concrete has hardened sufficiently to prevent damage by careful form removal. Forms shall not be struck until the strength of the concrete is such that form removal will not result in perceptible cracking,

breaking of surfaces, or other damage to the concrete and that the concrete can sustain the loads to be borne at the time of striking. Forms shall be struck with care so as to avoid injury to the concrete, and any concrete so damaged shall be repaired at the Contractor’s expense.

No forms shall be removed without the express permission of the Engineer’s Representative, but the Contractor shall, nevertheless, accept sole responsibility for the removal and consequences thereof.

In no case shall forms to soffits be struck until test cubes from the actual concrete concerned have yielded the 7 days strengths specified.

As a guide to the Contractor and subject to the foregoing requirements the followings minimum striking times, from the completion of concrete placing, may be assumed:

– For sides of Foundations, slabs, etc. - 24 hours
– For sides of Beams in suspended work, sides of walls and columns - 48 hours
– For sides of Retaining Walls - 36 hours
– For soffits of Beams and Slabs in suspended works (spans up to 3 meters) - 10 days
– For soffits of Beams and Slabs in suspended works (spans 3 to 6 meters) - 12 days
– For soffits of Beams and Slabs in suspended works (spans over 6 meters) - 14 days
– For the soffits of beams having a span of more than 5.0 m, at least one support and for those of slabs having a span exceeding 6.0 m, at least one row of supports shall be left in place for an additional period of seven days.

If the striking times stated above are not sufficient to permit the unsupported concrete to sustain superimposed loads (such as support for the shuttering of an upper floor, storing of building materials, etc..). Such loads will require special supports to sustain theim.

202.11 MISCELLANEOUS CONCRETE WORKS

202.11.1 Openings and Holes in Concrete

Openings in concrete walls or slabs or reservoirs shall be predetermined and subject to the approval of the Employer. No openings shall be made after formworks removal. The Contractor shall be responsible for the co-ordination of all requirements of his sub-contractors as regards provision of openings, holes and fixings, and prepare shop drawings.

Holes left after the removal of formwork shall be filled with a compensating epoxy-based mortar or any similar product. For water retaining structures water stop tie rods shall be used when filling the holes to ensure watertightness.

Where it is impracticable, as determined by the Engineer's Representative, to install metal parts in the forms as required under Subsection 202.10.4 suitable holes or recesses shall be formed in

the concrete structure into which the metal parts can be placed and grouted in. The shape and dimensions of such holes shall be as shown on the Drawings or as determined by the Engineer's Representative, and they shall be formed with wooden core boxes, fabricated in such a manner that they can be completely withdrawn or broken up and removed after the concrete has set. All such core boxes shall be set with great accuracy with the aid of templates and securely fixed to prevent displacement during concreting. The supply and installation of all such core boxes and their removal when the concrete has hardened sufficiently shall be deemed to be included in the unit rates for formwork and concrete work and shall not be paid for separately.

Where the holes or openings have not been formed in the concrete during placement, the Engineer may either order the tearing down and rebuilding of the structure or the part thereof concerned, or permit such holes or openings to be cut in the hardened concrete to the

dimensions shown on the Drawings or as directed by the Engineer. Such cutting shall be kept to the minimum necessary dimensions and shall be done by drilling, chiselling or the use of a power tool, all as approved by the Engineer and in such a manner as not to cause any damage to the concrete structure.

Reinforcement bars passing through such holes or openings shall not be cut without the express written permission of the Engineer's representative.

Where the forming of the openings or holes has been omitted by the Contractor's neglect, all tearing-down and rebuilding or cutting of holes and openings in the hardened concrete as aforesaid shall be done by the Contractor at his own expense, in all other cases the cost thereof shall be borne by the Employer and shall be paid for as extra work under Clause 51 of the Conditions of Contract.

202.11.2 Manholes and Chambers

Manholes and chambers shall be constructed in the positions and to the details shown on the Drawings. The grades of concrete and types of formwork shall be as shown on the Drawings, as required in the Specification or as directed by the Engineer. The inside dimensions, unless otherwise specified, will be after plastering or to otherwise finished surfaces.

A base slab of concrete, supporting the walls, shall be cast on firm ground foundations (so as to prevent any differential settlement), on a blinding layer of Lean Concrete (Grade C10). Where shown on the Drawings, smoothly constructed U-shaped channels, to carry and direct the flow, shall be formed integrally with the concrete base, or may be constructed separately by benching. Adjacent floor areas shall slope to drain to the channel with a gradient of about 5% to 10%. All transition curves shall be smooth.
The whole of the floor areas and channel surfaces shall be finished with a smooth coat of cement mortar.

The walls of the manholes shall be made of cast-in-situ concrete or of precast concrete rings, all as shown on the Drawings. The construction of walls shall not start sooner than 24 hours after slab had been cast. Cast-in-situ concrete and precast concrete shall be Grade C30 for floors, walls; ceilings and Grade C15 for benching. Precast concrete Chamber and Shaft rings

shall conform to requirements of B.S. 556, shall be of the tongue and groove type and shall be assembled with cement-mortar joints to ensure complete water tightness of the joints.

Internal surfaces of Manholes and Chambers shall be absolutely smooth. This shall be achieved by the use of wrought formwork or by plastering with cement mortar 1:1½ and steel trowel finish with the addition of cement in the proportion of 1 kg per square meter as shown on the Drawings or as directed by the Engineer.

Aluminium or galvanized steel steps, or a ladder if so shown on the Drawings, shall be provided in all manholes 1.25 m deep and over. The steps shall be staggered and spaced at about 25 cm vertically, or as shown on the Drawings. They shall be solidly embedded in the walls prior to the plastering. The top step shall always be located to accommodate the right foot. Step irons for manholes shall comply with B.S. 1247 type A and shall be hot-dip galvanized. All steps shall be built in as the work proceeds. Cutting out completed work for inserting steps or other fittings shall only be permitted where it is impossible to built them in as the concrete is being cast. Unless otherwise specified, in manholes with depths greater than

5.25 m, laders shall be installed instead of steps. The ladders shall comply with the Drawings or shall be as specified or directed by the Engineer.

Where shown on the Drawings or directed by the Engineer, pipe stubs for future connections shall be installed. The stubs shall extend at least 50 cm beyond the outside of the walls of the manhole and shall be plugged watertightly. Appropriate channels for the future connections shall also be prepared in the benching.

Unless otherwise indicated, manhole and chamber covers shall be suitable for heavy duty and shall be made of cast-iron to B.S. EN124 or concrete with cast-iron frames, of a type approved by the Engineer. Suitable lifting keys of mild steel shall be provided with the covers at a rate of 1 set of keys for each 10 covers. After the completion of the work, cast iron parts of the covers and the frames shall be thoroughly cleaned and painted with bitumen paint.

Manholes shall be watertight. The Contractor shall, if so required, test them in the presence of the Engineer. The Contractor shall provide all water labour, drains, stoppers, bends and other needful appliances for carrying out tests and no manholes or other work must be covered up until they have been seen and passed by the Engineer. The test to be applied to manholes and chambers shall be their filling with water to 10 cm below the slab or to finished ground level and after allowing due time for saturation of the concrete, by topping up to the original level. Thereafter the loss of water shall not be greater than the equivalent of 2 cm over the whole area of the chamber in 24 hours.

202.11.3 Thrust and Anchor Blocks

Concrete thrust and anchor blocks shall be formed at bends, tees and valves in accordance with the details shown on the Drawings or as directed by the Engineer. Excavation shall be made after pipelaying, and the blocks concreted immediately after excavation. The back of supports and blocks shall abut on to solid ground with all loose material being removed before concreting.

No pressure shall be applied in any section of main until the concrete has achieved adequate strength and at least three day's curing.

Flexible joints shall not normally be cast in. Where the size of the block does not make this possible, additional flexible joints shall be provided no greater than half a pipe diameter beyond each face of the block.

202.11.4 Concrete Surround to Pipes

Where pipelines pass under streams and rivers or where directed by the Engineer, the pipeline shall be surrounded with concrete as shown on the Drawings.

Concrete surround shall be broken at all pipe joints to retain flexibility in the pipeline. No joints shall be concreted in without the prior approval of the Engineer.

202.11.5 Precast Concrete

All precast concrete members to be used in the works, such as covers, lintels, sills, slabs, stairs, etc.., shall be manufactured on site or obtained from approved manufacturer. In either case casting shall be done under the supervision of the Engineer, whose approval of the place and method of casting must be obtained before starting work. If casting is done on the site, the Contractor shall prepare a suitable area near the structure for which the precast parts are intended, and samples of the precast work shall be submitted to the Engineer for approval before proceeding with the manufacture on site. Casting of the precast parts shall be completed in due time so as not to delay the completion of the structures and everything connected therewith.

Unless otherwise directed, precast elements shall be of concrete Grade C30P. All precast elements shall be true to dimensions and shapes as shown on the Drawings. Concrete surfaces shall be smooth and all corners square or chamfered, as shown on the Drawings or directed by the Engineer. Lifting lugs and similar metal parts, whether part of the reinforcement steel or not, shall be incorporated in the elements during manufacture. Precast elements shall not be transported or otherwise handled until the end of the curing period, which shall be at least 14 days.

Any precast concrete element becoming defective during casting or placing or from any other cause, and rejected by the Engineer, shall be removed from the Site by the Contractor who shall cast new elements to replace the rejected ones, and all expenses in connection therewith shall be borne by the Contractor.

202.11.6 Cast-in-situ Reinforced Concrete piles

The piles shall be cast in boreholes of the required diameter and depth drilled into the ground. The exact depth will be fixed in-situ by the Engineer. The deviation of the centre of the pipe

from its exact location as shown on the Drawing shall be no more than 3 cm and the deviation of the completed shaft from its true vertical alignment shall not exceed 1%.

A number of drill core samples shall be taken and a log-book kept providing the required profile data. The shaft shall be filled with concrete as soon as it has been bored and the reinforcement has been placed. In the event that concreting cannot be done on the same day as the boring, the boring of the last meter of the pile shall be postponed till the next day. In any event, the last meter of boring shall always be done just before concreting.

The reinforcement cages shall be provided as shown on the Drawings. They shall be prepared in appropriate lengths, but not longer than 12.0 m. Consecutive lengths shall be welded together by the electrical fusion method. The cages shall be carefully placed with the aid of a crane and kept in position before and during placement of the concrete. Appropriate arrangements, to be approved by the Engineer's Representative, shall be made so as to ensure the required distance between the cage and the inner surface of the shaft, which shall be not less than 5 cm, if not otherwise specified.

The Contractor shall submit to the Engineer's approval a complete description of the method and equipment he proposes to use for pile construction. The whole work of pile construction

shall be carried out by skilled and experienced workmen under expert supervision, and if the Contractor is not himself a piling specialist, he shall employ one as a sub-contractor.

The method of pile construction, whether the dry shaft or wet shaft, shall be chosen according to subsoil conditions on the site, with which the Contractor shall be well acquainted.

a) Dry Shaft method:

The dry shaft method may be used where subsoil conditions so permit. Generally, drilling shall be done through a steel casing which shall be continuously lowered into the borehole. The casing shall consist of sections that can be easily jointed and separated to permit lowering and raising of the casing as required.

In special cases when the boring is done in soil possessing high cohesion and plasticity, the boring may be done without a temporary casing. However, the top 1.5 m shall always be cased and the casing allowed to project at least 0.3 m above ground level. After concreting, this casing shall be withdrawn.

When the pile borehole has been bored to its correct depth, great care shall be taken to ensure that the bottom of the shaft is clean. A small bailer can be used for the last dig to do the job.

The concrete used in piles shall be Grade C20P or stronger as specified; its slump shall be 10 to 15 cm. Concrete shall be cast into the shaft through a circular tremie, the mouth of which shall be near the level of the cast concrete or immersed in it and in any case no more than 0.5 m above the top level of the concrete at any time. The tremie shall be built up of separate sections which can be easily disconnected to be taken off as the concrete rises in the shaft. The casing shall be gradually extracted as the concrete is cast, so that the shaft is well filled with concrete. During casting of concrete, the lower end of the casing shall remain immersed in the concrete for at least 3 m at any time.

b) Wet Shaft Method

The wet shaft method shall be used whenever required due to the presence of artesian water and may be used elsewhere if preferred over the dry-shaft method.

Under the wet-shaft method, the shaft is filled during the excavation and concreting stages with a bentonite suspension, the volume weight of which shall be between 1.03 to 1.08 t/m^3 so as to be : (1) sufficiently high to keep the soil from caving into the shaft and prevent any groundwater inflow; and (2) sufficiently low in order not to intermingle with the concrete. The bentonite level in the shaft shall always be higher than the underground water level existing at the site.

The dry bentonite particle size distribution shall be characterized by 90% particles smaller than 2 microns. The bentonite mixture shall be such that, in a laboratory sample mixture made with clean potable water, no decantation will occur after a time equal to the expected time of bentonite mixture presence in the shaft, nor after two hours, whichever is longer.
At the top of the shaft a protruding section of a temporary casing of about 1.0-2.0 m length shall be provided, and shall be withdrawn after concreting has been completed. Before concreting starts, the bottom of the shaft be cleaned from sand and any drill cuttings, using a mud or air-lift pump. The recirculated bentonite shall be passed through a vibrating sieve or settling tanks till no more fragments are discharged by the pump.

The concrete shall be cast through a tremie, as specified above, except that before concrete placement begins, the bottom of the tremie shall be lowered to a distance above the shaft bottom equal to 0.5 to 1 times the diameter of the tremie. It shall be kept in this position till the concrete rises about 4-5 m, whereupon the withdrawal of the tremie shall begin. Generally, the bottom of the tube shall be submerged in the concrete for about 3 m and in no instance less than 1.5 m.

The concrete slump shall be 15 to 20 cm so as to ensure good workability.
At the start of concrete casting a quantity of foamed polystyrene chips shall be introduced into the tremie to prevent segregation of the first batch of concrete reaching the bottom of the shaft shall lift and drive up the bentonite suspension, as well as any sand and silt that may have accumulated at the bottom of the shaft.

Pouring of concrete shall continue until the shaft has been completely filled with concrete and any sand, drill cuttings and silt have been driven out at the top of the temporary casting and until clean concrete will appear.

202.11.7 Hourdis Slabs

A Hourdis slab is a monolithical reinforced concrete slab consisting of embedded beams and ribs separated by raws of hollow blocks (Hourdis blocks).

The reinforcement bars of the beams and ribs as well as the hourdis blocks shall be placed on the formwork prior to start concreting.

The hourdis slabs shall be carried out in accordance with the details and dimensions shown on the Drawings.

202.12 JOINT SEALS WITH ELASTOMERIC SEALANTS

202.12.1 Major Components

The major components of a good joint seal are:

- The substrate,
- The joint filler,
- The bond breaker, and
- The sealant.

a) The substrate:

The more common substrates are masonry concrete, metal, and glass; these are generally classified as porous /or/ non porous.

- Some substrate may not be suitable for achieving a bond unless, treated mechanically, chemically, or both.

- When the substrate has a coating, this coating must be compatible with the sealant and

its bond to the substrate and sealant must be adequate.

- The Contractor must consult both substrate and sealant manufacturers for suitable joint preparation methods and primers to be used before applying joint materials.

- Adhesion testing of trial applications in the site is recommended.

- Surface laitance and incompatible or bond-inhibiting form release agents on concrete surfaces, must be removed.

- Substrates must be clean, dry, sound, and free of loose particles, contaminants, foreign matter, water-soluble material, and frost.

- Joints in masonry and concrete should be sealed before cleaning exposed surfaces and applying required protective barriers.

b) Primer:

The purpose of a primer is to improve the adhesion of a sealant to a substrate. Many sealant require primers on all substrate; some on only certain substrate or on none at **all.** Most require a primer for maximum adhesion to concrete and masonry surfaces.

c) Joint Fillers:

A joint filler is used to control the depth of sealant in the joint and permit full wetting of the intended interface when tooled.

Some joints fillers may be incompatible with the substrate and sealant, causing stains, on either one of them or both. Some may be factory coated with a suitable material that provides a barrier to staining.

The Contractor must confirm this suitability, i.e. that the barrier coating must be acceptable to both, the sealant and the joint filler manufacturers.

Joint filler for vertical application may be flexible, compatible, closed cell plastic foam /or/ sponge rubber rod stock, and elastomeric tubing of such materials as:

- neoprene,
- butyl, and
- E.P.D.M.

They should resist permanent deformation before and during sealant application, be non absorbent to water or gas, and resist flowing upon mild heating since this can cause bubbling of the sealant.

- Open cell sponge type materials such as urethane foam may be satisfactory, provided that their water absorption characteristics are recognised. The sealant should be applied immediately after joint filler placement to prevent water absorption from rain.

- Elastomeric tubing of neoprene, butyl, or EPDM may be applied immediately as a temporary seal until the primary sealant is put in place, after which they serve to a limitated degree as a secondary water barrier.

  Joint filler for horizontal application (for floors, pavements, sidewalks, patios and other light-traffic areas may be compatible, extruded, closed cell, high density flexible foams, corkboard, resin-impregnated fiber board /or/ elastomeric tubing /or/ rods).

- These joint fillers should remain resilient in cold temperature, exhibit good recovery, not cause the sealant to bubble in the joint because of heat, and be capable of supporting the sealant in traffic areas.

- They should not exude liquids under compression, which could hydraulically cause sealant failure by forcing the sealant from the joint.

- Combination of joint filler may be used to form a joint in concrete and an additional filler material may be installed under compression across the width and to the proper depth just before the sealant is applied to provide a clean, dry, compatible backup.

d) Bond breaker:

A bond breaker may be necessary to prevent adhesion of the sealant to any surface or material where such adhesion would be detrimental to the performance of the sealant.

- The use of a joint filler to which the sealant will not adhere may preclude the need for a bond breaker.

- The bond breaker may be a polyethylene tape with pressure-sensitive adhesive on one side /or/ various liquid applied compounds, as recommended by the sealant manufacturer.

e) Sealant

Sealants are classified as:

- single component /or/ multicomponent
- non sag /or/ self leveling,
- traffic /or/ non traffic use

as well as according to movement capability.

- Characteristics of common elastic sealants are listed in the following Table 2.5:

Table 2.5

CHARACTERISTICS OF COMMON ELASTOMERIC SEALANTS

	ACRYLIC (SOLVENT RELEASES)	POLYSULFIDE		POLYURETHANE		SILICONE
	(ONE PART)	TWO-PART	ONE-PART	TWO-PART	ONE-PART	(ONE PART)
Chief ingredients	Acrylic terpolymer, inert pigments, stabilizer, and selected fillers	Polysulfide polymers, activators, pigments, plasticizers, inert fillers, gelling, and curing agents		Polyurethane prepolymer, inert fillers, pigments, plasticizers, accelerators, activators, and extenders	Polyurethane prepolymer, inert fillers, pigment, and plasticizers,	Siloxane polymer pigment, and selected fillers
Percent solids	85-95	95-100	95-100	95-100	95-100	95-100
Curing process	Solvent release and very slow chemical cure	Chemical reaction with curing agent	Chemical reaction with moisture in the air	Chemical reaction with curing agent	Chemical reaction with moisture in all, also oxygen	Chemical reaction with moisture in all
Curing characteristics	Skins on exposed surface; interior remains soft and tacky	Cures uniformly throughout; rate affected by temperature and humidity	Skins over, cures progressively inward; final cure uniform throughout	Cures uniformity throughout; rate affected by temperature and humidity	Skins over, cures progressively inward; final cure uniform throughout	Cures progressively inward; final cure uniform throughout
Primer	Generally not required	Manufacturer's approved primer required for porous surfaces, sometimes for other surfaces		Manufacturer's approved primer required for most surfaces		Required for most surfaces
Application temperature (°F)	40-120	40-100	60-100	40-120	40-120	0-120
Tackfree time	1-7 days	6-24 hr	6-72 hr	1-24 hr	Slightly tacky until weathered	1 hr or less
Hardness, Shore A Cured 1 to 6 months Aged 5 years	 0-25 45-55	 15-45 30-60	 25-35 40-50	 20-40 35-55	 25-45 30-50	 20-40 35-55
Toxicity	Nontoxic	Curing agent is toxic	Contains toxic ingredients	Toxic; gloves recommended for handling		Nontoxic
Cure time (days)	14	7	14-21	3-5	14	5
Joint movement capability (max.)	± 12.5%	± 25%	± 15%	± 25%	± 15%	± 25% high modulus ± 50% low modulus
Ultraviolet resistance (direct)	Very good	Poor to good	Good	Poor to good	Poor to good	Excellent
Dirt resistance cured	Good	Good	Good	Good	Good	Poor
Use characteristics	Excellent adhesion; poor low-temperature flexibility; not usable in traffic areas; unpleasant odor 5-12 days	Wide range of appropriate applications; curing time depends on temperature and humidity	Unpleasant odor; broad range of cured hardnesses available	Sets very fast; broad range of cured hardnesses; excellent for concrete joints and traffic areas	Excellent for concrete joints and traffic areas, but substrate must be absolutely dry; short package stability	Requires contact with air for curing; low abrasion resistance; not tough enough for use in traffic areas

202.12.2 Joint Design

The design geometry of a joint seal is related to numerous factors including:

- desired appearance,
- spacing of joints,

- anticipated movement in joint,
- movement capability of sealant to be used,
- required sealant width to accommodate anticipated movement,
- and tooling methods.

a) Sealant width

The required sealant width relative to thermal movement is determined by:

- the application temperature range of the sealant
- the temperature extremes anticipated at the site location
- the temperature at the time of sealant application, and
- the movement capability of the sealant to be used.

1) In the absence of specific application temperature knowledge, an ambient application temperature from 4ºC to 38ºC (40º to 100ºF) should be assumed in determining the anticipated amount of joint movement in the design of joints.

2) Although affected by ambient temperatures, anticipated joint movement must be determined from anticipated building material temperature extremes, rather than ambient temperature extremes.

3) Many other factors can be involved in building joint movement including but not limited to:

   a) material mass
   b) color
   c) insulation
   d) differential thermal stress (bowing)
   e) residual growth or shrinkage of materials
   f) building sway and
   g) seismic forces

4) The design joint width should be calculated taking all possible movement and tolerance factors into consideration.

5) A simplified method (but no as accurate) is to use the accompanying graph.

b) Joint depth:

The sealant depth, when applied, depends on the sealant width; the following guidelines are normally accepted practice

1) For a recommended minimum width of ¼ in, the depth should be ¼ in

2) For joints in concrete, masonry, or stone, the depth of the sealant may be equal to the sealant width in joint up to ½ in

   a) for joints ½ in to 1 in wide, the sealant depth should be one-half of the width.
   b) for joints 1 to 2 in wide, the sealant depth should not be greater than ½ in.
   c) for widths exceeding 2 in, the depth should be determined by the sealant manufacturer.

3) For sealant widths over ¼ in and up to ½ in in metal, glass and other nonporous surface joints the minimum of ¼ in in depth applies, and over ½in in width the sealant depth should be one-half the sealant width and should in no case exceed ½in.

When determining the location of the joint filler in the joint, consideration should be given to the reduction in sealant depth with concave and recessed tooled joints, and the joint should be designed accordingly.

202.12.3 Application

To obtain proper adhesion, it is essential that:

- the sealant comes in direct contact with the substrate,
- the sealant wets the surface of the substrate
- the substrate is strong enough to provide a firm anchor for the sealant.

– If any of these conditions is not met, poor adherence will usually result.

– The sealant should be installed in such manner as to completely fill the recess provided in the joint.

Against a porous material, the sealant must enter the pores if goal adhesion is to be obtained. Sealants used for this application are thixotropic and will resist flow into the pores unless an external force is applied. Proper filling of the recess accomplishes this, in part, and proper tooling ensures it.

a) Joint preparation:

For a joint to receive sealant it must be cleaned out and raked to full width and depth required for installation of joint seal materials. Thoroughly cleaning all joints is by removing all foreign matter such as: dust, paint (unless it is a permanent protective coating), oil, grease, water proofing or water-repellent treatments, water, surface dirt and frost.

– Clean porous materials such as: concrete, masonry and unglazed surfaces of ceramic tile, by brushing, grinding blast cleaning, mechanical abrading, acid washing or a combination of these methods to provide a clean, sound substrate for optimum sealant adhesion.

– The surface of concrete may be cut back to remove contaminants and expose & clean surface when acceptable to the purchaser.

– Remove laitance from concrete by:

  - Acid washing
  - grinding or
  - mechanical abrading

– remove all form of oils from concrete by blast cleaning.

– remove loose particles originally present or resulting from

  - grinding abrading or

- blast cleaning

– by blowing out joints with oil free compressed air (or vacuuming) prior to application of primer or sealant.

– Clean nonporous surfaces, such as metal, glass, porcelain enamel and glazed surfaces of ceramic tile chemically or by other means that are not harmful to the substrate and are acceptable to the substrate manufacturer.

– Remove temporary coatings on metallic surfaces by a solvent that leaves no residue. Apply the solvent with clean oil free cloths or lintless paper towels. Do not dip cleaning cloth in the solvent. Always poor the solvent on the cloth to eliminate the possibility of contaminating the solvent. Do now allow the solvent to air-dry without wiping. Wipe dry with a clean dry cloth or lintless paper towels. Permanent cloathings that are to be remain must not be removed or damaged.

b) Masquing Tape:

Install masquing tape at joint edges when necessary to avoid undesirable sealant smears on exposed visible surfaces. Use a non staining, non-absorbent, compatible type.

c) Primer and Joint Filler:

Install primer when and as recommended by the sealant manufacturer for optimum adhesion.

Install compatible joint filler uniformly to proper depth without twisting and braiding.

d) Sealant:

Install sealant in strict accordance with the manufacturer's recommendations and precautions. Completely fill the recess provided in the joint. Sealants are more safety applied at temperature above $40^{o}F$ ($\approx 5^{o}C$)

e) Tooling:

– Tooling nonsag sealants is essential to force the sealant into the joint and eliminate air pockets and should be done as soon as possible after application and before skinning or curing begins. Tooling also ensures contact of the sealant to the sides of the joint.

– Plastic or metal tools can be used. Most applicators use dry tools but they may be surface-treated to prevent adhesion to the sealant and may be shaped as desired to produce the desired joint profile. Dipping tools in certain liquids decreases the adhesion of the sealant to the tool. All liquids should be first tested and accepted for by the manufacturer. The use of some liquids may result in surface discoloration. In using tooling liquids, cares should be taken to ensure that the liquid does not contact joint surfaces prior to the sealant contacting the joint surface. If the sealant overlap the area contaminated with the liquid, the sealant bond may be adversely affected.

– Tool sealant so as to force it into the joint, eliminating air pockets and ensuring contact of the sealant with the sides of the joint. Use appropriate tool to provide a concare, flush, or recessed joint as required.

– Immediately after tooling the joint, remove masking tape carefully if used, without disturbing the sealant.

f) Field testing

In case where the building joints are ready to receive sealant and the question of adhesion of the sealant to novel or untried surfaces arises, it is advisable to install the sealant in a 1.5m (5 feet) length of joint as a test.

– It would be good practice to do this as a matter of standard procedure on all sites even though unusual conditions are not suspected.

– Following instructions of the sealant manufacturer and using primer as and when recommended, the Contractor will install the sealant in the joint and examine for adhesion after cure to determine whether proper adhesion has been obtained.

202.12.4 Bituminous sealant to waterproof horizontal joints

Once the joint sealant are approved by the Engineer, the Contractor shall submit for approval the application procedures.

Application conditions

1) Prior to filling the joints, the Contractor shall:

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

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

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

202.12.5 Surface strip joint seal (combiflex type or similar)

Surface strip joint seal, is applied, where shown on the drawings or indicated by the Engineer.

1) Many joints can be reliably and durably sealed with a system based on an elastomeric strip bridging the joint and bond on both sides of the joints with a special epoxy adhesive.

   a) This is a flexible water proof seal for joints. The strip is highly flexible and fully weather-resistant elastomeric membrane (neoprene, hypalon or E.P.D.M)

   b) The width of the strip varies from 100mm minimum to more than 500mm.

c) The thickness varies from 1 to 3mm.

d) In some cases the strip must be protected.

2) The Contractor shall apply the whole system in accordance with the manufacturer technical data sheet.

202.13 ELASTOMERIC SUPPORT

202.13.1 General

Elastomeric supports must comply with the following criteria:

1) to be of simple design under normal execution procedures.
2) to permit:
a) horizontal displacement due to any cause,
b) rotation of the support due to bending under permanent loads, working loads and the effects of hydraulique shrinkage and thermal phenomena, without building liable stresses outside the elastomeric support.

The elastomeric support can fill all the substrate surface of the wearing walls /or/ only a part of this surface; the unoccupied surface. In this case must be filled by a compressible material to avoid the intrusion of concrete grout between the various elements of the elastomeric support.

202.13.2 Material and Application

The elastomeric support is generally constituted by a non-hooped elastomeric polychloroprene (neoprene) which under various movements and loads will sustain deformation, transmitting to the underneath wearing walls, vertical and horizontal efforts.

a) Eveness of the wearing substrate

The substrate wearing surface must be evened to avoid any accidental contact outside the designed contact surfaces; anyhow the wearing zones must be made horizontal.

The Contractor must furnish to the Engineer all necessary justifications concerning the elastomeric support and the procedures for the execution of the wearing surface.

b) Minimal characteristics

The following minimal characteristics must be submitted by the Contractor for the Engineer's approval:

- Maximal constraint which varies with the type of material used (around 30 bars /or/ 3 MPa for the non-hooped polychoroprene = neoprene)

- Minimal constraint to be obtained and which is needed to respect the condition of non-slipping of the elastomeric support on its substrate (around 15 bars or 1.5 MPa for the non-hooped polychloroprene = neoprene)

This condition may result for the elastomeric support to have a maximal dimension implicating sometime the impossibility to design a continuous linear elastomeric support. Thus needing to

consider the use of strips or pads of elastomeric material.

A continuous break of ties must be then insured between the pads by incorporating between the pads of neoprene of a compressible material (polystyrene type) and making the joints between pads and polystyrene water tight to avoid concrete grout intrusion.

c) Minimal thickness of the Elastomeric Support

The required thickness of the neoprene support shall depends on the loads, the amount of sliding and permissible rotations.

The Contractor shall submit technical certificate from the manufacturer to the Engineer allowing him to control and approve the chosen sizes and thickness of the elastomeric support.

The minimal thickness is conditioned by two factors:

- the maximal distortion of the neoprene (α) which must not exceed $\alpha \leq 0.5$ radians.
- the thickness must be large enough to permit rotation of the support avoiding contact in the maximum compression corner zones.

d) Determination of the Horizontal stresses

As an example, horizontal stresses may be controlled by the following formula (DTU.20.12)

$$H = G \times S \times \frac{U}{e}$$

e = thickness of the support
S = surface of the support in contact with the substrate
G = Transversal elasticity coefficient of the neoprene (around 0.8 to 1.3 MPa or 8 to 13 bars depending of the neoprene quality)
U = displacement

The admissible displacement (U) in relation with the thickness (e) can be first estimated as follows:

Thickness (mm) e =	5	10	15	20
Displacement (mm) U =	2.5	5	7.5	10

e) Other approved elastomeric support

The elastomeric constituting the pad may be a mix vulcanised based on Ethylene - Propylene - Diene - Monomer (E.P.D.M) which has the following average characteristics:

- A shore hardness of 60 ± 5
- Specific weight 1.06 ± 0.02 g/ml
- Ultimate resistance (rupture) ≥ 15.0 MPa
- Maximum elongation (Rupture) ≥ 400%
- Tearing resistance ≥ 15.0 MPa
- Permanent deformation after 24 hours at 70oC ≥ 20%
- Module “G” of transversal elasticity 0.8 ± 0.1 MPa

f) Compression Sollicitation

The admissible load over an elastomeric linear pads support depends of the dimensions and number of elastomeric pads constituting the support.

The average admissible constraint on every single pad is obtained for example by using the following formula

$$\text{average} = 1.2 \times \beta \leq 5 \text{ MPa}$$

Where β (form factor) $= \frac{a \times b}{2xt(a+b)}$

t = thickness of the elastomeric support
a,b = dimensions (in plan) of the elastomeric support

g) Special dispositions

In case the horizontal effort is greater than the value of friction of the interface between the elastomeric support and the substrate, the following dispositions must be taken by the Contractor:

If not otherwise specified by the Engineer the Contractor may stick the pads to avoid uncontrolled displacement when setting the different elements.

A special glue approved by the Engineer must be laid on the primed substrate and on the back side of the pad. After a maturation time, the pad shall be applied on the glued substrate with force.

202.13.3 Slip membrane

This slip membrane is constituted generally

- a protection sheet
- a slip plate around 3mm thick
- a silicone lubrication or similar
- an elastomeric pad recovered with special slipping cover adhering to it.

This system fulfills most of the usual functions of elastomeric support as:

- uniform distribution of vertical loads
- horizontal displacement by slipping of the supported construction over it.

This system will permit under small thickness, wide horizontal displacement with minimum limitation of the horizontal stresses transmitted and after the displacement it does not exerce any underpinning stress on the construction at the contact interface.

The Contractor is asked to submit all technical specifications to the Engineer for approval before any purchase of the material.

202.14 METHODS OF MEASUREMENTS

202.14.1 General

Except where otherwise specified, cast-in-situ concrete will be measured and paid for by volume. Separate payment will be made for reinforcement steel (by weight) and formwork (by area).

The following items shall be measured and paid for as specified hereafter :
- Manholes and chambers - by completed units.
- Precast concrete elements - by completed units, or by length or area.
- Cast-in-situ reinforced concrete piles - by linear meters.

A detailed description of the methods of measurements and payment for the different concrete works is given in the following subsections.

202.14.2 Cast-in-situ Concrete

Concrete will be classified for payment in accordance with grades, structural elements and location in the structure.

Except as otherwise specified, all cast-in-situ concrete will be measured by volume to the neat lines and dimensions shown on the Drawings or determined by the Engineer. The volume of all openings, holes and shown on the Drawings or determined by the Engineer. The volume of all openings, holes and recesses not actually filled by concrete will be deducted, but no deduction will be made for the volume of reinforcing steel or small openings (less than 0.1 sq.m. in surface area) and metal parts embedded in the concrete. No payment will be made for concrete that has been rejected or for concrete used to fill over-excavations.

Floors and intermediate and roof slabs will be measured over the external walls. Columns will be measured from top of foundation to first floor soffit and between floor slabs. Beams will be measured between columns or walls in length, and to floor soffits in height.

The unit rates for concrete shall include for : supply and transport of all materials to the site; batching, mixing, placing, vibrating and curing of concrete; testing of concrete; finishing of concrete, except as otherwise paid for under specially provided items in the Bill of Quantities.

Binding layers of lean concrete will be measured by square meters to a stated thickness. Cyclopean concrete will be measured by cubic meters including stones.

The shotcrete concrete will be measured by cubic meters including all means of application.

The Fiber concrete will be measured by cubic meters including all necessary metallic fibers.

202.14.3 Reinforcement Steel

Reinforcement steel will be classified for payment in accordance with the type of bars or fabric.

Measurement for payment of reinforcement bars will be made only of the weight of the bars placed in the concrete, on the basis of the net lengths and sizes, in accordance with the Drawings or as directed. Overlaps not shown on the Drawings will not be measured for payment. Payment for reinforcement bars will be made at the unit rates per kilogram (or ton) bid therefore in the Bill of Quantities, which unit rates shall include the cost of furnishing the reinforcement bars, furnishing and attaching tie rods and fasteners, wire ties and metal supports, if used, and of delivering, unloading, hauling, storing, sorting, cutting, bending, cleaning, welding if necessary, placing, and securing and maintaining in position all reinforcement bars, as shown on the Drawings or as directed, as well as waste and overlaps not shown on the Drawings.

Fabric reinforcement, required, will be measured on the basis of the area of work covered and will be paid for at the unit rates per kilogram (or ton) bid therefore in the Bill of Quantities, which unit rates shall include the cost of furnishing the fabric, cutting it to the required sizes, bending, placing, binding, supplying and placing all supports that are required, as well as the cost of all laps and waste.

202.14.4 Formwork

Formwork shall be measured for payment in m^2, classified by type (unwrought, wrought and for fairface concrete). Measurement for payment shall be of the net area of contact of concrete with the forms, after deduction of all openings and gaps exceeding 0.25 m^2 in area. The unit rates shall include for the use and waste of timber and of other materials and the supply of nails, tie-wires and fasteners; erection of forms, including scaffolding, shoring and shuttering; forming of levels, fillets, rebates, recesses, openings, etc.; removal of forms and for all materials (including waste), labour and equipment necessary for obtaining the required finish of

the surfaces. It will also include temporary structures necessary for execution of all structure works.

Where no specific items for formwork are inserted in the Bill of Quantities, the cost of formwork as above shall be deemed to be included by the Contractor in his unit rates for the various items for concrete work and shall not be paid for separately.

202.14.5 Manholes and Chambers

Chambers shall be measured and paid for as defined in the Particular Specification.

Sewer manholes shall be measured by the number of complete units, classified according to type and depth as defined in the Bill of Quantities. For this purpose the depth shall be taken as the difference between the level of the manhole cover and the invert of the lowest pipe where it leaves the manhole. The unit rates of manholes shall each include : the cost of the required excavation in all kinds of soil; the blinding layer under the concrete floor; construction of the floor, walls, and ceiling, inclusive of reinforcement, all in accordance with the Drawings and as specified in the Bill of Quantities; supply and fixing of hooks, step irons and/or ladders; the construction of inlets and outlets; benching of the floor as shown on the Drawings; applying the specified finish to all internal surfaces including lastering where required; supply and installation of frames and covers; supply and fixing of pipe stubs for future connections; compacted backfill around the structure and removal of all surplus spoil, and all ancillary works required to complete the manholes in accordance with the Drawings and specifications and to the Engineer's satisfaction.

The unit rates for manholes will not include for external drops, which will be measured and paid for as an extra over the rates of manholes and chambers. They will be measured by number and classified by diameter only, irrespective of depth. The unit rates shall include for the supply of all materials and all work necessary in the construction of the external drop to the details shown on the Drawings.

202.14.6 Thrust and Anchor Blocks

The thrust and anchor blocks shall be measured and paid for per cubic metre of concrete to the dimensions shown on the Drawings. The unit rate per cubic metre shall include excavation, erecting formwork, placing steel reinforcement, pouring concrete, backfilling works and all other related works.

202.14.7 Precast Concrete Elements

Precast concrete elements will be measured by number, length or area as detailed in the Bill of Quantities. The unit rates shall include for the costs involved incomplying with all requirements of Section 202.11.3 and in addition all material, labour and equipment required in the manufacture, transport and placing the precast units in the structure, including also reinforcement steel and other metal parts that are part of the precast element.

202.14.8 Cast-in-situ Reinforced Concrete Piles

Cast-in-situ reinforced concrete piles will be measured by linear meters of concrete piles cast in boreholes, classified according to the depth and diameter of the borehole as specified in the Bill of Quantities.

The length of the pile will be measured from the bottom of the borehole to the bottom of the beam or column. The bottom of the borehole shall be taken as shown on the Drawings and/or determined by the Engineer. Lengths exceeding those shown on the Drawings or required by the Engineer shall not be measured.

The unit rates inserted in the Bill of Quantities shall include for : boring the hole for the pile and removal of the excavated material, protection of the borehole against caving in by installation and use of steel sheet casings and/or bentonite suspensions, supply of all materials for concrete, mixing and placing of concrete and all other works required according to the specifications.

Supply and placing of reinforcement cages will be measured and paid for separately according to Subsection 202.14.3 above.

202.14.9 Joint Seals

Joint seals will be measured by length, and will be paid per linear metre.

The unit rates for joint seals shall include the cost of supplied materials and all necessary works to complete the joint sealing.

202.14.10 Elastomeric Support

Elastomeric supports will be measured by units and will be paid separately for each specified support as shown on the drawings.

202.14.11 Hourdis Slabs

Hourdis slabs shall be measured and paid for per cubic metre of finished monolithical slab measured to the dimensions shown on the Drawings.

The unit rate per cubic metre shall include for formwork, steel bars, hourdis blocks placing concrete and all related works unless otherwise specified in the bill of Quantities.

205 PLASTERING

205.1 GENERAL

205.1.1 Miscellaneous Requirements

Surfaces

a) Nature of surfaces

Plasterworks specified in this Section shall be applied to the following surfaces:

- traditional masonry made of stones, bricks, concrete blocks, traditional floors or with precast small girders.
- ordinary aggregate concrete or lightweight concrete.

- plaster tiles and plates including cellular plaster tiles.
- Plaster plates and perforated cardboard.
- methal lathing.

b) Condition of Surfaces

All surfaces to be plastered shall be dry, clean, free from soot, efflorescence, dust and oil. They shall be rough and unevenness of joints shall not exceed one third the plastering thickness.

Plastering frozen surfaces is not permitted.

Plastering work shall be classified into internal and external work, each of which may be applied in one-coat or two-coat work as indicated on the Drawings and/or in the Particular Specification or as directed by the Engineer.

The Contractor shall not carry out any plastering on days of extremely dry weather without the prior approval of the Engineer, who may require special precautions to be taken by the Contractor to prevent the early drying out of the plaster. Each layer of plaster shall be wetted prior to placing the next layer and at least 24 hours shall elapse before an additional layer is placed. All corners, whether internal or external, shall be neat and true, special care being taken to ensure a true, straight line at the junction of walls to the ceilings. All finished plastered surfaces shall be even, smooth, straight, plumb, with true angles (except where curved surfaces are shown on the Drawings) and free from trowel marks, cracks and other blemishes. Plane surfaces shall contact a 3 m straight edge with not over 3 mm deviation either way. Plaster showing cracks, blisters, pits or discoloration will not be accepted. It shall be removed by the Contractor and made up again at his own expense to the complete satisfaction of the Engineer.

205.1.2 Samples

Samples of each type of plaster to be used in the Works shall be prepared, each sample covering at least 1 square meter. Each sample shall be subject to approval by the Engineer, prior to actual commencement of plastering.

205.1.3 Scaffolding

Scaffolding shall be of sturdy and stable construction. Where a decorative spray or thrown finish is required to the plaster, the scaffolding shall not be connected to the wall to be plastered.

205.1.4 Repairs to Finished Plaster

Repairs of plaster, at skirting and elsewhere, as for instance around pipework, passages and channels, after the completion of other trades, shall be done in a neat manner so that all repairs will have a uniform appearance, indistinguishable from the general area of the plaster.

205.1.5 Levelling Course

A levelling Course shall be applied under all plasterwork and where called for on the Drawings and/or in the Particular Specification or directed by the Engineer, in order to straighten or correct imperfections in the base (brickwork, concrete, etc.). The levelling course shall consist of a cement-sand mix containing not less than 400 kg cement per meter cube of material. The course shall be applied as a thick paste with the aid of trowels, the minimum thickness being not less than 3 mm. Should the thickness be 10 mm or more, reinforcing wire mesh shall be used.

205.2 MATERIALS

Lime shall comply with the requirements of BS 890.

Lime shall be stored in a dry place protected from excessive temperature and wind.

Water shall be of potable quality, clean, fresh, free of salts, chemicals and impurities.

Sand shall be natural sand or quarry sand, free from dust, dirt and organic and foreign matter, complying with B.S. 1198 and 1199. Quarry sand shall not contain fines passing a No. 200 sieve in a quantity exceeding 6% - 8%. The sand for the first coat in two-coat work shall be coarse and graded. For the top-coat the sand shall be fine and well-screened, except where a special plaster made of coarse sand is required. Dune sand shall only be used for the top-coat of smooth internal plaster. The sand shall be supplied to the Site and stored according to type,

each type separately. Sand in storage shall be placed on a layer of suitable material or any other stable surface in order to prevent contact and mixing with earth. The use of siliceous sand instead of calcareous sand is advisable.

Additives to control the workability or setting time of plaster may be used only with the prior approval of the Engineer, and shall be suited, in quality and quantity, to the type of cement used. No additional payment will be made to the Contractor for the use of any additive.

Coloured plaster shall be obtained by adding pigmenting powders to white or gray cement or by using coloured cement. Such cement shall comply in all respects with the requirements of the standards for ordinary Portland cement. Pigmenting powders shall be mineral oxide of metals. The use of compounds of organic origin will not be permitted. The pigmenting powders shall be obtained from approved manufacturers. They shall be thoroughly mixed with the dry cement before being introduced into the mixing machine.

Metal Lathing for plastering on false ceilings and partitions shall be expanded metal (XPM), at least 0.6 mm thick, with mesh size openings of at least 12 mm and the opened mesh weighing at least 1 kg per square meter. Wire Mesh used for plastering chases in brick or block work shall be XPM as above or chicken wire with a thickness of 0.7 mm and a mesh of at least 12 mm.

205.3 WORKMANSHIP

205.3.1 Preparation of Surfaces

Plastering shall be done only after all other finishing works such as window sills, terrazzo work, electrical work, drain pipes, etc., has been completed. Only with the Engineer's consent in writing will the Contractor be allowed to carry out plaster, prior to the completion of all other works. In exterior plasterwork, care shall be taken to avoid staining or damaging any completed elements of the building.

No plastering shall be done until at least two weeks have passed since completion of the brickwork or concrete on which the plaster is to be placed. All surfaces to be plastered shall be thoroughly brushed down with stiff brushes to remove any efflorescence and all loose and flaky particles. Grease and oil patches must be removed.

Prior to commencement of plastering, all necessary repairs shall be made to the base, protrusions shall be removed and any exposed steel reinforcement shall be covered with a 1:3 cement-sand mortar.

Considerable holes or local unevenness shall be patched with mortar, plaster mortal or plaster. Where holes or local unevenness exceed 5cm, they shall be filled with parts of brick and hollow blocks, as well as, with lime mortar or plaster mortar.

Patching on plaster masonry shall be carried out with plaster or plaster mortar.

Junctions between two different materials (e.g., concrete and blockwork) shall be covered with 15 cm wide strips of XPM mesh. No mesh will, however, be required where junction between brickwork and concrete is toothstepped.

Pipe chases containing two or more pipes shall be covered with wire mesh, the mesh being stretched across the chase with a 5 cm minimum overlap on each side, and fastened down with galvanized nails. The mesh shall be covered with a 1:3 cement-sand mortar. Minor chases, holes, etc., need not be covered with wire mesh, but shall be carefully filled with a 1:3 cement-sand mortar, the face of which shall be slightly roughened.

All repairs shall be thoroughly cured and allowed to dry, and moistened prior to commencing the plastering.

All smooth surfaces, such as concrete, shall be scarified in order to increase the bond of the plaster to the wall or ceiling. In blockwork the joints shall be raked out to a depth of 1 cm and all exterior surfaces shall be spatterdashed in 1:2 cement sand mortar to provide a key for the plastering. The spatterdash shall be wetted an hour or two after application to ensure adequate hydration and shall be allowed to harden thoroughly for 3 days during which time it shall be covered up for protection against the sun and kept moist by watering.

Surfaces to be plastered shall be cleaned and moistened, prior to application of plaster. Where necessary, ingrained dirt and other foreign materials shall be removed by wire brushing. Twenty-four hours prior to application of plaster the surface shall be soaked with a light spray of water, but not to an excess causing water to flow down the face of the wall to be plastered. During warm, dry weather the area shall be lightly wetted for a second time immediately before commencing the plastering.

205.3.2 Plastering

a) <u>General</u>

It is not allowed to re-mix plastering having began to dry out with or without adding fresh plaster.

Plaster mix shall consist of the following:

- cement mortar: 300 to 350 kg of cement per cubic meter of dry sand
- lime mortar: 350 kg of mix (one part of lime to two parts of cement) per cubic meter of dry sand
- plaster mortar: 300 to 350 kg of plaster per cubic meter of dry sand.

Smooth surfaces shall be roughened and cleaned from loose particles or treated with a sand cement or plaster sand mix to which an admixture is added to increase the bond (acetate or vinyl propionate).

b) Type of Plastering

Plastering shall be applied and smoothed by hand in two coats to a methal lathing.

c) Application of fine structural plaster or coarse structural plaster rendering

Plastering shall be applied in two coats, the first is a coarse structural plaster. The mix contains at least 100 kg of plaster per 100 liters of water.

The base coat shall be applied to the levelling course with a trowel but not smoothed. As soon as this coat hardens it shall be scarified with a special tool and the top coat applied.

The mix of the second layer shall be at least equal to that of the first applied. The total thickness shall reach 12mm with a tolerance of 2mm. Where a metal lathing is to be placed plastering shall be 6mm thick.

205.3.3 Condition of surfaces

After the surface preparation (wire brushing and removal of loose particles) plastered surfaces shall show no cracks, holes flakes nor streaks of more than 1mm deep. Moreover, the number of holes and streaks of less than one mm deep shall also be limited. Surface unevenness shall be repaired by traditional surface preparation work taken into account the type of paint to be applied and the required finishing quality.

The deflection under a 0.20m long ruler drawn over the surface in all directions shall not exceed 1mm (local evenness). A two meters long ruler drawn over the surface shall not show a deflection exceeding 5mm (general evenness).

The tolerance on verticality shall be 5mm maximum for one floor.

205.3.4 Reinforcement of Corners

External corners at intersections of plastered surfaces shall be reinforced by means of special approved angle beads of galvanized steel, aluminium or plastic, all as specified or shown on the Drawings. The height of the angle beads shall be not less than 1.8 m measured above the top of the skirting. The angle beads shall be securely fastened to the base wall under the plaster by

use of galvanized nails. Plaster of the type used on the wall shall be carefully filled under and around the angle bead. The apex of the angle shall coincide exactly with the edge of the corner with regard to position and plumb.

205.4 METHODS OF MEASUREMENT AND PAYMENT

205.4.1 General

The unit rates for plastering shall include for the use of all tools scaffolding, labour and materials, including supply, processing and use of cement lime - slaked or otherwise - sands, gravels, additives and colouring pigments, mica flakes, and including for metal lath, all as

specified and as applicable. Unless otherwise specified, the unit rates shall include for the use of ordinary Portland cement. The unit rates shall also include for all cleaning and wetting of all surfaces prior to plastering and the protection and curing of the plaster, inclusive of all surface treatments required.

205.4.2 Measurement

Measurement will be in all cases be net in square meters, as measured on the Drawings, all openings, tiling, skirtings and other areas not covered by plaster being deducted with no allowance for waste, overlap, etc. Reveals, jambs, and rebates to openings (doors, windows, etc.) will be measured for payment together with the general area of the plaster and no special rates will be paid for them.

For purposes of measuring external plaster, the bottom edge will be taken as being 10 cm below final external ground level, unless otherwise shown on the Drawings.

205.4.3 Payment

Samples, making good to other trades and repairs will not be paid for separately and the cost thereof shall be included in the unit rates for plastering, which shall also allow for the supply of wire mesh for covering pipe chases, etc., where required.

Internal or external plaster will be paid under the same item in the Bill of Quantities.

214 WATER PROOFING, THERMAL INSULATION AND DISINFECTION

214.1 GENERAL

The provisions of this division shall apply to the:

a) Waterproofing of the inside surfaces of the new water retaining structures (reservoirs)

b) Waterproofing of old reservoirs under rehabilitation.

c) Waterproofing “old or new treatment plants” namely:

- the decanters,
- the filtering system
- the retention basin after filtering.

d) Waterproofing and eventual thermal insulation of all reservoir covers and building roofs.

e) Testing and disinfection of liquid retaining structures and roofs.

214.2 WATERPROOFING MATERIALS AND APPLICATION

214.2.1 New Reservoirs

The type of concrete for new reservoirs, is required to be waterproof as well as load bearing.

The inner surface of drinking water reservoirs (slab, walls and under roof) shall receive a surface waterproofing coating based on chemical treatment by crystallization or mineralisation and which will improves the waterproofness of the watertight concrete reservoir.

This surface coating shall be applied after concrete has almost complete shrinkage.

- This coating is applied in liquid and/or sludge form and will penetrate the concrete down to a variable depth depending upon the products, the porosity of concrete, the period of time elapsed since application, etc..

- The penetration develops in a naturally humid or moisturized concrete a chemical reaction between the impregnation compound and concrete free lime and forms insoluble crystals that seal the capillary system.

These products are constituted generally of a mixture of:

- siliceous products,
- active chemical products,
- Portland cement.

These products known under the name of crystallization or mineralization products have a long permanent action specially on concrete from artificial Portland cement C.P.A. which generate a large quantity of free lime during the hydration cycle.

The non-soluble crystals shall be activated to a depth of more than 20mm, depending on concrete compactness.

The Contractor shall contact the manufacturer to obtain all conditions of use and specifications concerning the product and specially:

- the methods for surface preparation,
- the number of vertical and horizontal coats,
- the treatment of all singular points,
- etc...

The products and applications shall be guaranteed for a period of ten (10) years from both the

furnisher for the products and the Contractor for the good execution.

The advantages and limits of use of these products can be resumed as follows:

- The coat can be applied on a humid surface,
- Additional or repeated applications are possible,
- Singular points can be coated with special techniques stated in the technical sheet.
- These coats may be applied only on surfaces showing micro-cracks; existing cracks or those which appear after filling the reservoir shall be treated as specified in the technical specifications.
- These coats are deemed to improve the waterproofness of the concrete surface as well as its resistance to chemical actions (condensated water, etc.)

There is a wide range of surface waterproofing products, efficiency of which, must be checked.

Only products which have been subject to satisfactory test by a Control Bureau, shall be proposed by the Contractor to the approval of the Engineer for coating the inner surfaces of the new reservoirs.

The application of the surface waterproofing coats must be done on a duly prepared and sound concrete surface. The products penetrate to the necessary depth that is in relation with several conditions of concrete substrate and water pressure; the development of non soluble crystals (crystallization or mineralisation) allows the concrete to reach a degree of waterproofness that varies with the homogeneity of the concrete (compactness) and the size and pore's structure (capillary).

It is recommended, if approved by the Engineer, that the Contractor eventually backfills the external surfaces of the reservoir before application of the coats to insure a more constant temperature of the inner surface to be coated.

The concrete surface shall be cleaned with a strong water blasting or wet sand blasting to remove all loose particules and open all surface pores, thus facilitating the penetration of the product during application.

The Contractor shall reduce the inside high relative humidity by natural or forced ventilation to obtain a dryer inner condition avoiding eventual condensation (generally 3 days dehydration are deemed necessary before and after application). The condensation effects often cause water rivulets to seep on reservoir vertical walls washing away the unset coating.

No application must take place when extreme high humidity exist in the inside of the reservoir (> 90%) because this will prevents the adhesion of the coats on a humid substrate.

Condensated water is very soft and adversely affects the cement curing process, and in extreme cases it can prevent the coating material from quick setting and causes it to disintegrate later.

The Contractor is asked to dehumidify the interior of the reservoir before and after placing the inner final coating to prevent condensed water from running down incurred surfaces.

The surface waterproofing coating must provide on the concrete a smooth and homogeneous surface.

That is why qualified personnel under the supervision of an expert from the manufacturer must insure that the products are applied in conformity with the manufacturer's technical

specifications.

Special attention shall be paid to coating singular points such as:

- eventual construction joints, and specially,
- pipe penetration, location and treatment of which must be previously agreed with the Engineer.

The Contractor shall follow all the steps and the several phases of application in conformity with the technical specifications of the manufacturer as well as with the site instructions of the Engineer.

In some cases the inner surfaces of potable water reservoirs shall receive a flexible protective and waterprofing slurry. The product shall be composed of a cement based two component polymer modified waterprofing slurry (liquid and powder) and shall be applied to concrete to prevent water infiltrations. The product shall be suitable for external and internal waterproofing. Concrete surfaces must be clean-free from grease, oil and loosely adhering particles and as flat as possible. Application on saturated surfaces of two coats minimum. is always required. Mixing, application, curing and cleaning must be in conformity of technical data sheet of approved material.

214.2.2 Existing Reservoirs Under Rehabilitation

These underlined provisions shall apply to the materials, execution procedures related to the rehabilitation of the existing reservoir's concrete structures.

The waterproofing materials and products concerns mainly: the inner reservoir surfaces (walls, slab and under cover); the exterior surfaces and the upper cover are not included in these provisions).

The rehabilitation of existing reservoirs concerns the execution of the following steps (non limited list)

- the Concrete repairs of the inner surface
- the application of a new waterproofing treatment based on an approved thin ready-mix mortar as a "first layer" and a final protection coating as a "second layer"

a) The concrete repairs and protection to existing reservoir structures

The purpose of damage assessment made previously on existing reservoirs aimed to facilitate to the Engineer and the Contractor the research of the specific causes of the reservoir structural damages, prior to planning the repairs procedures works by the Contractor.

The structural investigation must meet later on, confirmation by the contractor using appropriate methods of analysis to examine the damaged members and zones of the existent reservoir (case by case) and produces a diagnosis to form the basis for successful repairs.

Otherwise specified by the Engineer the Contractor shall follow several defined steps under the supervision of the Engineer.

Step one or site survey : concerns the general description of the structure it consists of the production by the Contractor of the following: (non limited list).

- Plans, sections and elevations of the existing structures (with at least 5 colored photos)

by site reservoir,
- Indications on the plans and sections of all zones where cracks, defects, weak points, penetration pipes etc. appears in the reservoir structures.

N.B.: This first step is important and is needed for to confirm and complete previous damage assessments, and most of all to elaborate for each reservoir a basic record which could help to resolve future eventual conflicts.

Step two or structural survey : concerns the preliminary works on the inner surfaces of the reservoir; the works are resumed as follows (non limited list).

- Removing of all existing render and coating and deteriorated concrete substrate from the inner surface of the reservoir.

- Applying a high water jetting pressure on the nuded concrete substrate surfaces aiming to remove all dirts, contamination and loose friable matters (pressure of water jetting ≥ 200 bars)

- A first visual examination or "auscultation" and an analysis must reveal to both the Engineer and the Contractor: the several weak points and singularities, to be treated, as well as the average depth of carbonation of concrete substrate.

- A special attention is to be given by the Contractor when analyzing the ground floor slab, and the foundation of each reservoir to insure that no differential settlement may have been the cause of living cracks.

N.B.: The Contractor must at this stage be able to submit to the Engineer his proposal for the materials to be used and the procedure for repairing, using approved materials.

Third step: concerns the carry on to the repairs after the detection and listing of the various defects in the structure, substructure and cover, and after the approval by the Engineer of the Contractor's proposal for both the materials and repair procedures.

The common defects and weak points encountered can be resumed as follows: (non limited list)

- Inside cracks in the inner concrete surface (dead cracks, moving cracks, trespassing cracks)
- Construction joints (concreting stopping)
- Blasted concrete zones and corroded steel reinforcement.
- Penetration leaks and other leaks.
- Bad inserts to be removed.
- Bad accessories (cover inlet, ladder)
- etc..

N.B.: The Contractor at the end of this stage must have the approval of the Engineer concerning the substrate's final and good preparation state, and ready to receive the new waterproofing treatment based on the approved thin ready-mix mortar as a first layer before the second application of the second final layer concerning the final protection coating described in part c.

b) Thin ready-mix mortar render

This provision concerns the first inner layer sealing following the approval by the Engineer of the final substrate preparation of the inner concrete support.

This cementitious sealing mortar is normally used to render the internal surfaces of the potable water reservoirs.

This ready-mix mortar render has to meet extremely high standards. This product consists of specially selected and graded sands, special cements and various admixtures. Factory production and continuous inspection are a guarantee of consistent high quality.

The ready-mix mortar specifications must indicate having been tested, to food and drink regulation standards and having been approved for potable water contact.

The pre-batched mortar is delivered to site in palleted bags which take up little storage space (in a dry place). The mortar can be produced using a mixing tank and a small mechanical mixer. Its good workability and laying time for only two layers also helps to reduce the contract time.

N.B.: The Engineer has decided to forbid the in-situ traditional heavy mortar fabrication (applied in 3 or 4 stages) and instruct the Contractor to use the only thin ready mix mortar approved by the Engineer.

The main properties of the thin ready-mix render are the following: (non limited list)

- Two layers are enough generally (unless some specific zones need a thickness that could reach 20mm thick in surface restoration and where more layers may be necessary to render the substrate homogeneous).

- A well balanced water retention capacity in thin layers of fresh mortar is very important, if it is too low the mortar wall dry out quickly. A well balanced water retention capacity (also prevents the formation of shrinkage cracks) greatly improves the waterproofing qualities of the coating. If the water reduction is too great, mortar adhesion may be decreased.

- This thin first seal coat should also be frost-resistant when it is fully set, because it is quite possible (for the empty top section part of a reservoir) to freeze.

- The most important quality of the thin ready-mix render is waterproofing. Practically even a good surface coating does not by itself make a reservoir waterproof. Because zones of weakness are often found at the inserts and construction joints. Therefore the details of the connections at insert pipe entry and at construction joints must be carefully executed and designed by the Contractor because a water reservoir is only as watertight as its weakest point.

c) Final Surface Sealing Coat (second coat)

This final application on the thin ready-mix render must be very precise and accurate in order to produce a high final quality seal and protection.

A clean, sound plaster render is essential for good adhesion; grease, oil residues and other foreign substances must be carefully removed and fins and projection must be scraped off.

Climate conditions are an important factors in the placement of the final surface sealing coat. Ideally the temperature should be around 10ºC to 15ºC and relative humidity around 70% to 80%.

Condensation in very high humidity is a particular difficulty because adhesion problems may occur if there is too much moisture in the thin ready-mix plaster substrate.

The condensated water is also very soft and may adversely affect the curing process in extreme cases because it can prevent the coating material setting process on the surface and cause it to run off later.

Condensation can also appear sometime in vertical rivulets on the wall which washes away the unset coating.

The Contractor must contact the manufacturer and obtain all latest original technical specifications concerning the material and obtain approval from the Engineer concerning the steps and procedure of execution.

214.2.3 Water Treatment Plants

The underline provisions shall apply to either new or existing water treatment plant under rehabilitation.

New treatment plants consist mainly of:

- Decanters or settling tanks
- Treatment stations or filter zones
- Retention basin after filtering
- etc.

N.B.: The waterproofing materials and application procedures are the same than for the new concrete reservoirs (see 214.2.1) by application of a surface water proofing coating acting by crystallization or mineralisation.

If the substrate is rendered by a mortar, only the kind of product that may change. The Engineer's criteria will in this case prevail in the choice of the materials and the procedures.

214.2.4 Reservoir roof covers and Building roof terraces, Waterproofing and eventual thermal insulation

The provisions here below shall apply to the materials, products and execution procedures concerning the waterproofing of the reservoir roof covers and the building roof terraces.

The Engineer criteria will determine which reservoir cover or roof terrace are to be thermally insulated or not.

Waterproofing approved membranes (for both reservoir covers and roof building terraces) will be one layer of 4mm minimum thickness (minimum 4.7 kg/m^2 with protection):

- Elastomeric (styrene-butadiene styrene = SBS) (for altitude above 300m) or
- Plastomeric (Atactic Polypropylene = APP) (for altitude below 300m).

The assembly of manufactured sheets will be by torch welding.

These membranes will generally be self-protected from the factory (mineral self-protection).

The general characteristics of the membranes are as follows: (non limited list)

- Elongation at break (for reinforced membrane ≥ 50%).

The Contractor shall comply with the technical certificate of SBS and APP membranes defined by the UEAtc tests and requirements.

In case of special architectural designed roof (dome) the waterproofing coat could be constituted by a liquid elastomeric bitumen which characteristics must be proposed by the Contractor for the approval of the Engineer. Anyhow a U.V. radiations resistance shall be required in any case.

The particular characteristics of the SBS and APP membranes are resumed here below (non limited list)

a) SBS elastomeric membranes are classified according to the type of reinforcement.

- Rolls reinforced with polyester (PY = 180 to 350 g/m^2)

b) APP Polymeric membranes are modified bitumen base sheet with APP polymers.

  - 4mm thick reinforced with polyester min weight 180 g/m^2 non woven polyester (PY)

The Contractor must in his offer enumerate all the characteristics of the membranes, namely: (non limited list):

- their dimensions (rolls) (1 m x 10m)
- their thickness or their weight (minimum thickness 4mm, minimum weight 4.7 kg/m^2)
- the type of bitumen
- the kind and weight of reinforcement (g/m2)
- the surface protection
- their mechanical characteristics
- the overlapping size (overlapping waterproofing membrane shall be not less than 10 cm).
- etc.

SBS and APP membranes shall be applied by the Contractor on site according to the technical sheets specifications of each product and to the manufacturer's prescriptions.

All reservoir roof covers and roof building terraces are deemed to be not accessible unless to repairs necessity.

- Horizontal and vertical exposed membrane will be mineral self-protected.

Thermal insulation

A normal insulation with extruded polystyrene thermal insulation is approved.

- The insulation panels must be protected against weather.

- The Contractor shall propose to the Engineer's approval all insulation material and specific original documentation from the manufacturer, mainly (non limited list):

  - the thermal conductivity ($\lambda \cong 0.029$ w/m ^{o}C)
  - the laying procedure
  - all limitations of use, according to associated waterproofing, destination of reservoir cover or roof terraces.
  - the thickness of the insulation panels with the way this thickness was determined according to the total thermal resistance of the reservoir cover or roof terrace. (thickness $\geq$ 50mm)
  - separation and protection sheet layer (non woven polyester) thermally bounded non woven polypropylene: Mass: 100 – 105 g/m^2.
  - the protection needed (graded gravels, screed, circulation slabs (500 x 500 x 50 mm)

214.3 WATER PROOFING FOR WASTEWATER BEARING STRUCTURES

214.3.1 General

Special performance criteria in sewage treatment is to be achieved by the contractor by the simultaneous use of:

- A high performance concrete, and
- A high performance protection, applied to the concrete substrate

214.3.2 High Performance Concrete in Sewage Treatment Applications

The concrete used in the construction of sewage treatment plants and related structures has to meet a very different set of performance criteria from those that apply in normal civil engineering works. It is usual for the mix-design to be generally determined by the need for strength and specific loading properties. The principal requirements for concrete in sewage treatment industry are more extensive and are as follows:

a) Resistance to aggressive effluents and sludge.

b) A dense and unpermeable concrete free from cracks (to protect steel reinforcement against corrosion).

c) Resistance to wear and abrasion, particularly with regard to overflows energy conversion areas and the bearing surfaces for sludge scrapers, etc...

d) Smooth and crack-free surfaces (to minimise routine cleaning and maintenance).

The aggressive effect of water-borne waste on concrete depends not only on its chemical constituents and the concentrations in which these are present, but also on such factors as:

- The pH value
- Temperature
- Oxygen supply
- etc...

- Acids with a pH value below 4.5 have a particularly aggressive effect on concrete due to the fact that they interact with the components of the set cement to form salts, which for the most part are soluble.

- However concrete may be attacked by certain alkaline solutions, salts and organic substances (especially vegetable and animal fats and oils).

  The speed of the chemical reaction increases dramatically with the rise in ambient temperature.

  In the absence of an adequate supply of oxygen (in long enclosed pipe runs, pits, tanks, etc.) fermentation processes may be set up that decisively alter the aggressively of the effluent (formation of hydrogen sulphide, sulphurous acid, etc.).

  (A) Durability of Concrete is largely determined by its resistance to the ingress of liquid or gaseous substances

- Since nearly all the attack mechanisms to which concrete is subject (including chemical and physical attack, corrosion of the steel reinforcement, etc.) are associated with the transport of moisture, the following may be stated as a general principle: “The more dense

  and impermeable the set cement, the greater the resistance of the concrete to chemical attack.” It is generally recognised that this is also associated with an increase in compressive strength and improved resistance to wear and abrasion: hence the fact that high compressive strength is frequently equated in civil engineering practice with outstanding durability.

  The inference is only valid, of course, if the increase in compressive strength results from a minimization of the capillary porosity of the set cement and a reduction in the diameter of the remaining pores.

- Damage to concrete or the underlying reinforcement via chemical attack is usually caused by the ingress of aggressive substances or water into the capillary pore system of the set cement (or into the contact zones between the set cement and aggregate). The aggressive medium may occur in liquid or gaseous form.

- The transport mechanism is activated by the following:

  a) An unbalance of pressures (permeation), as in the exerted by water on the wall of a tank or basin.

  b) Movements of molecules or ions resulting from differences in concentration (diffusion), as in the penetration of carbon dioxide from the air (carbonation).

c) The absorption of wetting liquids through porous substances (capillary action), as in the case of rising groundwater in a concrete foundation.

– The principal factors influencing the rate of transport are:

- the presence of cracks in the concrete
- its capillary porosity and
- the size of the pores

– An additional factor in the case of gazes is the moisture content of the concrete (the higher the moisture content, the more difficult the transport of gaz.

214.3.3 Design and production of High-Performance Concrete

The pore structure of the concrete is largely determined by:

- the degree of compaction,
- the entrained air content
- the water content of the fresh concrete, and
- the degree of hydration in the set concrete

In order to maximize the density of the set concrete matrix and thereby achieve a high degree of chemical resistance. The well-compacted concrete must exhibit the following properties:

a) A proper distribution of aggregate gradings, including a sufficient proportion of fines (particle diameter < 0,125 mm: approximative 350-400 kg/m^3)

b) Low water/cement ration around 0.40 - 0.45

c) High degree of hydration

d) Absence of cracks.

– To insure that the concrete remains workable at low W/C ratios and to minimize the entrainment of air bubbles during compaction, the contractor is asked to use a super plasticizer.

  The best way to maximise hydration and avoid cracks is that contractor follow the correct curing procedures (keeping the concrete damp for an extended period of time using a suitable curing compound).

– The insistence on a proper distribution of aggregate grading and an adequate fines content has to do with the attempt to maximise the density and uniformity of the internal structure of the set concrete. At the same time correct granulometrie also improve the workability of the fresh concrete and greatly reduces its tendency to bleed. Bleeding produces a localized increase in the water/cement ratio and a corresponding enlargement of the pore structure in the set cement matrix close to the surface of the concrete, thus rendering it specially vulnerable to chemical attack. Many of the sands

used have a low fines content (particle size < 0.125 mm) but a relatively high proportion of particles in the 0.125 - 0.25 mm grading zone. Since these require a relatively large amount of water to achieve thorough wetting, but possess only a limited capacity to retain water themselves, the contractor will make mistake to try and make up the deficiency in fines content by overdosing the mix with sand (result: bleeding of the fresh concrete). Instead the contractor's mix needs to be supplemented by a suitable alternative fines content which must be particularly effective.

(A) The use of Silica Fume Products in High Performance Concrete

The Contractor is invited to use a silica fume product (minimum 90% pure latently reactive silicone dioxide) to enhance the performance of structural concrete in a number of significant ways:

a) Reduction in porosity: silica fume is finer than cement, mineral fillers, (powdered quartz) or commercially available fly ash.

Since the mean particle size of silicate fume is approximately 100 times smaller than a normal grain of cement, it is able to lodge in the interstices between the finest particles in the set cement matrix. The super plasticiser allows low water/cement ratios whilst maintaining good workability. This ensures a dense, tightly packed particle structure even at the micro capillary system.

b) Increased strength: A pozzolanic reaction takes place between the silica fume and the free lime that is present in the set cement in the form of calcium hydroxide, a natural by-product of cement hydration. As a result of this reaction the weakest and most readily soluble component of the set cement is transformed into solid calcium silicate hydrate, this combined with the low water/cement ration produces significant gains in concrete strength.

As mentioned in 214.3.2(A) the chief requirement for concrete in sewage treatment applications is not so much for compressive strength in the core zone, but rather for a high degree of density and strength in the surface zone: This is the critical factor affecting the durability of structural components under these conditions.

c) Retarding the process of carbonation : The high alkalinity of the cement provides a measure of natural protection to the reinforcement steel. The pH value of the cement paste is around 12.5 which is sufficient to passivate the steel and prevent it from rusting even in the event of the ingress of oxygen and moisture. However exposure to carbon dioxide from the atmosphere means that the alkalinity is being constantly reduced as the lime content is neutralised. If the carbonated zone reaches the steel reinforcement, the latter begins to rust. The use of silica fume significantly retards the process of carbonation in concrete.

d) Increased resistance to abrasion: the use of silica fume products (silica fume/plasticiser technology) in concrete can also effect a marked improvement in its resistance to abrasion. Tests carried out at the French CEBTP in Paris on mortar samples incorporating silica fume demonstrate this very clearly.

e) Improved workability of fresh concrete: The addition of silica fume products to the mix produces a fresh concrete of outstanding stability and cohesion, with no loss of workability. Bleeding, segregation and sedimentation during transport are effectively prevented even with mixes of very plastic consistency.

(B) Curing procedures for High-Performance Concrete

The chemical reaction of silica fume with the free lime in the set cement generates the same hardening product that is produced during the hardening of cement. The reaction proceeds somewhat more slowly than in the case of cement but is more or less complete after 28 days. In order to achieve a concrete surface offering the maximum resistance to chemical attack, thorough and careful curing of the concrete is an essential requirement and the contractor must take in account the curing time in his construction schedule. At the end of the curing period the strength of the concrete in the surface zone should be at least 50% of the specified cube strength. This normally requires a curing period of at least 3-5 days; under unfavorable conditions (strong winds and sunlight or low relative humidity) the curing period should be extended by an addition 2-3 days in order to prevent premature drying-out of the concrete.

N.B. Concrete that will be exposed to "very severe" chemical attack (as defined, for example, in DIN 4030) for long periods during its service life should be finished with a suitable coating material designed to afford additional protection against the aggressive medium.

However the application of such a coating is no substitute for a well-made concrete not least because a high-quality coating material needs a high quality concrete substrate in order to perform effectively. The contractor must in practice furnish a concrete capable to withstand "severe" chemical attack without taking in account the additional protection.

214.3.4 Protection of the Concrete Surface

a) Substrate preparation

Before applying the protection on the concrete, the concrete surface must receive a preparation to unable this substrate to be ideal for the application of the protective coating. High pressure water jet, pressure stream clearing or wet blast cleaning will be used by the contractor after reception of the concrete surface by the Engineer.

Any joint sealing must be done by the Contractor usually before the application of the protection coating.

Any joint sealing material must receive the early approval of the Engineer.

Any joint sealing will be purchased from the same furnisher than the protective coating.

b) Pore sealing :

The pore seal is necessary and must allow a rapid application of the coating protection - the pore sealing must be compatible with all the applied products (superplasticizer, silica fume, water stop....) and purchased from the same furnisher it must fill all blowholes and act as a vapour - release intermediate coat.

c) The protective coating :

The known causes of damage to structures in the sewage industry show that the best concrete is still affected by some substances, which should be separated from its surface by suitable coating, or surface protection systems.

Often the concrete cover on the reinforcement does not comply with the standards.

Concrete for sewage must be coated to meat certain long term standards and the surface protection is also required to meet these standards long term.

The protection is also designed for the relevant mechanical constraints and withstand the interaction between concrete substrate and the protection system and also the mechanical, chemical, thermal and other stresses...

The Coating material requirements are:

- Chemical resistance
- Abrasion resistance
- Aging and weather resistance
- Alkali and water resistance
- Water vapour diffusion or vapour barrier qualities.
- Impermeability to gase (carbon dioxide, sulphur dioxide)
- Specific strength properties
- Adhesion to surface to be coated
- Crack bridging or sealing function

- The protective coating will generally be applied in two or three coats.

  As all coating material properties listed above can be influenced by the system and formulation used, the contractor is asked to submit to the Engineer's approval all the coating materials and furnisher specifications concerning the protective coating and glass fabric reinforcement.
- All details arising additional difficulties (pipe connection, openings, angles etc), must receive adequate solutions from the contractor to be submitted to the Engineer's approval before any application.
- The protective system, covers usually:
  - Epoxy resin
  - Epoxy / Tar modified systems
  - Epoxy / polyurethane coating system
  - etc....

  Apart from general protection, the protective coat system has to fulfil two functions.
  - Restoration and levelling of the concrete surface which may be extremely rough after preparation.
  - The formation of a non-porous protective film with possibility to work directly on the damp concrete surface without long waiting times while the structure is drying out.

A very important feature which should not be ignored by the contractor, is the prevention of heating in the structure in areas not in contact with water. This reduces the stresses in the coating system, the concrete and (even more important) at the coating system/concrete interface. Damage can also be avoided by the contractor by choosing the right colour.

The contractor technology must offer the maximum advantages to permit execution of the protection directly on the damp concrete surface without long waiting times while the structure is drying out.

The durability of a correctly applied coating varies considerably. The longest life span can be expected in the underwater section since the protective system is in a constant environment and not exposed to the UV and thermal shock i.e. it can remain in a low stress state.

The durability of coatings is affected by maximum stresses due to several loading, since there are exposed (in addition to high mechanical stress) to additional thermal shock caused by de-icing salts and weather and are used at the most susceptible construction points (areas at risk from cracking).

Systems which are exposed to abrasion and constant water turbulence and are used in water line zone are said to be subject to average stress.

Protective systems in digested tanks suffer the highest stresses.

The contractor is deemed to choose the protection system taken in account the importance of the stresses applied and the water covering situation.

214.3.5 Concrete Additives

The contractor is deemed having made all necessary contacts with the various furnisher of materials related with the project in order to select the best adequate materials such as:

- Superplasticiser
- The water proofing mass additive
- The waterstops
- The silica fume
- The curing material
- etc..

The superplasticiser, waterstop and waterproofing will give high impermeability to the concrete structure.

The superplasticiser and silica fume will insure reduction of porosity, increase in the surface strength, resistance to abrasion, improved workability of the fresh concrete with low water/cement ration.

The curing procedures will achieve a concrete surface offering the maximum resistance to chemical attach.

214.3.6 Sealing Joints in Concrete Construction in Sewage Installation

Although flexible sealant have an important part to play in sealing structural joints in sewage installations, they cannot seal structures containing water without additional measures. Concrete constructed with integral or surface mounted waterstop systems are obviously essential.

The Contractor will submit to the Engineer's approval all joints sealing material and waterstops which specifications must meet the Drawings Specifications.

a) Flexible Joint Sealant: of the various raw materials normally used in the production of joint sealant (polyurethane, acrylic, silicone and polysulphide) the two-part polyurethane sealant (often containing tar) have proved most effective in sewage treatment applications.

   Pouring grade is used for horizontal joints and thixotropic grade for vertical joints.

b) Flexible Elastomeric Strip: Joints liable to greater movement and construction joints may be sealed with a flexible elastomeric strip (hypalon or butyl rubber) kept in place with a compatible epoxy adhesive. Strip thickness varies from 1 to 3 mm; standard width are : 100 mm, 150 mm, and 200 mm.

   The Contractor is asked to submit his solution for sealing the various joints to the approval of the Engineer before any application.

214.3.7 Later Repairs

Effective concrete protection gives long-term security to all structural members, even if the effluent composition changes over time. High performance coatings greatly assist the prevention of damage from a number of sources. That is why detailed advance planning of concrete coating in sewage plants is to be seriously taken into account by the Contractor. If repairs are necessary later, this will be an expensive operation because of costly cleaning and re-preparation of contaminated substrate...

The Contractor must be aware that sewage plants cannot be shutdown and that later repairs and costs are out of proportion to the cost of providing good and effective protective coating on concrete initially.

The cost of all later repairs must be borne by the Contractor.

214.4 WATERPROOFING OF PLANTED ZONES

214.4.1 General

The waterproofing complex will consist in a two-ply waterproofing membrane chosen to resist roots penetration and puncturing by gardening implements .

Waterproofing membranes will be applied to zones intended to be planted such as gardens, roof terraces and flower tubs.

A screed to form a slope shall be executed before applying the waterproofing membranes.

The waterproofing membrane shall consist of:

– a first lower bitumen layer reinforced by a non-woven polyester sheet (NW PY ≥ 180 g/m^2, weight ≥ 4.7 kg/m^2)

– an upper bitumen layer reinforced (non-woven polyester ≥ 180 g/m^2, weight ≥ 4.7 kg/m^2) with anti-root additif.

The application of the waterproofing membrane shall usually be by welding using a propane blowtorch.

The waterproofing shall be applied to an approved substrate and comprise:

– an under layer membrane
– a top layer membrane shall be fully adherent on the first layer.
– a drainage layer (rounded gravels, size > 5mm).
– the agronomic soil.

The design of terrace-gardens and the choice of the agronomic soil thickness shall take into account the type of plants.

Overflows and water gullies shall be designed to limit the height of stagnant water so as to facilitate plants growth.

The substrate slope will generally be between 1% and 5%. The substrate surface shall be after completion, neat, straight and free from foreign matters. The allowable deflections, the surface tolerances, the differences in height between jointed elements shall be defined for each substrate as prescribed in the applicable standards.

214.4.2 Materials

214.4.2.1 Membranes

a) The first layer of the system shall consist of :

- SBS-elastomeric membrane reinforced with non-woven polyester, weight ≥ 180 gr/m^2.
- Thickness: 4 mm minimum.
- Packing: Rolls of (10 m x 1.00m) - Weight 44 kg.

Characteristics of the under layer:

- Tensile strength: longitudinal L = 900 N/5 cm, transversal T = 700 N/5 cm.
- Elongation at break: longitudinal L = 50%, transversal T = 55%.
- Puncture resistance static L4.

b) The top layer of the system shall consist of:

- SBS-elastomeric membrane reinforced with non-woven polyester, weight ≥ 180 gr/m2.
- Anti-roots admixture: Preventol B2 or equivalent, minimal quantity: 20gr/m^2.
- Thickness : 4 mm minimum.
- Packing: in rolls of (10 m x 1.00 m) - weight 44 kg.

Characteristics of the upper layer:

– Tensile strength longitudinal L = 800 N/5 cm, transversal T = 600 N/5 cm

– Elongation at break: longitudinal L = 45%, transversal T = 50%.

– Puncture resistance static L4.

214.4.2.2 Other Materials

a) The drainage layer

The drainage layer will be executed by the waterproofing Contractor. This layer shall protect the waterproofing membrane from mechanical stresses and allow the drainage of water.

This layer shall have a minimum thickness of 10 cm and consist of 25/40 gravels.
Other drainage system can be proposed by the Contractor to the Engineer's approval. The drainage layer shall be applied by hand directly to the upper layer of the waterproofing membrane.

b) The percolating filter

The percolating filter has no waterproofing function, it is used generally to prevent the clogging of the drainage layer, retain the nutrients of the soil and distribute humidity required for plants growth. It also keeps the pH of the soil and fertilizers above 3, and ensures that the pressure exerted by the agronomic soil and plants do not exceed that admissible by the bearing surface.

The percolating layer is applied to all the parapets till 10 cm over the highest level of the agronomic soil.

Laps between succeeding rolls shall be 10 cm. The percolating layer may be constituted by any special filtering material having a minimum thickness of 25mm.

c) Waterproofing for expansion joints

An SBS elastomeric membrane shall be applied to expansion joints. Its characteristics are:

- width : 1000 mm
- weight: 4.7 kg/m^2
- thickness > 4 mm

d) Agronomic Soil

The agronomic soil layer will be applied by the waterproofing Contractor. Its thickness varies according to the type of plants, it must not however be less than 30 cm before settlement (25% reduction after settlement)

Agronomic soil shall be placed directly on the percolating filter without causing any displacement nor damage to the filtering material.

e) Upstands

The waterproofing membrane shall be raised 15 cm above the graded agronomic soil.
The upper part of the parapet must include a device preventing the run-offs from penetrating behind the upstand.

The waterproofing of upstands shall be as follow:

- the first horizontal layer is raised to 10 cm.
- the first vertical layer is applied to the entire upstand and continued 10 cm over the first horizontal layer and welded on both ends.
- the second horizontal layer is raised to 10 cm over the first vertical upstand.
- the second vertical upstand is extended 15 cm over the horizontal second layer.

Joints between horizontal layers and vertical upstands shall be staggered.
Laps between two layers shall be ≥ 60 mm

f) Ancillary works

- All other works as fittings, edges, penetrations, joints, gullies etc.. will be treated in compliance with applicable standards.
- The connection between the waterproofing membrane and the gullies will be made as specified by the manufacturer.
- Water inlets shall be protected by a special device to prevent pipe obstruction.
- Removable paved blocks over the expansion joint must permit the repairs and checking of the joint. These elements must be executed by the Contractor at no additional cost.

g) Flower Tub

- The waterproofing membrane for the flower tub will be identical to that used for terrace-gardens.
- A 1% minimum concrete sloping shall ensure the evacuation of water to the gully.
- The waterproofing of the upstand will be continued over the horizontal section of the flower tub parapet.

NB: Before starting waterproofing works, the Contractor shall submit to the Engineer's approval:

- the material samples
- the execution details in the horizontal parts, upstands, and intersections.
- all details of waterproofing penetration, expansion joints.
- the details of the waterproofing protection (if any).

214.5 WATERPROOFING WORKS ON BURIED WALLS

214.5.1 General

Prior to backfilling, all buried walls shall be waterproofed. The waterproofing product shall be applied to the vertical surface of walls down to the footing of the foundation.

The waterproofing of the foundation walls is conditional upon several parameters, namely:

Nature of the foundation ground (pervious, impervious)

- Nature of the backfilling material
- Existence of a drainage system
- Existence of waterproof structures near the buildings (slabs, sidewalks, ...) or protection of the surroundings of the foundation peripheral wall by protruding structures (protection slabs, protruding roofs, ...)
- Importance of run-offs eventually in contact with the peripheral walls of the building
- Eventual existence of an aquifer

After the excavation of trenches, all measures that bind the Contractor alone shall be consulted beforehand with the Engineer.

214.5.2 Selection of the waterproofing coating

- The specifications given in this Section are applicable only when water is not likely to be in contact with the peripheral walls for a long time, or when no differential settling of the building is expected.
- The choice of the wall coating shall be efficient only if:
  - a drainage system is unnecessary (pervious ground)
  - or, a drainage system is necessary and provided for.

In fact, should the drainage system be necessary but not provided for, the application of the coating shall not be sufficient because water may infiltrate from beneath the foundation or through any crack in the wall. In this case, tanking will be the best solution.

a) No drainage system is required (pervious foundation ground)

Buried walls shall be waterproofed by applying a rendering to the external facing of the wall. Rendering shall consist of:

- A traditional rendering consistent with standards specifications.
- A hydraulic binders based waterproofing coat having a technical certificate that proves its suitability to the type of buried masonry.

In both cases, the coating shall only be applied to the external facing of the buried wall; the waterproofing of the inner side would prevent the capillary rise.
In some cases a bitumen coating shall be applied for walls protection.

b) A drainage system is required (impervious or slightly pervious foundation ground)

The waterproofing system shall be reinforced and shall consist of:

- An SBS or APP elasto-plastic membrane applied directly to the substrate or to a rendering and consisting of:
  - Cold-applied primer : 350 kg/m^2
  - Hot welded SBS or APP elasto-plastic membrane as specified in 214.4.1.
    - non-woven polyester (180 kg/m^2 minimum)
    - separation layer.

It is advisable to protect the membranes from shocks, especially during backfilling, as well as from any eventual settling of the backfill material. Should the Engineer disapprove the quality of the backfilling material and the workmanship, a 10 cm thick concrete blocks protection shall be obligatorily provided for, with non woven thermally bounded textile separation layer or by 3.2mm thick semi rigid bituminous board.

The application of waterproofing membranes to singular points especially to the footings, etc.. shall be carefully studied (details to be provided by the Contractor).

Prior to any backfilling, the Contractor shall submit to the Engineer's approval the method of laying the drainage system in the bottom of the trench, the quality of filtering material, the size and location of the trench with regard to the building and the foundations, the diameter and length of drains as well as the eventual protection of the drainage layer with a non-woven textile.

214.5.3 Manholes (a drainage system is required)

Manholes shall be constructed:

- At the upstream of the drain
- At each change of direction
- At the connection of two drains.

The manholes shall have such diameters as to allow eventual cleaning operations. The Contractor shall submit for approval the shop drawing of the manhole which is equipped with a cover preventing the intrusion of earth, gravels or any foreign matters.

The Contractor shall submit for approval waterproofing works of buried parts:

- Samples of waterproofing products
- Samples of the drains

as well as all shop drawings of waterproofing and drainage works.

214.6 TESTING AND DISINFECTION

214.6.1 Testing

The Contractor shall perform all cleaning, flushing, testing of all liquid retaining structures, reservoirs and buildings roofs, including conveyance of test water to point of use, and including all disposal thereof, complete and acceptable, all in accordance with the requirements of the BS 8007 and the contract documents.

All testing operations shall be done in the presence of the Engineer.

a) Roofs

The roofs of liquid retaining structures and buildings should be watertight and be tested by flooding the roof with water. The roof should be considered satisfactory if no leaks or damp patches shown on the soffit. The roof insulation, covering and waterproofing should be completed only, and as soon as possible, after remedial work if needed is done and satisfactory testing.

b) Liquid retaining structures

After construction is completed, the interior of the liquid retaining structures shall be completely hosed and cleaned of all dirt and loose material. Testing shall be done prior to backfilling if any, and shall not be sooner than 14 days after all portions of structure walls and associated roof systems have been completed.

The structure shall be filled to the normal maximum level with the specified liquid at a uniform rate of not greater than 2m in 24 h. The liquid level should be maintained by the addition of further liquid for a stabilizing period which may vary between 7 and 21 days according to the maximum design cracks.

After the stabilizing period and during a 7 days test period the total permissible drop in level, after allowing for evaporation and rainfall should not exceed 1/500th of the average water depth of the full tank or 10mm.
In case of seepage of the liquid or leakage, necessary remedial treatment of the concrete, or joints, holes or cracks shall be carried out from the liquid face (pumped and sealed with a two part water-insensitive epoxy, nontoxic for potable water reservoirs). Retesting after the completion of remedial work shall be carried out according to this clause.
Interior waterproofing if required, shall be applied after satisfactory results.

214.6.2 Disinfection

The Contractor shall perform disinfection of reservoirs and appurtenant piping for potable water. Disinfection shall be accomplished by chlorination and performed in accordance with the relative requirements after completing all repairs and waterproofing works if any. All chlorinating operations shall be done in the presence of the Engineer. Disinfection operations shall be scheduled by the Contractor as late as possible during the Contract time period so as to assure the maximum degree of sterility of the facilities at the time the work is accepted by the Engineer.

Bacteriological analyses shall be performed by a certified testing laboratory acceptable to the Engineer.

a) Chlorination

A strong chlorine solution (about 200 mg/l) shall be sprayed on all interior surfaces of the structure, including the underside of the roof areas. Following this, the structure shall be partially filled with water to depth of approximately 30 cm. During the partial filling operation, a chlorine-water mixture shall be injected by means of a solution-feed chlorinating device in such a way as to give a uniform chlorine concentration during the entire filling operation. The point of application shall be such that the chlorine solution will mix readily with the inflaming water. The dosage applied to the water shall be sufficient to provide a chlorine residual of at least 50 mg/l upon completion of the partial filling operation. Precaution shall be taken to prevent the strong chlorine solution from flowing back into the lines supplying the water. After the partial filling has been completed, sufficient water shall be drained from the lower ends of appurtenant piping to ensure filling the lines with the heavily chlorinated water.

b) Retention Period

Chlorinated water shall be retained in the partially filled structure and appurtenant piping long enough to destroy all non-spore-forming bacteria, and in any event, for at least 24 hours. After the chlorine-treated water has been retained for the required time, the free chlorine residual in the structure and appurtenant piping shall be at least 25 mg/l. All valves shall be operated while the lines are filled with the heavily chlorinated water.

c) Final Filling of Structure

After the free chlorine residual has been checked, and has been found to satisfy the above requirements, the reservoir shall be filled in approximately 2m increments every 24 hours by addition of potable water. The existing chlorinated water, may not be used as part of the final filling. Final filling water, when the water level is raised to its final elevation, shall produce a free chlorine residual of between 1 and 2 mg/l. If the free chlorine residual is less than one mg/l, an additional dosage shall be applied to the water in the structure. If the free chlorine residual is greater than 2 mg/l, the structure shall be partially emptied and additional potable water added. In no case shall water be released prior to the expiration of the required retention period (24 hours)

214.6.3 Bacteriological Analyses

The Contractor shall have a laboratory certified by the Engineer to take samples of water from the tank in order to perform bacteriological analyses according to the relevant section.

If the volatile organic or coliform bacteria levels exceed those allowed, the tank content, shall be drained to waste. The tank shall be refilled at the Contractor's expense, soaked and retested for coliform bacteria and volatile organic until satisfactory test results are obtained. Failure of the reservoir to attain acceptable levels shall be the responsibility of the Contractor and remedial measures shall be at his expense.

214.7 MEASUREMENT AND PAYMENT

214.7.1 Inner Waterproofing of new reservoir, new or existing treatment plants, etc...

Waterproofing shall be measured for payment by square meters (m^2) of net area of surfaces to which waterproofing has been applied, after the deduction of all openings and areas which have not been waterproofed.

The unit rates shall include:

- The supply of material,
- Cleaning and preparation of the surfaces as specified,
- Treatment of all singular points,
- Application of the inner coating as specified, to horizontal, vertical and under roof surfaces including all overlaps and extra work on corners, edges and around drain outlet and other structures in walls and slab, and including all materials, equipment and workmanship necessary for the completion of the inner waterproofing of the reservoir in accordance with the Specifications and Drawings, and to the satisfaction of the Engineer.

214.7.2 Existing reservoirs under rehabilitation

Waterproofing shall be measured for payment by square meters (m^2) of net area of surfaces to which waterproofing has been applied, after deduction of all openings and areas which have not been waterproofed.

The unit rates shall include :

- The site survey (step one of the specifications) showing the general characteristics of the existing reservoir, pipe chamber, pipes and hydraulic connections, etc...

- The structural survey (step two of the specifications) which includes :

- the removing of the existing render and coating and deteriorated concrete substrate...
- the application of high water jetting pressure,
- the visual examination, the "auscultation" and analysis of all weak points to be treated,
- the submittal of procedures and materials for rehabilitation and repairing,
- etc.

– The repairing works (third step of the specifications) as approved by the Engineer,

– The application of the ready mix mortar as specified,

– The final surface seal coating (second coat) as specified,

– Etc.

214.7.3 Waterproofing of roof covers, Building terraces and Eventual Thermal Insulation

Waterproofing shall be measured for payment by square meters (m^2) of net area of surfaces on which waterproofing has actually been applied, after deduction of all openings and areas which have not been waterproofed.

The unit rates shall include :

– For the supply of all approval materials.
– Cleaning and preparation of substrates, including the execution of the necessary concrete slopping towards the outlets,
– Application of primer,
– Heating and application by torch welding of the elastomeric or plastomeric membrane 4 mm thick (~ 6 kg/m^2) including the overlaps and upstanding extending over the parapet wall, and any reinforcement on the Detailed Drawings approval by the Engineer,
– Any circulating concrete pads necessary for repairs installed over the waterproofing (pads 500 x 500 x 40 mm) as ordered by the Engineer,
– All drain outlets and any extra works around them and around any existing opening or penetration throughout the roof,
– All necessary protection of the waterproofing, and all materials and equipment and labour necessary for the completion of waterproofing of roofs and reservoir covers in accordance with the Specification and Drawings and to the satisfaction of the Engineer.

N.B. Normal or inversed extruded polystyrene thermal insulation shall be installed when directed by the Engineer Thermal insulation ≥ 50 mm thick will be paid for as separate item and will be measured by square meters (m^2) of net area of surfaces where thermal insulation is applied.

Normal thermal insulation unit rate is deemed to comprise the cost of furnishing and applying a vapor barrier approved by the Engineer.

214.7.4 Waterproofing Protection for Wastewater Bearing Structures

Waterproofing of external surface of the concrete substrate (Protection of the concrete surface by applying a protective coating) shall be measured for payment by square meters (m^2) of net area of surfaces on which waterproofing has actually been laid, after deduction of all openings and areas which have not been waterproofed. The unit rates shall include for :

- The supply of all the approved material,
- Cleaning and preparation of the concrete substrate as specified,
- Supply and execution of all joint sealing,
- The pore sealing as specified,
- The application of the approved protective coating in two or three coats reinforced with the glass fabric material, as specified,
- The treatment of eventual defects encountered throughout the works according to the Engineer's instructions,
- All extra works required for extending the protective layer over all kind of pitched surfaces, around drains, over parapets etc...,
- All furniture for materials, equipment and workmanship necessary for the completion of the protection coating over the total substrate surfaces in accordance with the Specifications and Drawings and to the satisfaction of the Engineer.

214.7.5 Waterproofing of planted zones

Waterproofing shall be measured for payment by square meters (m^2) of horizontal net-area of surfaces to which waterproofing has been applied, after deduction of all openings and areas which have not been waterproofed.

The unit rates shall include:

- The supply of all approved materials.
- Cleaning and preparation of substrates, including the execution of the necessary concrete sloping toward the outlets.
- A lower membrane.
- An upper membrane
- A drainage layer
- A percolating filter
- All drain outlets (overflows, water gullies) and any extra works around them and around any existing opening.
- Bridging joints, upstands, waterproofing protections or any other material required to accomplish the work according to the standards.

The agronomic soil shall be measured by cubic meters (m3) according to the Engineer's instructions.

214.7.6 Waterproofing works on buried walls

a) No drainage system is required

The waterproofing shall be measured for payment by square meters (m^2) of net area of rendered surfaces.

The unit rates shall include:

The rendering, hydraulic binders based waterproofing coat and eventually two coats of asphalt. It also includes scaffolding, workmanship, expenses, supply, transport, equipment, and all works required for waterproofing.

In case a bituminous coating is required, no extra payment shall be done. The price must be included in concrete works or in backfilling materials.

b) A drainage system is required

The waterproofing shall be measured for payment by square meters (m^2) of net area of surfaces where the waterproofing system is applied.

The unit rates shall include:

- The elasto-plastic membranes (primer, membranes, fibreglass and non-woven polyester)
- The membranes protection.
- Singular points and drainage system required (pipes, manholes, gravels, geotextile,...)

All necessary materials, equipment, workmanship, and expenses in order to achieve the waterproofing work.

214.7.7 Testing

All water used in testing the liquid retaining structure and roofs including that used for retesting which requires disposal following such testing, retesting shall be provided and disposed by the Contractor at his hole expense. The price of such work are deemed to be included in concrete works unless otherwise noted and shall include all expenses to reach satisfactory result.

214.7.8 Disinfection and Bacteriological Analyses

All water used in disinfecting the reservoir including that used for retesting and disinfecting shall be provided and disposed by the Contractor at his hole expense. Fees for all laboratory analysis shall be borne by the Contractor.
The disinfection and analyses shall be paid on the basis of a lump sum price unless noted otherwise, and shall include all expenses to reach satisfactory results.

217 PIPELINES AND PIPEWORKS

217.1 SCOPE

This part of the specification shall apply to the supply, delivery, laying, jointing and testing of all pipes, fittings and accessories, and includes:

Concrete pipes
Asbestos-Cement pipes
Steel pipes
Cast Iron and ductile Iron pipes
G.R.P. pipes
P.V.C. pipes
HDPE pipes

217.2 CONCRETE PIPES

217.2.1 Quality Requirements

Concrete pipes, fittings and junctions shall comply in all respects with B.S. 5911 or ASTM C76M for reinforced concrete pipes or with B.S.5911 or ASTMC14M or DIN4032 for non reinforced concrete pipes. The pipes shall be truly circular and have bell joints, or spigot and socket joints, or rubber gasket joints, as noted on the Drawings or in the Bill of Quantities, and as specified hereafter.

Concrete pipes, fittings and junctions shall be tested for compliance with B.S. 5911 (and BS EN681-1:96 or DIN 4060/2 for jointing system) in approved laboratories or in their place of manufacture. The pipes shall be subjected to Hydraulic and Crushing Tests. The number and selection of samples for testing, the test procedures and the requirements shall all be as specified in B.S. 5911.

The selection of samples and the Tests shall be witnessed by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

The cost of samples, their transportation to the test site and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

Alternatively, the Contractor may submit to the Engineer certificates from approved laboratories certifying that the pipes have been subjected to and have satisfactorily undergone

the required tests according to the specified standards. In that case the Engineer shall be entitled (but shall not be bound) to renounce any further testing.

The concrete pipes should be protected by HDPE lining, (according to DIN 50 049-2.2) or PVC lining or should have an epoxy coal tar interior coating not less than 1000 microns thick.

217.2.2 Hauling and Handling of Pipes

The entire curing period of the pipes shall be completed before any pipe shall be loaded and transported. The Contractor shall check each pipe before loading and shall reject all damaged or defective pipes. The Contractor shall load with the greatest care and properly secure the pipes on the vehicles for transportation and take all necessary measures to prevent any damage to the pipes during transport. The Contractor shall be responsible for the quality of the pipes and for their condition upon and after delivery to the Site. The Engineer will check the pipes upon their delivery to the Site and the Contractor shall forthwith remove from the Site all rejected pipes and replace them at his own expenses by pipes acceptable to the Engineer. Only pipes inspected and accepted on the Site by the Engineer shall be incorporated in the Works.

The Contractor shall ensure that all pipes are properly handled by his staff. During transport, pipes shall not be allowed to rest on their joints, narrow cross-members of vehicles, or anything else that might give rise to concentrated loads due to the weight of the pipe or bumping of the vehicle but shall be properly supported on soft material. Sufficient labour and equipment shall be on hand before loading and unloading is commenced and under no circumstances shall any pipe be dropped from a vehicle. For storage on site, the ground must be level and free from loose stones.

The Engineer shall have the right to reject consignments or stocks of pipes from which failed pipes have been drawn, or order them to be pressure-tested outside the pipelines, even though no defects are apparent, if there is reason to believe that mishandling has taken place. All costs incurred in this respect shall be borne by the Contractor.

217.2.3 Laying of Pipes

After the excavation and preparation of a section of pipe trench has been completed by the contractor, it shall be inspected by the Engineer. No pipe shall be laid before the excavation has been approved by the Engineer. Just before pipelaying, the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipelaying shall be carried out by experienced pipe-layers well skilled in this work. Pipes shall be laid true to line by means of a line stretched along the side of the pipes and true to level by means of a straight edge of 4 meters in length kept inside the pipes and pulled forward to pegs boned in at suitable intervals between sight rails set to the proper levels.

Immediately before being laid, each pipe and fitting shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying. The use of a badger will be ordered by the Engineer, if, in his opinion, dirt is not being satisfactorily excluded. The badger on a sound rope is to remain within the bore of the pipe previously laid and jointed and is to be drawn forward as the work proceeds throughout the whole length of the conduit. The badger is to be of soft material which will not damage the internal surfaces of the pipes.

In order to prevent stones, soil or small animals from entering the pipe, a suitable cap end or plug shall be provided with which the last pipe laid shall be sealed when pipelaying is not

actually in progress. The plug shall be of the screw-up expanding type or of tapered wood.

The completed section between two manholes shall form one continuous tube well supported over its entire length and with a straight and even invert according to the lines and grades shown on the Drawings. The straightness of each section between manholes shall be checked externally by means of a string stretched parallel to the designed invert line and supported at intervals not exceeding 7.5 m, and internally by means of a beam of light. The maximum permissible deviation in invert level in one section shall not exceed 2.0 cm or 1 mm per pipe, whichever is less. The alignment and location in plan shall not deviate by more than 20 cm from the design line. The axial displacement of pipes entering any manhole and issuing from it shall not exceed 2 cm. Pipelaying shall proceed upstream with the bells or sockets of the pipes pointing upstream.

Where shown on the Drawings or required by the Engineer, concrete pipes shall be laid on a sand bedding, or concrete bedding or with concrete surround.

217.2.4 Jointing

Rubber Gasket Joints - Where pipes with bell and spigot joints and rubber sealing gaskets are approved by the Engineer, the following provisions shall apply to jointing: rubber gaskets shall be of synthetic rubber resistant to oils and fats, and shall meet the requirements of (B.S. EN681-1 or DIN 4060/2) - Elastomeric Joint Rings for Pipework and Pipelines (Types 1 and 2) or of I.S.O. 1398.

> All pipes, and especially the bells and spigots, as well as the rubber gaskets shall be carefully inspected before being incorporated into the work, and no defective pipes or gaskets shall be used. Before making any joints, the rubber gaskets, spigot and bell shall be well cleaned and thoroughly covered with a special lubricating compound not harmful to rubber, as approved by the Engineer. After lubrication, the rubber gasket shall be stretched around the spigot of the pipe to be laid and fitted into the groove, care being taken to ensure uniform tension and to prevent twisting of the gasket. The spigot with the gasket on it shall then be inserted into the bell of the previously laid pipe and the new pipe shoved into position. Shoving-in may be done while the pipe is still suspended from the crane or lifting tackle to minimize friction between pipe barrel and trench bottom.

The bell, spigot, and gasket shall be protected from contact with earth, dirt, or any other deleterious matter until the joint is completed. The use of undue force to overcome improper fitting of the gasket into the spigot groove shall not be permitted, since this may cause twisting or dislocation of the gasket resulting in a faulty joint. If the pipes are properly aligned, the gasket properly fitted and the gasket and bell well lubricated, the pipe should slide in smoothly without the application of much force.

217.2.5 Cast-in-Situ R.C. Conduits

Cast-in-Situ R.C. conduits shall conform to all relevant sections of this Specification with regard to concrete, reinforcement, shuttering, etc. All cast-in-situ R.C. conduits shall be made of grade C30P, unless otherwise noted.

Cast-in-situ R.C. conduits shall be perfectly true to dimensions in cross section. Construction joints shall be installed along the conduit at intervals shown on the Drawings and between joints the conduit shall be cast continuously, with no interruption.

The bottom of the trench shall be excavated by hand to the longitudinal slope of the conduit, and to the exact shape of the bottom of the conduit, moistened and well compacted. On the ground, a 5 cm blinding layer of lean concrete grade C7P shall be cast, to the longitudinal slope of the conduit, as a base for the bottom horizontal and inclined surfaces of the conduit, as shown on the Drawings.

Generally, conduits shall be cast in two vertical lifts, with a keyed construction joint separating these lifts, in accordance with the Drawings. Great care shall be exercised in pouring the lower lift, to ensure that the space directly under the interior form is completely and densely filled with concrete. In pouring the upper lift, concrete shall be placed equally on both sides of the form, to minimize lateral pressures on it. The internal surface of the conduits shall be smooth, perfectly true, and free of any irregularities.

Where permitted in writing by the Engineer, precast elements may be incorporated in cast-in-situ R.C. conduits. Such precast elements shall be manufactured and installed in the cast-in-situ conduit in accordance with the specification and the instructions of the Engineer.

217.2.6 Inspection and Testing of Concrete Gravity Pipelines

(a) General - After the laying and jointing of a section of pipeline (defined as the length of pipeline between two adjoining manholes) has been completed, that section shall be inspected and tested, as specified hereafter. The joints shall remain exposed, joint grooves shall not be filled and any bedding or surround or backfill shall be carried no higher than the invert of the pipe until all inspections and tests have been completed to the satisfaction of the Engineer and until he has given permission in writing to proceed with the covering-up of the pipeline.

The following inspections and tests shall be carried out:

Visual Inspection, in which the Engineer shall inspect the section for grade, direction, line, appearance of inner surface, depth and correct jointing.

Hydrostatic Test, as specified hereafter, which will be carried out in the presence of the Engineer.

After the completion of the above inspection and test to the satisfaction of the Engineer, any required beddings and/or surrounds shall be completed and backfilling shall be carried out as specified in Part 2 Section 201.3 of this Specification.

The Contractor shall inform the Engineer at least 24 hours before a section is ready for inspection and testing.

(b) Hydrostatic Test - The water tightness of every completed section between two manholes shall be tested by a hydrostatic test as hereinafter described. The section to be tested shall be cleared of any material or object that may be lying in it and all bellholes shall be cleaned so that the joints may be observed from the outside. The two ends of the section shall be hermetically sealed by suitable temporary plugs provided with pipe nipples. The upstream plug shall be connected to a standpipe extending at least 4 m above the top of the highest pipe. Water shall then be introduced through the opening in the lower pipe end to fill the pipe and expel the air through the standpipe, until the water level in the standpipe is 4 m above the top of the highest pipe. The section shall then be permitted to absorb water for 24-48 hours and all visible leaks in the joints shall be repaired. After this period the water level shall be restored and the pipe observed for 2 hours, while the water level in the standpipe is being maintained at 4 m above the highest pipe. The quantity of water that must be added to maintain the water level in the standpipe shall be measured and this will be considered as the leakage of the tested section. The leakage under test, for pipeline diameter ≤ 400 mm, shall not exceed 0.8 litre/m2 of internal wall pipe area per hour and for pipeline diameter > 400 mm, the leakage shall not exceed 0.8% of inside pipe volume per hour. If the leakage during the test period exceeds the permissible rate, the Contractor shall search for and make good all defects causing such leakage. The test and repairs shall be repeated as often as necessary until all visible leaks have been repaired and the leakage does not exceed the permitted limit.

All necessary testing apparatus, expanding plugs, stoppers, bladders etc., labour, water and any other materials necessary shall be provided by the Contractor at his own expense.

(c) Infiltration Test - Where the line has been laid in groundwater, after the trench has been backfilled, the interior of the pipe shall be tested for infiltration of external water through the joints into the interior of the pipe. Any leak so detected shall be repaired as instructed by the Engineer and to his entire satisfaction and the pipeline shall be retested, all at the Contractor's own expense.

217.2.7 Final Cleaning and Inspection

Before the works are accepted by the Engineer, the entire pipe system, including all structures, shall be thoroughly cleaned by flushing or by passing a brush, sphere or other suitable tool through it, or by any other approved method, to ensure that it is clean, and free of obstructions and that pipe runs are perfectly straight. Before taking over, the pipeline will be finally inspected by the Engineer.

217.2.8 Methods of Measurement and Payment

Precast concrete pipes and cast-in-situ R.C. conduits shall be classified for payment according to type and diameter and shall be measured for payment in linear meters of completed pipeline in place, measured along the crown of the pipeline, between internal surfaces of manholes or

chambers and the length measured for payment shall include the lengths of all fittings, specials, junctions, bends, etc. installed in the pipeline.

The price of fittings, specials, bends, junctions, etc. for precast concrete pipes and cast-in-situ R.C. conduits shall be, unless otherwise specified in the particular specifications or the B.O.Q. considered as included in the cost of pipes.

Alternatively, if so stated in the Particular Specification and/or in the Bill of Quantities, precast concrete pipes and fittings may be measured by number of pipes of defined net lengths and by number of fittings.

Payment for precast concrete pipes and for fittings, specials, etc., shall include:

(a) Supply, hauling, handling, unloading and stacking of pipes and fittings including all necessary jointing materials.

(b) Removal from stacks; hauling and stringing alongside trench; laying, jointing and testing at any depth of trench; connections to manholes and chambers; and final cleaning and flushing of pipeline. The unit rates for this item, for each type and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

Payment for each type and diameter of cast-in-situ R.C. conduits shall be made under a single item in the Bill of Quantities and payment for each type and diameter of bend, junction etc. for cast-in-situ conduits shall be made under a single "extra-over" item in the Bill of Quantities, and each of these unit rates shall include for the blinding layer, formwork, concrete, reinforcing steel, joints, curing, testing and all labour and materials necessary to construct and complete the cast-in-situ R.C. conduit.

The unit rates for constructing each type and diameter of cast-in-situ conduit and fittings, junctions etc. shall be the same for all depths of trench in which the conduits and fittings are to be constructed.
Only pipes, fittings, junctions, bends, etc. actually laid in trench, and tested and accepted by the Engineer, shall be measured for payment above, and no allowance whatsoever will be made for any breakage, loss, etc. en route.

Excavation and backfill, special beddings, surrounds and manholes shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

217.3 ASBESTOS CEMENT PIPES AND FITTINGS

217.3.1 Quality Requirements

All asbestos cement pipes, joints, specials and fittings shall be supplied by the Contractor unless otherwise stated. They shall be made by an approved manufacturer and shall be of the class and nominal diameter as shown on the Drawings and shall comply in all respects with the following standards:

Gravity Flow Pipes - for conveying fluids at working pressures up to but not exceeding 1.0 kg/cm^2 - B.S. 3656 or I.S.O. R-881

Pressure Flow Pipes - for conveying fluids at working pressures exceeding 1.0 kg/cm^2- B.S. 486 or I.S.O. R-160

The standard joint used on the A.C. pipes shall be the "Simplex", or "Supersimplex" (Comet, kaltite, Reka or similar) type coupling consisting of asbestos-cement sleeves and self-sealing rubber gaskets, and complying with the above standards.

Cast iron detachable joints and long collar detachable joints and other cast iron fittings for use with asbestos cement pipes shall comply with the requirements of B.S. 486 and shall be supplied with rubber rings, bolts and nuts, etc. The external diameters of all cast iron joints and fittings shall be adapted to the external diameter of the asbestos cement pipes of the corresponding nominal diameters.

Unless otherwise stated, A.C. pipes shall be coated and lined as provided under Clause 2.3 of B.S. 486. Cast iron joints and fittings for A.C. pipes shall be coated and lined as specified for C.I. pipes.

Rubber gaskets shall be of synthetic rubber and shall meet the requirements of B.S. 2494 or I.S.O. 1398, for water pipes or drainage, whichever is applicable.

The Contractor shall supply all the necessary asbestos-cement and cast iron fittings, such as reducers, bends, tees, crosses, end caps, adaptors, etc. All such fittings shall match the pipes they are to be connected to in diameter and class. All pipes, fittings, couplings, and gaskets shall be obtained from approved manufacturers who shall supervise the transportation and laying of the pipes and shall guarantee the quality of the pipes and fittings for a period not less than the period of maintenance specified in this Contract.

The Contractor shall submit to the Engineer certificates from approved laboratories that the pipes have been subjected to and have satisfactorily undergone the tests specified in the above-mentioned standards and have satisfied all their requirements.

217.3.2 Hauling and Handling of Pipes and Couplings

No pipe shall be loaded for transportation or transported until after the end of the curing period. The Contractor shall check each pipe before loading and shall reject every pipe found to be damaged or defective. The Contractor shall properly secure all the pipes on the vehicles and take all necessary measures to prevent any damage to the pipes. The Contractor will be held responsible for the quality of the pipes and for their condition after delivery to the Site. The loading, transportation and unloading of the pipes shall be done with the greatest care. Under no circumstances shall pipes be thrown down on the ground or dragged along it. Pipes up to 6" in diameter may be unloaded by two workmen standing on the vehicle and handing them down to two other workers standing below who shall place them and stack them gently on

the ground. Alternatively these pipes may be unloaded by rolling them down gently and carefully from the truck on two strong planks and placing them alongside the trench in which they are to be laid. Larger pipes shall be handled by suitable cranes. Care shall be taken not to damage the edges of the pipes during unloading operations. The rubber rings of the joints shall be supplied separately from the couplings and shall be stored in the shade and in dustproof containers. Where conditions do not allow for the stringing of pipes alongside the trench into which they are to be laid, they may be unloaded at a central point, stacked on planks and secured by stop blocks until they are required in the Works.

The Engineer will check the pipes on the Site and the Contractor shall mark all defective or damaged pipes in accordance with the Engineer's instructions and shall remove them from the Site immediately and replace them with acceptable pipes at his own expense. Only pipes marked as accepted by the Engineer after inspection on the Site shall be incorporated in the Works.

217.3.3 Mounting of Joint Couplings

The rubber gaskets shall be brought to the Site separately and shall not be inserted into the joint couplings until immediately before the mounting of the joint. As far as practicable, the coupling shall be mounted on the pipe end before the pipe is lowered into the trench. Before assembly, the coupling grooves, rubber gaskets and pipe ends shall be thoroughly cleaned and lubricated with a lubricant provided or approved by the pipe manufacturer. One sealing gasket and the central spacing ring (or spacers) shall be inserted in their respective grooves. Since the sealing gaskets have a special asymmetric cross section, care shall be taken to insert them in the correct direction. Gaskets and spacing rings shall be placed in their grooves neatly and evenly without twists, distortion or bulges. The coupling shall then be slipped on to the pipe end until the spacing ring or spacers rest against the edge of the pipe. On large diameter pipes (450 mm and above) a mounting tool operated by a screwed rod or similar device shall be used to pull the coupling over the pipe end. Where no spacing rings or spacers are provided a special fixing clip shall be used to keep the coupling in place while the next pipe is inserted into it.

217.3.4 Laying and Jointing of Asbestos-Cement Pipelines - General

Attention is drawn to the necessity of ensuring a perfectly even bed for the pipes. Where shown on the Drawings or required by the Engineer, asbestos-cement pipes shall be laid on a sand bedding placed in accordance with Part 2 Section 201.3.7. Bellholes sufficient in size to permit jointing of pipes as described hereinafter shall be excavated in the trench bottom, bedding and trench walls as necessary. No pipe shall be laid until the surface of the excavated trench bottom or that of the sand bedding, as the case may be, has been inspected by the Engineer and approved for pipelaying.

Before the line is handed over to the Employer, the inside of all pipes shall be cleaned of all dirt, mortar and other foreign matter. At the end of each work day and after a pipeline section

is completed, the open pipe ends shall be suitably plugged to prevent entry of dirt or small animals.

All pipes shall be placed in position carefully and shall be laid true to line and grade. Under no circumstances shall pipes be thrown into the trench. Lowering shall be carried out manually or by means of lifting tackle and/or ropes. Before any pipe is lowered into the trench, it shall be cleaned and examined for cracks and flaws. If undamaged it shall be placed in position ready for jointing in accordance with the requirements hereinafter.

217.3.5 Laying A.C. Gravity Flow Pipes

Asbestos-cement pipes in gravity flow lines shall be laid consecutively in straight lines between adjacent inspection manholes. Special joint couplings shall be built into the walls of the manholes to ensure a tight joint between pipe and manhole. After being laid and jointed the completed section between two manholes shall form one continuous tube, well supported over its entire length and with a straight and even invert according to the lines and grades shown on the Drawings. The straightness of each section between manholes shall be checked externally by means of a string stretched parallel to the designed invert line and supported at intervals not exceeding 7.5 m, and internally by means of a beam of light (either torch or sunlight reflected by a mirror).

All pipes and manholes shall be laid and constructed according to the lines and grades shown on the Drawings, or as instructed by the Engineer, with the following tolerances:

The maximum permissible deviation in invert level in one section shall not exceed 2.0 cm or 1 mm per pipe, whichever is less. The alignment and location in plan shall not deviate by more than 20 cm from the design line. The axial displacement of pipes entering any manhole and issuing from it shall not exceed 2 cm.

217.3.6 Laying A.C. Pressure Pipes

In pressure lines the pipes shall be laid in straight lines where possible, but curves of long radius may be required, and these shall be obtained by deflection at the joints. Such deflections, however, unless specifically otherwise ordered by the Engineer, shall comply with the following:

ND (mm)	80 - 250	300 - 350	400 - 600	700 - 1200	≥ 1300
α Less than	4°	3°	2°	1 ½°	1°

Where a change in direction cannot be made by deflection at the joints of ordinary straight pipes, prefabricated bends shall be used. The approximate locations of such bends and other specials are indicated upon the Drawings, and their exact positions will be determined by the Engineer on the Site.

217.3.7 Jointing Asbestos-Cement Pipes

Before jointing a new pipe to one already laid in the trench, the second gasket shall be installed in the free end of the coupling mounted on the pipe in place, in the manner described above. The new pipe, with the joint coupling mounted on it shall be lowered into the trench, its free end cleaned, lubricated and inserted into the open end of the coupling on the pipe already in place. The pipe shall then be shoved home until its end abuts against the central spacing ring or spacers in the coupling. Small to medium size pipes may be shoved home by hand with or without the aid of crowbars. Larger size pipes, which are handled by means of cranes or hoists, may be shoved in while being suspended at balance point slightly lifted above the ground, thus eliminating friction with the trench bottom. Large size pipes may require the use of a special pulling device. Jointing shall always be done coaxially, any deflection in the joint as described in Subsection 217.3.6 above being produced after the joint has been completed.

217.3.8 Cutting of Asbestos-Cement Pipes

For closing lengths it will be necessary to cut asbestos-cement pipes. For this purpose, the Engineer may allow, at his discretion, the use of pipes with damaged ends but otherwise sound. Asbestos-cement pipes shall be cut by a suitable cutting machine, care being taken that the cut ends are truly perpendicular to the pipe axis and that no breaking or cracking occurs. Cutting by hammer and chisel will not be allowed.

For jointing, the outside diameter of the pipe ends shall then be reduced to the required distance, unless special pipes turned to the correct diameter are supplied by the manufacturer. Such reduction of outside diameter of pipe ends shall always be done with an approved machine mounted on or inside the pipe barrel; filing down by hand shall not be permitted. In every case the edges of the cut pipe ends shall be given the correct shape required for jointing.

217.3.9 Backfilling

As each pipe is placed in its final position and jointed, the trench shall be filled, leaving only the joints uncovered. The materials used for backfilling and their placing and compacting shall be in accordance with the Drawings and the requirements of the Specification. The joints shall be left uncovered until the hydrostatic tests have been successfully completed and the Engineer has given permission to cover the joints.

217.3.10 Testing of Asbestos-Cement Pipelines

A.C. pipelines shall be tested in accordance with standard I.S.O. 4483, and as specified hereafter and as directed by the Engineer:

(a) Gravity Pipelines - Gravity pipelines shall be subjected to the tests and shall meet the requirements prescribed for concrete gravity lines in Subsection 217.2.6.

(b) Pressure Pipelines - Pressure pipelines shall undergo a hydrostatic pressure test. They shall be tested in sections not larger than 500 m, or as may be directed by the Engineer, and tests shall be made only on sections which are completed, except for backfilling over joints and fittings which are to be left exposed for inspection. Weights and thrust blocks intended to prevent lateral and vertical displacement of the pipes or specials must be completed and must have attained their design strength before tests are commenced.

Test sections shall be preferably carried out between shut-off or sectioning valves. Where this is not practicable, test sections shall be sealed off by suitable bulkheads, properly braced.

Prior to testing, air shall be evacuated from the line by filling it with water with all valves and taps open. After the first filling and the closing of all valves and taps, the water shall remain in the line for at least 48 hours to allow for absorption, and water being added as required to make up for losses. During this period the Contractor shall inspect the line and all fittings and valves installed on it for leaks. Any leaks found shall be promptly repaired by the Contractor, who shall then proceed with the test, unless otherwise noted on the drawings, in the particular specifications, or by the Engineer, the “Test presssure” measured at the lowest point of the section shall be equal to one of the following values:

For pressure gravity driven pipelines:

(a) (1.5 x Rated Working Pressure) for rated working pressure equal to or less than 10 kg/cm^2 or the static pressure whichever is higher.
(b) (Rated Working Pressure + 5.0 kg/cm^2.) for rated working pressures exceeding 10kg/cm^2 or the static pressure whichever is higher.

For lift pipelines:

Rated working pressure plus calculated water hammer surge plus 2Kgf/cm^2. The water hammer surge will be calculated as follows: $\Delta H = \frac{a\,\Delta V}{g}$

where:

ΔH = Water hammer surge
ΔV = design velocity as indicated on the drawings expressed as meter per second.
a = surge velocity expressed as meter per second (a = 1100m/s).
g = acceleration due to gravity in meters per second per second = 9.81 m/s^2.

The pressure shall be slowly raised by pumping to the required "Test Pressure". Pumping shall then be discontinued, the pump disconnected, and the line kept under pressure for at least 15 minutes. For the line to be accepted, the pressure shall not drop by more than 10% during the said 15 minute period and there shall be no visible leaks at joints, fittings, valves, etc. Should the drop of pressure exceed this value, the Contractor shall search for the defects causing such pressure drop, shall make all necessary repairs and repeat the test until the section under test meets the requirements. Provided always that all visible leaks must be repaired whatever the loss of pressure. The Contractor shall at his own cost provide all necessary test pumps,

pressure gauges, cocks and other accessories and shall make such temporary connections as may be required for filling and testing the line in the manner herein specified.

The water used for pressure testing shall be provided by the Contractor and shall be free from inpurities and of such a quality which will not pollute or injure the pipeline. The Contractor shall be responsible for obtaining the water, transporting it and for its safe disposal on completion.

217.3.11 Methods of Measurement and Payment

Asbestos-Cement pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place measured along the crown of the pipeline as follows:

- In gravity flow lines: between internal surfaces of manhole or chambers.
- In pressure flow lines: between stations.

The length measured for payment shall include the lengths of all fittings, valves and specials installed in the line.

The price of fittings, specials, junctions, bends, etc. shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications or the B.O.Q.

Alternatively, if so stated in the Particular Specification and/or in the Bill of Quantities, pipes and fittings may be measured by numbers of pipes of defined net lengths and by number of fittings.

Payment for asbestos-cement pipes and for fittings, specials, etc. shall include:

- Supply, hauling, handling, unloading and stacking of pipes and fittings including all necessary A.C. joints and jointing materials for pipes and all A.C. and C.I. joints and jointing materials for fittings, specials, valves, etc.

- Removal from stacks; hauling and stringing alongside trench; laying and jointing of pipes and fittings at any depth of trench; connections to manholes and/or chambers, and final cleaning and flushing of pipeline. The unit rates for this item, for each type, class and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of complete pipeline:
  - For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid separately.
  - For pressure pipelines: the cost of testing shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid in trench and tested and accepted by the Engineer shall be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers and site test shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

217.4 STEEL PIPES AND FITTINGS

217.4.1 Quality Requirements

Steel pipes for use in the Works shall be made by an approved manufacturer and shall meet the requirements of B.S. 534, 1387, 3600 and 3601 or American Water Works Association Standard C202, or equivalent European standards, carbon content shall not exceed 25 percent. Unless specified otherwise all steel pipes shall have minimum pipe wall thickness schedule 40 for nominal pressures up to PN 40, for higher pressures NP 64 and more wall thickness should comply with schedule 80.

Pipe ends shall generally be plain squared for jointing with Viking-Johnson type couplings, or bevelled for butt welding joints or flanged with flanges according to B.S. 4504 for flanged joints or with a bell on one end for fillet welded lap joints.

Unless otherwise specified or directed by the Engineer, fittings, bends, branches, specials etc. for use with steel pipes shall be prefabricated, factory made and shall be equal in quality and strength to steel pipes. Ends of fittings etc. shall be plain squared, bevelled or flanged to fit pipe ends.

Steel pipes and specials intended for laying below ground shall be cement-mortar lined or epoxy lined internally, and epoxy or bitumen coated externally not less than 150 micron thick. The hot bitumen of the coating shall be wrapped with bitumen saturated asbestos felt or glass-fibre mat and whitewashed. Other types of linings or coatings which may be required shall be as detailed in the Particular Specification. The ends of pipes shall be left uncoated for jointing. Sufficient lining, coating and wrapping materials and implements thereto shall be provided to complete coating on uncoated sections after jointing and to make good after laying of pipes.

Steel pipes and specials to be laid above ground in open air shall be epoxy or cement mortar on the inside and painted on the outside not less than 150 micron thick.

Steel pipes and specials to be laid inside buildings shall be epoxy coated internally and externally 150 microns minimum thickness.

Mechanical joints for use with steel pipes shall be of the Viking-Johnson sleeve type made by an approved manufacturer. The joints shall be watertight when assembled and shall be sufficiently flexible to permit small deflections without impairing their watertightness. Rubber rings to be used with joints shall comply with the requirements of B.S 2494. The Contractor shall supply sufficient quantities of specially sized pipes for cutting of closure pieces and of

Johnson Couplings without centre register to permit the insertion of closing sections in the pipelines.

Galvanized and black iron pipes and fittings shall comply with B.S. 1387 (Steel Tubes and Tubulars Suitable for Screwing to B.S. 21 pipe threads). Fittings not included in B.S. 1387 shall comply with B.S. 143 (Malleable Pipe Fittings) heavy quality. Pipes and fittings ordered galvanized shall comply with the requirements of the applicable Clauses of the above-mentioned British Standards.

The Contractor shall submit to the Engineer certificates from approved laboratories certifying that the pipes and fittings supplied comply with the requirements of the relevant specifications.

217.4.2 Hauling and Handling of Pipes and Fittings

Pipes and fittings shall not be allowed to drop, roll freely or strike objects which may damage them. When fitting pipes or fittings by their open ends, special hooks or plates shaped to fit the wall shall be used. Chaining will be allowed on bare pipes only; wrapped pipes shall be lifted by padded straps at least 20 centimeters wide. Care shall be exercised in transporting, handling or storing pipes and fittings in order to avoid distortion, flattening, denting, scoring or any other damage to pipes and fittings and to their outer coating and/or inner lining.

217.4.3 Stringing of Pipes

Pipes of the various diameters and wall thickness shall be strung along the alignment as closely as possible to their final position.

Pipes and fittings strung along the alignment shall be protected against intrusion of earth, mud, dirt and other foreign bodies, and against damage to the outer coating. Pipes shall not be strung on the side of the trench where excavation material has been or is to be placed. Where

necessary or as directed by the Engineer gaps shall be left in stringing in order to allow movement of vehicles or men across the alignment. Wrapped pipes shall be whitewashed unless they have been supplied with whitewash and the latter is in good condition after stringing.

217.4.4 Handling of Mortar-Lined Steel Pipes

No internal hooks or similar equipment likely to damage the mortar lining shall be used. Excessive bending of the pipe that may cause cracking of the mortar lining shall be prevented.

217.4.5 Repairs of Defective Pipes

Should laminations, cracks or other defects be discovered on any pipe or its coating or its lining, the Engineer will issue instructions as to whether such defects shall be repaired or the

defective part cut out or the defective pipe removed. Where the pipes were supplied by the Employer, he will pay the Contractor the cost of the repairs or other extra work necessitated thereby, but otherwise pipes shall be repaired or replaced by the Contractor at his own cost.

217.4.6 Welding of Pipes

(a) Welding Methods - All welds shall be made by the manual shielded metal-arc method. The welding procedure to be applied by the Contractor shall be submitted to the Engineer for approval, before the commencement of the work. All welding works shall be carried out by welders having passed the welders qualification tests in accordance with B.S. 4871 part 1 and B.S. 4872 part 1, whichever is applicable. Welds will be either butt welds for plain-ended pipe joints or fillet welds for lap joints (bell and spigot). The use of welding machines with two outlets will not be permitted; every welder shall work with a separate machine.

(b) Electrodes - Electrodes used for welding shall meet the requirements of B.S. 639 and B.S. 4215. Generally, with D.C. generators, Class E-100 (DCRP) electrodes shall be used. In any case, the electrodes proposed by the Contractor shall be subject to the Engineer's approval prior to their use.

Electrodes shall be stored in the unopened original containers in such a manner as to prevent absorption or loss of moisture or mechanical damage to the coating. Electrodes in open containers shall be protected against moisture. Electrodes that have been damaged, moistened or otherwise deteriorated, shall be rejected.

(c) Cleaning of Pipes - Pipe ends to be welded together shall be thoroughly cleaned of any dirt, oil, residues of paint and asphalt, and any other foreign matter that may adversely affect the quality of the weld. Paint and oil residues shall be removed with kerosene or gasoline.

(d) Welding of Joints - The number of beads in each weld seam shall be not less than two, and their thickness shall not exceed 3.0 mm.

In butt welds, the thickness and number of the beads shall be so adjusted that the height of the weld reinforcement shall be not less than 0.8 mm and not more than 1.5 mm above the pipe surface. The width of the cover bead shall be approximately 3.0 mm more than the width of the groove before welding. In fillet welds the thickness of the throat shall be at least $0.5\sqrt{2}$ (= 0.707) of the pipe wall thickness. Cutting back of the edge of the bell shall be kept to a minimum. All weld metal shall be thoroughly fused to the parent metal and to the previously placed weld metal.

After the completion of each bend, the weld shall be thoroughly cleaned of all scale, slag, or dirt. All spots on the weld where electrodes are changed shall also be cleaned. A peening hammer and steel brush may be used for cleaning, provided it is done to sound and bright metal. The finished seam shall be thoroughly cleaned by means of steel brushes.

(e) Fitting -up of Pipes - In butt joints the root opening between the pipes shall be such as will ensure full penetration without burn-through in accordance with the approved welding procedure. When aligning pipes, the offset between pipe ends about to be joined shall be reduced to a minimum. External line-up clamps shall be used to centre pipes. Internal clamps may be used when approved by the Engineer.

The external line-up clamp may be removed only after 50% of the root bead has already been welded, in segments equally distributed around the pipe, not shorter than 7 cm each; their quality and thickness shall not be inferior to those required for root welding. The internal clamp may be removed only after the whole of the root bead has been welded.

In lap joints the plain end of one pipe shall be shoved in until it abuts against the shoulder of the bell, so that the gap between the mortar lining of the two pipes is reduced to a minimum.

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

(g) Jointing of Line Sections - Pipes shall be connected to each other by welding as specified above, while they are placed on suitable supports on the trench bottom or on the ground beside the trench.

The length of sections to be welded together before lowering them into the trench shall be as directed by the Engineer. The position of every pipe or elbow in the section shall be such that, when the section has been lowered to the trench bottom the longitudinal seams will be located between the figures 10 and 2 on the clock face, so that repairs on the seams can be done in the trench without necessitating deep excavation.
Before being connected to the line, the inside of each pipe and each elbow shall be cleaned.
(h) Welding Mortar-lined Pipes - When butt-welding mortar-lined pipes, the Contractor shall
take steps to ensure the continuity of the lining at the joints. The materials and methods employed to this end shall be as recommended by the manufacturers of the pipes, and approved by the Engineer or as directed by the Engineer. The cost of all materials and work required to ensure the continuity of the cement-mortar lining shall be deemed to be included in the unit rates for supply, laying and jointing of the pipes and shall not be paid for separately.

In pipes with lap joints which are not accessible from the inside, a sufficient quantity of mortar shall be placed in the bell just before the new pipe is shoved in. After the new pipe is laid in place, excessive mortar shall be removed and the inside of the joint finished by pulling a rubber ball or equivalent through the joint. Where the inside of the pipe is accessible, the mortar lining at the joint shall be completed by plastering on with a good bond to the existing lining and trowelling smooth and flush with the adjacent mortar lining.

The mortar employed as specified above shall conform in all respects to requirements of Subsection 217.4.9 of this Specification.

(i) Repair of Weld Defects - The Engineer may permit repairs of defects in the root or filler beads to be made, but any weld that shows evidence of repair work having been done without such permission may be rejected. Pinholes and undercuts in the final bead may be repaired but such repairs shall be subject to the Engineer's approval. Undercuts not exceeding 1.0 mm in depth will not be considered as defects.

Before repairs are made, the defective areas shall be removed by chipping, grinding, or flame gouging. Any slag and scale shall be removed by wire brushing. When cracks are found, the entire seam shall be cut away and rewelded.

The Contractor shall clearly mark with oil paint on top of the pipe any defect that has been discovered in the pipe or weld.

217.4.7 Miscellaneous Welding Works

(a) Cutting and Preparing Pipes for Welding - The plane of square cuts shall be perpendicular to the pipe axis. Oblique cuts shall be accurately made to the required angle and in such a manner that the cut edge is in one plane. Pipe ends for butt welding shall be bevelled to an angle of 30° with the plane of the edge, with a permissible deviation of 0° to $+5^{o}$. All cutting shall be done by mechanical tools, or by acetylene flame-cutting by means of a special cutting device or by Arc-air (carbon electrode with air jet). Flame cut surfaces shall be perfectly clean, and where necessary, the cut surfaces shall be filed smooth. Mortar-lined pipes shall always be cut by Arc-air cutting equipment. After the metal has been cut through to the mortar lining, the latter shall be carefully broken along the cut and the pipe edge prepared for welding as required above.

(b) Welding of Flanges - The welding of flanges to pipes shall be of the same quality as that specified for pipe welds. Slip-on flanges shall receive an interior weld inside the flange opening, in addition to the external weld. Weld-neck flanges shall be attached to pipe ends as specified above for the welding together of pipes, care being taken to ensure a perfect concentric alignment between pipe and flange.

Flanges shall be welded to pipes very carefully, so that the faces of the flanges shall be truly perpendicular to the pipe axes. Flange faces shall be kept free from weld material or other defects such as splutter, dirt, etc. All defects in flange faces that may interfere with the proper sealing of flanges shall be repaired.

(c) Fabricated Fittings - Where shown on the Drawings or where directed by the Engineer, fabricated fittings, specials, etc., as specified hereafter, will be used instead of factory-made fittings.

Welded elbows shall consist of suitable obliquely cut pieces of pipe ("mitres") welded together. The mitres shall be cut to the exact dimensions shown on the Drawings and accurately fitted together so that after welding the completed elbow will have the exact shape and dimensions shown on the Drawings. The ends of mitres shall be bevelled for welding as specified above. In all elbows of 12" (300 mm) diameter and larger the seams between mitres shall also receive an internal weld pass which shall be made after the weld root has been thoroughly cleaned.

Fabricated T and Y branch connections shall be produced by cutting the branch pipe to the correct intersection fitting the curvature of the main pipe, cutting the required opening in the main pipe and welding the branch to the main pipe. Where shown on the Drawings or instructed by the Engineer the fabricated T and Y branches shall be reinforced by welded saddles. The saddle shall be cut and bent to the required shape and slipped over the branch, its outside edges shall be welded to the main pipe while the edge of its opening shall be welded to the branch pipe.

The quality of welds shall be as specified for pipe connections. The inside of the pipe intersection shall be cleaned and smoothed to ensure unobstructed flow in the pipe.

Pipe reducers shall be fabricated from steel plate properly cut, rolled and welded or by cutting out wedge-shaped pieces from a length of pipe the diameter of which shall be equal to the larger diameter of the required reducer, squeezing the pipe together to the shape of the reducer and welding along the cut edges, which shall be straight and bevelled for welding, the gap between them being of uniform width over the whole length. On reducers of 12" (300 mm) diameter and larger an internal pass shall be added to each weld, which shall not protrude more than 1.5 mm into the inside of the pipe. The end planes of the reducer shall be parallel to each other and truly perpendicular to the pipe axis and shall be bevelled for butt welding.

In all fabricated fittings, the quality of welds shall be as specified for welded pipe connections and the insides of intersections shall be cleaned and smoothed to ensure unobstructed flow in the pipe.

(d) Prefabricated Fittings - Prefabricated elbows, tees and reducers shall be jointed to pipes by square butt welds or by lap welds or by flanges, all as specified above for pipe-welding, care being taken that the true alignment and correct position of the fitting are ensured.

217.4.8 Installation of Valves and Fittings

(a) General - Before being installed, valves, fittings, and especially valve seats, shall be cleaned of any dirt. The correct positioning of valves shall be ensured by means of a spirit level. Flanges shall be welded to the pipes in accordance with the requirements of Subsection 217.4.7 (b) above.

Fitting the valves to pipes shall be done accurately, but without using force. Fitting of valves by tightening bolts forcibly or by any other method that may cause internal stresses in valves or flanges will not be permitted.

(b) Bolts - Only bolts of the correct diameter shall be used. All bolts used on a valve shall be of equal length, which shall be such that after the nut has been tightened not less than one thread and not more than three threads of the bolt will protrude from the nut. Bolts shall be tightened crosswise, gradually and uniformly.

(c) Gaskets - Only one sealing gasket shall be used between each pair of flanges. Gaskets shall be of the ring type, i.e. their outer rim shall just touch the bolt holes and their inside diameter shall be equal to that of the corresponding pipe.

Gasket material shall be either fabric reinforced rubber or compressed asbestos sheets of a type and make approved by the Engineer. Gaskets shall be fabricated by cutting from sheets. Cutting gaskets by hammering on the flange will be strictly prohibited. When being installed, the gaskets shall be absolutely clean. Each gasket shall be used only once.

(d) Gate Valves - Before installation, each valve shall be fully opened and cleaned on the inside with a clean rag soaked in kerosene. Then the valve shall be completely closed and the flange faces also cleaned with kerosene. After cleaning, the flange faces shall be protected with wooden or cardboard covers, which may be removed only just prior to installation of the valve.

(e) Butterfly Valves shall be installed between companion flanges welded to the pipe ends, in accordance with manufacturer's instructions.

(f) Mechanical Couplings shall be of the "Dresser", "Viking-Johnson" or "Victaulic" type, as shown on the Drawings. Ends of pipes to be jointed by Victaulic couplings shall be fitted with accurately machined rings. Ends of pipes to be jointed by Dresser couplings shall be clean of paint, coating or other foreign matter and shall be sufficiently round for at least 20 cm from the pipe edge so that joint rings and couplings shall slide freely onto pipes; no forcing on rings by hammer blows will be permitted. All joint components and pipe ends shall be cleaned and inspected before installation of joint. Rubber gaskets shall be kept in a clean and dry place and protected against sunshine until immediately before installation. Coupling bolts shall be tightened evenly and gradually with sufficient force to attain a tight joint but without causing undue stresses in bolts or joint components. All mechanical coupling shall be bonded and bridged for electrical continuity.

217.4.9 Lining, Coating and Painting of Pipes

(a) General - Where noted on the Drawings, and/or required in the Specification or Bill of Quantities and/or directed by the Engineer, steel pipes, fittings and specials shall be protected against corrosion by internal linings or external coatings or by both internal linings and external coatings. Internal protection shall be provided by cement-mortar, or bitumen linings. External protection shall be provided by reinforced bitumen, or point coatings. Other types of linings and coatings may be required in the Particular Specification.

(b) Cement-Mortar Lining -Where required, steel pipes, fittings and specials shall be internally cement-mortar lined in accordance with the provisions of B.S. 534. Cement-mortar lining for specials and short unlined pipe sections, and repairs to damaged existing lining shall be carried out by hand, to the approval of the Engineer.

Where hand applied lining is approved by the Engineer, the materials, the preparation and the application of the cement-mortar shall conform in all respects to B.S. 534. The mixing of mortar shall be done in a suitable mechanical mixer until a homogeneous mixture of uniform colour and of the required consistency is obtained. The quantity of mortar prepared at a time shall not exceed that required for a half an hour's work.

The steel surfaces to be lined with cement-mortar shall be cleaned thoroughly from dirt, oil, grease, traces of paint or mortar, slag, heavy rust and mill scale. Light rust adhering to the steel surface can be left. Immediately before applying mortar, the steel surface shall be wetted.

Cement-mortar shall be applied to the inter surface of the pipe or special by a steel trowel to the thicknesses specified in B.S. 534. The cement-mortar lining shall be given a smooth surface with a steel trowel and shall be finished off flush with the ends of the pipe or special. Curing compound shall be applied to the lining immediately after its completion to prevent its rapid drying.

The cement-mortar lining at pipe ends shall be of full thickness and shall end flush with the pipe edge. Small defects and depressions not exceeding 1.5 mm in depth are permissible, provided that their aggregate length does not exceed half the pipe circumference. When larger defects or cracks are found in the lining, the pipe will be rejected unless the Engineer permits repair of the lining or cutting away of the defective sections of the pipes. To repair defects in the cement-mortar lining, the defective portion of lining shall be removed to sound and undisturbed mortar, the metal shall be cleaned and new cement-mortar shall be applied as specified. The thickness of the new lining shall be equal to that of the existing lining and shall be finished smooth and flush with it. The mortar of the repair shall be well bonded to the pipe metal and to the existing lining.

(c) Bitumen Lining - Where required, steel pipes, fittings and specials shall be internally bitumen-lined in accordance with B.S. 534 and B.S. 4147.

(d) Bitumen Coating on Underground Piping - Underground steel pipes shall be externally protected by a fiberglass reinforced bitumen coating, in accordance with B.S. 534, B.S. 3415 and B.S. 4147.

The coating will be of the Single Wrap or Double Wrap, or Multiple Wrap type as indicated on the Drawings or in the Particular Specification. Pipe ends to be welded shall be bare. All valves, fittings and pipe to be laid below ground and which have not been factory-coated shall be supplied with an anticorrosive priming and receive a bitumen coating in-situ.

The Contractor's work under this Subsection shall include coating of weld joints; the repair of defects in factory-applied coating and the coating of primed or bare pipes, fittings and valves.

In-situ coating applied by the Contractor shall be equal in all respects to factory-made coatings. Repairs, coating of welds on coated pipes and the coating of bare pipes and fittings shall be bonded to the existing pipe coating so that a continuous uninterrupted coating over the entire length of pipeline is achieved. No joint shall be coated before the Engineer's approval to proceed with coating has been given.

After all joints, bare sections, valves and fittings and defects in coating have been coated and repaired as specified and before lowering the coated steel pipe into the trench, the continuity and integrity of the coating shall be tested by means of an electric Holiday detector, in accordance with A.W.W.A. Specification C203-62 Section 3.13, in application to a single bitumen coat. Test voltages for multiple coats shall be specified by the Engineer.

All defects in coating shall be repaired and retested.

(e) Painting of Exposed Piping - The metal surfaces of all pipes laid above ground together with valves, straps and supports as well as all steel structures shall be painted as specified in Subsection 207.1.7 of this Specification.

The outside surface of coated bitumen pipes shall be given a coat of water-resistant whitewash to protect the bitumen from sunlight and overheating.

217.4.10 Laying of Steel Pipelines

Steel pipes shall be laid underground in trenches, or above ground on supports, or built-in in earth or concrete works, as shown on Drawings or directed by the Engineer. All joints between pipes and between pipes and fittings shall be done by welding or by flanges or by mechanical joints, as shown on Drawings or as directed by the Engineer.

Before lowering in, the pipe coating shall be inspected and all defects repaired. Lowering the pipes into the trench shall be done by pipelayers or other equipment acceptable to the Engineer, so that no damage or deformation is caused to the pipes or the coating and lining. Welded pipes shall be laid on the finished trench bottom, so that each pipe is supported over its entire length.

Where valves, or flanges or mechanical joints are to be installed, or overhead welds are to be made in the trench, the latter shall be widened and deepened by additional excavation around the pipe in order to provide working space (bell holes). Before joining each pipe to the line a cleaning swab with a cable attached to it shall be introduced into the pipe last welded before the new pipe. When the welding to the line has been completed the swab shall be pulled forward by means of the cable through the new pipe, thus cleaning and removing all slag, metal, dirt

and foreign matter which may have accumulated inside the pipe. Where pipes are large enough to be entered by workmen, the said cleaning shall be done by hand.

At the end of each working day and whenever work is discontinued for a considerable time, the ends of each welded section whether in or alongside the trench shall be closed by a suitable cover snapping onto the pipe end.
Lowering-in of pipes or placing them on permanent supports shall be done carefully to prevent damage to pipe coating or paint. To prevent pipes from slipping out of mechanical joints or excessive stresses building up in welds as a result of temperature changes, lowering-in of pipes and joining of sections shall be carried out in the early morning only.

The first stage backfill of the trench shall be done before the final tie-in welds or bolted connections (in the case of mechanical joints or flanges) are made, leaving a stretch of about 20 m uncovered on either side of such final joint.

217.4.11 Weld Inspection and Tests

(a) General - The Engineer will exercise a continuous control of the welding work and will inspect the quality of the welds. In addition to routine supervision and visual inspection of the completed welds, the Engineer will have the right to request samples to be cut out from welds for destructive tests and to order the welds to be tested by radiography.

(b) Destructive Tests - Destructive tests shall include all or some of the following, at the discretion of the Engineer:

- Break Test
- Bend Test
- Tensile Test (in special cases only)

Both the Contractor and the Engineer will endeavour to ensure the proper execution of welds, so as to avoid altogether or minimize the number of destructive tests.

Should one of the samples taken for the destructive tests fail to meet the standards of acceptability set out below, the Contractor will be required to cut additional samples from the same weld or from other welds made by the same welder. If any of the new samples fails to meet the requirements, the Contractor will cut more samples for testing until a clear picture of the extent of defective welds is obtained.

Should such additional tests show that the quality of the welds is unacceptable, as determined by the Engineer, the Engineer may require the Contractor to remove and reweld all welds made by the welder concerned.

Unless otherwise specified, the cost of cutting the sample and preparing and testing the specimens, and that of patching the pipe where the sample has been cut out, as well as the cost of all additional tests that may be required to determine the extent of defective

welds as aforesaid, shall be borne by the Contractor and deemed to be included in the various unit rates.

Samples for Bending, Breaking and Tensile Tests shall be cut out from the pipe in the form of strips 5 cm wide, perpendicular to the weld seam and extending 10 cm on either side of the weld, so that the weld will be located in the centre of the sample. The opening resulting from cutting the sample shall be closed by welding on a patch of steel plate having a thickness not less than that of the pipe wall. The cost of patching up openings as herein described shall be included in the cost of taking samples as specified above.

The bend test samples shall be bent in a suitable jig in the field or in the shop. The bend shall be located exactly over the weld with the weld face on the convex side. The sample shall be considered to have met the requirements if it does not break and no cracks larger than 3 mm in any direction appear on the convex side of the bend.

The break test samples shall be hacksaw-notched on both edges across the centre of the weld to ensure breaking of the sample in the weld. The sample shall be supported on both sides of the weld and broken by a strong hammer blow. For the weld to be acceptable, the broken surface shall show full penetration of the weld and no burns or excessive slag inclusions. The breaked surface shall show no more than one gas pocket

per square centimeter, provided that no gas pocket has a diameter larger than 1.5 mm.

Samples for tensile strength and elongation tests shall be sent for testing to an authorized laboratory. These tests will serve as a control of the welding procedure and of the quality of the electrodes, but not to test the welder's ability. In this test the samples shall show a tensile strength not less than that required of the steel of which the pipes are made.

(c) Radiographic Tests - Where required, radiographic tests shall be performed in accordance with B.S. 2910. Unless otherwise specified, 10 (ten) percent of all weld seams shall be radiographed. If these primary tests should not give satisfactory results, the Engineer will conduct additional radiographic tests to ascertain the quality of the welding work. All weld defects discovered by the tests shall be repaired as directed by the Engineer and all repaired welds shall be retested.

The cost of the routine radiographic test (10 percent), as well as any additional tests which the Engineer may think it necessary to conduct because of the defective quality of the welds, shall be borne by the Contractor and deemed to be included in the various unit rates. The Contractor shall also bear the cost of repair of all welds found defective under test as well as the cost of retesting such repaired welds.

217.4.12 Hydrostatic Pressure Test

After pipelaying, casting of concrete structures on the line and partial backfill have been completed, the pipeline shall be subjected to a hydrostatic pressure test. The line shall be tested

over its entire length or, in the case of long lines, in sections, as approved by the Engineer. Pressure tests shall be performed only in the presence of the Engineer.

The magnitude of the test pressure, the testing procedure and all other requirements shall be as described in Subsection 217.3.10 (b) of this Specification, except that the Hydrostatic Pressure Test can commence 24 hours after the completion of filling, if permitted by the Engineer.

217.4.13 Methods of Measurement and Payment

Steel pipes shall be classified for payment according to type of joint, diameter and nominal pressure, and shall be measured in linear meters of completed pipeline in place measured along the crown of the pipeline. The length measured for payment shall include the lengths of all fittings, valves and specials installed in the line.

Price for fittings, bends, junctions, specials, detachable joints, flanges (where not an integral part of pipe or fitting), etc., shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications on the B.O.Q..

Payment for steel pipes and for fittings, specials etc... shall include:

– Supply, hauling, handling, unloading and stacking of pipes and fittings including all necessary jointing materials, electrodes, gaskets, nuts and bolts etc. for pipes and fittings and factory coating and lining up of all pipes and fittings.

– Removal from stacks; hauling and stringing alongside trench; laying and jointing of pipes and fittings by welding (including square and mitred welds, both in and above trench) and/or mechanical joints; field coating and lining of joints and of pipes and fittings where required and all repairs to factory coatings and linings, including supply of all necessary materials; inspection and testing of coating, weld inspections and welders' qualification tests; and final cleaning and flushing of pipeline. The unit rates for this item, for each type, wall thickness and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

Only pipes, fittings, junctions, bends etc. actually laid in trench and tested and accepted by the Engineer shall be measured for payment under the above items, and no allowance whatsoever will be made for any waste, loss, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

a) Testing of completed pipeline - the cost of carrying out hydrostatic pressure test, as specified, shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

b) Valve Assemblies for which items have been included in the Bill of Quantities shall be classified according to their diameter and measured for payment by the number of complete units as described.

   The unit rate for a valve assembly shall include for: the supply of the valves complete with counter-flanges and accessories; supply of gaskets, bolts and nuts, all welding electrodes, paints and coating materials; cleaning and complete installation of the assemblies, inclusive of all cuts and welds; fitting up of flanges and fittings, placing them in their exact position and completing the joints, inclusive of tightening of bolts and anchors; bridging of mechanical joints; making good of paint and coating and sealing off pipes passing through chamber walls.

c) Pipe Assemblies that are described as such in the Bill of Quantities shall, for purposes of payment, be measured by the number of complete units within the limits shown in the Drawings and/or defined in the relevant items of the Bill of Quantities.

   The price of each assembly shall include for the necessary excavation and backfill; supply of all pipes, accessories, joints, valves, supports and all other parts of the assembly; cutting, fitting, welding, jointing and installation of pipes in position; fixing of supports for pipes; internal and/or external coating as required; testing of welds; pressure tests of the assembly and all other works required for the fitting of the completed assembly between the limiting points.

d) Various Welding and Installation Works - In case of measurement of welding and installation works - whether as separate items in the Bill of Quantities or for the purpose of varying any of the rates for complete assemblies under Subsection (d) and (e), or if the Engineer should deem such separate measurement necessary for any other reason - such works shall be measured and paid for as provided in the following paragraphs (1) and (5).

The necessity for such measurement will in each case be determined by the Engineer. Measurement will be by number, classified by type and size as detailed in the Bill of Quantities. The unit rates shall include everything as detailed below and in addition also the supply of all materials and all additional excavation necessary for installation.

1) Square and Mitre Welds: The unit rates shall include for the necessary cutting, bevelling, fitting-up and welding of pipes as specified.

2) Welding of Tee, Y and Weld-O-Let Outlets: The unit rates shall include for cutting, shaping, bevelling, and welding the outlet pipe to the main pipe, as well as for cutting the opening in the main pipe.

3) Welding Flanges: The unit rate shall include for squaring the pipe end as required, welding-on the flange to the pipe at right angles to the pipe axis and for both the external and the internal welds. Welding of weld-neck flanges will be considered as a square weld under (1).

4) Fabrication of Pipe Reducers: The unit rate for fabricating a pipe reducer shall include for cutting the pipe to required length, cutting out wedges in the pipe wall, tapering the reducer to the correct shape and welding the longitudinal seams.

5) Making of Flanged Connection and Mechanical Joints and Installation of Valves and Fittings: The work shall include cleaning and fitting-up of flanges, joints, valves, etc., installation of joint rings, gaskets etc.; insertion and tightening up of bolts, nuts and washers; and welding on of anchor lugs and installing of threaded rods in anchored "Dresser" couplings, where required.

The cost of the work described in Paragraphs (1)-(5) above shall be deemed to be included in the various items of supply, laying and jointing of steel pipes and fittings and shall not be paid for separately.

e) Inserting of Line Pipe in Casing shall be measured, separately for each diameter of line pipe, in linear meters by the length of the casings and shall be paid as an extra over the price for pipelaying. The unit rate inserted in the Bill(s) of Quantities for inserting line pipes in casing shall be deemed to cover the cost of the supply and hauling of casing pipe, welding of casing pipe sections, supply and spacing of spacers, coating of casing pipe where practicable, installing line pipe in casing and sealing of openings at both ends of casing pipe.

217.5 CAST IRON AND DUCTILE IRON PIPES AND FITTINGS

217.5.1 Quality Requirements

All cast iron and ductile iron pipes and fittings to be supplied under this Specification shall be obtained from approved manufacturers. They shall be of the class and shall have joint ends as shown on the Drawings or as specified and shall otherwise comply in all respects with B.S. 4622 - Grey Iron Pipes and Fittings, and B.S. 4772 - Ductile Iron Pipes and Fittings.

– External Coating: pipes and fittings shall be given an external coating of zinc in accordance with ISO 8179 or BS 4772 and a finishing coating of either cold applied

bitumen complying with the performance requirements of BS 3416 Type II material, or hot applied bitumen to BS 4147 Type I Grade C.

- Internal Lining: All pipes and fittings shall be lined internally with cement motar and shall comply with ISO 4179 or BS 4772. The inside of the sockets shall be coated with bitumen as used for the finishing coating to the pipes.

While the pipes are still suspended over the trench before lowering or before mounting, they shall be inspected for defects and rung with a light hammer to detect cracks. Defective pipes shall be dismounted, removed from the site and replaced by flawless pipes. Only pipes inspected and accepted on the site by the Engineer shall be incorporated into the works.

217.5.2 Hauling and Handling of Pipes

The Contractor shall check each pipe before loading and shall reject all damaged or defective pipes. The Contractor shall load and properly secure the pipes on the vehicles and take all necessary measures to prevent any damage to the pipes during transport. The Contractor shall be responsible for the quality of the pipes and for their condition upon and after delivery to the site, and shall immediately remove from the site any damaged or defective pipes and replace them at his own expense.

No pipes or fittings shall be allowed to drop, roll freely or strike objects which are likely to damage them. Special care shall be taken not to spoil the tar or bitumen coating.

217.5.3 Laying and Jointing

(a) Laying - Before C.I. or Ductile pipes are laid, all dirt and foreign matter shall be removed from inside and all lumps blisters, excess coal tar, oil, grease and moisture shall be eliminated from the surfaces of the joints. After the pipe is laid and mounted, care shall be taken to avoid entrance of dirt, water and foreign matter from the trench or from elsewhere by the use of tight bulkheads.

(b) Jointing of cast iron pipes and fittings - Joints shall be flanged; or mechanical joints; or rubber gasket “push-in” flexible joints, all as specified and/or shown on Drawings.

(c) Jointing of ductile iron pipes and fittings - Joints in ductile iron pipes and fittings shall be of one of the following types according to the Drawing and the Particular Specification:

- Spigot and socket joint with rubber gasket
- Flanged joints
- Mechanical joints

All joints shall conform to B.S. 4772.

217.5.4 Testing

Testing instructions and requirements for Cast Iron and Ductile Iron pipelines shall be as specified in Subsection 217.4.12 for steel pipelines.

217.5.5 Methods of Measurement and Payment

Cast Iron pipes and Ductile Iron pipes and fittings shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place,

measured along the crown of the pipeline. The length measured for payment shall include the lengths of all fittings, valves and specials installed in the line.

The price for fittings, bends, junctions, specials, detachable joints, flanges (when not integral part of pipe or fitting) etc. shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications or the B.O.Q.

Alternatively, if so stated in the Particular Specification and/or in the Bill of Quantities, C.I. and Ductile Iron pipes and fittings may be measured by number of pipes of defined net lengths and by number of fittings.

The payment for C.I. and Ductile Iron pipes and (under separate items) for fittings, bends, junctions etc. shall include:

- Supply, hauling, unloading and stacking of pipes and fittings including all necessary joints and jointing materials.

- Removal from stacks, hauling and stringing alongside the trench, laying and jointing of pipes and fittings at any depth of trench, connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item for each type, class and diameter of pipe and fitting shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of completed pipeline
  - For pressure and gravity pipelines shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid, jointed and tested and accepted by the Engineer shall be taken into account for payment under items and no allowance whatsoever will be made for any breakage, loss, etc.
Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

217.6 G.R.P. PIPES

217.6.1 Quality Requirements

a- Manufacturers Pre-qualification

GRP pipes and fittings shall be manufactured by an established pipe Manufacturer in a purpose-built facility for the production of such materials. The Manufacturer shall have at least 5 years experience at the facility in the production of the full range of pipe diameters (25 - 3000 mm) pipe, fittings and related products. Evidence of previous experience shall be presented. The Manufacturer shall have an approved Quality Management System complying with ISO 9001 which shall cover all activities being undertaken during the manufacturing, supervision and installation of the subject pipe systems.

b- Applicable Codes and Standards

The following internationally accepted standards are the minimum requirements for the manufacture of GRP Pipe Systems and should be referenced throughout the Project Specification where appropriate.

AWWA C950	Glass Fiber Reinforced Thermosetting Resin Pressure (Latest Edition).
ASTM D3262	"Fiberglass" (Glass - Fiber - Reinforced Thermosetting - Resin) Gravity Sewer pipe.
BS 5480	Glass reinforced plastics (GRP) pipes, joints and fittings for use for water supply or sewerage.
ASTM D3517	Specification for Glass Fiber Reinforced thermosetting resin pressure pipe.
ASTM D3754	Specification for GRP sewer and industrial pressure pipe.

c- Product Description

c.1- <u>General</u>

The GRP pipe shall consist of a corrosion resistant liner, a structural wall and a resin rich exterior layer. The resin to be used is of the Isophtalic type.

<u>Liner</u>
Pipe and Fittings shall have a resin rich liner consisting of a 0.25mm thick resin rich layer and "C" glass backed by a 0.75mm thick layer with a resin glass ratio of 70:30.

<u>Structural Wall</u>
The pipe structural wall shall be as specified in AWWA C950-01 Sec. 4.3 cell classification system with the resin systems to be the appropriate grade of Isophtalic as required by the system type and operating conditions.

External Layer
Pipe shall have a 0.01" (0.30mm) thick resin rich exterior surface impregnated with Isophtalic resin as required by the system type and operating conditions.

c.2- Materials

– Glass Reinforcements shall be compatible with the impregnating resin used.
– Resins used shall be a commercial high grade thermosetting Isophtalic type as specified under Section c.1 above.
– No dark pigments shall be used in the GRP pipe or joints. No additives shall be used except when required for viscosity control.
– Aggregates and Fillers use shall be limited to 30% maximum for any Pressure Application.
Care should be taken to ensure no aggregate becomes embedded in the resin rich liners.
– All GRP pipes and fittings conveying potable water shall be certified and listed for potable water use by internationally recognized independent water authority such as the Water Research Council "WRc", the DVGW, KIWA, Lyonnaises Des Eaux, or NSF etc..

d- Requirements

d.1- Wall Thickness
GRP pipe systems up to and including 2000 mm diameter shall be of the solid wall type. The wall thickness required for each size/pressure and stiffness class shall be established by the Manufacturer to meet the design requirements but in no case shall wall thickness be less than (0.010 x ND); where ND is the nominal pipe inside diameter. The pipe working pressure class shall be based on the Hydrostatic design basis (HDB) of the pipe with a design (service) factor of 0.5.

d.2- Length
GRP (Standard = 6 or 12 Meters) pipe shall be manufactured in standard laying lengths of not greater than 12 meters. Random short lengths, if supplied, shall not exceed 5% of the quantity supplied of each size. The tolerance on the Manufacturer's declared laying length shall not exceed ± 25 mm.

d.3- Diameters
Pipe shall be manufactured in standard metric sizes based on the pipe nominal inside diameter in sizes 25mm and larger. The actual inside diameter shall not vary from the nominal inside diameter by more than 1.5% or 4 mm whichever is greater.

d.4- Stiffness
The pipe stiffness shall be determined by the Manufacturer to meet the design requirement with particular regard to installation method, burial depths, deflection limits, buckling and vacuum requirements, in accordance with AWWA M45. However, stiffness shall be at least 5000 N/m^2 or as stated in the drawings or in the particular specifications.

d.7- Joints

Standard buried pipe with unrestrained joints shall be filament wound GRP coupling, with two rubber ring gaskets. Rubber rings shall be suitable for the intended application. Joints shall allow for at least 0.75-degree deviation while remaining water tight at 1.5 times the pipe

operating pressure. The rubber rings shall be the sole element depended upon for water tightness. This system will require thrust blocks at changes in direction to accommodate thrust loads.

d.8- Workmanship

- GRP pipe, fittings and joints shall be free from de-laminations, cracks, bubbles, pinholes, pits, blisters, foreign inclusions and resin-starved areas that due to their nature, degree or extent detrimentally affect the strength and serviceability of the pipe. No glass fiber reinforcements shall penetrate the interior surface of the pipe wall.
- Joint sealing surfaces shall be free of dents, gouges, de-laminations, or other surface irregularities that will affect the integrity of the joints.
- GRP pipe, fittings and joints shall be as uniform as commercially practicable in color, capacity, density and other physical properties.

d.9- Fittings

- GRP fittings such as bends, tees, junctions and reducers shall be equal or superior in performance to the GRP pipe of the same diameter and pressure. All fittings shall be have a smooth internal surface with similar wall construction.
- For GRP fittings, the deviation from the stated value of the angle of change of direction of a bend, tee, junction etc. shall not exceed ± 1 degree.
- The tolerance on the Manufacturer's declared length of fitting shall be ± 10 mm taken from the point of intersection to the end of the fitting or ± 10 mm on a straight fittings.
- All GRP fittings shall be fabricated in the factory to ensure Quality Control (under no circumstance shall fabrication of fittings be allowed on site by Contractor). Complex fittings arrangements may be pre-assembled by the pipe Manufacturer in the factory such that field joints are kept to a minimum.

e- Design Parameters

Pipe shall meet the following minimum design requirements:

- Operating Pressure (Pw) — As specified; Min 1000 Kpa for Pressure pipes
- Surge Pressure (Ps) — 40% of 'Pw' unless otherwise specified.
- Vacuum (Pc) — As specified.
- Minimum Earth Cover — 1.0 m or as shown on drawings for buried pipe.
- Initial Installed Deflection for Buried pipe — 2.0% Max.
- Long Term Installed Deflection for Buried Pipe — 5.0% Max
- Safety factors
  - Pressure Rating >= 1.8
  - Ring Bending Strain (stress) >= 1.5
  - Combined Strain (stress) >= 1.5
  - Buckling >= 2.5

The Contractor shall be responsible for implementing / installing the correct design for each GRP pipe system.

f- Inspection & Testing

f.1- The Manufacturer shall take adequate measures in the production of the GRP pipes and fittings covered by this specifications to assure compliance with the requirements herein. An Inspection and Testing Plan (ITP) should be established by the Manufacturer. Plant inspection by the Engineer and/or the Contractor's qualified personnel or the omission of such inspections shall not relieve the Manufacturer of the responsibility to furnish products complying with the requirements of the minimum manufacturing requirements given herein.

f.2- Production and Testing Notice - When plant inspection is required by the Engineer or the Contractor, the Manufacturer shall provide adequate advance notice of when and where production and testing of ordered products will commence.

f.3- The Engineer and the Contractor shall have free access with reasonable advance notice to the Manufacturer's plant areas that are necessary to assure that products comply with all requirements herein.

f.4- As a minimum the following tests shall be performed at the indicated intervals unless otherwise agreed-upon, and shall form a part of the Manufacturers overall quality control program.

The following tests shall be conducted on every pipe;

- Visual Inspection, as per manufacturer standard
- Dimension Measurements, as per manufacturer standard
- Resin cure (Barcol Hardness), ASTM D2583
- Hydrostatic Pressure test for pipe up to 2000 mm in diameter, ASTM D3517

The following tests shall be conducted on pipe samples at a frequency of not less than one per 50 pipes (one lot) of the same Diameter and Pressure.

- Stiffness, ASTM D24313 or BS5480 App. H.
- Hoop Tensile Strength by split disc, ASTM D2290 or BS5480 App. C or D.
- Longitudinal Tensile Strength, ASTM D638 or BS5480 App. A
- Loss on ignition (composition), ASTM D2584

The Supplier shall submit to the consultant qualification test reports for the following test:

- HDB in accordance with ASTM D2992 procedure B or BS5480 App. E
- HDB reconfirmation in accordance with ASTM D2992 section 12
- Cyclic test
- Long term ring bending test in accordance with ASTM D5365-93
- Coupling tightness in accordance with ASTM D4161 or BS5480 App. M

The supplier shall give evidence that the GRP pipe produced in his own plant has successfully passed the above mentioned tests. All these tests should be conducted in the plant and witnessed by a third party. If so directed by the Engineer, the selection of samples and the tests shall be witnessed also by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

Test methods shall be in accordance with AWWA C950-01 and BS 5480 or other relevant standards. Copies of all test reports shall be submitted to the Engineer for each lot delivered to Site.

The cost of samples, their transportation to the laboratory and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

f.5- Pipe Data Sheet should be as follows:

Nominal Diameter (ND)		(mm)
Service (Specify) Underground / Aboveground		KPa
Rated Working Pressure		KPa
Allowable Vacuum		Kpa
Pipe Wall		
Nominal total thickness		mm
Inner Liner	Thickness	mm
	Resin Type	
	Glass Type	
Structural Wall	Thickness	mm
	Resin Type	
	Glass Type	
	(Aggregate type)	
Exterior Layer	Thickness	mm
Mechanical Properties		
Minimum initial specific stiffness STIS		N/M^2
Initial longitudinal tensile strength		KN/M^2
Initial Hoop tensile strength		KN/M^2

217.6.2 Hauling, Handling and Storage

GRP pipes shall be handled, stored and installed in strict accordance to the Manufacturer written instructions.

Rough handling of pipes shall at all times be avoided, pipes shall not be dropped or thrown on the ground. Severe impact with other pipes or object must be avoided. All pipes should be lifted at their mid-point. Pipes must not be lifted with chains, wire ropes etc, a suitable textile sling must be used.

During unloading the pipes, joints and specials must be carefully inspected to verify the following:

a) Products are not damaged
b) Joints are positioned correctly
c) Classification is as specified

Attention shall be paid to stack heights to avoid the possible deformation of the pipe diameter. No stacking of pipe larger than 1.8m in diameter shall be allowed on site or during transport.

217.6.3 Laying and Jointing

After the excavation and preparation of a section of pipe trench has been completed, it shall be inspected by the Engineer. Just before pipe laying, the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipe laying shall be carried out by experienced pipe-layers, well skilled in this work.

The Contractor shall submit the pipe Manufacturer's Installation Manual and associated Data for Engineer review. A site meeting to include Engineer, Contractor and Manufacturer is to occur to clarify any outstanding issues / questions on the given installation procedures.

The pipe installation procedures and practices chosen shall meet the design requirements specified.

Immediately before being laid, each pipe and fittings shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying.

In order to prevent stones and soil from entering the pipe, a suitable cap or plug shall be provided with which the last pipe laid shall be closed when pipelaying is not actually in progress. The plug will be of the screw-up expanding type or of tapered wood.

Where bends are required, performed bends of the desired radius shall be used. Hot bending on site is not permitted.

All joints shall be flexible, with approved rubber rings. Rubber rings shall comply with B.S. EN681-1 (Elastomeric Joint Rings for Pipework and Pipelines) and shall be of the type designated on the Drawings, or in the Particular Specification, or as directed by the Engineer.

Prior to laying, the pipe and joint must be thoroughly inspected. Check for damage, joint position, pressure classification and cleanliness.

To ensure clean assembly and to prevent the weight of the pipe being taken on the joint, a hole should be excavated at the joint position prior to laying the pipe. When the joint has been made, fill and compact the hole with bedding material to provide continuous support to the pipe along its entire length.

Reinforced Concrete Thrust Blocks shall be used at all changes in direction, size reduction / expansion. Thrust blocks shall encase the entire GRP fitting at the directional change and should be constructed to fully absorb all thrust loads.

Pipe Deflection readings shall be taken and recorded on all buried pipe at two meter intervals. Initial deflections shall not show a reduction in internal vertical diameter for over 2.0 percent of the pipe ID.

For standard buried unrestrained pipeline sections, a flexibly jointed short pipe shall be incorporated outside rigid structures to provide pipeline flexibility against differential settlement. A minimum of two (2) flexible joints on either side of a rigid structure is required. The length of the short pipe shall be in accordance with the Manufacturers recommendation.

217.6.4 Testing

Testing instructions and requirements for GRP gravity pipelines shall be as specified in Subsection 217.2.6 for concrete pipelines. Testing instructions and requirements for GRP pressure pipelines shall be as specified in Subsection 217.3.10 (b) for A.C. pressure pipes, except that the Hydrostatic pressure test can commence 24 hours after the completion of filling if permitted by the Engineer.

217.6.5 Methods of Measurement and Payment

GRP pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place, along the crown of the pipeline, as follows:

- In gravity flow lines: between internal surfaces of manholes or chambers.
- In pressure flow lines: between stations.

The length measured for payment shall include the length of all fittings, valves and specials installed in the line.

Payment for GRP pipes and for fittings; specials etc. shall include:

- Supply, hauling, handling, unloading and staking of pipes and fittings including all necessary GRP joints and jointing materials for pipes and all GRP joints and jointing materials for fittings, specials, valves, etc.

- Removal from stacks; hauling and stringing alongside trench; laying and jointing of pipes and fittings, at any depth of trench; connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item, for each type, class and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of completed pipeline
  - For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid for separately.
  - For pressure pipelines: the cost of testing shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid in trench and tested and accepted by the Engineer can be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, waste, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise stated.

217.7 P.V.C. PIPES

217.7.1 Quality Requirements

P.V.C. pipes and fittings shall comply in all respects with the following standards:

- B.S. 3506 Unplasticized P.V.C. pipes for industrial uses.
- EN1452 Outside Diameters and Pressure Ratings of Pipe of Plastics Materials.
- EN1329 Unplasticized P.V.C. Underground Drain Pipe and Fittings.
- EN1401 Unplasticized P.V.C. Pipe and Fittings for Gravity Sewers.

All pipes and fittings shall be supplied by approved manufacturers. Class of pipes shall be as stated in the Drawings or in the Particular Specification. The nominal length of pipes shall be not less than 6.0 m and not greater than 9.0 m.

P.V.C. pipes shall be factory tested and shall be subjected to Hydraulic and to Impact (Falling Weight) Tests. The number and selection of samples for testing, the test procedure and the requirements shall all be as specified in the relevant EN. If so directed by the Engineer, the selection of samples and the Tests shall be witnessed by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

The cost of samples, their transportation to the laboratory and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

217.7.2 Hauling, Handling and Storage

Rough handling of pipes shall at all times be avoided, especially at low temperatures. During storage and transport, rigid P.V.C. pipes shall have as near continuous support as possible at all times, and care shall be taken to avoid damage to pipe by sharp edged angle irons, exposed nail heads, etc.

For long term storage in average ambient temperature, attention shall be paid to stack heights to avoid the possible deformation of the pipe diameters. A maximum stack height of 1 meter is recommended. For temporary storage on site, care shall be taken to ensure that the ground is level and free from bricks, stones and sharp edges. At high temperatures, rigid P.V.C. pipes shall be kept in the shade during long term storage. P.V.C. pipes with spigot and socket shall be stacked with the sockets protruding in alternate layers. Pipes bent, deformed in any way or changed in colour shall be rejected and no payment whatsoever shall be made for such pipes.

While transporting, the pipes shall not overhang the vehicle by more than 0.6 m. Pipe loads shall not be stacked higher than 2.0 m.

Where pipes are transported one inside another, care shall be taken that:

(a) The pipes are clean and free from grit.

(b) Suitable covering be provided over the exposed ends of the pipes to prevent the entry of grit during transport.

(c) The pipes in the lower layers are not excessively loaded to such a degree as would cause damage or undue distortion.

217.7.3 Laying and Jointing

After the excavation and preparation of a section of pipe trench has been completed, it shall be inspected by the Engineer. Just before pipelaying the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipelaying shall be carried out by experienced pipe-layers, well skilled in this work.

Immediately before being laid, each pipe and fittings shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying. The use of a badger will be ordered by the Engineer, if in his opinion, dirt is not being satisfactorily excluded. The badger, on a sound rope, is to remain within the bore of the pipe previously laid and jointed and it is to be drawn forward as the work proceeds throughout the whole length of the sewer. The badger is to be of soft material which will not damage the internal surface of the pipes.

In order to prevent stones and soil from entering the pipe, a suitable cap or plug shall be provided with which the last pipe laid shall be closed when pipelaying is not actually in progress. The plug will be of the screw-up expanding type or of tapered wood.

Where bends are required, performed bends of the desired radii shall be used. Hot bending on site is not permitted.

All joints shall be flexible, with approved rubber rings. Rubber rings shall comply with B.S. EN681-1 (Elastomeric Joint Rings for Pipework and Pipelines) and shall be of the type designated on the Drawings, or in the Particular Specification, or as directed by the Engineer.

Pipe lengths and fittings shall be supplied with a chamfer on the spigot end. Where pipes have to be cut to length, the pipe shall be cut square and a chamfer formed on the spigot end using a medium file. Any saw flushing shall be scraped off with a knife. The spigot and socket shall be free from mud or grit, and the ring correctly located in its groove. A lubricant approved by

the Engineer shall be applied to the chamfered portion of the spigot before its insertion in the socket.

Flanges complying with B.S. 4504 (flanges and Bolting for Pipes, Valves and Fittings, metric units) shall be used for the jointing of P.V.C. pipes with steel pipes and for the connection of valves and other appurtenances. The joint shall be made by compression of a gasket or ring seal set in the face of the flange.

Pipes shall be laid true to line by means of a line stretched along the sides of the pipes and true to level by means of a straight edge of suitable length kept inside the pipes and pulled forward to pegs boned in at suitable intervals between sight rails set to the proper levels.

217.7.4 Testing

Testing instructions and requirements for P.V.C. gravity pipelines shall be as specified in Subsection 217.2.6 for concrete pipelines except that the leakage under test shall not exceed 0.08 litre/m2 of internal wall pipe area/hour. Testing instructions and requirements for P.V.C. pressure pipelines shall be as specified in Subsection 217.3.10(b) for A.C. pressure pipes, except that the Hydrostatic pressure test can commence 24 hours after the completion of filing if permitted by the Engineer.

217.7.5 Methods of Measurements and Payment

P.V.C. pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place, along the crown of the pipeline, as follows:

- In gravity flow lines: between internal surfaces of manholes or chambers.
- In pressure flow lines: between stations.

The length measured for payment shall include the length of all fittings, valves and specials installed in the line.

The price for fittings, specials, junctions, bends, detachable joints, valves, etc., shall be classified for payment according to type, diameter and class; shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications or the B.O.Q.

Alternatively, if so stated in the Particular Specification and/or in the Bill of Quantities, pipe and fittings may be measured by number of pipes of defined net lengths and by number of fittings.

Payment for P.V.C. pipes and for fittings; specials etc. shall include:

- Supply, hauling, unloading and staking of pipes and fittings including all necessary P.V.C. joints and jointing materials for pipes and all P.V.C. joints and jointing materials for fittings, specials, valves, etc.

- Removal from stacks, hauling and stringing alongside the trench, laying and jointing of pipes and fittings at any depth of trench, connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item for each type, class and diameter of pipe and fitting shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of completed pipeline

    - For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid for separately.

    - For pressure pipelines: the cost of testing shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid, in trench and tested and accepted by the Engineer shall be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, waste, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise noted.

217.8 HIGH DENSITY POLYETHYLENE PIPES (HDPE)

217.8.1 Quality Requirements

HDPE pipes and fittings shall comply in all respects with the following standards.

BS 6572 - 1984 - Specification for blue polythylene pipes up to nominal size 63 for below ground use for potable water.

WIS 4-32-02 Specification for polyethylene pressure pipe for cold potable water (underground use).

WIS 4-32-04 Specification for polyethylene socket and spigot fittings, saddless and drawn bends for fusion jointing for use with cold potable water PE pressure pipes.

WIS 4-32-06P - 1989 - Specification for polyethylene electrofusion couplers and fittings for cold potable water supply for nominal sizes up to and including 180.

WIS 4-32-13P - 1991 - Interim specification for higher performance blue polyethylene(PE/MRS 100) pressure pipes (nominal sizes 90 to 500) for underground or protected use for the conveyance of water intended for human consumption.

(WIS Water Industry Specifications UK).

DIN 8074/ DIN 8075 or the most recent ISO standards or European Norms (EN12201 part 1 and part 2).

All pipes and fittings shall be manufactured from approved raw materials and shall be supplied by approved manufacturers. Manufacturers shall have and maintain permanent Quality Control program and records.

Unless otherwise stated, pipes with OD up to 63mm must be produced from PE80 (MDPE) or PE100 (HDPE) material. Pipes with OD 75 mm and up must be produced from PE100 (HDPE) material. Pressure class for all diameters should be PN16.

Pipes with OD up to 63mm shall be supplied in coils where the inside diameter of the coil is 30 times OD. Pipes with OD 75mm and up shall be supplied in coils if possible or in straight length not less than 6 m.

The pipes shall be clearly and indelibly marked to show the name of the manufacturer, nominal diameter, wall thickness, PE designation, pressure class, standard (BS, DIN, EN, ...) and date of manufacture. The marking shall remain legible during normal handling, storage, installation, and service life and shall be applied in a manner that will not reduce the strength nor otherwise damage the products. The marking shall not initiate any defects in the surface and will not provide leakage channels when elastomeric gasket compression fittings are used to make joints. Both hot tape marking and Ink Jet printing are acceptable.

For instant identification as potable water service pipes, PE pipes shall be colored blue or black permanently color-coded with blue stripes. Stripes shall be provided by co-extruding four (or more) equally spaced blue color stripes into the pipe outside surface. The striping material shall be the same material as the pipe material except for color. Stripes printed on the pipe outside surface shall not be acceptable.
For applications other than potable water, i.e. Irrigation and drainage, pipes are to be colored black.

Pipes and fittings intended to be used for the conveyance of potable water shall be approved by an internationally recognized independent water authority such as WRC, DVGW, KIWA, Lyonnaise Des Eaux, etc... The effect on water quality test shall fulfill the requirements of BS 6920 or equivalent.

HDPE pipes shall be factory tested and shall be subjected to Hydraulic, Impact (Falling Weight) and acceptance Tests. The number and selection of samples for testing, the test procedure and the requirements shall all be as specified in the relevant EN. If so directed by the Engineer, the selection of samples and the Tests shall be witnessed by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

The cost of samples, their transportation to the laboratory and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

217.8.2 Hauling, Handling and Storage

Rough handling of pipes shall at all times be avoided, especially at low temperature, and care should be taken to prevent damage to pipes and fittings at all stages of handling, transporting and storage.

Pipes must be transported by a suitable vehicule and properly loaded and unloaded. Straight pipes should be supported along their full length.

When lifting with slings, only wide fabric choker slings shall be used to lift, move, or lower pipe and fittings. Wire rope or chains shall not be used. Slings shall be of sufficient capacity for the load, and shall be inspected before use. Worn or defective equipment shall not be used.

During storage, care must be taken to ensure that pipes do not become distorted or damaged. This can occur if pipe stacks are not properly constructed and are not limited in height. Pipe stacks must not exceed 1.5m and storage areas must be flat throughout the entire length of the pipe.

Pipes must be protected from materials which may soften or damage polyethylene, such as strong solvents.

Pipes must not be dragged across ground, which might damage the surface.

Similar precautions should be taken with fittings and these should be kept in protective wrappings until required for use. This is particularly important for all electrofusion fittings, each one of which should be individually wrapped and sealed immediately after manufacture.

It is similarly important to protect spigot ends of pipes and fittings to be jointed by Electrofusion or Mechanical jointing methods.

217.8.3 Weathering

Blue and yellow polyethylene should not be permanently installed above ground where it is exposed to direct UV light.

217.8.4 Laying

After the excavation and preparation of a section of pipe trench has been completed, it shall be inspected by the Engineer. Just before pipelaying the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipelaying shall be carried out by experienced pipe-layers, well skilled in this work and in the presence of the Engineer unless prior permission has been received.

Immediately before being laid, each pipe and fittings shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying. The use of a badger will be ordered by the Engineer, if in his opinion, dirt is not being satisfactorily excluded. The badger, on a sound rope, is to remain within the bore of the pipe previously laid and joined and it is to be drawn forward as the work proceeds throughout the whole length of the pipe. The badger is to be of soft material which will not damage the internal surface of the pipes.

In order to prevent stones and soil from entering the pipe, a suitable cap or plug shall be provided with which the last pipe laid shall be closed when pipelaying is not actually in progress. The plug will be of the screw-up expanding type or of tapered wood.

Where bends are required, performed bends of the desired radiis shall be used. Hot bending on site is not permitted.

<u>Additional general installation details for HDPE duct for telemetry cables</u>

The line and level of the duct formation shall be kept as straight as possible. Bends will be required for duct formations to be routed around corners at intersecting roads. (For safety reasons manholes shall usually be planned and located away from intersections).

The configuration of the duct formation shall be as shown on drawings.

All ducts shall be located in accordance with applicable roads and municipal Standards. In the absence of relevant Standards, the Engineer must be consulted to ensure compliance with the appropriate standard which may vary depending upon the nature of the undertaking.

Ducts shall be watertight between manholes. Installation methods shall prevent sand and soil from entering the ducts.

At manhole, the bond between the outside surface of the duct and the wall shall be watertight.

Ducts shall be terminated flush to manhole inside walls. Edges shall be bevelled off.

Ducts entering manholes, shall be plugged and watertight. The plugging mechanism or material shall be readily removable to allow for future cable installation.

Ducts shall leave a manhole in a standard formation and enter the subsequent manhole with each duct in the same relative location.

At location between manholes where the duct formation must be modified due to obstructions the formation shall be altered to minimise the movement of each duct.

The separation either longitudinal or perpendicular, to other services, should be minimum 150mm. Where such is not possible a separating/retaining layer of 50 mm of concrete is required.

The Engineer shall have the authority to change the construction method to HDPE in concrete or steel ducts, should the circumstances indicate such a requirement.

If two ducts are to be laid, they shall be supported by spacers so that the formation will maintain the standard spacing between ducts throughout the length of the installation. Sand, to the appropriate highway specification, shall be placed to fill all spaces between ducts, and compacted.

The duct formation shall be covered with 200 mm of sand. This is to be followed by approximately 200 mm of suitable backfill and a plastic warning tape. Warning tape shall be 70mm wide, yellow PVC, durably marked with the text 'WARNING - TELEMETRY CABLE' at no more than 50 cm intervals. Backfill and compaction shall follow.

HDPE tubes shall have minimum 2" inside diameter and minimum 5mm thickness with manholes maximum 100 meters apart.

217.8.5 Jointing

Jointing of HPDE can be one of the following systems:

a) Electro-fusion Fittings and Saddles

Electro-fusion can be used for all polyethylene pipes irrespective of size and pressure rating as long as pipe and fitting are manufactured from polyethylene resin of the same class and series. It is possible to use fittings with higher pressure rating than pipe, but the opposite is strictly forbidden.

- All fittings shall be injection moulded from recognised top quality PE 100 or PE 80 resin.
- All fittings must conform with the requirements of the related standard EN, BS, ..
- All fittings must be packed in such a way to allow instant use on site without additional cleaning.
- Each protective package must clearly indicate its contents.

- The heating coils contained in each individual fitting and saddle should be so designed that only one complete process cycle is necessary to fully electro-fuse the fitting to the adjoining pipe or pipes.
- No heating coil may be exposed and is to be fully imbedded into the body of the fitting for protection purposes during assembly.
- The pipe fixation device shall be an integral part of the fitting body in the sizes up to and including nominal diameter 63 mm.
- An individual magnetic card containing a magnetic strip and an appropriate barcode for data transfer purposes must be supplied with each fitting.
- All fittings must have moulded-in identification and product information.
- Process voltage of all fittings must not exceed a maximum of 40 volts.
- Insulated contacts for the terminal pins are to be provided.

- Terminal pin size shall be 4 mm in diameter.
- A limited path style fusion indicator acting for each fusion zone as visual recognition of completed fusion cycle should be incorporated in the body of the fitting.
- The design of the indicators must prevent the escape of fusion melt.
- All couplers in the sizes up to and including nominal diameter 160 mm must have an easily removable center stop not requiring tools for removal.
- All internal or externally threaded transition adaptors in the nominal sizes up to and including 2" must be designed with an integral polyethylene collar form PE 100 or PE 80 not relying on rubber or synthetic seals.
- Threaded adaptor bodies may be from brass or stainless steel and should be of the modular principle not being supplied moulded into an electro-fusion fitting socket.
- Electro-fusion machines used in the electro-fusion process must be supplied by the same manufacturer of fittings. It strictly forbidden to fuse one manufacturer fitting with another manufacturer machine.

Additional Requirements for Electro-fusion Saddles

- All saddles up to nominal diameter 250 mm should be designed with two separate halves having a single hinge type attachment and are to be correctly processed without specialized 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, adopters, valve tees, stop-off attachments etc., that are simultaneously fused together with the saddle to mains joint in one operation.
- Each branch outlet is to be equipped with an integral clamping device.
- The branch spigot of tapping tees must be long enough to allow a second joint if necessary.
- All pipe saddles sizes above nominal diameter 63 x 20 mm are to allow a 360° rotation of the branch outlet.
- Safe tapping into a main must be possible under the defined allowable maximum water pressure according the respective pipe series and ambient temperature.
- The tapping saddle cutter is to be designed to seal-off the central passage in the uppermost position.

b) Butt-fusion:

Butt-fusion jointing is a thermofusion welding process which invloves the simultaneous heating of the annular end sufaces of two components to be joined until a melt state is attained on each contact surface. The two surfaces are then brought together under controlled pressure for a

specified cooling time and a homogeneous weld is formed upon cooling.

The resultant joint is end thrust resistant and has comparable performance under pressure to the unwelded pipe.

In the fabrication and installation of a butt-welded polyethylene system, it is essential that all items which are to be butt-welded are made from compatible material.

The compatibility is dependent upon the process of manufacture, density amd melt flow index.

It is also important that proper butt-welding machines are used to make welds and that these are maintained in good condition as welding pressures and temperatures are critical to achieving satisfactory welds.

c) Compression Fittings

All fittings must be manufactured of pure virgin compounded PP ensuring the best performance as to mechanical properties and flexibilities.

- All fittings must be Push-fit type: to assemble, the installer must just cut the pipe square and clean (no need to chamfering), loosen the nut, push the pipe all the way through the stroke and close the nut. The fittings should be easily disassembled without the need for a special tool.
- All fittings must have a floating split clamp ring to compensate thermal and mechanical stress on the pipe. (Ring must be made of acetalic resin or C-PVC).
- All fittings must have a heavy-duty thrust ring to ensure axial compression of the gasket on ovalized, undersized and scratched pipes.
- All fittings must have a gasket. giving the gasket a broader contact surface with the pipe, allowing a tighter grip and a higher resistance in case of vacuum or suction. Also, permitting higher protection against pipe pullout (Gasket must me made from EPDM or NBR Rubber).
- All female offtakes must be reinforcing with metal rings (Rings must be made of stainless steel).
- All fittings must have an easy traceability of the production batch. The production date must appear on the fitting's body and/or nut.

Certificates and Approvals:

All fittings must pass the testing requirements of ISO 3458/3459/3501/3503. At the time of submission, Manufacturers of fittings must hold valid certificates of conformity in respect to the following:

Toxicological requirements:

- WRc * Low sensitivity to bacteria migration
- DVGW * Low sensitivity to chlorine absorption
- KIWA * Alimentary compatibility as ATA test for color, odor, taste and toxic components in concentrations - BRL-K533

Ageing Test requirement:

- DVGW * 95° C - 1,000 hours - 0.5 x Nominal Pressure (PN)

Pullout Test requirement:

- WRc * For sizes up to 63 mm Diam.
- UNI9562 * for sizes greater than 63mm Diam.

Pressure test requirement:

- IIP * 3 x Nominal Pressure (PN) - 1 hour - 20°C Water

Temperature

Clamp Saddles

All clamp saddles must be manufactured of pure virgin compounded PP ensuring the best performance as to mechanical properties and flexibility.

- Clamp saddles could be used on distribution lines of 63mm and below, for section rated at PN16 bars or less.
- All saddle off-takes must be reinforced with metal stiffeners.
- All saddles must have a feature to prevent bolt's rotation during assembly.
- All saddles over 40 mm and outlets ½" to 2" must have flat gasket to ensure added flexibility on ovalized, undersized or scratched pipes and to prevent gasket's pulling-out in case of water hammer.
- All bolts and nuts should be from stainless steel (series 400).

217.8.6 Testing

Testing instructions and requirements for HPDE gravity pipelines shall be as specified in Subsection 217.2.6 except that the leakage under test shall not exceed 0.08 litre/m2 of internal wall pipe area/hour. Testing instructions and requirements for HPDE pressure pipelines shall be as specified in Subsection 217.3.10 (b) for A.C. pressure pipes, except that the Hydrostatic pressure test can commence 24 hours after the completion of filling if permitted by the Engineer. Manufacturer's recommended procedure of testing should be submitted to the Engineer who could accept to take it into consideration or not.

217.8.7 Methods of Measurement and Payment

HPDE pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters of completed pipeline in place, along the crown of the pipeline, as follows:

- In gravity flow lines: between internal surfaces of manholes or chambers.
- In pressure flow lines: between stations.

The length measured for payment shall include the length of all fittings, valves and specials installed in the line.

Payment for HPDE pipes and for fittings; specials etc. include:

- Supply, hauling, handling, unloading and staking of pipes and fittings including all necessary HPDE joints and jointing materials for pipes and all HPDE joints and jointing materials for fittings, specials, valves, etc.

- Removal from stacks; hauling and stringing alongside trench; laying and jointing of pipes and fittings, at any depth of trench; connections to manholes and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item, for each type, class and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of completed pipeline
  - For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid for separately.
  - For pressure pipelines: the cost of testing shall be paid for under a separate item in the Bill of Quantities, by linear meters of pipe tested.

Only pipes, fittings, junctions, bends etc. actually laid in trench and tested and accepted by the Engineer can be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, waste, etc.

Excavation and backfill, special beddings, surrounds and manholes and chambers shall be paid for under separate items in the Bill of Quantities, unless otherwise stated.

217.9 WATER SERVICE CONNECTIONS

217.9.1 Scope

Service connections shall consist of pipes and fittings of small diameters which distribute water from the mains to the consumers.

The nature of these connections shall vary according to the main pipes material.

For DI mains, service connections shall include the following:
- Tapping collars
- Ferrules (Self-sealing fittings for vertical under pressure tappings)
- Stop valves
- Pipes and fittings

and shall end up with:
- House connection accessories

For HDPE mains, the tapping collars and ferrules shall be replaced with saddles and tapping tees respectively. The remaining components (stop valves, pipes and fittings and house connection accessories) shall be identical to those used for DI mains.

217.9.2 Ductile Iron Mains

217.9.2.1 Tapping Collars

Tapping collars shall be used for connecting DI mains to service lines. They shall be made from coated ductile iron with anti-corrosive bolts and shall have large threaded boss on which ferrules shall be vertically mounted.

Elastomer gaskets of appropriate shapes shall ensure the seal between the mains and tapping collar.

217.9.2.2 Ferrules (Self-sealing fittings for vertical under pressure tappings)

They shall be mounted on large threaded boss tapping collars for connecting mains to service lines.

They shall consist of:

- a body, ductile iron, threaded at its lower part, and screwed on under pressure tapping collars. A polyurethane gasket shall allow to obtain the required orientation of the fitting once the fitting is completely screwed to the collar.
- an ABS float valve (Acrylonitrèle - Butadiene - Styrene)
- a ductile iron seat coated with elastomer and screwed inside the body.
- a ductile iron cap fitted with a polyurethane gasket
- an internal threaded outlet on which a nipple for polyethylene or PVC pipe shall be mounted. No need for nipple if stop valves are directly connected to ferrules.

217.9.3 HDPE mains

217.9.3.1 Saddles

HDPE mains shall be connected to the service lines through electrofusion saddles, which are made from HDPE and consist of:

- An upper semi-cylindrical piece having a small cylindrical neck incorporated at the center of its convex face; a tapping tee shall be vertically mounted on this upper part through the above-mentioned neck.
  The seal between the upper part of the saddle and the main pipe shall be effected through electrofusion. To this effect, this upper part shall include two ports used to connect the electrofusion machine to the saddle. Two limited path fusion indicators shall also be present to indicate the point beyond which no more sealing is necessary. One of these ports shall be located on the semicylindrical surface of the upper saddle part and the other on the saddle neck to seal the saddle to the main and the tapping tee to the neck, respectively.
- A lower semi-cylindrical part that shall be attached to the upper one via two pin connectors from one side, the other side being joined together by the means of a hook, formed through appropriate fashioning of the upper and lower saddle ends. This lower part is used to fix the upper one in place prior to sealing this latter to the main through electrofusion.

217.9.3.2 Tapping Tees

They shall be mounted on the above-mentioned saddles for connecting HDPE mains to service lines.

They shall be made from HDPE and shall consist of:

- A lower cylindrical branch to be inserted in the saddle neck specified above.
- An upper threaded branch that could be closed with a screw cap of the same material (HDPE).

- An outlet branch that could be joined to the service pipe via a coupler, or could be directly connected to the stop valve.
- An O-ring sealed screw cap made from HDPE.

The seal between the tapping tee and the saddle shall be effected through electrofusion as above. The saddle neck shall also be equipped with two pin connectors to be tightened after inserting the tapping tee and orienting it in the right direction, and prior to sealing it to the neck.

As for the coupler connecting the outlet tee branch to the service pipe, it shall be sealed to these through electrofusion as well but shall include four pin connectors for better control before sealing, as well as two limited path fusion indicators.

217.9.4 Stop Valves

Stop valves shall be equipped with two push-in fittings for connecting standard polyethylene or PVC pipes (this could be applied either for DI or HDPE mains) or they shall be equipped at one end with a threaded nose for direct connection to tapping collars or ferrules installed on the DI mains, and on the other end with a push-in fitting for standard polyethylene or PVC pipe in accordance with NFT 54-003, NFT 54072, ISO 161-1, ISO 3607 or any equivalent.

Stop valves shall consist of :

- a ductile iron body coated with powder epoxy or copper alloy, drilled for automatic draining of service line (after closing of the ferrule).
- a rotary inverted plug, copper alloy, ¼ turn, fitted at its upper part with an operating cap.
- a ductile iron base coated with powder epoxy and screwed to the body lower part. The base and the body shall be of the same material.
- a stainless steel spring supported by the screwed base and pushes the inverted plug against the body.

Stop valves shall be protected by complete systems of surface boxes for operation from the surface. These boxes shall consist of a lower protective hood which shall contain the valve and isolate it from the surrounding soil. The hood shall be surmounted by a PVC extension tube which shall house the spindle used to operate the stop valve (Each stop valve shall be equipped with such a spindle). Finally, the extension tube shall be topped by a surface box made of ductile iron, the cover of which shall be flush with the sidewalk surface and the entire assembly (stop valve, spindle, hood, tube, surface box) located outside the property line.

The stop valve shall be at least 60cm beneath the road surface.

217.9.5 Service Pipes

Service pipes shall be from HDPE. For further information, refer to section 217.8.

217.9.6 Test Pressure

Service connection fittings shall undergo a double hydrostatic test:

1. a mechanical strength test, in opened position, under the maximum allowable pressure increased by 50%:
2. a seal test, in closed position, under the maximum allowable pressure increased by 10%:

Test certificate from factory or from approved laboratory shall be submitted with the equipment.

217.9.7 House Connection Accessories

House connection accessories for each consumer shall consist of a ball valve followed by a water meter and then a pollution check valve including all necessary fittings.

House connection accessories shall be protected by adequate water meter boxes. These boxes shall have generally three sizes: first size for individual consumers, second size for three subscribers and a third size for five subscribers. In these two latter cases, a collector linked to

the downstream end of the service line shall distribute water to each house connection.

For pricing purposes, this collector shall be considered an integral part of the water meter box(es) it is supplying.

Water meter boxes shall be watertight, and equipped each with a lock to prevent unauthorized access. These locks shall be identical for a given number of boxes. This number may vary according to the Engineer's request. In addition, a sight glass shall be installed on each meter box cover to provide a proper reading of the water meter measurements without having to open the meter box.

For each group of similar locks, shall be provided a corresponding set of 5 identical keys.

The boxes shall be located inside the concerned property, and shall be provided by the Contractor. Their exact location shall be approved by the Engineer.

217.9.8 In Situ Testing and Method of Payment

Service lines shall be from HDPE, equipped where required with a ferrule mounted on the tapping collar installed on the main (for DI mains) or with a tapping tee on a tapping saddle in the case of HDPE mains, a stop valve installed on the service line and a ball valve installed at the end of the service line directly upstream the water meter.

Hydrostatic tests are conducted in two stages on service connections and DI mains at the same time:

1. The main is put under test pressure with ferrules and/or stop valves closed - The network tightness is monitored.
2. Ferrules and stop valves are opened and ball valves closed, the seal of service connections, under the same test pressure as stage 1, is monitored.

The same procedure shall be followed for HDPE mains (use tapping tees in place of ferrules).

Service connection testings shall be paid separately by unit of service connection.

217.10 MICROTUNNELLING SYSTEM

217.10.1 Reinforced Concrete Jacking pipes

217.10.1.1 Static Strength Calculation

The static strength calculation must be done for all expected load cases in axial direction of the pipes (jacking force for straight or curve drives) and perpendicular to the pipe axis (pipe weight, ground load, internal and external water pressure, traffic load etc.) based on actual valid rules such as general rules for concrete works (DIN 1045), special rules for pipe design and pipe manufacturing (DIN 4035) and detailed rules for the static strength calculation for the specific system of pipe installation (open trench installation or pipe jacking).

Structural calculations for jacking pipes must be according to worksheet ATV-A161- (Driven pipes, Edition I/90).

217.10.1.2 Concrete and Reinforcing Steel

Reinforced concrete pipes, to be manufactured according to DIN 1045 and DIN 4035, using approved steel, aggregates, cement (sulfate resistant if need), admixtures and water.

1. Reinforcing steel must be of weldable quality (BSt 500 P / BSt 500 S or similar), fulfilling all tests after cage welding procedure according to DIN 488.

2. The reinforcing cages have to be produced by automatic welding machine according to the structural strength calculation and pipe design.

3. For pipes of a wall thickness of 120 mm or more, two layers of concentric cages must be foreseen, which should be completely embedded in the concrete.

4. A minimum of 30 mm concrete cover must be secured, using special polymer-concrete spacers with roughened surface securing homogeneous adherence to the concrete.

5. Cage design, rod and coil sizes, spiral spacing and relevant dimensions must be as per ATV-A161.

217.10.2 Pipe Design and Geometry

1. Jacking pipes should be spigot/socket type, where the spigot includes an incorporate precast groove, allowing for the installation of a rubber seal joint, whereas the socket must be a steel collar including a prewelded steel water stop.

2. The steel grade of the collar should be corrosion resistant to the soil and water at the installation level. Such resistance to be calculated as per DIN 50929 / P3 considering the soil and water analysis. If the pipes are installed near the sea on coastal areas the collar should be stainless steel.

3. Standard mild construction steel according EN 10025 or steel containing chrome and molybdium, to be selected depending on the corrosion resistance calculations.

4. The thickness of the collar must not be less than 8 mm for mild steel and not less than 6 mm for stainless steel, respecting the corrosion resistance standard, but in any case should be designed to resist the physical forces resulting from the allowed angular deviations.

217.10.3 Handling Anchors

Each pipe must include 4 anchors, whose load resistance must be approved, two of which to allow for pipe handling at site and for transport, whereas the other two to be used for lifting and titling the pipes upon production. (DEHA anchors or similar).

217.10.4 Pipe Particulars

1. At least each third pipe of the jacked sequence should be a special pipe including three outlet nozzles to allow for external surface lubrication during pipe jacking. These nozzles to be precast during production.

2. Special pipes of long-sockets to be foreseen, as per design, to allow for the use of intermediary jacking stations.

3. As a compression absorber, each pipe, must include at the socket side a wooden ring of a thickness of 20 mm.

217.10.5 Joint seals

1. For the pipe joint sealing a slip-ring seal made of elastomer rubber of dense structure for permanent sealing has to be used. The seal compression should be of a minimum of 25%.

2. The pipe joint design, (spigot groove, rubber seal and steel collar) shall be designed to resist the internal and external hydrostatic pressures at the installation zone, but in any case should resist an internal pressure of at least 1 bar and an external pressure of at least 2.0 bars.

3. Joint of pipes used for storm water, do not need any internal treatment.

4. Joints of pipes for clear water transport, (eventual potable use), must be sealed with approved polyurethane base mastic, as recommended by the manufacturer.

217.10.6 Internal Pipe Lining for Sewage Pipes

1. The reinforced concrete pipes used for sewage shall be produced with 360° - Lining to prevent from corrosion due to the sewage and gas inside the tunnel.

2. The lining must cover the full pipe length, where the joint zone must also be sealed using thermoplastic hot air extrusion welding, applied by an automatic (satellite) device.

3. Minor repairs and patching the outlet nozzles, could be carried out by manual hot air thermowelding, using the welding rods as recommended by the manufacturer of the liner.

4. A joint strip of the same lining material has to be welded to both sides of the joint (recess joint system). This strip must be of a thickness of at least 3mm.

5. The lining to be of HDPE with minimum thickness of 2.0 mm.

6. The lining must be of the stud type securing resistant adherence (embedment) into the concrete resisting an external pressure of at least 2.0 bar.

217.10.7 System Pipe Length

Jacking pipes to be of a length of 3 meters. Shorter pipes could be used to allow for curved drives, as per ATV 161, as well as for length compensations at the connections to manholes and others.

217.10.8 Pipe Manufacturing

The pipes shall be manufactured according to the above mentioned standards in best quality, using special pipe molds with hydraulic shrinkable internal cores and expandable external molds.

The pipes should be kept for at least 4 hours inside the pipe molds to get high quality concrete and smooth pipe surface. During the first 10 hours after pouring the concrete curing shall be carried out by covering the pipes completely to conserve the humidity and avoid fast drying.

After production, the pipes should be sprayed with water for 2 days securing high surface concrete strength.

217.10.9 Microtunneling System and Machines

1. The tunneling machine and relevant logistics must be an integral system supplied by the same manufacturer, where the steering and guiding system are to be operated from the computerized, above ground, control room.
   The cutting wheel, its tools, and relevant selection of rock cutting and / or clay handling - etc must be adequately selected considering the soil condition, water table and ground cover.
2. The control plc / ddc system must control all the equipment, as well as their components, where a selectable manual / auto mode is allowed.

3. The computer, and display monitor, must sense and process the mechanical and hydraulic components, as well as the laser beamer, but not limited to:

   3.1. Cutting wheel, torque and rpm, both variable and controllable.

   3.2. Steering cylinders: course control and pressure indication.

   3.3. Roll and yawe display, and limiting levels control.

   3.4. Pitch and level sensing and control.

   3.5. Driven length indication.

   3.6. Main jacking cylinders pressure and speed control.

   3.7. Intermediary jacking station, pressure and course control.

   3.8. Lubrication and slurry pressure control.

   3.9. Laser magnitude and intensity control.

3.10. Oil level and temperature control.

3.11. Slurry flow and pressure at both supply and return lines (valid for slurry system).

218 ROAD WORKS

218.1 ROADS AND PAVED AREAS

218.1.1 General

Road construction under this division shall include construction of new roads and paved areas and repairs to existing roads and paved areas where such repairs are necessitated by the performance of the Works, and the term "road" as used in this division shall also include other areas on which a road surfacing is required.

All roads shall be constructed to the lines, levels and cross-sections shown on the Drawings and as detailed in the Particular specification. Road surfacing may consist of compacted local soil, gravel, laterite or similar suitable material, with or without a stabilizing spray of bitumen, or of asphalt concrete placed on a bearing course of compacted gravel, laterite or other suitable base course material.

All roads shall be fitted with a stormwater drainage system, sidewalks, etc.

218.1.2 Earthworks for Road Construction (Subgrade)

All excavation and fill required for road construction shall be carried out in accordance with the applicable requirements of Division 201. The materials to be used and the degree of compaction to be obtained in each layer of the road structure shall be as shown on the Drawings or as required in the Particular Specification.

218.1.3 Sub-Base and Base Courses

Sub-base preparation shall consist of the following:

- Scraping of the natural ground
- Earthworks and levelling of the surface
- Compaction with a pneumatic roller.

Unless otherwise specified, sub-base material shall consist of hard, durable particles or fragments of stone or gravel, screened and crushed to the required size and grading or an equivalent material, subject to the Engineer's approval. The material shall be free from vegetable matter, lumps or balls of clay and other objectionable matter.

The sub-base shall be levelled, watered, rolled and compacted to 96% of the Modified AASHTO Density. In case it consists of non-rock ground, the California Bearing Ratio CBR shall be greater than 30. The Material shall have a specific weight greater than 2.45 kg/dm^3.

If the bearing of the foundation soil be inadequate, the top soil shall be stripped to a 20cm depth. The stripped area shall be backfilled with material that meets the requirements and have a minimum CBR of 15 when compacted to 96% of Modified AASHTO Density. The frequency of tests shall be determined by the Engineer.

The sub-base course material layer shall conform to the following grading:

A.S.T.M.Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
1"½	100%
1"	60-100
¾"	55-85
No. 4	35-60
No. 10	25-50
No. 40	15-30
No. 200	0-15

The material shall have the following properties:

- Plasticity Index (AASHTO T90) 4-8
- Plastic Limit (AASHTO T89) 25 maximum
- Sand Equivalent (AASHTO T176) 50 minimum

Unless otherwise specified, base course material shall be crushed aggregate which shall consist of hard, durable particles or fragments of stone or gravel crushed to the required size, and a filler of sand or other finely divided mineral mater. When produced from gravel, not less than 50 percent by weight of the coarse aggregate shall be particles having at least one fractured face and, if necessary to meet his requirement or to eliminate an excess of filler, the gravel shall be screened before crushing. All suitable oversize material less than 10 inches in diameter shall be crushed. The material shall be free from vegetable matter, lumps or balls of clay and other objectionable matter.

The sub-base and base courses shall consist of a minimum of 20 cm thick each course of compacted layers of screened and crushed material.

The sub-base shall be watered prior to the placing of the base course. The material shall then be laid, watered and compacted with a pneumatic roller to 98% of Modified AASHTO Density.

The last base course shall be levelled to ± 1 cm according to the levels shown on the drawings or specified by the Employer. Newly placed base courses shall not be opened to traffic.

The base course material shall have a specific weight greater than 2.45 kg/dm^3 and shall conform to one of the following gradings:

A.S.T.M.Sieve designation	Percentage by Weight Passing Square Mesh Sieves								
	A	B	B-1	C	C-1	D	D-1	E	E-1
3 inch	100	-	-	-	-	-	-	-	-
2 inch	-	100	100	-	-	-	-	-	-
1 1/2 inch	-	-	70-100	100	100	-	-	-	-
1 inch	-	-	55-85	-	70-100	100	100	-	-
3/4 inch	-	-	50-80	-	60-90	-	70-100	100	100
3/8 inch	-	-	40-70	-	45-75	-	50-80	-	-
No. 4	15-45	20-50	30-60	25-55	30-60	30-60	35-65	35-65	45-80
No. 10	-	-	20-50	-	20-50	0	25-50	-	30-60
No. 40	-	-	10-30	-	10-30	0	15-30	-	20-35
No. 200	0-10	0-10	5-15(*)	0-10	5-15(*)	0 - 10	5-15(*)	0-10	5-15(*)

(*) For gradings B-1, C-1, D-1 and E-1, the fraction passing the No. 200 sieve shall not be greater than two-thirds of the fraction passing the No. 40 sieve.

If no specific grading is specified, the grading shall comply with C above.

If fine aggregate or filler in addition to that naturally present in the base-course material is necessary in order to meet the grading requirements or for satisfactory bonding of the material, it shall be uniformly blended with the base-course material at the screening and crushing plant or on the road. The material for such purpose shall be obtained from sources approved by the engineer and shall be free from hard lumps.

That portion of the base course material passing No. 40 sieve shall be nonplastic.

The base course material shall be tested for abrasion in accordance with B.S. 812 and the following maximum values shall be acceptable.

Aggregate fraction	Maximum abrasion (%)
3/4” - 1”	40
1/2” - 3/4”	35
3/8” - 1/2”	30
1/8” - 3/16”	28

Sub-base and base courses shall be placed in layers not exceeding 15 cm in thickness, after compaction. Unless otherwise specified, base course materials shall be placed only by means of spreader boxes or equivalent equipment. Placing base course materials directly by means of trucks, shovel dozers and other loading or hauling equipment will not be permitted. Blending material, where required, shall be added by means of spreader boxes or other approved equipment and the whole base course layer shall be thoroughly mixed to its full depth by means of graders, mixers or other approved equipment.

During placing and mixing, water shall be added in the amount necessary to provide the optimum moisture content for compacting.

Compaction shall be carried out in accordance with the applicable parts of Section 201.7.

Unless otherwise specified, the following densities shall be required:

- For sub-bases: 96% of the Modified A.A.S.H.T.O. Density
- For base-courses: 98% of the Modified A.A.S.H.T.O. Density

218.1.4 Bituminous Prime Coat and Tack Coat

Unless otherwise specified, a prime coat of medium curing cut-back bitumen of grade MC-70 shall be applied on top of finished base course, at the rate of 1.0 kg/m^2, and a tack coat of rapid curing cut-back bitumen of grade RC-250 shall be applied between asphalt concrete layers (where more than one wearing course is specified), at the rate of 0.25 kg/m^2.

Bituminous coats shall be applied one day before the next layer is placed on top of them. Prior to applying bituminous coats, the road surface shall be thoroughly cleaned of all dirt, oil, grease and other objectionable matter, to the satisfaction of the Engineer. The bitumen shall be heated in boilers of an approved type and spreading shall be carried out by means of mechanical pressure distributors.

218.1.5 Asphalt Concrete Wearing Courses

The number of asphalt concrete layers to be placed in the road surfacing and the thickness of each of them shall be as shown on the Drawings and/or required in the Particular Specification.

All aggregates and bituminous materials to be used in asphalt concrete shall be subject to approval by the Engineer. Samples of the materials shall be submitted to the Engineer at least 30 days prior to their use.

All aggregates, except natural sand, shall be obtained by crushing natural quarry stone, and the use of river gravel, whether crushed or not, will not be permitted. Coarse aggregate shall be of uniform quality, with the particles as nearly cubiform as possible, clean of dust or foreign matter, and shall comply with the requirements of Subsection 218.1.3 above for base course aggregate. Quarry sand shall be clean and free of clay, silt or other deleterious matter; it shall all pass sieve No. 10 and not more than 10 percent of it shall pass sieve 200. The grading of the aggregates shall be if not specified in the Particular Specification as follows:

A.S.T.M.Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
¾“	100%
½”	80-100
No. 4	50-70
No. 10	32-47
No. 40	16-26
No. 80	10-18
No. 200	4-10

Mix design shall be carried out as follows. The proposed aggregate mixture shall be mixed with 5.5% bitumen (if no other percentage is required in the Particular Specification). This sample shall be subjected to a set of Marshall tests (A.S.T.M.-D-1559 and A.S.T.M.-D-1188) at a laboratory in order to determine the optimum bitumen content.

The Engineer may change the grading of the aggregates and the bitumen content according to the results of laboratory tests conducted on samples of materials supplied from time to time by the Contractor at the request of the Engineer.

Placing of asphalt concrete, unless otherwise specified, shall be carried out by means of paving finishers, specially designed for that purpose. The asphalt concrete layers shall be compacted by tandem rollers, heavy pneumatic rollers and three-wheeled rollers, in that order to reach a density not less than 97% of the Marshall density. Parts of the layers inaccessible to heavy mechanical rollers shall be compacted by small vibratory tampers. Rolling shall proceed from the outer edges towards the centre of the road and the whole area shall receive a uniform compaction throughout and shall be finished accurately to the required lines and levels. When asphalt concrete is placed in more than one layer, longitudinal joints shall be staggered by 30 cm and transversal joints by 60 cm between layers. The permissible variations of the top surface from the design levels shall be -0 + 15 mm. The permissible variations from the plane in the top surface shall be 5 mm over a length of 5 m.

Newly paved asphalt concrete surfaces shall be opened to traffic only after permission to do so is given in writing by the Engineer.

Placing of asphalted concrete shall ensure an inclination for drainage of stormwaters in accordance with the drawings and as specified by the Engineer.

218.1.6 Bituminous Surface Treatment

Where shown on the Drawings or required in the Particular Specification, a surface treatment shall be applied to the base course by spraying cut-back bitumen followed by a rolled blinding layer of stone chippings. Unless otherwise specified, bituminous surface treatment shall consist of the following two layers:

- Cut-back bitumen MC-3000 at the rate of 2.8 kg/m^2, followed immediately by stone chippings of 3/4" - 1" size at the rate of 27 kg/m^2.

- Cut-back bitumen MC-3000 at the rate of 1.35 kg/m^2, followed immediately by stone chippings of No. 4 - 1/2" size at the rate of 22 kg/m^2.

The second layer shall be placed after the first layer has been rolled.

Prior to application of bituminous spray the base course surface shall be checked for accuracy and any irregularities shall be repaired. The surface shall then be swept clean of all loose material, foreign matter, dust and dirt. Areas contaminated by kerosene or diesel oil shall be removed and made good with clean and stable base course material.

The bitumen shall be heated in kettles of an approved type equipped with enclosed thermometers, the heat being conducted by oil or steam. Heating of bitumen in the barrels will not be permitted.

The entire area of the base course shall be sprayed uniformly at the prescribed rate by means of approved mechanical spraying equipment. Pools of excess liquid bitumen shall be sprinkled with fine sand which shall be swept off after it has absorbed the surplus bitumen.

The stone chippings shall be uniformly applied upon the entire sprayed surface. Trucks or other equipment for spreading the chippings shall be operated backwards so that the bituminous spray will be covered before wheels or workmen pass over it. Supplementary spreading and smoothing, where necessary, shall be done manually.

Following spreading and smoothing of chippings, each layer shall be rolled, to the satisfaction of the Engineer.

The completed road surface shall not be opened to traffic until permitted by the Engineer.

218.2 DRAINAGE SYSTEM

Stomrwater discharge channels and drainage systems shall be installed as shown on the drawings.

Excavation limits of channels and pipes as shown on the drawings shall be extended by 10 cm at the bottom and 30 cm on either sides.

Such over excavations shall be backfilled with graded fills and compacted to the satisfaction of the Engineer.

Excavations shall have a longitudinal slope as specified by the Engineer to facilitate water discharge.

The concrete drainage channels shall be either of precast or of cast-in-place concrete complying with the requirements of division 202.

Where specified, construction and expansion joints shall be performed to the details shown on the drawings and as directed by the Engineer.

A collector fitted with a metallic grid shall be mounted on channels and pipes as shown on shop drawings.

218.3 SIDEWALKS

Where specified on Drawings and required by the Engineer, sidewalks shall be executed.

Prior to the construction of sidewalks, the base course shall be prepared as determined in the previous articles. The Contractor shall be held liable for any future settlement of such layer.

Pavement works shall start upon the approval of the Engineer, and as shown on shop drawings.

For concrete paving, the flags shall be of an approved colour and laid in compliance with the requirements of the division 208, and in strict accordance with the lines and levels shown on shop drawings.

218.4 CONCRETE KERB-STONES

Precast concrete kerbs, channels, etc. shall be to the types and dimensions shown on the Drawings and/or defined in the Particular Specification. They shall be whole, sound, without cracks, air bubbles or other defects, and shall comply with the requirements of B.S. 340. Where specified, kerbs, channels etc. shall be bedded and backed with C 15 P concrete. Joints between units shall be filled with a 1:2 cement mortar.

All kerbs, channels, etc. shall be aligned in strict accordance with the lines shown on the Drawings. Special terminal units shall be provided at the edges of the alignment. Where required, units shall be cast-in-situ to the lines and dimensions shown on Drawings.

Kerbs, channels, etc. in sharp curves shall be shorter than those used on straight lines, in order to ensure proper alignment.

218.5 TESTING

218.5.1 Testing on fill materials

All natural fine fills shall conform to the below listed requirements:

a) Complete Identification Tests

- Sieve analysis and sedimentometry
- Atterberg limits (liquid limit, plasticity index, shrinkage)

b) Test on organic soils

c) Standard Proctor tests with complete determination of compaction diagram

d) Modified Proctor tests with complete determination of compaction diagram

e) CBR tests at 95% of the maximum dry density.

The number of the aforesaid tests shall be as determined by the Engineer.

218.5.2 Tests on Backfill

Placing natural fine fill shall be controlled by the Engineer in the following manner:

Three series of the following tests shall be conducted on each backfilled layer or on every 250 m^3 of placed backfills:

Measurement of moisture content

Measurement of compactness (dry density)

218.5.3 CBR tests on natural ground

CBR tests shall be conducted according to relevant standards.

The frequency of tests shall be as determined by the Engineer.

218.5.4 Tests on crushed aggregates

The required tests on crushed aggregates to be used for roads are the following:

- Measurement of the specific gravity
- Measurement of the compressive strength on 7 cm side cube
- Los Angeles test
- Sieve analysis
- tests on organic soils according to French Standards
- Measurement of the sand equivalent.

A series of tests shall be carried out on each 500 m^3 of aggregates or as directed by the Engineer.

Following are the two density control tests to be carried out on site on each placed crushed aggregate layer:

- Either on each finished layer,
- Or on each 250 m^3 of placed aggregates,
- Or as directed by the Engineer.

218.5.5 Tests on concrete asphalt aggregates

Following are the required tests to be carried out on concrete asphalt aggregates:

- Los Angeles Test
- Specific gravity
- Sieve analysis
- Loss in weight
- Sand equivalent
- Any other test as specified by standard ASTM D 693-54.

Three series of tests shall be conducted on each 500 m^3 of furnished material or on any volume exceeding by 50% this number, as required in writing by the Engineer.

218.5.6 Tests on bitumen

- Penetration at 25° C
- Penetration at 163° C
- Ductility at 25° C
- Flash point
- Solubility in carbon sulphide at 20° C
- Paraffin content.

Whenever required in writing by the Engineer, the tests above shall be carried out on each furnished bitumen volume prior to manufacture of asphalt concrete, or on bitumen that is being used.

218.5.7 Tests on asphalt concrete mixture

The Contractor shall conduct:

1) Tests to determine the grading of aggregates and the bitumen content

2) Marshall tests to determine the stability and density of bitumen-covered aggregates.

These tests shall be carried out before the commencement of works and repeated to the satisfaction of the Engineer.

218.5.8 Quality Control Tests

- Control of grading

- Control of moisture content and temperature

- Control of bituminous mixture, 2 samples to be tested daily/mixing plant

- Control of mixing plant.

Grading control shall be conducted once a day on 10 kg of samples of aggregates before putting them in the mixing plant, and whenever required by the Engineer.

Control of moisture content and temperature shall be carried out twice a day; moisture content shall not exceed 0.5% and temperature variations ± 5° C.

The control of bituminous mixture shall be carried out on the bitumen content and grading. Each tested sample consisting of four distinct samplings shall be taken from the mixing plant at short intervals as to ascertain that the proportioning remains unchanged.

The tolerance on bitumen content is relatively ± 5% of the measurements daily

average. Permissible tolerances are:

– ± 5% of the percentage fixed for the average bitumen content
– ± 10% of the percentage fixed for the corrector filler content.

218.5.9 Control of placing asphalt concrete

Throughout placing and compacting aggregates works, the temperature shall be controlled permanently in order to be ≥ 135° C.

After compaction, density shall be equal to 98% of the Marshall density; one core sample shall be taken of each 1000 m^2 of finished layer. These samples shall also be used to control the layer thickness.

Where specifically called for, the level and regularity of the surfacing shall be controlled.

No layer shall be executed by the Contractor unless the underlaying one has been duly taken over by the Engineer.

218.6 ROADS - METHODS OF MEASUREMENT AND PAYMENT

Unless otherwise specified, roads constructed in accordance with the Drawings or on specific instructions of the Engineer, shall be measured for payment. Access and construction roads for the Contractor's own use and reinstatement of paved areas are referred to in Subsection 201.1.10 respectively, and shall not be paid for under this division.

Unless otherwise specified, roads, shoulders and sidewalks shall be measured for payment - each separately - by m^2 of completed road shoulder or sidewalk, classified by type of surface and/or by cross-section. The unit rates shall include for all necessary earthwork; supply, hauling, spreading and compaction of all sub-base and base materials, bituminous coatings, chippings and asphalt concrete; and for all materials, equipment and labour necessary for completing roads, shoulders or sidewalks, in accordance with the Drawings and the Specification, and to the satisfaction of the Engineer.

Concrete kerbstones, channels etc. shall be measured for payment in linear meters of kerbstone etc. in place, classified by type and size. The unit rates shall include for supply of units and all necessary materials for bedding and support, laying and jointing. The same unit rates shall be paid for both straight and curved alignment.

Volume 2

Technical Specifications

Division 1

General Specifications

Part 3

Mechanical Works

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301. GENERAL MECHANICAL SPECIFICATION REQUIREMENTS

301.1 ABBREVIATIONS

The following abbreviations are used in these documents :

1/head/day	liters per head per day
AC	Asbestos Cement
AGMA	American Gear Manufacturer's Association
AOD	Above ordnance datum
BS	British Standard
CDR	Council for Development and Reconstruction.
CFM	cubic feet per minute
Ch	Chainage
CMR	Continuos Maximum Rating
CP	Code of Practice
CPU	Central Processing Unit
DI	Ductile Iron
DIN	Deutsch Industrie Normen
DOV	Double Orifice Valve
DPSK	Differential Phase Shift Keying
DTU	Documents Techniques Unifiés
EDL	Electricity of Lebanon
EMC	Electromagnetic Compatibility
EOH	End of hole.
FDS	Functional Design Specification
FIDIC	Federation Internationale des Ingénieurs- Conseils
FSK	Frequency Shift Keying
g	acceleration due to gravity ($9.807 m/s^2$)
GL	Ground level
gpm	gallons per minute
gr	gram
GRP	Glass Reinforced Plastic
GTSD	General Technical Specification Document
hr	hour
I/O	Input / Output
IEE	Institute of Electrical Engineer
ISO	International Standards Organization
ITS	Institute of Technical Studies
kgf	kilogram force
kPa	kilo Pascal
kVA	kilovolt-ampere
kW	kilowatts
kWh	kilowatt hour
LED	Light Emanating Diode

m	meters
m/s^2	meters per second per second
m^3	cubic meters
m^3/day	cubic meters per day
MDPE	Medium Density Polyethylene
mgd	million gallons per day
mhd	meters head
mm	millimeters
NFE	Normes Françaises - (Electrical)
NLQ	Near Letter Quality
NPSH	Net Positive Suction Head
PS	Particular Specification
PTT	Poste de Téléphone et de Télégraphe
PVC	Polyvinyl Chloride PWL
	Pumping Water Level
RAM	Random Access Memory
RBC	Rotating Biological Contractor
RTR	Reinforced Thermoplastic Resin
RTU	Remote Terminal Unit
SCADA	System Control And Data Acquisition
SOV	Single Orifice Valve
SPTD	Signal Pole Double Throw
SSU	System Supervisory Unit
SWL	Static Water Level
TDH	Total Dynamic Head TDM
	Time Division Multiplex
TEFC	Totally Enclosed Fan Cooled
UHF	Ultra High Frequency
UPS	Uninterrupted Power Supply
UPVE	Unsaturated Polyvinyl Chloride
VDU	Video Display Unit
VGA	Video Graphics Array
VHF	Very High Frequency
VHS	Video Home System

301.2 GENERAL

The following clauses shall specify general mechanical requirements and standards of workmanship for equipment and installations. These general specification clauses shall apply where appropriate except where particularly redefined in the individual sections of the specification.

301.3 FINISH

All covers, flanges and joints shall be properly faced, bored, fitted, hollowed, mounted or chamfered as the case may be, according to the best approved practice and all working parts of the plant and other apparatus, shall similarly be well and accurately fitted, finished, fixed and adjusted.

301.4 CALCULATIONS AND CONSTRAINTS

All parts shall be designed according to the most unfavorable conditions they might encounter during operation, the international regulations and standards and the specifications of the present tender document.

Parts shall be oversized and designed to withstand maximal strains and pressures occuring during operation; ensure a good anchorage and a perfect distribution of strains, and withstand dynamic stresses, untimely shut downs, etc...

Mechanical parts shall have a safety coefficient under normal working conditions of minimum 5 according to the breaking load of the metal used (provided that the adopted international standards do not impose another coefficient).

Welded parts likely to undergo great stresses shall be annealed.

Flanges and bolting materials shall be oversized and shall not generate, when used, elastic lengthenings incompatible with the sealing of the assemblings.

301.5 ASSEMBLING AND DISASSEMBLING

Assembling and disassembling for usual maintenance purposes shall be made as easy as possible, without having to modify any part of the structure. Thus, all junctions and branchings of pipes which diameter exceeds 2"1/2, with bends, T-joints and the like, shall be made exclusively by means of flanges and/or removable couplings, if need be.

301.6 GENERAL GUARANTEES AGAINST WEAR

The Contractor shall acknowledge the condition of the water used, and that, under normal working conditions, the supplied equipment shall not show any abnormal sign of wear.

Main elements subject to significant wear due to water, shall be fitted with removable parts. These elements and parts, shall be made from a resistant metal.

301.7 LIFESPAN

Equipment, especially outdoor plants shall be resistant to physical and chemical phenomena likely to reduce their lifespan.

Following are the main phenomena to be taken into consideration:

301.7.1 Oxydation

When selecting and using the materials and components of the equipment, the following conditions shall be taken into account :

- All sets of screws shall be coated with cadmium, bichromate, or zinc.
- Metalworks shall be of bronze, brass, copper alloy. Connections between metalworks and supports are designed to prevent any corrosion.
- The use of inflammable moulded plastic materials is permitted for small sets (small boxes, telephones, etc....) which do not undergo mechanical or thermal stresses.
- Electrical equipment shall be fixed on galvanized and painted iron mounts, frameworks or runs.
- Protection sleeves are of aluminium
- Gratings shall be hot dip galvanized
- Electrical equipment and components shall be internally and externally tropicalized.

Insulators of electrical equipment, and wedging and securing devices shall be of isolation class F, (unless otherwise specified). The windings shall have a vacuum double coating for tropicalized treatment.

It shall not be permitted to use any hygroscopic or likely to mould material, namely, cotton, asbestos, bakelite, shellac, natural rubber.

- Dielectric oil of machines shall not be put in direct contact with air.
- The use of heat resistances is mandatory in installed boxes and switchboards (condensation).
- Precautions shall be taken in order to avoid oxydation during transport and on site storage of the equipment. Packings suitable for sea transport, protective paintings or coatings and other means (terminals or cable ends weldings, tips or caps of pipes,...) must be used.

301.7.2 Corrosion caused by water

Equipment, in contact with water, shall be of metals and alloys, which nature, physical and chemical characteristics and conditions of use are capable to withstand corrosion of water.

Complementary measures of mechanical, chemical, and electrochemical protections (coating with paint, plastic deposit, zinc, or electrolytic cells) shall be taken, when selecting materials.

Cast iron parts, as long as the use of this material is permitted, shall be protected by a special coating in order to avoid graphitization.

Steel parts shall be coated, preferably, with an appropriate alloy.

301.7.3 Temperature

Materials - in particular insulators and couplings - shall be chosen to ensure a good mechanical lifespan, regardless of the temperature, the mechanical constraints and the temperature gradients due to their operation or the climatic conditions.

301.7.4 Heating

Temperature of bearings, reducers, and other mechanical parts shall not exceed 80°C during normal operation.

Electrical insulating materials shall not be subject to heating exceeding that of class B.

301.7.5 Dirt

Heat exchangers, coolers, etc... shall be calculated with a 5% margin on the surfaces. The maximum proportion of dirt corresponds to 15% decrease in the exchange coefficient.

301.7.6 Adverse weather

Installed equipment and machinery shall be designed to prevent any penetration, accumulation, water impregnation or encrustation caused by air or water entrained products (dust, sand, earth, ashes, vegetal detritus, insects, etc...)

Slopes and flows are designed accordingly.

Electrical, electronic or mechanical equipment, which cannot withstand adverse weather, shall be installed indoors, inside switchboards or boxes impervious to water jets and dust, and fitted with ventilation holes and necessary heating or ventilation means.

The external protective coating for pipes, valves and fittings or equipment shall be designed to be impervious to rain and water jets, without impeding dissassembling for inspection or maintenance purposes.

Great care shall be taken to ensure the sealing of bearings, pipes, casings, sheaths, electrical plugs, probes, and junctions. No leak is permissible.

Seal packings shall preserve their quality regardless of the temperature, temperature gradients, and industrial lubricants they are subject to.

Sliding surfaces, whether greased or not, shall be protected to prevent dust deposits which may cause plugging.

301.8 FOUNDATIONS, BUILDERS WORK AND SETTING OF MACHINERY

The Contractor shall ensure that the positions of foundations for machinery plinths, holding-down bolts and the setting of machinery are carried out in accordance with the approved machinery drawings and shall be held responsible for the accuracy of the particulars given thereon.

The Contractor shall, upon receipt of the necessary approved drawings for the machinery,

supervise the construction of all the necessary foundations and bases for the various items of plant, including the forming of holes and chases for pipework, cabling, conduit, ragbolts and where necessary, the building in of foundation bolts and sundry items of plant, all in accordance with the drawings. Spaces shall be left between the concrete and bedplates etc. for grouting and building in. The Contractor shall provide all necessary templates for fixing the positions of bolt holes, etc.

The machinery shall be mounted on flat steel packings of a thickness selected to take up variations in the level of the concrete foundations.

The packings shall be bedded by chipping or grinding of the concrete surface.

Only one packing of selected thickness shall be used at each location, which shall be adjacent to each holding down bolt. The number of shims shall not exceed two at each location and the thickness of each shim shall not exceed 3 mm.

The machinery shall be aligned, leveled and pulled down by the nuts of the holding down bolts with a spanner of normal length, and no grout shall be applied until the machinery has been run and checked by the Engineer for stability and vibration.

The Contractor shall clean the concrete and prepare for grouting up after the pumps, motors, girders, etc., have been finally fixed and packed up.

The Contractor shall supervise the grouting and building in of the equipment and shall take all responsibility for the satisfactory nature of this work.

The Contractor shall arrange for the delivery of all items of equipment that are required to be "built in" the civil works, as required by the construction program and shall arrange for a representative to be in attendance during the progress of such works.

When the foundations are completed and are in a suitable condition or when directed by the Engineer, the Contractor shall install the plant, which when leveled-up shall be grouted, by the Civil Contractor, to the Contractors instructions.

301.9 LOCATION AND ALIGNMENT

Where separate items of interconnected plant, such as motors, couplings, gearboxes and similar items depend upon correct alignment for satisfactory operation, then each and every item shall be positively located in its correct operational position by means of dowels, locating pins, fitted

bolts or other approved means to ensure that correct re-alignment can be easily achieved when re-assembling the items after removal for overhauls.

301.10 FASTENINGS TO CONCRETE OR MASONRY

Anchor bolts for the fixing of small items shall be of the torque-expanded type of approved make, installed strictly in accordance with the manufacturer's instructions. The size of hole required in the Civil work shall not exceed 38mm.

Where the base material will not withstand the expansion stresses imposed by the torque-expanded type or where the highest degree of resistance to vibration is required an approved type of chemically bonded anchor bolt may be used.

The minimum distance from any concrete edge shall be 100mm for expanding type fixings and 75mm for embedded bolts.

301.11 BASEPLATES

Separately mounted items of plant which are required to maintain an accurate alignment shall be mounted on a common baseplate, together with all associated items and guards.

The baseplate shall be of rigid construction, machined on all mating surfaces and drilled for foundation fixings. Machined datum faces shall be provided and levelling facilities incorporated in the underside.

Provision shall be made for the easy removal of any section of the drive and positive re-alignment using dowels or other approved means. Shims and packings shall be kept to a minimum and clearly identified for re-assembly.

All drain points on the assembled plant are to have easy access and drain piping shall extend beyond the baseplate.

301.12 PROVISION FOR HANDLING

Suitable provision approved by the Engineer shall be made by the Contractor to facilitate the handling of all items in excess of 36kgf.

Any item weighing one tonne or over and which may be required to be lifted during operation and maintenance shall be appropriately marked with its weight.

301.13 GUARDS

Adequate guards shall be supplied and installed throughout the installation to cover drive mechanism. All rotating and reciprocating parts, drive belts, etc. shall be securely shrouded to the satisfaction of the Engineer to ensure the complete safety for both maintenance and operating personnel. However, whilst all such guards shall be of adequate and substantial construction they shall also be readily removable for gaining access to the plant without the need for first removing or displacing any major item of plant.

301.14 BALANCING

All rotating parts of the machinery shall be statically and dynamically balanced unless otherwise agreed in writing by the Engineer. The complete rotating assembly shall be designed such that any critical speeds are outside the duty running speed range of the machine.

301.15 LUBRICATION

Any components requiring manual lubrication shall be provided with greasing nipples of an approved type mounted on a panel and identified.

A remotely mounted electrically operated lubricator of approved type shall be provided to serve components, if any, requiring continuous lubrication by external mechanical means.

The lubrication tubes, if any, shall be of approved material suitable for high pressure use.

The Contractor shall include for all grease and oil required for testing at works and site.

The first filling after tests shall be provided by the Contractor who shall submit details of his recommended lubricants, which shall be available from any of the major oil companies, for approval by the Engineer.

All bearing surfaces shall be properly charged with grease before the plant is operated.

301.16 NAMEPLATES AND LABELS

Instruction plates, nameplates and labels shall be provided for all items of the plant giving particulars of duty, size, serial number and full information for identification and operation. Their construction and engraving shall be to the Engineer's approval.

301.17 PLANT REFERENCES

After final painting, all plant items shall be identified by a unique reference character as detailed on the specification drawings or otherwise specified. Such references to be affixed in a prominent position on the plant body with characters not less than 100mm high or as otherwise

specified. Characters shall be bold capital letters and/or numerals. The abbreviation `No' shall not be used.

Unit references shall include any associated main and auxiliary drives and shall follow a logical sequence based on layout or history. In any particular installation, a set of similar duty drives where any number of units may run shall be suffixed 1, 2, 3, 4 etc., whereas alternative drives for the same duty where only one unit may run (ie.duty/standby) shall be suffixed A & B.

301.18 TOOLS AND TACKLE FOR MAINTENANCE

The Contractor shall supply a complete set of any special tools and other equipment necessary for the dismantling, re-erection and adjustment of the plant.

The tools provided shall be in new condition, adequately labelled as to their use and contained in stout and suitable padlocked boxes. The Engineer's instructions as to who shall be the recipient of the tools shall be sought before delivery is made.
Any special slings required shall be provided and clearly marked by embossed labels to show safe working loads. Test certificates shall be provided where applicable.

301.19 LOCKS AND KEYS FOR MECHANICAL PLANT

All locks of the same size shall be of the same type and manufacture but having different keys.

Three keys shall be provided for each lock.

Each key shall have permanently attached to it an embossed brass label stating the following:

a) Key number
b) Location of lock/Item of equipment

301.20 NOISE AND VIBRATION

All plant shall run with the least practicable amount of noise. The contact shall insulate the material when necessary.

All plant shall run without undue vibration. All parts supplied shall be designed such that when being used, opened or partially opened (under normal operating conditions) the dynamic stresses shall not cause any vibration, nor deformation.

Vibration levels shall not exceed these set cut in ISO 2372 for the particular type of equipment.

The double amplitude on the bearings shall not exceed 20 microns under normal working conditions.

Analytical and safety instruments, as well as control mechanisms shall be systematically protected from vibrations, and when necessary, installed far from machines (on independent support or panels). Particular precautions shall be taken in the event of a relay likely to lead untimely opening and closing of electrical contacts.

The equipment supplied shall never cause any vibration in masonries. Machines shall operate as quietly as possible.

To meet the environmental requirements, the Contractor shall provide all necessary equipment to meet the following conditions, based on the site layout shown on the specification drawings and with 75% of the plant running simultaneously:

a) the noise level generated at the site boundary by any new plant shall not exceed that generated by the existing plant, or the maximum background noise measured between 12 p.m. and 4 a.m. plus 5 dB. Background noise is defined as being the L_{A90} level, that is the level exceeded for 90% of the measurement period.

b) Warning notices shall be provided at all entrances to rooms where the noise level will exceed 75 dB (A).

301.21 BEARINGS AND LUBRICATORS

Ball and roller bearings shall be rated for a minimum plant life of 10 years, with due consideration being given to the number of starts and periods of operating under conditions of

maximum dynamic axial and radial loading. The size of bearing shall be not less than that calculated for a minimum L10 basic rating life in accordance with BS.5512 Part 1.

Taking into account all considerations of reliability, materials of manufacture and operating conditions.

All bearings shall be generously rated and sized to ensure satisfactory and stable running without vibration under all conditions of operation for a minimum life of 100.000 hours running. They shall be efficiently lubricated and adequately protected from ingress of moisture, dust and sand and the particular climatic conditions prevalent at the site. All bearings shall be to ISO standard SI unit dimension where practicable.

All ball or roller bearings, including those supplied as "sealed for life" shall be arranged for grease gun lubrication and a suitable high pressure grease gun shall be supplied. All grease nipples shall be standardised.

Adequate and as far as possible, automatic means of lubrication shall be provided for all moving parts. The position of all greasing and oiling points shall be arranged so as to be readily accessible for routing servicing. Where necessary to achieve this, suitable access platforms shall be provided.

The type of lubricant and intervals of lubrication, which shall be kept to a minimum (not less than nine days), for each individual item of plant shall be entered on a working schedule, which shall form part of the Operation and Maintenance instructions.

A list of recommended lubricants and their equivalents shall be entered in the operation and maintenance instructions.

301.22 FROST PROTECTION

The plant shall be adequately protected against damage from freezing, using an approved means of insulation.

Particular attention shall be given to pipework, pump casings, etc. and any part of the plant and equipment likely to stand for periods charged with static water.

Where lagging is used, it shall be suitable for outside installation and completely impervious to all weather and atmospheric conditions on the works. Lagging materials containing asbestos shall not be used.

The lagging shall be sectional and easily removed for maintenance purposes. Joints shall be sealed together with an approved waterproof adhesive tape.

Areas where lagging may be vulnerable to damage shall be suitably protected by an approved means.

302. MATERIALS

302.1 APPLICABILITY

All materials incorporated in the works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfection, and selected for long life and minimum maintenance.

302.1.1 Materials in Contact with Potable Water

Any non-metallic materials such as may be employed for bellows, packing or sleeves, coatings or linings etc. liable to come in contact with potable water shall be approved for the purpose by a recognised approval body.

302.1.2 Materials in Contact with Sewage

Materials in contact with sewage shall be suitable for the environment but particularly all bronze materials shall be true bronze (i.e. zinc free) alloys.

302.2 WROUGHT STEELS

Where not otherwise specified wrought steel shall be selected from the appropriate EN series of BS.970 and be free from blemishes, shot or hammer marks.

The Contractor shall submit for the approval of the Engineer, the EN number selected for the various components.

302.3 CAST MOLYBDENUM STEEL

Cast molybdenum steel shall be supplied to BS 3100.

302.4 CAST IRON

All grey iron castings supplied shall be to the appropriate grade in BS 1452.

All castings are to be free from blowholes, flaws and cracks.

The Contractor shall replace any casting which the Engineer considers is not of first class appearance or in any way is not the best which can be produced, although such a casting may have passed the necessary hydraulic test or other tests. No plugging, filling, welding or"burning on" will be acceptable.

302.5 BRONZE

Where not otherwise specified the bronze used shall be made of a strong and durable mixture of 88:10:2.

302.6 ALUMINIUM AND ALUMINIUM ALLOYS

Castings shall be manufactured from LM5 to BS 1490 and bars and sections from BS 5083 to BS 1490 and bars and sections from BS 5083 to BS 1474 or similar.

Full details of the composition of each alloy shall be supplied to the Engineer for approval, before commencing manufacture.

Immersed structures or structures that are periodically immersed shall not be constructed from aluminium or aluminium alloys.

303. EQUIPMENT

303.1 FLEXIBLE COUPLINGS

Flexible couplings where supplied, shall be generously rated to cover the full range of duty.

Couplings liable to impregnation by oil shall be of the all metal flexible type.

General service couplings shall be of the flexible multi-pin and bush type, having not less than six bushes and each bush shall have an inner sleeve to allow rotation on the pin (bushes shall not be in direct contact with the pin). All pins shall have shoulders to allow positive location and securing to the bosses.

Bosses shall be a tight fit on the shafts and secured with hand fitted keys.

Couplings shall be supplied in matching balanced sets and shall be machined, balanced and marked before leaving manufacturer's works.

303.2 STRAINERS

Strainers shall be flange mounted type. Foot strainers shall be installed at least 0.5 m above the bottom of the water reservoirs.

The strainer basket shall be of the perforated cylinder type made from galvanized steel or stainless steel. It shall be easily accesible via a removable flange.

303.3 GEARBOXES GENERAL REQUIREMENTS

The gearboxes shall be totally enclosed, robustly constructed and suitable for continuous and arduous duty. They shall incorporate ball and/or roller bearings. Taper roller bearings shall be incorporated in the gearbox when thrust loads are to be sustained.

Longlife seals on the input and output shafts shall be fitted up to prevent the escape of lubricant and the ingress of dust, sand and moisture. Breather holes and/or pipes shall be sealed to prevent ingress of lubrican contaminants.

Oil level sight glasses fully protected, shall be provided with levels marked for running and filling, minimum and maximum positions respectively. These shall be arranged for easy viewing. Oil filled caps and oil drain plugs shall be provided.

The design ambient ranges shall be 0° - 50° C.

Lubrication of bearings, etc. shall be by either splash or forced feed system.

The Contractor shall ensure that the lubricant used for the initial filling and specified in the maintenance manual is adequate for prolonged operation in ambient temperatures of up to 55°C without overheating.

Cooling may be by convection from the gearbox casings but without assistance from cooling fins or fans. Adequate other cooling means shall be provided as applicable. The exterior of the gearbox shall be free from dust or moisture traps.

Access for inspection purposes shall be allowed for in the design of the gearbox casing.

Substantial eye bolts shall be provided for all reasonable lifting purposes.

The gearboxes shall carry the manufacturer's identification details together with the rated shaft speeds, output power and maximum ambient temperature.

The gearboxes shall conform to the relevant British Standards with respect to the following requirements :

i) The design ambient shall be 0°C to 50°C.

ii) The noise at 120% of the full output power and 50°C ambient shall not exceed 90 dBA at 1 meter.

iii) The gearing shall give double the life of the bearings if subjected to similar loading.

303.4 SURGE SUPPRESSION EQUIPMENT

Surge suppression equipment may be of one of the following systems:

i) A Hydro-Pneumatic system
ii) A Hydro-Nitrogen system
iii) A Surge Anticipation valve system.

303.4.1 Surge Pressure Vessels

Surge pressure vessels shall be designed and constructed to BS 5500, construction category 1, 2 or 3, post weld heat treated and with a corrosion allowance of 1mm. The vessel shall be cylindrical, carbon steel, fusion welded with domed ends and mounted vertically on steel supports. The vessel shall be provided complete including the following fittings:

- McNeil type access manhole with opening not less than 450 mm x 410 mm;
- Water inlet/outlet branch flanged to BS 4504 Table 16 or 25 as necessary;
- 100 mm dia. drain branch with gunmetal valve and handwheel with drain pipework discharging to drainage channel.

- Spring loaded gunmetal safety valve;
- 100 mm dia. glycerine filled pressure gauge complete with gunmetal isolating cock;
- Air/Nitrogen inlet fitting incorporating a release valve, isolating and non-return valves;
- Access ladder;
- Lifting lugs;
- Nameplate giving vessel details.

The pressure vessel may be constructed with or without a bladder of suitable material and shall withstand the maximum test pressure of the system.

The Hydro-Nitrogen pressure vessel shall be connected to and supplied with a Nitrogen bottle(s) and necessary accessories. The Nitrogen bottle(s) shall be of sufficient volume capable of pressurising the vessel to the working pressure.

303.4.2 Magnetic Level Indicator

The sight glass level indicator shall have the following characteristics:

Temperature operating range: -40°C - 400 °C.
Operating pressure range: Vacuum - Max test pressure.
No requirement for energy source.
Pressure compensated floats to avoid float drowning.
Magnetic coupling of the indicator elements.
An excellent readability ensured by resistance against product contamination and UV rays.
Corrosion resistant.
Highest operational safety through separation of liquid & indicator display.
No re-calibration required.
High mechanical strength.

The level indicator shall be equipped with magnetic switches and a continuous control elements and transmitter allowing remote monitoring of water level alarms and controls.

303.4.3 Air Compressors

The air compressor shall be capable of charging the pressure vessel from full of water in approximately 30 minutes. The compressors shall be air cooled, electrically driven and complete with baseplates.

The compressors are required to deliver completely oil-free air but may be of the air lubricated type with two stage carbon air delivery filters providing complete removal of moisture and oil vapour. Each compressor shall be provided with the following features:

- Outlet pressure gauge.
- Pressure relief valve on each stage of compression.

- Suction filter with high separation capacity and silencer.
- Automatic unloading valve for a no-load start under all conditions
- Non-return valve.
- Protective guard between motor and compressor.
- Oil separator filter (Residual oil content 0.05 ppm).
- Filter and dryer for holding back solid and liquid particles of 5 microns.
- Airtight and automatic drainage system with: pneumatic slides, adjustable frequency and duration and controlled by a remote PLC.

303.4.4 Electric Control Panels

Control equipment to provide fully automatic control of the selected duty compressor from the water level measuring instrument of the surge vessel. A time delay shall be incorporated to prevent operation of the compressor during water level changes under surge conditions and a push button feature shall be provided for manual test of the system. The front side shall have a full width door hinged with a rotating handle and positive closing action. The control panel shall include:

- One lock with a key
- Meters with selector switches, HOURMETER/VOLTMETER/ANMETER.
- One switch START/STOP.
- Status indication ON/OFF/FAULT
- Contractors - (Starter).
- One differential thermal protection.
- Control circuit protection circuit breakers.
- One connection terminal (control and power).
- One PLC.
- The required relays for transmitting safety and system regulating data.
- A three pole isolating switch, with operating handle interlocked with the enclosure door.
- A water level control module.
- A non-latching motor test push-button.
- One selection switch LOCAL/REMOTE/ZERO

303.4.5 Pipework

The pipework shall consist of:

Connection between the ductile iron flanged inlet/outlet of the surge vessel and a flanged tee on the pumping station or wellhead delivery pipework.

Compressed air connection pipe shall be seamless galvanised steel for working pressures greater than 35 bars and copper or galvanised steel for working pressures less than 35 bars. Connection pipes to pressure gauge and air compressor shall have a diameter of 12.5 mm (1/2”). The pipework shall be suitably coated and wrapped.

The pipework shall also include an isolating valve, a pierced swing check valve and all necessary bends and fittings required for the complete installation.

303.4.6 Cabling

Between the switchboard and the control panel
Between the control panel and the compressors
Between the control panel and the level electrodes on the surge vessel
Earthing of all equipment.

303.4.7 Surge Anticipation Valves

The valve shall be installed in a by-pass line immediately downstream of the pump(s) and the check valve. The surge anticipation valve shall be interlocked to the pump(s) via the control valve that shall be supplied with the valve.

The basic valve shall be a single-seated, line-pressure-operated, diaphragm - actuated, pilot controlled globe or angle valve. The valve shall seal by means of a corrosion - resistant seal and resilient, rectangular seat disc. These and other parts shall be replaceable in the field; all such service and adjustments to be possible without removing the valve from the line.

The stem of the basic valve shall be guided top and bottom by integral bushings. The basic valve and its pilot control system shall contain no packing glands nor stuffing boxes.

The diaphragm shall not be used as a seating surface nor shall pistons be used as an operating medium. All internal and external ferrous surfaces shall be coated with a high quality, two-part epoxy primer; the exterior to receive a coat of backed enamel paint.

The pilot control system of the valve shall consist of a controlled pilot-valve, an accumulator, a three-way diaphragm actuated pilot valve, an adjustable needle valve for opening speed control, an adjustable needle valve for closing speed control and a "Y" strainer. To isolate the control system from the main valve, inlet and outlet ball stop valves shall be provided.

– Temperature ratings: 0 ºC - 85 ºC

Maximum pressure differential across the diaphragm of the basic valve must not exceed 20 bars.

Valve materials [Pressure Ratings] : Cast iron - ASTM A126/B [< 25 bars]
Forged or Cast steel - ASTM A126/WCB [> 25 bars]
Cast bronze - ASTM B61, B62 [16 - 35 bars]
Cast aluminium 356 - T6 [< 20 bars]
or equivalent International Standards.

– Stem: Stainless steel/Ductile iron

– Seat Ring: Cast bronze or stainless steel

– Electrical Power:

AC, 50HZ, in 110/220 volts.
DC 6, 12, 24, 120, 240 volts.

303.5 LIFTING & HANDLING EQUIPMENT

303.5.1 General

Cranes and hoists shall be of standard proven design in accordance with BS 466, rated for lifting the specified working loads, utilisation and service conditions and shall be suitable for operation from the runway beams provided. Motions shall be motorised as specified with dual speed hoisting facility and controlled from a pendant push button unit via a crane control panel mounted on the gantry.

All operations, wether manual or electric, shall be controlled or performed from motor room floor level unless otherwise specified.

The lifting assembly shall be rated for the highest lift that could occur during installation and maintenance operations, including allowance for stiction.

The crane shall consist of a gantry or jib, crab and hoist assembly, ropes, block and hook together with the necessary running rails and all electrical supply requirements.

Chains used for lifting or travel shall be alloy steel and corrosion protected by an electro-deposited, zinc coated finish after manufacture. They shall not be hot-dip galvanised.

The load chain anchorage, associated fittings and framework at the slack end shall be at least equal in strength to 2.5 times the maximum tension in the load chain when the working load limit is being lifted. Any links used for connecting the load chain to a terminal fitting shall be the material specified for the chain and heat treated to provide mechanical properties and strength equivalent to those of the load chain. the hook shall be made from high grade forged steel complying with BS 2903 "C" type, and provided with a safety catch. The safe working load shall be marked.

Jibs or gantries shall be of plate or box girder design and securely attached to end mountings or carriages.

A reliable braking and locking arrangement shall be incorporated and a load chain collection box shall be incorporated with the crab.

303.5.2 Cross Travel and Long Travel

End carriages for gantries shall be fabricated from rolled steel plates and have two, double-flanged, cast steel wheels to match the track rails. Where rails are supplied and installed under this contract, they shall be adequately supported throughout their length to carry all the dynamic and static loads imposed by the crane duty.

Crab assemblies shall be mounted on four flanged cast steel wheels to suit the jib runway beam or cross-travel rails fixed to the main crane gantry.

Each travel range shall be the maximum permitted by the building and runway constraints. Where applicable the extent of each travel motion shall be limited by electrical limit switches

with mechanical end stops secured to the travel rails beyond the electrical limit switch positions, to prevent overrun and building damage from swinging loads mechanical end stops shall also be provided where travel is by manual operation.

In the case of electric motor driven travel two travel speeds shall be provided. The fast speed shall not exceed 16m/min and the slow speed not exceed 4m/min. These drives shall always start at the lower speed and incorporate smooth acceleration and deceleration controls.

303.5.3 Hoist

The hoist unit on travelling beams shall be mounted to provide the highest possible lifting facility whilst maintaining adequate clearance between the crab/hoist assembly and the building structure and fittings.

Hoist units fitted to single runway beams, fixed or jib mounted, shall be of the self-suspension type mounted on a single rigid trolley suitable for manual geared travel along the runway beam. Two end stops shall be provided on the beam suitable for the trolley provided. The trolley shall have ball or roller bearings grease packed for life.

The hook shall be fitted with a swivel and a safety catch and be capable of touching the floor and providing a minimum lifting height as specified.

In the case of electrically operated hoists the normal hoist speed shall be approximately 4 metres/min and the creep speed shall be approximately 600mm/min or nearest standards. An overload device and overwind limit shall be included to prevent dangerous overloads. Raise and lower limit switches shall be provided at the maximum and minimum lift positions. Instantaneous fail safe braking in the event of power failure shall be provided.

Where operation is by electric motor a power supply shall be provided under the contract. Power shall be taken from a feed in the main distribution panel forming part of the works and a wall mounted fused isolator shall be provided at a suitable location approximately 1.5 m above floor level alongside the lifting installation.
Power transmission to the moving installation shell be by pick up shoe running along the underside of shrouded rails, suspended concertina cable running on slides or a rail or a cable from a self winding cable reeling drum. In the latter case the tension in the cable shell be controlled and supports provided to prevent the cable drooping more than one metre below the crame rail (s).

303.5.4 Rating Plates

The SWL shall be clearly marked in Arabic and English language on the rating plate and shall be legible from the plant working level.

303.5.5 Paint Finish

The finish colour shall be a full gloss Yellow Colour No. 356 to BS381C or equivalent reference 08 E 51 to BS 4800.

303.5.6 Crane Access

Where clearances permit, provision for safe access for maintenance shall be provided in accordance with BS 466 and shall include a walkway across the span having a height clearance of 2m and be fitted with double-tiered handrails and toe boards.

An extending, portable aluminium ladder shall be provided for access to the crane for maintenance etc.

303.5.7 Crane Controls

The electrical controls shall be designed to prevent excessive acceleration, retardation, skidding and load swinging and all motions of the crane shall be arranged to be switched through the slower speed where provided.

The control circuits for the crane/hoist shall operate at not more than 110V and be derived from a double wound, screen earthed isolating transformer with one side of the secondary winding connected to neutral/earth. The primary supply shall normally be from the phase conductors.

Fuses shall be provided on each primary and secondary supply and be clearly labeled and segregated. A link shall be fitted in the neutral/earth connection.

303.5.8 Control Panels

The crane control panels shall be constructed of sheet steel or other approved material and shall be hoseproof (IP65).

The control panel shall be mounted on the traveling crane hoist bogie in a convenient position for inspection and maintenance, and shall house all the fuses, motor protection devices, starters and control equipment for controlling the crane/hoist. All contactors shall be of the air-break, electrically operated hold-on type with all necessary auxiliary contacts. Reversing contactors shall be mechanically and electrically interlocked to prevent conflicting operations.

The panel shall be fitted with a main isolating switch interlocked with the door to allow access only when the switch is open.

The motor starters shall be provided with adjustable overload protection devices suitable for the motor load at each speed and having manual resetting facilities within the panel.

All control equipment shall be fitted with suitably rated fuses. Fuse ratings shall be rationalised as far as possible to limit spares. Where practicable, fuses shall be housed in all-insulated carriers with fully shrouded bases.

Fuse links shall be HRC cartridge type to BS 88, Class Q1, having provision for screw fixings for attachment to the carrier.

303.5.9 Pendant Controls

A heavy duty, industrial pattern pendant push-button control station shall be provided, having sets of non-maintained push-buttons for each hoist speed and function specified.

Each set of buttons shall be electrically and mechanically interlocked so that conflicting operations are prevented and only one function can be initiated at one time.

The push-button enclosure shall be of a tough neoprene rubber suitable for withstanding arduous duty and provide full electrical safety, each button being suitably labelled with its function. It shall have an IP55.

The pendant shall be divorced from the crab and capable of independent cross travel. It shall be suitable for vertical adjustment for operation from alternative levels by means of spring loaded reeling drum fitted with a ratchet device or motor driven reeling drum and have a cable guide runner to assist re-coiling.

Pendant control cables shall be designed for reeling drum application and have stranded copper flexible conductors, EPR insulated to 300/500V, multicores laid-up with an internal central textile strain carrier and heavy duty, textile braid reinforced, PCP sheath.

For non-reeling applications, the outer sheath may be flexible PVC, incorporating externally laid, galvanised steel, nylon coated strainer wires.

303.5.10 Radio Control

Where specified, the crane remote control shall be by means of radio transmitter and receiver units operating within the UHF waveband range approved by the relevant authority. The receiver shall be accommodated on the crane in a metal enclosure to IP55, having shock absorbing, rubber mountings, an external receiving aerial and incorporate an output relay for each transmitter function.

The transmitter shall be a lightweight, hand held device enclosed in a heavy duty impact resistant enclosure to IP67 complete with a bandoleer carrying strap.

The unit shall be powered by rechargeable batteries having capacity for 10 hours continuous operation on fully charged batteries. To conserve battery life, a 'time out when not in use' function shall be incorporated and the stop button shall be fitted with a key switch to prevent unauthorised use. All push buttons shall be spring returned to the 'off' position and interlocked to prevent conflicting operations. Programmable security coding shall prevent operation from unwanted signal interference.

A suitable wall mounted, metal enclosed charger shall be provided to enable the transmitter to be connected and maintained in a fully charged condition when not in use.

303.5.11 Flexible Cable Systems

The supply to the crane for both cross travel power together with pendant cross travel connections, shall be by flexible round or flat-form cable systems suspended on trolleys sliding in galvanised track from the crane structure.

The trolleys shall be formed from stainless steel side plates and axles with nylon runners. Sufficient trolleys shall be provided to effect a maximum cable loop of 0.5m.

The cables shall be PVC insulated and flexible PVC sheathed type designed for the application, incorporating flexible stranded copper live and earth conductors, terminated in suitable junction boxes as specified with weatherproof glands designed for the cable shape.

303.5.12 Busbar Collector System

The power supply and earth connection for the long travel shall be from a current collector system of fixed busbar conductors which shall each be fully shrouded with PVC covers suitable for outdoor use.

The conductors shall be suitable for the current capacity, voltage drop and temperature conditions for the installation. Current collectors shall be of the sliding contact type with insulated contact heads mounted on spring loaded trolley arms. No current carrying surfaces shall be exposed.

303.5.13 Cable Reeling Drums

Cable reeling drums shall be of the spring loaded type which coils the cable radially about the drum axis and arranged for direct pulling off the drum, the core diameter being not less than the minimum bending radius of the cable. The springs of the drum shall be adequately rated to reel the useable length of cable fitted with the maximum tension applied shall not exceed the cable makers recommendation. Motor driven reels shall be provided where the spring loading is excessive.

The cable shall not overheat when used with the cable fully retracted. A totally enclosed slip ring connection box suitable for glanding the incoming supply cable, shall be fitted and the slip rings shall be rated to carry the full load current continuously and be accessible for maintenance.

Where specified, anti-condensation heaters shall be provided in the slip-ring enclosure, supplied at 240V AC or less from the appropriate slip rings via a fuse and link which shall be accessible without removal of the slip ring housing.

303.5.14 Trailing Cable

The trailing cable shall be 450/750V grade multicore type, designed to be suitable for use with a reeling drum. The size of the cable shall be such that a maximum recommended tension that may be applied to the cable is not less than the tension produced by the reeling drum.

Conductors shall be of flexible stranded copper, vulcanised rubber insulated with numbered tapes over each core. They shall be formed in a short lay round a flexible non-conducting centre core, sheathed overall with a textile covering and heavy duty PCP sheath.

Cable conductors shall be not less than 2.5mm² and sized so that they will carry the maximum full load working current involved without excessive voltage drop and take account of thermal de-rating in accordance with the IEE Regulations, as applicable to the particular drum and mode of cable winding.

In addition to any supply, control, or motor feed cores, the cable shall contain an earth core of size not less than that of the largest phase conductor.

NB. Cable material descriptions:

PVC Polyvinyl chloride (BS 6746)
EPR Ethylene propylene rubber (BS 6899)
CSP Chlorosulphated polyethylene
PCP Polychloroprene (propylene/chlorosulphated polyethylene)

303.5.15 Rail Bonding

Each section of running rail on the side adjacent to the supply isolator shall be bonded together and the rail connected to the earth terminal on the supply isolator by a protective earth conductor having a conductivity not less than that provided by a $4mm^2$ section copper cable. The rail bonds shall be made by either of the following methods:-

i) Each section of rail is to be drilled near its end with a 7mm (9/32") hole.

An 8 SWG steel wire bond, galvanised to grade GLS400 to BS 182, is to be connected across each joint and secured at each end into the hole in the rail section by means of a tinned tapered steel pin which has a semi-circular groove along its length to hold the wire. The wire is to be overlength and the excess taken up by forming the wire into a 'Z' shape to absorb the expansion.

ii) For indoor locations, an overlength, $4mm^2$ section of tinned copper braid, fitted with crimped lugs at each end shall be bolted to each rail end by means of brass bolts and washers of not less than 6mm dia.

303.6 ENCLOSURES

303.6.1 Definitions

The generic term enclosures shall be taken to mean any housing which encloses overall any items of plant or equipment. To distinguish between the different forms of enclosure, the following definitions shall be used.

a) Cabinets will be regarded as any wall or pedestal mounted, thermally controlled enclosure.

b) Kiosks shall mean any floor standing, thermally controlled, overall enclosure which may incorporate either an integral base or use the ground or floor slab as the base of the enclosure. The Kiosk shall be sized to permit man access for servicing the equipment within.

c) Shelters shall mean overall floor standing housing providing general weather protection without sealing or thermal control.

d) Housing shall mean the specific enclosure without thermal control for items of equipment, either located externally or within another enclosure.

e) Compounds shall mean areas enclosed by fencing or walls but generally exposed to the weather.

303.6.2 General

All cabinets and kiosks shall be fully weatherproof enclosures to IP 55, manufactured from maintenance-free, resin bonded, glass fiber reinforced, polyester (GRP) inner and outer skins, encapsulating not less than 12mm plywood reinforcement and insulation to give a `u' value of at least 1.5W/m²°C. The doors shall have flexible neoprene seals.

All cabinets, kiosks and shelters shall have doors incorporating steel reinforcement for rigidity and self-locking stays to maintain the doors open to at least 90°.

Door hinges shall be black epoxy coated, vandal-proof pattern with stainless steel pins. Locking door handles shall also be black epoxy coated steel with stainless steel cam action locking plates.

Where double doors are provided, shoot bolts shall be fitted to the top and bottom of the left hand door, central dead-locking of latch to right hand door to incorporate a security keyed `Yale' type lock to suit local key or other specified standards.

The closing edges of the doors shall have an external or internal overlap for weather sealing.

Ventilation to kiosks and shelters shall be provided either as under-eaves or via high level louvered vents protected by a fine mesh stainless steel/aluminium insect screen. Ventilation provided shall be equivalent to a 10mm continuous gap around the enclosure perimeter.

The interior shall be finished with a white based abrasion resistant vinyl paint. The exterior finish shall be GRP coloured Dark Green to BS 4800 (14 C 39) unless otherwise specified.

303.6.3 Cabinets

Wall mounted equipment cabinets shall have external fixing lugs and have removable gland plates fitted to the base for cable or pipework entry.

All cabinets shall have mounting rails bonded to the rear wall to facilitate equipment fixing and have an anti-condensation heater fitted. Outdoor mounted cabinets shall have a rear sloping top and a 50mm projecting drip canopy above the access door.

Inspection windows of toughened glass secured in a rubber gasket shall be provided where specified.

303.6.4 Kiosks

Where control panels are to be protected in outdoor locations they shall be enclosed in a cross ventilated weatherproof kiosk, sized to allow at least 1.0m clear working space in front of the panel. Battens shall be moulded to the inside walls to provide fixings for internal equipment and fittings.

The kiosk materials shall have a ½ hr fire resistance rating for retention of stability, integrity and insulation in accordance with BS 476 Pt 8.

Sectional kiosks shall be pre-assembled and fully sealed before delivery to site.

Fixing holes shall be provided in the base sections and the whole unit shall be fixed and sealed to the concrete base by means of a mastic compound applied before and after the kiosk sections are in place, to prevent ingress of moisture.

Kiosks shall be fitted with:

a) A suitable corrosion proof fluorescent light fitting, not less than 60 watt, so arranged to illuminate the face of the control panel complete with MK `Seal' On/Off switch inside the kiosk, wall mounted adjacent to the kiosk door, and wiring.

b) A suitably rated anti-condensation heater complete with thermostat, On/Off switch and wiring.

All electrical fittings to be connected by wiring in surface mounted PVC conduit to a 2 way metalclad consumer unit.

When space for the Electricity Supply Authority metering equipment and cut-outs is specified, a separate section within the main frame of the kiosk is to be provided complete with fire resistant chipboard panel. Details of size required and position in relation to the panel are to be obtained from the appropriate Electricity Supply Authority. Where specified, a lockable hinged door shall be provided to enable the meters to be read from outside the kiosk.

Where an external generator connection as specified, a small door or `cat-flap' shall be fitted opposite the panel mounted appliance inlet to provide access for a generator cable and connector. The door shall be large enough to pass the connector and it shall be horizontally hinged at the top, outward opening and lockable with a suitable padlock.

303.6.5 Shelters

Protection for plant requiring limited attention shall be of maintenance free materials, single skin GRP insulated panels or hot dipped galvanised steel panels with plastic skin external coating and alkyd paint interior. The shelter shall provide a degree of protection to IP44.

303.6.6 Housing

Field mounted electrical components and junction boxes shall be heavy duty industrial type, accommodated in totally enclosed hoseproof housings to IP65, of die cast, cast aluminium or rigid non-ferrous/polycarbonate materials having tapped conduit entries and recessed neoprene gaskets to seal the covers, the cover and housing fixings being outside the sealed area of the box.

303.7 COMPRESSORS/BLOWERS

303.7.1 Compressors

303.7.1.1 Air Compressors

Air compressors shall be air cooled capable of oil and dust free air delivery at the volume and pressures specified when directly or indirectly driven by an electric motor.

The compressor performance shall be in accordance with BS 1571 for the site condition and duty cycle specified and shall include the following components:

a) Suction air filter/silencer

b) Solenoid operated unloader valve

c) Pressure relief valve

d) Non-return valve

e) Isolating valve

f) Low oil pressure switch (if pressure lubricated)

g) Pressure gauge

h) Emergency stop push button

The equipment shall be suitable for operating in the climatic conditions detailed in the tender documents.

Where necessary, depending on load factor, the compressor shall include cylinder jacket and after cooler facilities for cooling the delivered air, the aftercooler having a suitable pressure relief valve and automatic drain valve.

303.7.1.2 Air Receivers

Air compressors shall deliver air into an air receiver manufactured in accordance with BS 5169 Class III Grade E or F, to accommodate the specified design pressure and internal volume.

Receivers shall incorporate the following items:-

a) One safety relief valve.

b) One automatic drain valve.

c) One pressure gauge (0 - bar).

d) Pressure and temperature switches to suit the control.

e) Inspection access to permit internal examination of the receiver.

f) Lifting facilities as determined by the receiver weight.

Receivers shall preferably be located in low ambient temperature areas to minimise condensation and the inlet and outlet pipe connections shall be arranged to promote air circulation.

303.7.1.3 Separators

The air distribution main shall include a separator designed to remove suspended moisture in the air main.

303.7.1.4 Compressed Air Filters

The air supply shall incorporate filters of the disposable element type as near as possible to the point of use.

Filtration shall be carried out using two filters in series, the first filter graded for course filtration and the second for fine filtration as defined in the Specific Requirements.

303.7.1.5 Drain Traps/Strainers

Automatic drain traps shall be provided for air receivers, filters and separators. Strainers shall be provided for protection of the drain traps. Ball traps shall have cast iron bodies with stainless steel internal parts (Spirax Sarco or equal).

303.7.1.6 Air Pressure Control

The compressor shall be arranged to maintain the air pressure in the system within the specified

limits by means of pressure switches in conjunction with unloader valves and timers to prevent prolonged off-load running.

The frequency of starting and stopping shall be within the limitations of the drive arrangement.

Where two compressors are operated on a duty/standby basis, the duty compressor shall operate whenever the low pressure switch closes and shall cease operation when the high

pressure switch opens. Should the pressure fall to the standby low pressure, the standby compressor shall operate in conjunction with the duty compressor and shall similarly cease operation when the high pressure switch opens.

The circuits for the compressor motor starters shall be completely separate. Either unit shall be capable of duty or standby operation and periodically their modes will be reversed.

303.7.2 Blowers

303.7.2.1 Air blowers

Blowers shall discharge continuously the specified free air delivery at specified suction and delivery pressures. They shall be suitable for automatic operation in all aspects.

Blowers shall be of the centrifugal or positive displacement rotary type capable of delivering oil-free air with high grade cast iron casings adequately ribbed to avoid distortion. The blower shall be fitted with mechanical seals and incorporate a mechanical oil lubrication system, including an oil flow indicator, level indicator, pressure gauge, filling and drain plugs.

The design of the blowers is to be such that the noise level is to be kept to a minimum.

The impellers shall have accurate contour. Impeller and shaft shall be made from one casting. Impellers shall be statically and dynamically balanced.

Impellers shall each be equipped with heavy duty spherical roller bearings at each end. Gear end bearings shall be axially located on the inner and outer races to control thrust and maintain factory set clearances at all times. Adequate facilities shall be made for the inspection of the rotors.

The two timing gears shall be of nickel cast iron or other approved material, accurately machined to position the impellers in the impeller case and shall be secured to the shafts by locking kits. Gears shall be enclosed in an oil-tight housing.

The shaft sealing arrangement shall comprise a garter spring viton lip seal and a piston ring seal with an intermediate space vented to atmosphere.

Gears and gear end bearings shall be lubricated by a splash oiling system from oil maintained in the gear housing. Drive end bearings shall be grease lubricated or lubricated by a splash oiling system from oil maintained in the drive cover, depending upon gear size.

Each blower is to be direct driven through a flexible coupling, or indirectly via `V' belts, by

means of an electric motor, the complete assembly being mounted on a cast iron combination or fabricated steel base plate. Anti-vibration mountings and flexible pipe joints shall be provided. Both driver and driven units are to be dowelled or otherwise positively located to the base plate and substantial guards provided over all moving parts.

All covers and flanges associated with spigotted joints should be provided with easing screws if possible.

In view of high discharge air temperature, the Contractor shall install a protective barrier around all pipe work below 2.5m above blower room floor level.

303.7.2.2 Blower Accessories

Each blower shall include a tachometer, an adjustable weight operated lever type air relief valve, delivery pressure and suction gauges each with isolating cocks mounted on a panel secured to the blower. An automatic unloader vented to outside atmosphere or an approved by-pass system is also to be included if this will assist in starting.

The air relief valve is to be of double flanged cast iron construction with gunmetal trim. The adjustable weight shall have provision for locking to prevent any unauthorised interference.

Bosses shall be provided on each blower discharge pipe, upstream of the non-return valves, suitably tapped for connection by capillary tubing to pressure switches.

303.7.2.3 Blower Filters

The filters shall be capable of handling the designed throughput of air with the minimum of pressure drop whilst excluding 99.7% of all particles down to 2 microns.

The filters shall be of the two stage type comprising a hand operated roller mounted first stage roll type element and a disposable cartridge type second stage having access from one side only. The first stage unit is to be mounted in a galvanised sheet steel case with easily removable covers, the roller handle being conveniently positioned for easy adjustment of the roll. The second stage unit is to be mounted in a galvanised sheet steel case and the units connected by a transition piece, a further transition piece being arranged between the second stage and the silencer. Connections with isolation taps are to be provided on both sides of each stage and suitable manometers fitted to allow for measurement of the differential pressure.

Where required the suction of each blower shall incorporate an "in-line" air filter and silencer. The air filter shall be of the replaceable paper element type and shall be fitted with a differential pressure gauge with adjustable alarm contacts to initiate an alarm in the control panel on high differential pressure across the filter.

Each unit shall be supported from the floor on substantial steel frames with welded plate feet.

303.7.2.4 Air Silencers

Single inlet and outlet silencers shall be included for the blowers and manufactured of sheet

steel, comprising a perforated inner tube and an outer galvanised casing, the space between being filled with a sound absorbing material. A flange is to be provided at each end, and all necessary supports extending to floor level are to be included. The silencers are to be designed for the minimum pressure drop.

303.7.2.5 Lifting and Handling

Blower units shall incorporate lifting eye bolts for ease of handling and installation/Removal.

303.7.2.6 Method of Control

Both manual and automatic control shall be provided for the blowers. A "hand-off-auto" selector switch shall be provided in the motor control and distribution panel.

In auto mode, the standby blower will alternate to duty position every 24 hours of operation.

303.8 DIESEL ENGINES

303.8.1 General

The engine shall be a cold starting 4 stroke water cooled, multi-cylinder in-line or "V" form, naturally aspirated or turbocharged and intercooled, totally enclosed industrial diesel of standard proven design, designed to run on liquid petroleum fuel to BS 2869 Class `A' and incorporate all starting, lubricating, cooling, monitoring, alarm and shut-down systems suitable for automatic and continuous unattended operation.

The engine crankcase shall be fitted with a breather pipe and safety devices to provide protection in the event of an explosion.

Crankcase access panels shall be provided for maintenance/inspection where possible.

Each engine shall be designed to operate with an ambient air temperature of 50°C and be capable of satisfactorily providing an output 10% percent in excess of the BS rating at the same speed for one hour in any period of 12 hours consecutive running.

All electric motors provided for ancillary equipment associated with the electric generation plant shall be of the squirrel cage type protected to IP55.

303.8.2 Duty and Rating

The engine shall be rated in accordance with BS 5514 to provide the necessary torque and power output at a rated speed not greater than 1500 rpm, to drive the specified load under the given site conditions.

303.8.3 Flywheel

The engine crankshaft shall be fitted with a flywheel of suitable inertia to absorb speed variation to within the specified limits. The flywheel shall incorporate all necessary barring facilities and timing marks. Safety devices shall be fitted to prevent the engine starting when any barring gear is in use.

The crankshaft shall be of solid forged steel statically and dynamically balanced to very close limits.

Hand operated barring gear shall be provided for each engine.

303.8.4 Torsional and Cyclic Characteristics

The rotating system of the engine and ancillaries shall be statically and dynamically balanced during manufacture. Detachable components eg. fans shall either be separately balanced or permanently marked in a manner that ensures correct angular positioning.

For alternator drives, the coupling between the engine and alternator shall be a flexible type of the manufacturer's standard arrangement and the torsional characteristics, cyclic irregularity, angular deviation and freedom from resonance shall comply with BS 4999, Part 142 and BS 5514 Part 5. The interchange of information between the engine and alternator manufacturers as directed therein shall be observed so as to ensure this.

303.8.5 Governor and Speed Control

The engine shall be fitted with a governor suitable for automatically controlling the engine speed in accordance with class 2 of BS 5514, Part 4. Provision shall be made for variable hand speed control, emergency manual shutdown and an over-speed trip arranged to cut-off the fuel supply.

Motor operated speed regulating gear shall be provided to enable the speed of the engine to be varied by 5% percent up or down from normal speed while in operation. The remote control for this regulating gear is to be operated from the switchboard.

303.8.6 Overspeed Protection

Overspeed protection shall be provided so that in the event of the engine speed exceeding 10% percent above the maximum operating speed an audible warning and indicator light shall be

brought into operation, but should be speed still continue to rise to a figure of 15% percent above normal speed the fuel supply shall be automatically cut off and the engine brought to rest. The audible warning and indicator light, together with the other indicating lights and alarms specified hereafter, shall indicate on the monitoring panel in the alternator switchboard.

303.8.7 Air Intake

The combustion air for the engine shall be drawn from the area specified, through an air filter having elements of a type commonly available.

Where combustion air is ducted from outside the building, the duct entry shall be fitted with a coarse mesh and fixed louvres arranged to prevent the entry of debris, small animals and the products of inclement weather.

303.8.8 Fuel Systems

The engine fuel system shall consist of an engine mounted daily service tank, filters and fuel injection equipment with solenoid operated fuel cut-off valve, a gear driven mechanical high pressure fuel pump and isolating valves for the fuel supply to and from the service tank, all mounted adjacent to the engine.

Fuel leak off shall be piped back to the fuel filter assembly or the daily service tank. The high pressure fuel lines between the pump and injectors shall be sheathed to contain and return any spillage to the daily service tank. Such return pipework shall incorporate a reservoir chamber with a float switch to detect any accumulated leakage. Fuel atomisers shall be easily removable and interchangeable.

All fuel pipework on the engine shall be rigid tubing neatly dressed and clipped to avoid vibration or interference with maintenance procedures, have simple facilities for the relief of air locks and be spaced at least 50mm clear of any surfaces whose temperature exceeds 200°C.

Fuel filters shall be full flow type fitted with re-usable mesh material. For continuously running, base load applications, filters shall be twin or triple compartment type with a change-over cock to enable one cartridge to be removed for cleaning without stopping the engine.

303.8.9 Lubricating System

The lubrication system shall permit automatic starting of the engine and immediate load acceptance and consist of a wet sump with integral engine driven gear type pump providing forced lubrication to working parts through an oil cooler and a duplex full flow filter. The filter shall use disposable elements commonly available and be of adequate capacity to allow continuous periods of running without changing or cleaning.

Independent electric motor driven engine lubricating/pre-heating units shall be provided to give automatic periodic priming in accordance with the manufacturer's recommendation while the engine is at rest.

A hand priming pump shall also be fitted to enable all parts of the engine to be lubricated as required.

The cooling of lubricating oil on engines with engine mounted radiators may be by an `oil' section in the radiator. Engines with remote mounted radiators shall be provided with engine mounted water-to-oil heat exchangers for the cooling of lubricating oil.

The engine shall employ thermostatically controlled, liquid cooling using fresh water in a closed circuit, designed to suit the ambient conditions specified and comprise an engine driven

circulating pump and a self-venting radiator. The pump shall also be capable of circulating sufficient coolant through the engine's lubricating oil cooler. Facilities for topping up and draining the system shall be provided together with a thermostat with a warming up by-pass.

Protected thermometers in suitable pockets shall be provided for measuring the temperature of the inlet and outlet cooling water and lubricating oil.

In addition to the overspeed alarm, protection devices shall be provided in the lubricating oil circuits and cooling water circuits to operate alarms and indicator lights, in the event of abnormal running conditions prevailing. These lights shall indicate on the remote monitoring panel. The engine shall shut down under alarm conditions.

A make-up header tank and automatic float valve shall be provided, together with all necessary connections to the specified supply source and the cooling system.

The cooling water shall include a quantity of anti-freeze to give protection to minus 10 degrees centigrade. An immersion heater and control thermostat shall be fitted to the system within the engine block to protect the coolant from freezing and shall operate from a 220V AC supply when the engine is not running.

Radiators mounted on engines shall be cooled by a `pusher' type engine driven fan which draws air from the vicinity of the engine block and discharges it through the radiator core. They shall also include a suitable mounting flange for the attachment of air duct trunking.

Remotely mounted radiators shall be cooled by an electric motor driven fan fed from an auxiliary generator directly driven by the engine.

If the engine cannot be fitted with a suitable direct driven coolant circulating pump capable of maintaining adequate circulation through a remote radiator, an auxiliary electric motor driven pump shall be provided. This pump shall be arranged to operate from the same supply serving the electric motor driven radiator fan.

303.8.10 Engine Cooling Equipment

Each engine shall be cooled by a bedplate mounted tropical rated radiator and cooling fan, adequately rated to maintain the normal working temperature, under continous, full load operation, working in conjunction with a pressurised water system, thermostatically controlled with centrifugal water circulating pump, valves and pipeworks.

303.8.11 Exhaust System

Each engine shall be fitted with a suitable exhaust system from the engine to the specified discharge point. The route shall be as short as site conditions allow and minimise the number of bends, which must be of large radius. The system shall include a primary residential type silencer, flexible and rigid pipework, roof cowl, flashing and all necessary ties and supports. The primary silencer shall be supported from the engine set and shall have a flanged outlet incorporating a flexible stainless steel bellows section for ease of disconnection from the remainder of the exhaust system. The exhaust system shall be insulated with a non-asbestos material. Removable cladding shall be provided on the exhaust system where specified.

Support brackets shall allow for pipe expansion and where the pipe passes through walls, a sleeve or wall plate shall be fitted with an adequate hole clearance to prevent wall damage or fire hazard. Pipe flanges shall be fitted on each side of the wall.

The interior of the pipework and silencers shall be metallic aluminium spray coated to BS 2569 Part 2 Class `D'. Where insulation is not applied, the exterior shall be similarly coated and shall be finished with a coat of high temperature aluminium paint from an approved manufacturer.

303.8.12 Fuel Oil System

A complete fuel oil systems including bulk storage and daily service tanks and transfer pumps shall be provided. It shall comprise steel, domed end horizontal cylindrical bulk storage tanks. Each tank shall be mounted on prepared foundations, and shall be complete with manholes, filling and draw-off connections, vent pipes and inspections holes an externally indicating contents gages. The necessary access ladder and platforms over the tanks shall also be supplied.

There shall be no gravity feed from bulk fuel tanks to service tanks, and no possibility of promonting and maintaining siphoning through fuel transfer pumps. All necessary valves

shall be included to ensure this. Service tank overflows shall be carried back to the bulk fuel storage to avoid any flooding of the engine room with fuel oil.

Arrangement drawings shall be supplied to illustrates the complete fuel supply system showing the position of tanks, valves, pumps and all other related equipment.

A single line scheme diagram of the system shall be submitted and of a form suitable for permanent display in the generator building.

An accurate fuel oil meter shall be inserted in each feed from the daily service tanks to the engines. These meters shall be in such a position to be readily readable.

Two filters shall be provided in the main fuel oil supply line with by-passes enabling one filter to be taken out and cleaned without interrupting the supply of oil through the other filter.

The whole of the fuel system including bulk tanks and daily service tanks shall comply with the requirements of painting and metal protection, finished colour as instructed by the Engineer.

A) BULK FUEL TANKS

A bulk fuel storage tank shall be provided or alternatively 2 tanks to provide the required storage volume and shall be manufactured and arranged with all ancillary apparatus to fit within the areas allocated on the Drawings. The size of tank(s) shall be such as to contain a sufficient quantity of fuel oil for operation at full load continuously as specified in the particular specifications.

The tank(s) shall be constructed of not less than 3 mm thick (nominal) plate which shall be free from imperfections and constructed as a rigid unit with internal partitions or bracing if necessary. The contractor shall submit for approval the calculation note justifying the selection of the final thickness to be adopted. The tank(s), or where it has more than one compartment,

each compartment, shall be provided with a manhole and provision for ventilation to a single point shall be made.

All seams shall be continuously welded from both sides. Provisions shall be made to prevent damage to the tank bottom by impact from the dip-stick. For this purpose a welded stop collar shall be provided at the top of the dip-stick to rest on the manhole cover.

The dip-stick shall be of non-ferrous material accurately calibrated and clearly marked so as to be readily identifiable with its respective tank and shall be supplied, calibrated in liters, by the tank manufacturer.

The dip-stick tube shall be incorporated in the manhole cover, no separate tank opening being provided for this purpose.

Each tank shall be arranged for filling via a direct filling pipe which shall be positioned to give easy access for the delivery tanker. A minimum of 5% percent by volume of the tanks contents shall be allowed as ullage.

The filling pipe and dip-stick tube shall each have a liquid and vapour-proof screwed cap with captive chain and fitted with a lock with four keys.

The filling pipe and dipping tube shall be carried down to within 50 mm. of the tank bottom. The suction and return flow pipes shall terminate not less than 25 mm. above the bottom of the filling and dipping pipe so as to maintain a liquid seal.

A vent pipe not less than 75 mm. diameter shall be fitted to the highest point of the tank, and shall terminate with a wire cage for protective purposes (fine gauge shall not be used).

Each storage tank manhole shall be in an accessible positition and shall not be less than 600 mm. diameter clear opening. The manhole lid shall be securely fixed by bolts and have a liquid and vapour tight joint (close woven proofed asbestos graphited).

The outlet pipe shall be so arrange as to leave a minimum of dead space in bottom of the tank.

Each tank shall have connections to receive the excess flow from daily tank overflow.

Each tank shall also be provided with an externally indicating contents gauge marked in Arabic and English to read "full - 1/2 full - empty with intermediate tenths marking.

All openings shall be closed with steel plugs and blanking off steel plates bolted to flanges for transit to site.

The Contractor shall provide all details of his requirements for access holes, etc. required to the storage tanks to enable the constructive of the tank installations generally to the arrangement shown on the Contract drawings.

Bulk storage tanks shall have the internal and external surfaces descaled by grit blasting, pickling or other approved method. After descaling, external surfaces shall be given a phosphate coating followed by a cold water washdown. External surfaces shall be painted as specified. The interior shall immediately be oiled.

B) DAILY STORAGE TANKS

Each engine shall be provided with a free standing daily tank of sufficient capacity to allow 24 hours of continuous operation at full load and shall be provided with the following fittings :

i- Air vent of not less than 50 mm diameter.

ii- Overflow piping of not less than 150% percent diameter of the fuel delivery line.

iii- Cleaning handhole and cover of not less than 300 mm diameter.

iv- Contents gauge graduated in Arabic and English to read "Full - 1/2 ful - empty". The gauge shall be of the magnetically operated type and shall be complete with low and high level control contracts.

v- Outlet connection to engine not less than 50 mm above tank base.

vi- Fuel outlet isolating valve lockable in open position.

vii- Drain plug.

viii-Excess fuel return connection if necessary.

ix- Inlet connection from bulk fuel supply system including pipework and connections.

There shall be allowed a minimum of 10% percent of the volume of the tank contents as ullage. The top oil level of the tank shall not be less than 75 mm from the top of the tank.

Tanks prior to despatch from manufacturers works shall be tested hydraulically to a pressure 0.5 bars.

Daily tanks shall be complete with all supports and fixing bolts for mounting remote from engine base or skid mounted tanks will not be accepted.

There shall be provided all necessary fuel oil pipework, unions and valves between the day tank and the engine.

Fuel connecting pipework to engine shall be seamless steel and all pipes shall incorporate flexible section, if not less than 250 mm long (plastic pipes or fittings are not acceptable).

C) FUEL TRANSFER PUMPS

Adjacent to each daily service tank there shall be provided an electrically driven fuel transfer pump operating in conjunction with the control switches fitted to the daily tank contents gauge. The pump shall be of the positive displacement type rated at a capacity to enable the associated daily tank to be completely filled from empty within 2 hours. The pump motor shall be in accordance with section four and suitable for 380 volts, 3-phase, 60 Hz operation. Automatic control shall be provided for each pump, via the control contacts fitted to the associated fuel contents gauge, to maintain a minimum of 24 hours fuel storage in the daily tank. A semi-rotary, hand operated pump shall be installed and connected in parallel with each electric pump. Both pumps shall be completed with a minimum of 4 m of flexible nose and a two position hand valve to enable the pumps to extract from the bulk fuel tank or, if necessary from a portable drum situated adjacent to the daily service tank.

D) WARNING AND SAFETY DEVICES

The following warning notice shall be supplied and fixed in a prominent position in the vicinity of each bulk fuel tank with 50 mm plain block black letters on a yellow background, printed in Arabic and English.

NO SMOKING

DIESEL FUEL - HIGHLY INFLAMMABLE

Additional notices shall be provided in accordance with the labels signs and notices requirements. The wording of the notices shall be subject to the Engineer's approval.

303.8.13 Fire Cut-off Valves

Fire cut-off valves shall be incorporated in the fuel delivery pipe to each engine from the daily service tank and be located in an accessible horizontal position, coil uppermost, close to the tank.

The valves shall be manually operated and solenoid maintained in accordance with BS 799 Part 7, the solenoid will be arranged to release in the event of a fire signal. The emergency handle shall be labelled with a conspicuous permanent notice reading:

"FIRE VALVE-PULL LEVER DOWN TO ISOLATE FUEL SUPPLY.
LIFT TO RESET".

Where specified, a dump valve shall be fitted in the pipeline immediately beneath the daily service tank so that the tank contents can be returned by gravity head to the bulk storage tank or a suitable external dump tank in the event of a fire signal. Electrically operated valves shall open when the operating solenoid is de-energised.

Fire detection devices shall be installed in suitable locations for alarm and signalling.

303.8.14 Engine Starting

The engine shall be arranged for automatic starting and stopping arranged in conjunction with the overall control system. The engines shall not require pre-start priming of lubrication and shall be arranged for instant starting by batteries or compressed air as specified, the starter motor(s) engaging with the flywheel ring gear and disengaging automatically when the engine starts. The system when fully charged, shall have sufficient capacity to crank the engine when cold, for at least 10 consecutive 15 second periods at 20°C. A self contained charging system shall be provided to meet these requirements.

Batteries shall be of the heavy duty, 24 volt, lead acid type complete with charger, housing cabinet and necessary interconnecting cable.

Each battery charger shall be connected to the main motor control center board in the control room.

303.8.15 Engine Instruments

An instrument panel shall be resiliently mounted on the engine complete with the necessary piping, connections, isolating cocks and indicators for the following:-

- Cooling water temperature
- Lubricating oil temperature
- Lubricating oil pressure

- Revolutions per minute
- Exhaust temperature at each cylinder outlet
- Running hours totaliser (showing 5 digits & non-resettable).
- All instruments shall be scaled in approved metric units and gauges shall comply with C1 5.1.3 - Indicator gauges.

303.8.16 Engine Protection

The engine shall be provided with alarm and shutdown features as specified in Volume 3, Part 4 - Electrical Works. Shutdown conditions shall be arranged to operate through the fuel solenoid.

A manual fuel rack release knob shall be provided for emergency use.

303.8.17 Engine Wiring

All wiring for engine mounted electrical components shall be carried out in suitably rated heat and oil resistant cabling fixed to the equipment where necessary and terminated in a wiring terminal box or boxes mounted in an accessible position on the bedplate, suitable for the necessary cabling to be extended to the local control panel. Separate boxes shall be provided for AC and DC circuits.

For full details of terminal boxes and auxiliary switches see Volume 3, Part 4 - Electrical Works.

303.8.18 Engine Mounting Arrangement

Engine driven sets shall be either close coupled or open coupled as specified, via a flexible coupling. The driven unit shall have two independent bearings and all major items of the rotating assembly shall be dowelled to preserve alignment.

Close coupled sets shall be secured through anti-vibration mounts to a substantial fabricated steel base fixed to the floor.

Open coupled sets shall be fixed to a substantial fabricated steel base frame, secured direct to the floor, or where specified, secured through anti-vibration mounts between the base frame and floor.

The base frame shall be structurally designed and constructed to ensure maximum strength and may be used to mount engine ancillaries, set wiring marshalling boxes and control panels. The frame shall include jacking facilities where anti-vibration mountings are used. These shall not project to cause hazards to operating personnel.

Anti-vibration mountings shall be multiple neoprene bonded pattern, arranged to distribute without resonance the total weight and dynamic loads of the assembled engine set and auxiliaries supported on the base frame.

303.8.19 Drip Tray

A drip tray, complete with drainage cock, shall be fitted within the confines of the baseframe and shall have a capacity at least equal to that of the lubricating oil contained in the engine.

303.8.20 Noise Attenuating Enclosure

The enclosure shall be removable pre-fabricated type designed to reduce the noise level by approximately 20 dB(A).

The enclosure shall incorporate access doors or panels such that routine maintenance can be carried out without removing the entire enclosure. It shall be possible to remove the enclosure without disconnection of the silencer mounted outside the enclosure. The operating sound pressure level of the set, measured in accordance with BS 4196 at a distance of 3 metres, with the exhaust silencer and the noise attenuating enclosure in position, shall be as elsewere specified.

The Tenderer shall state**,** the predicted sound pressure level of the plant under the specified operating conditions, with and without the noise attenuating enclosure fitted.

303.8.21 Ventilation Equipment

Each of the generator rooms shall be provided with fixed, sand-trap type, inlet louvres to allow passage of cooling and aspiration air necessary, during the generator operating periods. Inlet louvres will be supplied and fitted by the civil Contractor. However, the Contractor shall provide and install for each generator set an automatically operated, cooling air exhaust louvre complete with flexible ducting for connection between the radiator and louvre flange. Each louvre shall provide a weather proof seal during non-operating periods and arranged to automatically open on generator start-up, each louvre shall be supplied complete with a matching "bird-guard" wire mesh frame for installation on the exterior wall of the generator room.

Louvres and bird-guards shall be manufactured from aluminium and the Contractor shall advise the size of clear opening required for the extract louvre and confirm the sizes of inlet louvres for the required duty. The ambiant temperature of the generator rooms shall not exceed 40 °C.

303.8.22 Steelworks

The following steelwork shall be provided and fixed in accordance with metal protection and painting requirements.

i- Support frames and access platforms for fuel storage tanks.

ii- All necessary pipe supports.

iii- All ancillary brackets, clamps, etc.

303.8.23 Pipework

All fuel pipes and fittings shall be of seamless stainless steel, all valves shall be cast steel, and designed for the duty they are required to perform. Galvanized pipework and fittings shall not be used for any line handling fuel. All pipeworks shall be fully supported and complete with all brackets and fixings.

Pipework installations shall be carried out for the various items of plant, equipment and shall include : -

i- All pipework and valves from the bulk storage tanks to the daily storage tanks and filling point.

ii- For the bulk storage tanks.

1 No. easily cleaned filter.

2 No. shut off hand operated valves (one each side of filter).

iii- The main fuel line from the bulk storage tank installation shall be fitted with fail safe quick closing emergency valve with replaceable fusible link arrangement to shut fuel off in event of fire. The operating temperature of the heat sensitivity element shall be 93°C.

iv- One complete set valves for each set of fuel transfer pumps comprising suction and delivery isolating valves, non-return valves and pressure relief valve with return pipe.

v- Overflow pipework and fittings from each daily tank to the bulk storage tanks.

The pipework installation shall comply with the general protection requirements. Finish colour shall be as instructed by the Engineer.

303.8.24 Stop Push Button Stations

Local "Emergency Stop" push button stations shall be provided.

Each generator set shall be provided with 1 No. emergency stop push button station, suitably positioned at the end of the generator set assembly.

303.9 FLUMES

Flume formers shall be provided for construction of concrete flumes by the Civil Contractor. The liners shall be a matched pair and a locating jig shall be included to ensure correct installation in the channel. The liners shall conform to BS 3680: Part 4C: 19/4. (Level shall be measured by an ultrasonic measuring system, the detector head to be mounted over the channel. The requirements for ultrasonic level detectors are specified separately.)

303.10 WEIRS (VEE NOTCH OR STRAIGHT WEIR)

Weir plates shall be manufactured from stainless steel or non-ferrous material suitable for the liquid being measured. The weir plate shall be mounted on a fabricated mild steel plate for fixing into the weir chamber. The mounting plate shall be sealed where it fits into the chamber and against the weir plate. The weir plate fixings shall be slotted to allow adjustment on site.

The weir and Vee-notch weir plates shall comply with BS 3680: Part 4A.

Thin plate weirs will only be used on sediment free water.

304. PUMPS

304.1 GENERAL REQUIREMENTS

304.1.1 Materials

Materials of construction of pumps shall be in compliance with the following requirements unless otherwise specified in the Particular Specifications. Other materials of superior quality may be used subject to the approval of the Engineer.

TYPE OF USE	RAW WATER	DRINKING WATER	SEWAGE	HYDROCARBON	DRAINAGE
CASING	NI-RESIST	CAST IRON EPOXY COATED (150 μ) OR SS 316L	CAST IRON	STEEL	CAST IRON
IMPELLER	NI-RESIST	ZINC FREE BRONZE (MAX 3% ZINC)	CAST IRON	STEEL	CAST IRON
TRIM	NI-RESIST 316 L	ZINC FREE BRONZE (MAX 3% ZINC)	CAST IRON	CAST IRON 13 CR	CAST IRON
MECH.SEAL	MANUFACTURER STANDARD	MANUFACTURER STANDARD	MANUFACTURER STANDARD	MANUFACTURER STANDARD	MANUFACTURER STANDARD
STUDS	ASTM A193 GRADE B7	ASTM A193 GRADE B7	ASTM A193 GRADE B7	ASTM A193 GRADE B7	ASTM A193 GRADE B8M
NUTS	ASTM A194 GRADE 2H	ASTM A194 GRADE 2H	ASTM A194 GRADE 2H	ASTM A194 GRADE 2H	ASTM A194 GRADE 8M

304.1.2 Pump Units

All pump units shall have means of isolation from their associated pipework system.

In dry well installations, the suction valve will normally be left open, unless used for isolation when the pump is out of service.

The delivery side of the pump set shall include a non-return device to prevent back circulation when the set is not running. This shall be a fail-safe device such that in the event of pump failure or loss of external services, the device shall independently close eg. ball valves, check valves or gate valves closed by gravity or stored energy systems in exceptional circumstances.

A gate valve will normally also be installed on the pump delivery side, downstream of the non return device, for pump isolation.

304.1.3 Pump Unit Control

The pump unit control panel shall include all control and indication elements for the pump motor, together with any associated valve actuators, lubricating systems and valves, cooling fans, flushing pumps and other ancillary control equipment required by a pump drive, all arranged to operate in a safe and proper sequence.

Where external services are required to open the delivery valve, the control system shall initiate the valve opening procedure as soon as the pump is up to a speed sufficient to overcome any existing delivery pressure.

Normal starting sequence will therefore cause the pump to run-up to operating speed then initiate opening of the delivery valve. Normal stopping sequence will first initiate delivery valve closure, after valve has closed then pump motor will be de-energised.

Failure of the valve to open within the time allowed, or closure occurring whilst running, shall initiate an alarm and shut down the pump set. The maximum running time with the delivery valve closed shall be 3 minutes unless otherwise specified.

304.1.4 Pump Duty

Pumps shall be of the type specified in the PS. They shall be designed to give specified output against all losses including those relating to the pump.

The Contractor shall match his pump characteristics to the pipe system network to achieve high pump efficiency and reliability.

Each set must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system characteristics given.

The pump section and arrangement shall be such as to ensure that the head available exceeds the N.P.S.H. requirements of the pump under all operational conditions.

Where the system and pump characteristics are such as to give rise to the possibility of surge in the pipeline with consequential damage, a surge investigation shall be undertaken; if the results of the investigation show that there is a problem, measures shall be proposed by the contractor to alleviate the problem. These measures shall be agreed with the Engineer.

Centrifugal pumps shall have a non-overloading characteristic over the complete range of head and quantity delivered and the drive shall be capable of starting the pumps against a closed valve, ie. maximum pump head conditions.

The whole pumping unit shall be capable of withstanding without detriment, reverse rotation to a speed that would occur if the pump were to stop when the differential head was at a maximum and the delivery and/or non-return valve failed to close.

The design of the pumps shall be such that there will be no tendency to unlock any part due to possible reversal of rotation and shall not pass through or approach a critical speed.

The pumps shall be capable of working for long periods without cleaning or attention.

For sewage pumps the ability to operate with the maximum reliability is of prime importance, with efficiency being a secondary consideration. The pump shall operate without clogging, being designed to pass a sphere as specified in Particular Specification (PS) where the size of the delivery mains permits. Whilst the pumps shall be designed to meet a specific duty they shall also be capable of operating over the duty range specified for prolonged periods and for standing idle for long periods without attention as in the case of storm pumping.

304.1.5 Pump Duty Control

Each of the pump units shall be capable of operating in any combination of duty sequence.

Any starting sequence, including those following restoration after a supply failure shall be time sequenced to prevent excessive load on the supply system. Each duty circuit shall include its

own timer, arranged to be initiated in the selected duty sequence by the preceding duty, the delay periods between each re-start being adjustable up to 20 secs.

Pumping sets shall be automatically operated according to water levels in the discharge and suction side reservoirs unless otherwise specified.

Successive levels shall be carefully chosen in order to ensure a smooth and safe operation of the pumping system, taking into consideration the characteristics of the pumps, networks, hydraulic inertia of the installation, as well as the sensitivity of the instrumentation.

Two sets of level measuring devices operating in redundancy shall be installed in each reservoir unless otherwise specified.

Where valves with motorised actuator are installed on pump outlet pipe section, the pump shall be started with a closed valve: each pump shall start when the valve is still closed. The valve begins to open at the starting command of the pump and shall be controlled by the discharge pressure. The time of the total opening of the valve shall be chosen according to the pump manufacturer recommendation. At the pump stop command, the corresponding valve shall receive a closing signal and shall close fully prior tot he shutdown of the pump.

Where more than one pumpset is installed for a water network and unless otherwise specified, pumps shall be operated with a cyclic duty program automatically executed by the supervisor system. However, a selection of pump duty order by the operator shall be possible.

304.1.6 Pumps Casings

Pump casings shall be capable of withstanding all pressures which may be produced due to operating pressure surges.

Particular attention shall be paid to the wear characteristics of the pumps. In the case of sewage pumps, due to the presence of grit in the sewage wear, could be appreciable.

The pump design shall ensure that alignment is maintained between the various assemblies by recesses, spigots and dowels and shall be such that all components liable to wear can be replaced.

Components shall be permanently marked with the manufacturer's number and where dowels are not used, permanently marked for correct assembly. The pump casing shall have detachable wear rings.

The casings of the pumps shall have flanges to match the specified pipework.

The waterways through the pumps shall be smooth in finish and free from recesses and obstructions.

Sewage pump casings shall be of substantial construction to give long life under abrasive conditions and suitably stiffened to withstand shock due to solids in suspension. Inspection holes shall be provided in any section bend and in the pump casing above the impeller for access to facilitate the clearance of obstructions. The inspection hole covers shall be shaped to conform to the interior profile of the waterway when in place and shall be fitted with starting screws where necessary.

304.1.7 Impellers

Impellers shall be securely fitted to pump shafts in such a manner to prevent them becoming loose or detached when the pump is in operation, or when rotating in the reverse direction, either by liquid flow or motor rotation.

The impellers and guide vanes (if any) shall be accurately machined and smoothly finished to minimise hydraulic losses.

The rotating elements type shall be specified in the PS and shall be statically and dynamically balanced before final assembly.

For sewage pumps the impeller shall be of the open type with the inlet ends of the vanes being of bulbous design and the impeller passages being as large as possible consistent with good performance. The impeller shall be readily withdrawable from the pump casing without the need to disconnect pipework. The inlet ends and surfaces of the vanes shall be dressed to give a smooth finish to prevent fouling by rags and fibrous matter within the pumps.

Impellers for both sewage and storm water pumps shall be of the non-shrouded type, constructed as specified in the PS, and designed to exclude gritty matter from the shaft and gland.

The impellers should have replaceable wear sings. The clearance at the wear rings shall be kept to a minimum, and where it is found necessary to cut back the impeller this is to be done on the vanes only.

304.1.8 Pump Shaft

The pump shaft shall be as specified in the PS adequately sized, with good fatigue, shock load and corrosion resistance. The duty speed range shall be well below the first critical speed of the shaft. Where a change in diameter of the shaft occurs the shoulder shall be radiussed or undercut to the appropriate BS to reduce stress concentration.

The shaft shall be complete with easily renewable protecting sleeves of suitable material (stainless steel) at glands and bearings.

304.1.9 Shaft Seals

Pump shaft sealing type shall be as specified in the PS.

Pump shaft sealing arrangement shall be suitable for the water pressures and shaft speeds involved.

Pumps shall be fitted with packing glands seals or a split type mechanical shaft seal arranged such that replacement of wearing components can be carried out without the need to dismantle the pump.

Special care in the selection of materials shall be taken in order to avoid binding and electrolytic action between the shaft sleeve and the mechanical seal components, particularly where long periods of idleness are inherent in the duty cycle as in the case of standby and storm pumping.

Each mechanical seal shall be equipped with leakage collection facilities and separately piped as specified.

Pump glands shall be of the soft packed type with wearing sleeves and shall be designed for grease lubrication and shall be provided with large size grease lubricators with tell-tales. Glands and lantern rings shall be of the split type to facilitate easy packing.

Pumps fitted with soft re-packable or packed gland type seals, shall have stuffing boxes designed to facilitate adjustment or replacement of the packing materials.

304.1.10 Bearings

All pumps shall incorporate bearing arrangements which prevent the escape of lubricant into the liquid being pumped. The bearings shall be located in dust/moisture-proof housings.

All bearings shall be liberally rated to ensure cool running and meet the load factors specified.

For vertically mounted pumps, the top bearing shall be a combined thrust and journal type, designed to prevent any thrust loads being transmitted to the drive motor. The pump bottom

bearing shall be lubricated by an enclosed water lubricated sleeve bearing for potable water applications but by grease or other approved means for sewage use. Storm pump bearings

shall also be suitable for standing idle for periods up to 2 months without attention or movement.

Where grease points are necessary they shall be fitted with removable screwed plugs which shall be accessible without removing guards. All bearings having automatic lubrication shall also have provision for hand lubrication.

304.1.11 Baseplates and Stools

For vertical pump units, heavy cast iron or fabricated steel floor plates and motor stools shall be provided for direct mounting on concrete floors or supporting steelwork. Suitable journal and thrust bearings shall be provided in the baseplates to carry the vertical drive shaft.

Where necessary the motor stools shall be designed to accommodate flywheels and bearing housings.

Floor plates shall be recessed and so arranged that the tops and fixing bolts are level with the finished floor.

The pump units shall be accurately aligned and located on the baseplate by set screws and parallel dowels or machined spigots. Approved means of dowel withdrawal shall be provided.

304.1.12 Lubrication/Cooling Monitoring

A lubrication system shall be arranged for the lubrication of all grease points on the pumps and shafting from motor room level. Individual bearings within the support tunnel tubes and on the pump sets themselves shall receive separate supplies of grease fed by pressure tubes laid from each bearing to battery plates readily accessible from motor floor level for grease gun operation.

Pressure tubes shall be grouped together where possible and securely attached by brackets, straps etc. to tunnel tubes, with connectors located near to the motor support plate for easy removal of shafting in the event of maintenance work. In exposed positions pressure tubes are protected from damage. Motor grease points will not be included in this lubrication system but shall receive individual attention.

The battery plates shall have sufficient greasing points for all bearings and be located on or adjacent to each pump motor stool.

A notice is to be supplied and fixed on the wall in a prominent position detailing the manufacturer's recommended greasing schedule. The notice shall include a warning of the dangers to bearings from `over greasing'.

A grease gun shall be supplied for all greasing purposes.

Bearings which require a continuous supply of lubricant shall incorporate a means of monitoring such a supply, either by flow or temperature rise as appropriate for the type of bearing employed; separate monitors being fitted for each bearing feed or housing.

Such monitors shall include all necessary ancillary power or pulse counting devices to enable the operation of any monitor to initiate a volt free contact rated at 240V 0.5A AC.

304.1.13 Pump Tundish

Where specified, each pump shall be equipped with a cast aluminium or fabricated steel tundish to accommodate the drain lines from mechanical seals, casing vent and other minor drainage points on the pump. A single drain pipe shall be run from the tundish to the house drainage system.

304.1.14 Air Release Cock

The highest point on the pump casing shall be fitted with a manual air release cock having a removable handle or an automatic air release valve with a lockable isolation valve as specified. Air release pipework on sewage pumps shall be not less than 30mm bore and shall discharge back into the wet well at high level and have facilities for rodding. The drain from each air release cock shall discharge via pipework as specified.

304.1.15 Couplings

Coupling materials shall be chromium stainless steel.

All couplings shall be of an approved type and the Contractor shall arrange for the provision and fitting of both coupling halves to each respective shaft and shall include for all necessary modifications to any existing shafts to be coupled.

Where specified, the Contractor shall include any equipment required to prevent damage to any part of the drive in the event of reverse rotation of the pumps.

304.1.16 Intermediate Shafts

Intermediate shafts between the pump and drive shall include universal couplings at each end allowing free axial movement to avoid end thrust being transmitted. The shaft and coupling shall be fitted with a full length guard manufactured from mild steel mesh on a mild steel framework, easily removable for maintenance purposes.

The frame and mesh shall be hot dip galvanised.

304.1.17 Gear Unit

Each unit shall be continuously rated to transmit the full power of the drive either directly in line or through a right angled, helical gear system, having an input/output speed ratio to suit the duty.
The gear case shall be made of substantially ribbed cast iron with machined mounting feet and shall form a totally enclosed, oil tight casing.

The gear unit case and bearings shall be designed to accommodate the total weight of any suspended drive shafting and couplings in addition to any dynamic load imparted during service, and run for a minimum of 10,000 hours before a major overhaul is required.
Where specified, an electric tachometer shall be fitted to indicate the output shaft speed.

(i) Lubrication

The gear unit shall be grease or oil lubricated, arranged to provide an adequate supply of lubricant for the duty.

Where oil lubrication is employed, the casing shall include an oil breather, level indicator and drain plug.

Units having a rated output greater than 500kW shall have inspection covers and include a forced lubrication system comprising an oil circulating pump, reservoir tank and full flow `Duplex' type oil filters having re-usable elements together with associated pipework; the oil

being circulated by either (a) an internal mechanically driven gear pump and an external electrically driven pump arranged to prime the gears as pre-set timings as recommended by the unit manufacturer, or (b) duplicate external electrically driven pumps, each of which may be selected to prime at pre-set intervals and run when the gear unit runs.

Such a lubrication system shall include dial gauges and alarm switches to monitor high oil temperature and low oil pressure.

(ii) Reverse rotation

Where specified, the gear unit shall be capable of withstanding reverse rotation for a limited period with no detriment to the unit. Where a forced lubrication system is used, this shall continue to operate satisfactorily under such conditions.

304.2 SUBMERSIBLE PUMPS FOR SEWAGE & RIVER WATER APPLICATION

The pumps shall be fully submersible and of the unchokeable type, capable of passing raw unscreened sewage. They shall have non-overloading characteristics and incorporate bearings sealed for life.

The sealing arrangements between pump and motor shall be by means of mechanical seals running in an oil bath which serves to lubricate and cool the interfaces of the seals.

The pump shall include renewable and easily replaceable wear rings.

Robustness of construction and the ability to operate automatically with a minimum of attention for long periods is essential.

The pumps shall be supplied with guide rails unless otherwise stated, and particular attention shall be given to the free passage of the pumps up and down the rails without jamming. The pump outlet flange, unless otherwise stated, shall have a boltless coupling on to the flange of the fixed delivery pipework and shall have positive location so as to provide an automatic coupling with a good seal when the pump is lowered into position.

The pump casing shall incorporate a lifting eye of not less than 80mm internal diameter suitable for the attachment of heavily galvanized lifting chains which shall be brought out of the wet well to a conveniently sited fastening. For electrical details, see Volume 3, Part 4 - Electrical Works.

Unless otherwise specified, sewage pumps shall be equipped with a flushing system that shall stirr the water in the sump prior to the start of the pumping cycle. The stirring shall be effective by putting sludge and solid particles into suspension and shall prevent the build up of sludge banks and debris on the sump floor.

304.3 PROGRESSIVE CAVITY PUMPS

The pump casing shall be manufactured in a close-grained cast iron in accordance with BS 1452, or in grades of stainless steel to suit the nature of the pumped liquid. The pump casing shall be pressure tested in accordance with BS 599.

The pumping element shall consist of a single helical rotor revolving within a resilient stator. The stator/rotor shall be designed in accordance with the normal operating conditions, taking into consideration temperature, corrosion, abrasion and reliability under maximum torsional load. The rotor material shall be stainless steel either ceramically coated or chrome plated in accordance with the relevant requirements of BS 970: Part 1.

The rotor's eccentric motion shall be facilitated by either a flexible drive shaft or by fitting a universal joint between the motor and drive unit. This motion shall permit a continuous seal line throughout the pumping element thus giving a constant positive displacement. The flexible or coupling rod drive shall be of a high strength stainless steel with an impermeable thermoplastic or equal coating to provide resistance to abrasion and corrosion.

The pump drive assembly may be directly coupled or arranged for a guarded toothed-belt drive arrangement. The pump speed shall not exceed 500 rpm.

Under no circumstances shall any grade of aluminium be employed in the fabrication of the pump's wetted parts.

All working surfaces shall be accurately machined and provided with deep registers, where necessary, to ensure true accurate alignment. The pump casing shall be capable of being fitted with a replacement rotor and stator components. Tapped bosses shall be provided for drainage purposes and suction and delivery gauge connections.

304.4 SCREW PUMPS

Screw pumping units shall be suitable in all respects for pumping crude sewage and returned activated sludge and for running continuously at all outputs up to the specified maximum. All parts and components shall be fully weather-proof and suitable for use out of doors.

i) Drive Arrangement

Each pump shall be driven by an electric motor, the drive being transmitted from the motor to the screw, either directly through a reduction gearbox or else through a V-belt drive and gearbox.
The gearbox shall have oil bath lubrication and shall be provided with an inspection cover, oil breather and oil level indicator. The gears shall be rated for continuous duty.

Connection between the drive unit and screw shall be by means of a pin-type flexible coupling with rubber bushes, or other approved flexible coupling.

If a V-belt drive is used ready means of belt tension adjustment shall be provided.

Means shall be provided to prevent reversal of rotation on shut down.

ii) Bearings and Lubrication

Each pump shall be complete with top and bottom bearings, driving mechanisms and automatic lubricators, all supplied and installed as a unit by one manufacturer.

The top bearing shall be designed to accommodate the main radial and axial loads which occur on the screw and shall be suitable for high pressure grease lubrication. The bottom bearing shall be of the bronze sleeve type secured in a watertight cast iron housing and designed to accommodate radial forces and end support load. The housing shall be mounted on a fabricated steel pedestal and plate which shall be swivel mounted to allow them to take up correct alignment on installation. The bearing shall be fitted with an external stationary shroud to prevent debris affecting the moving parts.

Lubrication shall be automatic from a grease or oil lubricator, the lubricator pump being driven by an electric motor or from the main drive. A friction drive is not acceptable. A `tell tale' indicator in the case of grease, and flow indicator in the case of oil, shall show that lubricant is passing to the bearing. Oil shall be returned from the bearing to the oil reservoir.

In the case of an electrically driven lubricator the electric drive shall be interlocked with that of the main pump drive so that the screw pump will not run without the lubricator. A warning light shall indicate `lubricating pump failed'. Where other means of driving the lubricator pump are used provision shall be made to stop the screw pump if the lubricator drive fails for any reason.

iii) Installation and Guards

Each screw pump shall be suitable for mounting in a concrete trough and shall be supplied complete with steel side profile member. Each screw shall also be supplied with a steel splash plate to fit round the shaft and seal the hole where the upper end of the screw passes through the wall into the motor room. The screw and its driving mechanism shall be such that they can be safely used to form the final screed of the concrete trough in which the screw rotor runs.

All equipment offered shall be designed to keep maintenance to a minimum, and to provide maximum safety to operatives and maintenance staff. Protective guards shall be fitted over all moving parts to prevent any possible contact.

304.5 DOUBLE DISC PUMPS

The double disc pump shall comprise two reciprocating, mechanically driven, tough resilient discs with a sufficiently large cavity between the discs to produce displacement in a smooth continuous flow.

The pump shall be valveless and glandless and be capable of operating dry indefinitely without pump damage occurring.

The double disc pump shall be available as a static or mobile unit, as specified. It shall be suitable for either electric motor or diesel engine drive, as specified.

The pump body shall be manufactured from cast iron to BS 1452 Grade 220, as a minimum.

The discs shall be manufactured from Nitrile rubber or equivalent.

304.6 DIAPHRAGM PUMPS

The pump shall be of the diaphragm type utilising a bullfrog type valve, suitable for pumping viscous solutions containing solids up to 55mm diameter as specified. It shall be driven by an electric motor through an oil bath reduction gear unit.

The main body of the pump shall be manufactured from LM6 aluminium and all wetted parts shall be supplied in 316 stainless steel.

The diaphragm shall be manufactured from neoprene, nitrile, hyperlon or viton elastomers and shall be reinforced with polyester fabric.

304.7 SUBMERSIBLE BOREHOLE PUMPS

Pumps impellers shall be closed or semi open type.

Pump body shall be treated against corrosion. The bowls shall be joined by flanges or by tie roads.

The shaft main guide bearings located in the suction and delivery end housings of the pump shall utilise a leaded-bronze material, and shall be provided with protection guards to prevent ingress of sand and grit. Pump bowl guide bearings shall utilise either leaded bronze or other approved abrasion resistant material. All pump bearings shall be lubricated by the water to be pumped. The pump delivery end housing shall incorporate a thrust washer of suitable material at the shaft end to absorb upthrusts that occur during pump starting. Unless otherwise specified, the pump shall incorporate a delivery check valve of hydrodynamic shape fitted with a spring to prevent reverse rotation of the shaft from back flow of water through the pump. The pumps shall be provided with a flanged discharge connection suitable for operating against the pump closed valve head or 16 bar whichever is the greater. The shaft coupling connecting the pump and driving motor shall be accurately machined and keyed to ensure precise shaft engagement and alignment. A strainer of suitable corrosion and abrasion resistant material, designed to guard against entry of foreign matter but permitting unrestricted flow of water into the pump, shall be provided on the pump suction housing.

Protection against the effect of sand shall provided by renewable wear rings (made from a hard smooth flexible material such as polymethane) mounted at the seating of the impellers and the passages of the shaft.

The pump shall be designed to pump water having a sand content of up to 40g/m3, unless otherwise specified

A centraliser shall be fitted to every pump to ensure central alignment of the pumpset in the borehole casing.

304.7.1 Borehole Pumps Rising Column

Borehole rising column shall be seamless steel and provided in section lengths not exceeding 3 metres with flanged joints or screwed couplings according to API5L grade B or equivqlent. The rising column shall allow for small deviations in borehole verticality. Cables and and water level dip tubing shall be securely fixed to the rising column by straps or bands at approximately 2 metre intervals.

The rising column shall be sufficient to take the stresses generated by the hanging weight of the pump, motor and rising column, the stresses produced by the water pressure together with any dynamic stresses which may occur under any circumstances including valve closure.
The rising column shall be protected internally and externally in factory against corrosion by a non toxic epoxy resin coating (300 μm minimum thickness) suitable for use with potable water.

304.7.2 Borehole Pumps Headworks

A fabricated steel discharge head piece shall be provided at the top of the borehole to support the complete rising column and electro-submersible pumpset assembly, and shall be complete with lifting eye bolts. The discharge head piece shall comprise a heavy duty sealing plate arranged for bolting to the borehole outer casing flange, and a 90° discharge bend arranged for flanged connection to both rising column and horizontal surface pipework. Lifting eyes shall be provided in the sealing plate. A flange shall be provided and welded by the Contractor to the top of the borehole outer casing. The flange shall be suitably drilled to accommodate the discharge head piece sealing plate bolts. Holes shall be provided in the sealing plate to accommodate an air vent pipe, motor and control cables, water level dip tubing, etc. and shall include adequate sealing arrangements to protect against borehole contamination.

A 25mm diameter screwed removable plug shall be provided over the dip tubing for water level measurement with electrical contact tape. A stainless steel air vent pipe shall be fitted to the discharge head sealing plate, terminating in an insect proof screen and arranged to prevent entry of rain or surface water.

304.8 VERTICAL TURBINE PUMPSETS

The pumps shall be of the vertical line shaft type. The discharge head shall be bolted onto a substantial steel bedplate or frame which shall in turn be bolted to the pump room floor. The

discharge head shall have a flanged discharge. Replaceable seal rings shall be fitted on the impeller suction side if required to maintain pump hydraulic efficiency.

The pump shaft shall be of chromium stainless steel (13% chromium) minimum supported by bearings above and below each stage. Protection shall be given against the effects of entrained solids in the water being pumped intermediate bearings shall be lubricated by the liquid being pumped.

The line shaft shall be of the same material as the pump shaft, supplied in lengths not exceeding 3.0m, with screwed couplings. The line shaft bearings shall be spider type to locate the shaft in the tube and may also double up as line shaft tube couplers. Lubrication shall be provided to the bearings.

The pump suction shall be of at least equal diameter to the pump and shall be fitted with a suction strainer.

Means shall be provided of adjusting the pump shaft tension and position.

304.9 CHEMICAL METERING AND DOSING PUMPS

Chemical dosing shall be by means of electrically driven metering pumps unless otherwise particularly specified.

Metering pumps shall be of the plunger or progressive cavity type.

The effective range of the metering pumps shall be between zero and maximum with an overall repeatable accuracy within ±3%. Output shall be adjustable through a stepless variable stroke mechanism in the case of plunger pumps and variable speed motor or gearbox in the case of progressive cavity pumps.

The metering pumps shall be manually adjusted, and shall be calibrated to allow setting at the required dosage. Dose adjustment shall be possible whilst the units are in operation. Accurate dosing shall be maintained down to 10% of the maximum dosing rate.

The Contractor shall consider the liquid to be pumped and select the materials of construction so as to avoid corrosion. Mechanical glands are generally undesirable but where unavoidable, shall be to the approval of the Engineer.

For metering pumps of the plunger type the materials in contact with the liquid shall be polypropylene, stainless steel grade 316, UPVC or PTFE. Plungers shall be a high-alumina ceramic or stainless steel, grade 316.

Metering pumps shall be mounted on bed plates which shall be protected from gland drip. The pumps shall be driven by close coupled motors with reduction gears and have mechanisms housed in a totally enclosed oil bath.

At least one standby pump, fully connected into the chemical dosing system, shall be provided for each chemical, with local manual selection of duty and standby units. When pump duty change-over is effected the appropriate suction and delivery isolating valves shall be manually

operated.

Stators and rotors for progressive cavity pumps shall be of materials selected having regard to the liquids being pumped.

The design and location of the metering pumps shall be such as to facilitate easy dismantling for the removal of any foreign matter.

Flushing facilities shall be provided for all chemical pipework at the inlet and outlet of each metering pump, together with drip trays to contain any spillage or leakage and piped to the nearest drain point. Provision shall be made for priming the systems to eliminate any air.

Each chemical dosing pump shall be provided with suitable isolating valves, an inter-connecting manifold system and, where necessary, loading valves. A calibrated glass container shall be provided connected into the suction manifold of each chemical pump so that its output can be checked.

Calibration curves shall be provided by the Contractor for all chemical dosing pumps.

304.10 PACKAGED BOOSTER SETS FOR COLD WATER SUPPLY

General

The set shall be a self-contained, fully automatic packaged unit which requires the minimum of maintenance to give maximum trouble-free operation. The systems consist of either 2, 3 or more individual pump and motor units which operate independently of one another and react immediately to fulfill system demand.

Each set incorporates diaphragm pressure vessels ready with a supply of water when demand arises. When draw-off exceeds the vessel's storage capacity, the lead pump is automatically started by a pressure switch to cope with the demand. In the event of unusually high demand, or failure of the lead pump, the support pump (or pumps) will immediately start.

Pumps

Vertical multistage or horizontal end-suction centrifugal pumps.

Control panel

Sheet steel enclosure incorporating all electrical components necessary for an automatic operation of the pumpset. Interwired with motors and pressure switches, requiring only connections to main supply on site. In the event of malfunction of any pump a stand-by pump will start automatically and panel will visually identify the faulty unit. The control panel in corporates a manual selector switch to allocate the role of lead pump in turns, to ensure an even distribution of work load.

Motors

Totally enclosed fan cooled (TEFC) direct-coupled motors, for 50 Hz supply, 380 voltages class F insulation.

Pressure vessel

Mild steel construction incorporating replaceable non-toxic butyl rubber diaphragm. Factory pre-charged to required pressure, eliminating the need for a compressor on site.

Valves

Each individual pump has an inlet and outlet isolating valve and a non-return valve on the discharge of each pump. This allows any pump to be removed from the set without the necessity to shutdown the system. An isolating valve is fitted on the pressure vessel line.

Pressure manifold

Each pump is controlled by its own individual pressure switch, factory set for system requirements and mounted with a common discharge pressure gauge on an aluminium manifold block. Receiving their signal through a high pressure PVC pipe which is connected to the discharge pipework.

Pipework

Pipework supplied in copper.

Baseframe

To be fabricated from 6 mm, flat mild steel plate, complete with panel support and holding-down lugs drilled and tapped to secure all pumpset components.

305. VALVES & PENSTOCKS

305.1 GENERAL REQUIREMENTS FOR VALVES

305.1.1 General

Small valves of ND less than or equal to 40 mm shall be provided with self locking handles or handwheels to prevent accidental operation.

Emergency isolation valves shall be gate, ball or plug valves.

Drain and vent valves shall be provided with a plug or blind on the discharge side.

Flangeless valves shall not be used as the first block valves against storage tank.

Unless otherwise specified, valves shall be epoxy coated internally and externally. The coating shall have a minimum thickness of 150 μm.

Threaded ends shall not be used for valve sizes larger than 50 mm ND.

All handwheels, headstock, foot brackets, guide bracket and thrust tubes shall be of cast iron.

Fixing nuts and bolts supplied by the manufacturer shall be as specified in the general requirements for fastners.

Valves shall be sized such that the velocity through the valve when fully open does not exceed 2.50 metres per second at the rated throughput. They shall have flanges to not less than BS.4504 NP.16 and shall be capable of withstanding the same test pressures as the pipeline on which they operate. All nuts and studs subject to vibration shall be fitted with spring washer or locking tabs.

305.1.2 Types and Operating Conditions

Valves shall be designed to meet the operational and environmental conditions specified for the types indicated in the specific valve schedule.

The closure rates of all valves shall be designed to prevent the effects of surge. Where necessary, valves with a varying closure rate shall be used.

Valve flanges or couplings shall be as specified in the valve schedule and match those specified for the pipework installation.

305.1.3 Identification

Each valve shall be identified by a unique reference as approved which shall identify the medium/plant controlled and be numbered in a logical sequence.

The reference shall be either engraved on a 3mm thick laminated white/black/white traffolyte disc or stamped on a 1.0mm (19g) thick brass disc. The discs shall be at least 35mm dia. with reference letters and numerals not less than 4mm and 8mm high respectively.

The discs shall be mounted on the hub of the handwheel or where this is impractical, they shall be attached to the valve stem by means of suitable brass 'S' hooks and/or jack chain through a hole at the top of the disc.

305.1.4 Access

All valves, spindles and handwheels shall be positioned to give good access for operational personnel. It shall be possible either to remove and replace or to recondition seats, gates or gland packings which shall be accessible without removal of the valve from the pipework or, in the case of power operated valves, without removal of the actuator from the valve.

Extension spindles shall be supplied wherever necessary to achieve the specified operating requirements.

305.1.5 Hand Operation

All handwheels shall be arranged to turn in a clockwise direction to close the valve or penstock, the direction of rotation for opening and closing being indicated on the handwheels.

The handwheels shall be coated with black plastic and incorporate facilities for padlocking in either the open or closed position.

Bituminous paints shall not be applied to any valve handwheel.

The operating gear of all valves and penstocks shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified service value and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 55kgf.

Power operated valves shall include equipment for manual operation by means of a handwheel or other suitable device which shall be interlocked with, and fixed to, the power unit.

Headstocks and valves of 125mm nominal bore and above shall be fitted with mechanical position indicators to show the amount which the valve is open or closed in relation to its full travel, i.e. 0.25, 0.50, 0.75, 1 etc.

305.2 VALVE MATERIALS

Valve bodies and other components shall be of corrosion resistant materials, compatible with the medium and of robust industrial design.

For water applications and where specified, valve bodies, discs and wedges shall be of cast iron, with facing rings, seating rings, wedge nut and other trim of corrosion resistant bronze or gun metal.

The valve stem, thrust washers, screws, nuts and other components exposed to the water shall be of a corrosion resistant grade of bronze or stainless steel.

For water works applications, wedge gate, metal seated valve materials shall be in accordance with BS 5163 Table 6A, fitted with a stuffing box and gland seal on the stem. Oil or grease shall not be used on any bearing or seal that may be in contact with the water being controlled.

The type and size of valve to be used to any particular location shall be as indicated on the contract drawings. Valve materials shall comply with the following minimum requirements.

ENVIRONMENT	BODY	TRIM**	REMARKS
Air	Carbon Steel or Bronze	410 SS Bronze	Blower discharge valves can be supplied to blower manufacturer standard.
Cl_2 Gas	Carbon Steel	410 SS	
Cl_2 Water	PVC	PVC	
Diesel Oil	Carbon Steel	410 SS	
Sewage	Ductile Iron Cast Iron PVC	Bronze* Bronze* PVC	Zinc free.
Potable Water	Bronze PVC Ductile Iron Cast Iron	Bronze* PVC Bronze* Bronze*	Less than 1000 mg/l total dissolved solids. Zinc free.

* Alternate acceptable materials for stem is aluminum bronze, or nickel aluminum bronze
** Trim material includes stem, body and closure seating surface, seat rings, bushings, springs, or any small parts in contact with service fluid.

305.3 SLUICE VALVES

All sluice valves, unless otherwise specified shall be of the rising spindle type, have wedge gates and be in accordance with the relevant clauses of BS 5150 and BS 5163.

Valves up to and including 300 mm ND shall be of the resilient seal or metal seal type. Valves larger than 300 mm ND shall have metal seals.

The valves shall be suitable for unbalanced head. A by-pass with gate valve forming an integral part of the valve shall be provided where recommended by the manufacturer for the pressures specified.

Where specified, sluice valves shall be fitted with easing screws and a clean-out box in the base.

Unless otherwise specified, each valve shall be provided with a suitable handwheel of adequate diameter for the duty required. Gearing shall be supplied where necessary, to ensure that the required operating force applied by hand to the rim of the wheel does not exceed 55 kgf.

Stem seals shall be of the stuffing box and gland type, arranged for easy replacement of packing and shall be accessible for maintenance without removal of the valve from service.

Extension spindles, headstocks and foot brackets shall be provided where required.

Where valves are required to be operated by tee keys spindle caps shall be fitted. The caps shall be drilled and each provided with nut and bolt for securing to the spindle, which shall likewise be drilled to accept the bolt. Each cap where fitted shall be supplied complete with operating tee key.

305.4 TELESCOPIC VALVES

All bellmouth telescopic valves shall have cast iron outer sleeves and bellmouths. The outer sleeves shall have machined labyrinth seals and the sliding tubes shall be manufactured from zinc free bronze.

A cast iron stirrup shall be affixed over the top of each bellmouth and these shall be connected to the rising screw thread by means of a stainless steel 'Rose' type coupling. To minimise fouling by rags etc. the valves shall not be fitted with outer guide rods.

305.5 NON-RETURN VALVES

Check valves shall comply with BS 5153.

All non-return valves shall be of a type that will operate without shock.

Valve bodies shall be of cast iron unless otherwise specified and shall be fitted with renewable type seatings.

Covers shall be provided to allow ample access for cleaning and service and shall be supplied complete with tapped bosses.

In the case of swing gate type valves the hinge pin shall be of stainless steel, mounted in zinc free bronze bushes and extended and fitted with external levers and counter balance weights, all protected by a screen guard.

Other types of valves will be considered. In every case the non return valve shall be selected with full consideration of the system characteristics, and shall avoid valve slam, and have low maintenance requirements.

Where specified, limit switches shall be provided to operate from the external lever. The screen guard being slotted to allow the guard to be removed without disturbing the switch cabling.

305.6 BUTTERFLY VALVES

Butterfly valves shall have a resilient disc seating and be designed for a positive leak-proof shut off at a minimum pressure of 16 bar. Non-wafer types are preferred.

Butterfly valves shall conform to BS 5155

The disc shall be in grey or ductile cast iron unless otherwise specified with a resilient seating ring in moulded rubber, or other material to the approval of the Engineer.

For valves of 350 mm ND and above, a suitably lubricated axial thrust bearing shall be fitted.

A stuffing box and gland shall be fitted on the operation shalft extension to seal the pressure side of the valve. The design shall be such as to facilitate packing replacement without removal of the valve from the pipeline.

A valve position indicator, to show the position of the disc, shall be provided on the valve operating gear.

Suitable stops shall be incorporated to prevent movement beyond the disc "fully open" and "fully closed" positions.

Valves for flow regulation shall be of all metal construction.

305.7 PLUG VALVES

Plug valves shall be of the wedge gate type, with cast bodies. The plug surface shall be coated or lubricated to ensure low torque operation with bubble tight shut-off and 'non-sticking' materials.

305.8 SLIDE VALVES

Unless otherwise specified, slide valves shall be of the lightweight pattern type with cast or ductile iron body, stainless steel slide and chromium steel outside rising screw spindle.

The valve body shall incorporate a transverse slide seal so arranged for easy replacement of the packing, which shall be accessible without removal of the valve from the pipeline.

Handwheels shall have smooth rims and of such diameter to enable one man to operate the valve. The direction of opening and closing shall be cast on the handwheel. The direction of closing shall be clockwise.

Valves of 125 mm, nominal bore and over shall be fitted with position indicators showing the amount which the valve is open or closed in relation to its full travel.

305.9 ISOLATING COCKS

For isolation of small bore pipework tappings for instrumentation equipment etc. and for individual component isolation, the cocks shall be stainless steel, quarter-turn, ball or plug valves with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or rear surface.

Where corporation cocks are specified, these shall be similar to the above isolating cocks but shall have a detachable key handle for fitting onto a squared operating shaft, the shaft end being marked to indicate the open and closed valve positions.

305.10 PENSTOCKS

305.10.1 General

All penstocks shall be designed and installed so that the maximum working pressure acts in a seating direction on the gate.
Both gate and frames shall be sufficiently rigid to withstand twice the maximum working pressure and any eccentric pressures created by the tightening of the anchor bolts during installation. All penstock frames shall have a spigot back.

The frame shall be designed to ensure that the gate is supported over not less than two thirds of its depth when the gate is fully raised.

Penstocks shall be of the rising spindle type unless otherwise specified, and the spindles shall be of adequate size to avoid buckling under load.

All spindle nuts shall be self aligning and their length shall be not less than twice the spindle diameter.

The top part of the penstock frames shall be sufficiently robust and substantial to prevent the frames bowing and if necessary, additional holding down bolts shall be fitted. The penstocks shall be fitted with matching wedges on doors and guides, the wedges shall be fitted with renewable seatings of zinc free bronze. Under no circumstances shall wedges be fitted to the bottom or lower sections of the penstock doors. The wedges shall be adjustable with stainless

steel adjusting screws and shall be readily removable.

On rectangular penstocks the inverts shall be flush with renewable synthetic rubber seals on the bottom of the doors. The rubber shall be suitable for the application and of an approved type.

The doors shall have lifting eyes cast in, or eye bolts of sufficient size to permit the lifting of the door against seating pressure.

Where extended spindles installations require to be operated at elevated floor level, spindle guides or guide brackets shall be provided close to the floor level.

Where penstocks are required to be operated by the tee keys, spindles caps shall be fitted. The caps shall be drilled and each provided with nut and bolt for securing to the spindle which shall also be drilled. Where caps are fitted they shall each be supplied complete with operating tee key.

All penstock shall be provided with headstocks (except where the Handwheels can be mounted on the penstock frames). For penstocks of 300 mm ND. (square or circular) and above and for all motorized and actuator operated penstocks, unless otherwise stated, thrust tubes shall be provided between the penstocks frame and the headstock, in order to absorb the operating thrust in both directions. Thrust tubes shall incorporate all necessary fixing brackets and spindle quid plates.

Headstocks and foot brackets shall be provided for non-rising spindle penstocks where the latter are specifically called for. Guide brackets shall be provided where necessary. Non-rising spindles shall be fitted with thrust collars and arranged so as to transmit the thrust arising from operation of the penstock directly to the Penstocks frame. Where headstocks are required on non-rings spindles installations they shall incorporate a penstock position indicator.

Penstock shall be water-tight under the conditions of head and direction of flow as stated in the appropriate clause or schedule of the specifications and/or the contract drawings.

Penstock shall be water-tight under the conditions of head and direction of flow as stated in the appropriate clause or schedule of the specification and/or the contract drawings.

All bolt holes shall be drilled and spot faced.

Simple templates shall be supplied as soon as possible after approval of drawings to enable the Civil contractor to position the holes for holding down bolts for all penstocks over 1.0 m square.

305.10.2 Penstock Materials

Penstock doors, wedge support beams, frames, guides, frame extensions, headstocks and bridge pieces shall be cast iron, of minimum grade 220 to BS 1452. Doors and frames shall be fitted with renewable seatings of zinc free bronze.

Spindles shall be manufactured from stainless steel 431S29 (EN 57) or similar approved material.

305.10.3 Extension Spindles

Extension spindles shall be adequately sized to prevent buckling and shall be attached to the valve/penstock stem by a suitable adaptor incorporating two muff couplings, scarf lap jointed and pinned with at least two coupling joints included. Universal joints and waterproof sleeves shall be provided where specified. Extension spindles shall be manufactured from 080M40 (EN 8) steel.

Intermediate bearing support or guide brackets of cast iron, with slotted holes for site adjustment, shall be fitted to long shafts where necessary. Bearings shall be of PTFE or similar approved type.

305.10.4 Pedestals and Spindle Covers

Penstock and valve pedestals shall be of cast iron or heavy duty, welded, mild steel construction with a substantial base and fixing provision. The base and top of the pedestals shall be machined normal to the axis of the drive shaft.

Where necessary, support guide bushes shall be fitted as the base of the pedestal.

The pedestal height shall be such that the handwheel is approximately 1 metre above the operator's floor level.

Clear polycarbonate covers of an approved type shall be provided for all rising spindles to totally enclose them when in the fully raised position.

Each tube shall be clearly and permanently engraved to indicate the position of the penstock.

305.11 AIR VALVES

Air valves shall be of two types:

a) Single (small) orifice valves (SOV), for the discharge of air during the normal operation of the pipeline.
b) Double orifice valves (DOV), consisting of a large orifice and a small orifice. These shall permit the bulk discharge of air from the main during filling and air inflow when emptying in addition to the discharge of small quantities of air during normal operating conditions.

Air valves shall be supplied with an independent isolating butterfly valve (DOV) or cook (SOV) which permits the complete removal of the air valve from the main, without affecting the flow of water in the main.

The sizing of the air valve and isolating assembly shall be such that the pressure drop at design flow capacity does not exceed 0.5 bar.

Each air valve assembly shall be suitable for connection to a flange on the pipeline.

At the connection between the air valve and its isolating valve a BSP tapping shall be made suitable for fitting of a pressure gauge. All tappings shall be sealed by a brass plug and copper compression ring gasket.

Air valves shall operate automatically and be constructed so that the operating mechanism will not jam in either the open or closed positions.

305.12 HANDSTOPS (FOR SEWAGE ONLY)

Handstops shall have cast iron frames with galvanised mild steel doors.

Handstops shall be semi-circular or rectangular pattern according to the application or as specified.

Handstops shall be suitable for channel or wall mounting according to the installation requirements.

Handstops doors shall be provided with hand-slots to facilitate operation and a peg and chain shall be provided to hold the door in the open position. Pegs and chains shall be of stainless steel.

On deep channels or where specified, handstop doors shall be provided with lifting handles. Lifting handles shall be of identical material to the doors and guide/retaining brackets shall be provided.

All materials used in the manufacture of handstops shall conform with the requirements for Penstocks specified herein.

305.13 FLAP VALVES

Flap valves shall be of the following categories :

i) General purpose (excluding category (ii) applications).

ii) Seawater and other aggressive applications.

Flap valves shall be normally closed, by weight of the door only, and shall open under minimum flow conditions. They shall be capable of withstanding 1.5 times the specified maximum seating head.

Flap valves on tidal installations shall be capable of withstanding a minimum static head of 6 metres and a minimum surge head of 10 metres.`

Where flap valves are required for flange mounting, they shall be supplied with rubber gasket and the full number of holes to BS.4504 NP 16.

Fixing nuts and bolts shall be as specified in the fastners general requirements with the exception of seawater and other aggressive locations in which case they shall be of stainless steel only.

All flap valves shall be operated and painted in accordance with metal painting and protection requirements.

General purpose flap valves shall be of the double hung type and all valves of 600 mm opening and above shall be of the double door type.

All doors shall be provided with lifting rings and those of 600 mm opening and above shall be fitted with galvanised lifting chains.

305.14 PRESSURE RELIEF VALVES

Pressure relief valves shall protect pipes from accidental overpressure and surge.

It shall consist either of a low inertia valve guided by a flexible diaphragm ensuring a rapid response, and easily adjusted on site, or of a spring operating under compression, a fixed tapered discharge nozzle and a flat-disc mobile shutter.

These valves shall only open under a determined pressure slightly higher (almost 5%) than the maximum pressure for normal working conditions.

The body, sleeve, and gland shall be cast iron. The spring shall be stainless steel.

They shall be wafer type and occupy minimal space.

305.15 PRESSURE / FLOW CONTROL VALVES (REDUCING/REGULATING)

Control valves shall function efficiently of line pressure or flow without human intervention. They shall be hydraulically or electrically operated depending on the availability of a power source. The basic valve shall be heavy duty globe type to BS 5152 & 5160. It shall have no packing glands or stuffing boxes and shall be maintained with ease without removal from the pipeline.

The valve shall be coated internally and externally with epoxy 150 μm minimum thickness. The material of the valve and its elements shall be selected to suit the fluid in the line and the environmental factors such as abrasion, corrosion, pressure and temperature.

306. FASTENERS

306.1 GENRERAL REQUIREMENTS

All fastenings and accessories in contact with the process water shall be of stainless steel, cadmium plated mild steel or other corrosion resistant material subject to the approval of the Engineer. All bolts, nuts, screws, washers and other fixings for anchoring the plant to walls, floors, ceilings, etc. shall be of corrosion resistant material or shall have a protective surface treatment to the approval of the Engineer.

All bolts in inaccessible positions shall be secured by either self locking nuts, spring washers and nuts, or castle nuts with split pins. Fasteners associated with items requiring removal during routine maintenance shall be of stainless steel. All other items shall be sheradised or hot dip galvanised in matched condition.

306.2 BOLTS & NUTS

All bolts, nuts, studs and studbolts, including those required for installation at terminal points to existing equipment, shall be provided by the Contractor and shall have metric threads to BS 3643.

After tightening, the minimum engagement of the thread shall equal the thickness of the nut. The projection of the thread beyond the outer face of the nut shall not exceed one quarter of the outside diameter of the thread. In no circumstances shall galvanised or coated bolts be shortened by cutting.

Washers 3 mm thick shall be provided under all nuts and bolt heads.

All bolts, nuts, washers and anchor plates, except high tensile, for all ferrous parts shall be steel galvanised to BS.729 or sheradised to BS.4921 Class 1, primed and painted after assembly and tightening.

All bolts, studs, nuts, washers and anchor plates, for fastening aluminium alloy components shall be of stainless steel grade 316S16 to BS.970 and shall remain unpainted. PTFE washers shall be fitted beneath stainless steel washers for both bolthead and nut.

All bolts, nuts, studs and washers used in the construction of submersible pumps shall be stainless steel grade 316S16 to BS.970.

306.3 HOLDING-DOWN & ANCHORS BOLTS & NUTS

All holding-down and anchor bolts, nuts, washers and anchor plates for use externally or in internal areas which are subject to contact with sewage or effluent or in "wet" areas but above the top water level shall be of high tensile stainless steel grade 316S16 to BS.970.

All holding-down and anchor bolts, nuts, washers and anchor plates for use internally in areas not subject to contact with sewage or effluent shall be steel galvanised to **BS.729** or sheradised to **BS.4921** class 1 and all exposed surfaces shall be painted after assembly and tightening.

All holding-down or foundation bolts shall be supplied and shall be complete with hexagon nuts and washers. Bolts of steel round bar formed into a loop at one end are not acceptable.

306.4 RIVETS

Rivets are to conform to the appropriate British Standard and for general use pan heads are preferred. Rivets on bearing surfaces are to be flat countersunk, driven flush. Whenever practicable, riveting is to be done by hydraulic tools and the rivets must completely fill the holes when closed. If loose, or if the heads are badly formed, cracked, eccentric to the shank or do not bear truly on the plate or bar, rivets, are to be cut out and replaced. All surfaces to be riveted must be in close contact throughout.

307. PLUMBING AND DRAINAGE

307.1 GENERAL

307.1.1 Scope of works

Work under this Section shall encompass the supply and installation of the following:

1. Sanitary fixtures including water heaters, valves and fittings, booster sets
2. Water distribution and supply system
3. Waste water drainage system from sanitary installations
4. Storm water drainage system.

Sanitary fixtures shall be complete and include labor, supply and installation of all pipes and their supports, connections to existing pipes or to sanitary fixtures, valves, accessories, as well as fixing, excavation and backfilling works required for the piercing and repair of walls, slabs and ceilings, and this, according to the drawings and the specifications of this Section.

307.1.2 Non restrictive list of works provided for in this Section

- Cold water distribution to sanitary installations and intakes
- Hot water distribution to sanitary installations
- Drainage of waste water and storm water to sewers or septic tanks
- Execution of primary ventilations
- Supply and installation of all floor drains
- Sanitary fixtures
- Waste water lifting systems
- Sinks
- Openings in partition walls and masonry
- Plugging up openings left in concrete surfaces after pipelaying
- Equipotential connections
- Branching of all fixtures
- Operation tests.

307.1.3 Contract documents

Nota: The list of texts mentioned hereunder is not restrictive. Works should be consistent with all texts in force at the time of their execution.

Plumbing

1) Unified Technical Documents (DTU)

1.1	Sanitary plumbing for dwellings (DTU P40-201)	
	Tender document	October 1959
	Chapter IV of tender document	November 1981
	Supplement N° 1: Installation of inserts in floors and walls	July/August 1969
	Supplement N° 4: Steel pipes for water distribution inside buildings	
	Particular specifications document and Memento thereto	January/February 1977

	Supplement N° 5 modifying supplement N° 4: Steel pipes for water distribution inside buildings	December 1979
	Erratum	April 1980
1.2	Cast iron pipes for waste water, storm water and sewage drainage (DTU P41-220)	
	Technical Specifications Document	July 1984
1.3	Calculation rules for sanitary plumbing installations and storm water drainage installations (DTU P40-202)	October 1988

Unplasticized P.V.C pipes

1.4	Storm water drainage (DTU P41-212)	
	Tender document	November 1981
1.5	Waste water and sewage drainage (DTU P41-213)	
	Tender document	November 1981

1.6 CIBSE Guide B8: Sanitation and waste disposal 1972

1.7 Code of practice CP3; Engineering and utility services

1.8 Code of practice CP304; 1968 Sanitary pipework above ground

1.9 Code of practice CP301; 1971 Building drainage

1.10 Code of practice CP305; Sanitary appliances

1.11 Code of practice CP308; 1974 Drainage of roofs and paved areas

1.12 The uniform plumbing code for housing

1.13 Plumbing manual

1.14 National plumbing code

2) Standards

French standards; NF class: A pipes

D fixtures
E valves and fittings - connections
P sanitary plumbing
T PVC

Simple faucet of sanitary fixture - Vocabulary	NF D 18-001
Sanitary valves and fittings - Simple faucets and washer type mixers - General technical specifications	NF D 18-201
Mechanical washerless mixers - General technical specifications	NF D 18-202
Valves and fittings - globe valves used as isolating valves - terminology specific to valves and fittings installed in buildings	NF E 29-064

Hot or cold water distribution (terminology)	NF P 41-101
Waste water drainage (terminology)	NF P 41-102
Code of the minimum conditions for the execution of plumbing works and urban sanitary installations	NF P 41-201
Globe valves used as isolating valves - General technical specifications	NF P 43-001
Water pressure reducers - General specifications	NF P 43-006
Globe valves used as intake valves - General technical specifications	NF P 43-015

British standards; BS class

Cast Iron Spigot and Socket Drain Pipes and Fittings, Part 1: Pipes, Bends, Branches and Access Fittings.	B.S. 437
Concrete Cylindrical Pipes and Fittings, Including Manholes, Inspection Chambers and Street Gullies. Part 2: Metric Units	B.S. 556
Schedule of Cast Iron Drain Fittings, Spigot and Socket Type, for use with Drain Pipes to B.S. 437	B.S. 1130
Steel Tubes and Tubulars Suitable for screwing to B.S. 21 Pipe Threads	B.S. 1387
Asbestos-Cement Pipes, Joints and Fittings for Sewerage and Drainage.	B.S. 3656
Unplasticized P.V.C. Soil and Ventilating Pipe, Fittings and Accessories.	B.S. 4514
Prestressed Concrete Pipes for Drainage and Sewerage.	B.S. 5178
Specification for Unplasticized P.V.C. Pipe and Fittings for Gravity Sewers.	B.S. 5481
Cast manhole covers, graings, gullys, etc	B.S. 497

307.1.4 Openings in concrete surfaces and repair works

The Contractor shall bear the costs of labor and supply of materials required for the execution of openings and reinstatement of masonry and/or concrete works, as well as for preliminary or complementary works pertaining to sanitary installations, regardless of the difficulty of such works. No piercing in load-bearing structures (columns, beams, ...) shall be allowed unless so approved by the Engineer. Openings and storm water drainage system shall be carried out in accordance with Sections: waterproofing of New Works and Concrete Works.

307.1.5 Cleaning and protection

The Contractor shall be responsible for the protection of all sanitary fixtures from any damage and until the taking over of works.

All openings in the slab shall be sealed and protected. Floor drains shall be covered. Pipes free

ends shall be protected against the intrusion of foreign bodies. The use of new sanitary fixtures throughout the works shall not be allowed.

Openings in roofs for storm water drainage shall be consistent with Waterproofing of New Works and Concrete Works. On completion, all fixtures and accessories shall be cleaned and polished.

Prior to taking over, the Contractor shall clean all the installation and purge all piping systems in order to ensure that they are free of wastes. In case pipes are plugged, the Contractor shall clean them and put them into service at his own expense.

307.2 PIPES AND FITTINGS

307.2.1 Application

Water pipes external to the buildings (i.e. undergound) shall be galvanized steel, threaded, in accordance with DIN 2440, medium duty or equivalent. (BS 1387).

Hot, cold and potable water pipes inside buildings shall be copper solder type to BS 2871 table X exposed and painted to Engineer requirement.

Waste water drainage pipes inside toilets shall be PVC according to DIN 19531 or UPVC to BS 4514.

Waste water drainage pipes underground shall be UPVC according to BS 4660 or equivalent.

Storm water drainage pipes inside shafts and between external manholes shall be of PVC according to DIN 19534, heavy duty or equivalent.

Storm water drainage pipes built-in walls shall be of PVC according to DIN 19531, heavy duty or equivalent.

Storm water drainage pipes between external manholes shall be of PVC according to DIN 19534, heavy duty or equivalent.

307.2.2 Galvanized steel pipes

307.2.2.1 Jointing of pipes

Pipes shall be gas threaded, WHITWORTH system; it shall bear at least 2 times the maximum pressure. Pipe threading shall be done with a screwing-stock without a ratchet, and shall stretch over 18 to 20 mm approximately.

No bending of pipes shall be permitted. Jointing by welding shall be prohibited. Jointing and connection works shall only be carried out by means of tees, elbows, couplings, hammer lug unions and flanges.

The seal of joints shall be ensured by a hemp tow coated with ceruse or linseed oil or an equivalent tape. Couplings shall have protruding rims to prevent ovalization due to vice tightening. Joints (elbows, tees, coupling, nipples, hammer lug unions, etc ...) shall be of a known trademark: A.F.L or G.F. or the like. Joints shall be reduced in factory and not by

means of reducing couplings.

Pipes shall be connected to the equipment or valves by means of hammer lug unions. Hammer lug unions or flanges shall be mounted on the pipes in judiciously chosen locations so as to facilitate the assembling and dismantling of a section of the distribution network.

307.2.2.2 Pipes fixing

Exposed pipes laid under a ceiling, on roofs and inside shafts shall be fixed on iron, U stay-rods and struts by means of rigid fixing collars.

U struts shall be clamped to the ceiling with two rods threaded at both ends. The upper end shall be inserted in a "read head" type female socket embedded in the slab. The lower end of the rod shall support the strut by means of a nut.

The number of supports shall be sufficient to avoid deflection, shocks, expansion, etc ...

Spacing between supports and the diameter of bearing rods depends on the pipe diameter.

Pipes	1/2″, 3/4″, 1″	1 1/4″, 1 1/2″, 2″	2 1/2″, 3″, 4″
Spacing	1.5 m	2.25 m	3 m
Diameter of the rod	12 mm	12 mm	12 mm

307.2.2.3 Sleeves

Walls and slabs penetrations shall be through steel sleeves embedded in the cement, allowing the free expansion of pipes.

The sleeves diameters shall be determined with due regard to the pipes diameters so as to insert an isolating plastic between the steel sleeve and the metal pipe whenever used.

Sleeves shall receive an inside and outside rustproof protection and shall be built-in in masonry prior to pipe installation.

Measures shall be taken to avoid dust projection and noise transmission through the sleeves from one room to the other.

307.2.2.4 Finishing and protection

Pipes embedded in masonry shall receive a cathodic protection by means of 3M plastic adhesive tape or Denso tapes or any approved equivalent. The tape shall be regularly applied to cover the entire pipe.

Threaded pipes shall be protected with an oil or graphite coating or any other equivalent to ensure total watertightness. Exposed water pipes shall be isolated with a 25 mm thick fibreglass.

Protruding pipes and their supports shall be coated with an anti-corrosion paint of an approved colour.

307.2.2.5 PVC drainage pipes

All material, pipes and fittings, various connections, tees, elbows, reducing couplings, O rings shall be of a European trademark.

307.2.2.6 Thickness of pipes

Thickness of pipes shall be to DIN 19531 or DIN 19534 or equivalent as follows:

1- Standard pipes to DIN 19531:

Diameter 1 1/2″	thickness 1.8 mm
Diameter 2″	thickness 1.8 mm
Diameter 3″	thickness 1.8 mm
Diameter 4″	thickness 2.2 mm

2- Heavy duty pipes to DIN 19534:

Diameter 4″	thickness 3 mm
Diameter 5″	thickness 3 mm
Diameter 6″	thickness 4.5 mm

307.2.2.7 Mounting, fixing and finishing works

Heavy duty pipes shall be jointed with O rings, and standard pipes with glued joints to the satisfaction of the manufacturer.

Pipes shall be cut with a saw. Male ends of sawn pipes shall be trimmed and beveled prior to jointing. Technical specifications of the manufacturer shall be observed. Inaccessible jointings shall be glued.

Storm water pipes crossing false columns or embedded in concrete shall be covered, prior to concrete placing, with corrugated cardboard which shall be well compacted around the pipe up to a uniform thickness of 2.5 cm minimum.

Crossing of partition walls load-bearing, walls, floors shall be through a sleeve having a diameter roughly larger than that of the pipe.

Exposed pipes shall be fixed by means of U rods as specified for galvanized pipes.

307.2.3 Pipe laying

Pipelaying shall be to D.T.U. 60.1.

Main lines shall be laid exposed at low-level or in false ceilings wherever existing. Branchings connected to fixtures shall be carried out exposed unless otherwise instructed by the Engineer.

Pipes and fittings shall have as much as possible vertical and horizontal routes and allow the free flow of water from and to all installations and fixtures.

Horizontal pipes shall have the following slopes, unless otherwise provided for by the Engineer:

Water supply pipes	0.5 to 1%
Waste water drainage pipes inside toilets	2%
Waste water and stormwater drainage pipes, buried or laid inside false ceilings	1%

Cleanouts, even where not specifically called for shall be installed at each change of direction in storm and waste water pipes.

Prior to jointing pipes, they shall be thoroughly cleaned so as to ensure the total absence of any foreign body.

Pipes having different diameters shall be jointed by means of eccentric reducers.

Except for pipes crossing masonry, all protruding pipes shall be kept 3 cm clear from vertical walls, slabs, ceilings and any other pipelines. However, the distance between such pipes and floors shall be 5 cm. Protruding or built-in pipes shall be accessible all along their route in order to facilitate inspection, maintenance or eventual modifications.

Automatic drain traps shall be mounted at high points of pressure water pipes.

To allow free expansion, the distribution network shall be so arranged as to move occurring expansions towards compensating devices. The latter shall be mounted by the Contractor although not specified on the drawings.

307.2.4 Pipe insulation

307.2.4.1 General requirements

- Insulation shall be carried out neatly and to a high standard by skilled workers, experienced in the trade.

- The thermal insulation shall be non-corrosive to the metal, water repellant and fire retardant.

- All metal surfaces shall be thoroughly cleaned and treated with approved corrosion inhibitor before applying insulation. Inhibitor coating would not be required for galvaniazed surfaces.

- Strainers, valves (size 80 mm and above) and other fittings which require opening for maintenance/repairs shall be provided with insulated boxes.

- All openings in roof slabs and walls for passing pipes should be suitably weather proofed. Metal sleeves should be provided where pipes pass through masonary walls or partitions. All openings in roof, ceiling or walls made for the purpose installation shall be sealed to prevent ingress of rodents, insects, dust, moisture and water. Opening in equipment casings shall be sealed likewise.

- All pipe insulation shall be covered with cotton canvas/fiberglass cloth and vapour sealed. The cloth shall be soaked in approved weather proofing compound and wrapped careffuly to provide a smooth surface, free from wrinkles and gaps. There should be at least 50 mm overlap at transverse and longitudinal cloth joints. Second coat of vapour seal shall be applied after drying of the first coat. This vapour barrier finish shall be carried over the load bearing inserts at location of supports or hangers without discontinuity or punctures.

- The vapour seal material shall be fire resistant, non-toxic, weather resistant and anti-fungus quality. Bitumen based products shall not be used.

307.2.4.2 Hot water pipe insulation

- All hot water pipes are to be insulated with rigid fibreglass sections of density not less than 96 kg/m^3, thickness of insulation shall be 25 mm. minimum, or 19 mm thick foam rubber.

  Higher thickness of insulation shall be used, for large pipes and headers, if specified.

  Performed sections of other insulation materials (except expanded polystyrene) may be specified subject to the considerations of safety, hygiene and finish and subject to the prior approval of Engineer.

- Threated hardwood rings or approved plastic inserts shall be provided between the pipes and supports.

- Aluminum cladding shall be provided for mechanical protection over insulated and vapour sealed exposed hot water pipes in plant rooms upto a height of 2.2 m from floor level and in the boiler room.

307.3 WATER SUPPLY VALVES AND FITTINGS

307.3.1 General

All necessary valves and fittings, required for the installation of sanitary fixtures according to the drawings and the following specifications, shall be supplied and installed.

Gate valves shall be used to isolate and cut off water from main lines or branchings. Washouts shall be installed at the foot of rising columns and at the low spots of water systems. They shall be ½" in diameter and have a male connection for flexible pipes or as shown on the drawings.

Threaded couplings valves shall be connected to the pipes and fittings by means of hammer lug unions.

Flanged valves shall be connected to the pipes and fittings by means of glands, joints and bolts; flanges and glands shall be drilled according to the standards of the country of origin.

Valves shall be installed to allow easy access and dismantling.

Working and tests pressures shall equal respectively 6 and 12 bars.

307.3.2 Check valves

Check valves shall be either of the swing or lift type. They shall be installed on horizontal or upward vertical pipes.

For diameters ≤ 2 ½″, the valves shall be bronze and fitted with tapped couplings. For diameters > 2 ½″, the valves shall be cast iron, fitted with flanges. Sealing surfaces and the hinge pin shall be of stainless steel.

307.3.3 Float valves

Float valves shall be of the swing handle type. The body and small handles shall be made of bronze, and the long handle of stainless steel.

The valve shall be made of durable and resistant plastic material or of rubber.

307.3.4 Automatic drain traps

They shall be fitted with a float that operates the air release mechanism.

The trap shall be supplied along with a stop valve, installed downstream of the trap and allowing the dismantling of the latter without need to empty the installation.

307.3.5 Surge suppression devices

Surge suppression devices shall be of stainless steel with an elastomer membrane for a working pressure of 10 bars with a ½″ pipe connection. They shall be of JOSAM trademark or any equivalent.

307.3.6 Slide valve

Slide valves ≤ 2″ in diameter shall be made entirely of bronze, with iron tubes thread, and fitted with an iron handwheel.

307.3.7 Gate Valve

Gate valves ≥ 2½″ in diameter shall have an iron body, fitted with glands and operated by an outside screw and yoke and a handwheel.

307.3.8 Globe Valve

Globe valves ≤ 2″ in diameter shall be made of bronze, with iron tubes thread and fitted with a replaceable disc of approved type.
Globe valves ≥ 2½″ in diameter shall have an iron body, fitted with glands and a replaceable bronze thrust plate of approved type.

307.4 DRAINAGE ACCESSORIES

307.4.1 Floor drains

Floor drains shall be PVC and of an approved European trademark.

Each floor drain shall have three 2″ inlets, and one 3″ horizontal outlet. It shall be equipped with a chromium bronze strainer screwed to the frame. The strainer's dimensions and orientation shall comply with tiling constraints.

307.4.2 Balcony drains

Balcony drains shall be made of PVC and of an approved European trademark. They shall be fitted with a stainless steel plated strainer and have a horizontal outlet for connection beneath the tiles.

307.4.3 Roof drains

Roof drains are installed to discharge storm water of unused roofs. They shall be PVC made and of an approved European trademark.

Each drain shall comprise a drainage funnel and a strainer screwed to the top of the funnel embedded in the sealing material.

307.4.4 PVC inspection holes

PVC right-angled crosses, 4 inches in diameter, having 3 inlets and one outlet shall be used as inspection holes inside toilets.

One of the inlets shall be fitted with a completely tight chromium bronze cover, screwed to the frame and intended for cleaning.

307.4.5 Floor cleanouts

They shall consist of PVC 45° bend or a T or F connection with a completely tight door screwed to the frame.

307.4.6 On-line cleanouts

They shall all be of the same trademark as the pipe and provided with a bolt down door. They shall be installed at every 90° deviation.

307.4.7 Concrete manholes

Concrete manholes shall be constructed outside the building to collect waste and storm waters into two distinct networks. They shall be constructed at each change of direction or diameter of the drainage pipe and to the details shown on the drawings.

Storm water manholes shall be fitted with a cast iron grating fixed on a cast iron frame.

Waste water manholes shall be equipped with a cast iron watertight cover fixed on a cast iron frame.

The lower part of the manhole shall consist of a concrete slab proportioned at 350 kg of cement per 1 m^3 of gravel and 0.5 m^3 of sand.

It shall be rendered with a cement mortar (600 kg) to have a perfectly smooth surface showing no asperity likely to retain impurities.

The concrete walls of the manholes shall be 0.20 cm thick and made of precast elements or cast-in-place.

The outgoing pipes bottom shall line up the lowest level of the waste water manhole. The base slab of storm water manholes shall be, on the contrary, 5 cm deeper than the outgoing pipes level in order to retain leaves and waste.
The dimensions of the manhole vary with the depth as indicated hereinafter:

Depth	Dimensions
Down to 40 cm	40 × 40 cm
Down to 120 cm	60 × 60 cm
From 120 to 180 cm	100 × 100 cm
More than 180 cm	120 × 120 cm

307.4.8 Main ventilation column

The top of the main ventilation column shall be fitted with PVC ventilation hood mounted on roofs and kept as much as possible away from visited places. They shall be equipped with an insect proof screen.

307.5 SANITARY FIXTURES

307.5.1 General

All sanitary fixtures shall be submitted to the Engineer for approval and prior to ordering.

All sanitary fixtures shall be new, of the colour specified by the Engineer, of first grade quality and flawless. All visible accessories such as flushes, fittings, escutcheons, pipes and fixing nuts shall be made of shiny chromium - plated brass, and shall have smooth lines with no protruding parts.

All sanitary fixtures shall be set level and true allowing to make right angled connections with adjacent walls. Openings and holes shall be plugged carefully as to comply with the finishing material of walls and floor.

All visible chromium plated fittings, as well as stainless steel connections and accessories shall receive, directly after installation, a thick coat of protective petroleum gelatinous material.

Brackets, supports and embedded ironworks shall be coated in situ with an anti corrosion paint.

307.5.2 Washbasins

Washbasins shall be made of glazed porcelain and shall be complete with chromium-plated taps and washer type mixer, brackets, an angle valve, U-bend pipes, supply and waste piping, a soapdish, a towel rail, a mirror, a shelf and all other accessories.

Each branching for hot or cold shall not be less than ½".

307.5.3 Water closets (seats)

Water closets shall be fitted with a 13 liters capacity flushing vessel and ½″ angle valve. No W.C. branching shall be less than ¾″.

Each branching for hot or cold shall not be less than ½".

307.5.4 Sinks

Sinks shall be of stainless steel and shall incorporate the worktop. They shall be equipped with three chromium plated taps (hot, cold and drinking water), a strainer, a polypropylene trap, stop valves, supply and waste piping, fixing devices and all other accessories.

Each branching for hot or cold shall not be less than ½".

307.5.5 Shower cabinet

Shower cabinets shall be of the built-in or surface mounted shower tray type measurements of $90 \times 90 \times 28$ cm^3. They shall include a shower head with variable direction, hot and cold water taps, a washer type mixer, connection and waste pipes and all other accessories.

Each branching for hot or cold shall not be less than ½".

307.5.6 Urinals

Urinals shall be glazed porcelain wall mounted $43 \times 24 \times 47$ cm^3 with pressurized flushing, separated each 60 cm by adequate partition walls.

They shall be complete with a push-button faucet, chromium plated trap, supply and waste piping as well as all accessories.

Each branching for hot or cold shall not be less than ½".

307.6 WASTE WATER DRAINAGE SYSTEM

307.6.1 General

The waste water drainage system shall be complete and consistent with the drawings and the specifications below. The system shall comprise manifolds of sanitary fixtures, drops, mains, ventilation pipes, inspection holes, manholes, the installation of sump pumps and their control mechanisms, accessories, suspensions, supports, fixings and all other required accessories necessary for the good functioning of the installations.

307.6.2 Piping

Pipes used for this system shall be consistent with the specifications of Waste water drainage pipes.

Unless otherwise indicated, the diameters of drainage pipes shall be as follows:

W.C.	4″
Sink, wash basin	2½″

Connections between drops and horizontal manifolds shall be through long radius elbows.

Cleanouts shall be mounted at the foot of every drop, every change of direction, at the end of every branch as indicated on the drawings or required by the Engineer. They shall not be more than 15 m apart for 4″ horizontal manifolds, and 30 m maximum apart for those of a diameter exceeding 4″. Manifolds shall have a gradient of 1% in the flow direction unless otherwise specified.

307.7 GULLY TRAPS

Gully traps shall be of concrete or asbestos-cement, as shown on the Drawings. All internal surfaces of the gully traps shall be smooth and all edges rounded. The inside of concrete traps shall be plastered with cement mortar trowelled to a glossy surface. The trap seal shall be 5 cm minimum. The trap shall be placed on a concrete bedding at least 10 cm thick and shall be surrounded by concrete.

307.8 RAINWATER DISPOSAL

The rainwater disposal system shall be in accordance with the Drawings and/or as required in the Particular Specification.

Unless otherwise specified, the minimum diameter of leaders shall be 100 mm, except that for draining very small areas the Engineer may permit the installation of 75 mm dia. leaders. In any case the outlet of the leader shall be a 100 mm dia. bend. All leaders shall be installed in a straight line from the gutter to the outlet. If bends in a leader cannot be avoided, appropriate openings, easily accessible for cleaning, shall be provided on the bends. The top inlets of leaders shall be protected by stainless steel or galvanized wire strainers. The free outlets of leaders, where not connected to manholes of the storm water pipe system, shall terminate in 45° of 60° bends. The drain water shall drop onto a precast concrete dish diverting the water away from the foundations of the buildings.

307.9 SEPTIC TANK

307.9.1 General

Septic tanks shall be provided for small communities, and only whenever it is not possible to connect the sewerage system to a wastewater treatment facility. The tank shall be constructed in accordance with the drawings and/or as required in the Particular Specifications.

The septic tank shall achieve liquid-solid separation and shall provide digestion and storage of the settled organic solids.

307.9.2 Detailed Specifications

Septic tanks shall be designed and constructed in accordance with the following criteria:

a) A minimum hydraulic retention time of one day for the end of the design period average daily flow.

b) A minimum of one year production of sludge and scum storage capacity.

c) Design flow of 120 liter/capita/day shall be used in calculating the tank capacity.

d) Overall tank length shall be 2 to 3 times the tank width.

e) Water depth shall be between 1.2 m to 1.7 m. Minimum clearance between tank roof and liquid level shall be 0.3 m.

The septic tank is divided into two compartments with the first compartment having twice the volume of the second compartment. This arrangement shall ensure that the hydraulic load and the turbulence created by the incoming wastewater is absorbed in the first compartment. The second compartment shall achieve settlement for the low density solids since it receives the hydraulic load at a lower rate than does the first compartment.

The incoming wastewater shall enter the first compartment via a 200 mm ductile iron tee. The tee shall be designed and installed so as to dissipate the energy of the incoming water, to minimize turbulence, and to prevent short circuiting. The vertical leg of the inlet tee shall extend below the liquid surface to the specified level in accordance with the drawings.

The outlet of the first and second compartment shall be constructed in a manner so as to retain the sludge and scum formed in both compartments. The outlet of the first compartment is comprised of two (2) 200 mm dia elbows equally spaced along the width of the intercompartmental wall. The outlet of the second compartment is comprised of a one(1) 200 mm dia tee. The outlets shall have the submergence and height above the liquid level in accordance with the drawings.

A gas deflection baffle shall be provided underneath the outlets to prevent the entrance of gas disturbed sludge in the rising leg of the outlets.

307.9.3 Venting Provisions

The septic tank shall be vented to allow for the escape of accumulated methane, hydrogen sulfide, and other gases produced from digestion of the settled solids.

A 200 mm vent pipe shall be constructed on top of the second compartment and shall extend 3m above the finished grade level. Gases formed in the first compartment shall be vented to the second compartment via two 100 mm dia openings in the intercompartmental wall. The two openings shall be located above the scum level in accordance with the drawings.

307.9.4 Access Manholes

Two manholes with cast iron covers shall be provided over the inlet and final outlet pipes. The manholes shall provide access and means to inspect the inside of both compartments. The manholes shall also be used whenever tank desludging is required. The manhole covers shall be fitted with gaskets to provide a weather proof seal. Two each 300 mm inspection pipes with

removable covers shall be provided on top of the first compartment outlets pipes.

307.9.5 Structure of the septic tank

External walls of the precast or cast-in-place septic tank shall have a nominal thickness of 25cm; the partition walls between the tank's compartments shall be 20 cm thick.

Each vertical wall shall be reinforced with two layers of high yield steel bars installed at the rate of 6 HA 14/m in both directions and on both sides. Bars shall be kept 4 cm clear from the formwork.

The base slab shall be connected to the upper slab by bending the bars in such a way as to ensure a 50 cm penetration into each of the slabs.

The upper slab shall be 25 cm thick for tanks 2 m wide.

The base slab of the tanks shall be 25 cm thick, and shall extend a distance of 15 cm, from both sides of the tank walls. It shall be laid on a 10 cm thick concrete blinding layer.

Following are the concrete mix design:

- Base slab, upper slab and vertical walls: 350 kg of supersulphated portland cement (CLK) for 400 liters of sand and 800 liters of fine gravels

Generally, hydrostatic tests shall be conducted on the pipes before they are connected to fixtures.

In no case shall the pressure tests of pipes, equipment, etc ... exceed the working pressure of such pipes, equipment, etc ... Prior to and upon completion of tests, all equipment, piping, strainers, etc ... shall be thoroughly cleaned and put into working order.

307.10 MISCELLANEOUS DEVICES

307.10.1 Domestic water reservoirs

Domestic water reservoirs shall be made of 4 mm thick polyethylene and suitable for drinking water storage.

The reservoir shall resist ultra violet radiations and support without showing any deflection whatsoever, a temperature equal to 70° C.

It shall be manufactured to FDA21 - CFR 177, 1526 or equivalent.

The capacity shall be indicated on the drawing (> 1000 liters). All necessary accessories for the good functioning of the reservoirs shall be provided.

307.10.2 Electric water heater

Electric water heaters shall be installed according to the drawings. They shall be of the wall mounted or under sink installed type. They shall have an enamelled tank and shall be fitted with an automatic drain trap, a safety valve and all necessary accessories (heating element, adjustable thermostat, thermal insulation, ...).

Water heater shall be capable of heating the water capacity mentioned on the drawings to 80°C.

307.11 PAINTS

Work under this Section include the following:

Prior to any insulation metal pipes and reservoirs shall be wire brushed and coated with a bituminous or rustproof paint. Exposed covers and covered equipment shall receive a primer and a finish paint.

Reservoirs shall be lined and coated with 2 layers of rustproof paint.

307.12 TESTING

Each test report shall contain the following minimum information:

- The nature, hour and place of the tests
- The adopted procedure
- Means, material and labor
- The results.

Watertightness and mechanical strength tests of supply pipes and their accessories shall be carried out prior to painting.

Before conducting any test, a thorough cleaning of the whole installation shall be carried out.

Sections of pipes shall be isolated in order to carry out tests thereon under the required pressure.

A hydrostatic test shall be carried out at a pressure of 9 bars that is 1.5 times the maximum working pressure in order to check out:

- The valves mechanical strength
- The watertightness of pipes and their accessories.

The test pressure shall be maintained for 24 hours. Should the pressure tests be unsatisfactory, the Contractor shall search for and make good all defects causing leakages. After repairs, the installation shall be retested until it satisfactorily passes the test. Upon completion of the watertightness test, another test under the maximum working pressure shall be conducted. The pressure shall be maintained unchanged for 12 hours.

The watertightness test of waste water drainage pipes shall be conducted using a smoke cartridge that produces a smoke volume superior to that of the tested pipes.

Ventholes shall not be plugged before smoke has come out through their whole sections. No joint shall show any smoke leak.

In the case of unavailability of appropriate material required for tests using smoke, hydrostatic tests under a 0.2 kg/cm^2 test pressure shall be carried out after having closed all the outlets and have purged all pipes.

All waste and storm water drainage system shall be subjected to a pressure test of 5 meters of water. The hydrostatic pressure of the test shall be maintained for two hours without the system showing any leak or drop in pressure.

308. FIRE FIGHTING

Portable type fire extinguishers shall be provided as detailed in the Particular Specifications.

The following types of Portable fire extinguishers are used:

All Portable fire extinguishers shall be in accordance with American regulations standard 10-1 and or equivalent European and internationally accepted standards such as BS 6535, 6643 and 5423.

- CO_2 type fire extinguisher (G) of 6 kg complete with hose, H Horn and wall mounting bracket.
- ABCE Powder type fire extinguisher (P) of 12 Kg complete with wall mounting brackets.
- ABCE Powder type on wheels fire extinguisher (PW) of 35 Kg.
- Cylinders shall be of 1.5 mm stamped iron plate of high quality, electric welding under electronic control, red oven painting with epoxy powders, and bursting pressure tested till 80 bars.
- Valves shall conform to European newest standards in stamped brass with safety device.
- Manometer of good quality.
- Rubber hose with working pressure of 20 bar.
- Dry nitrogen propeller.
- Temperature stability -60ºC + 80ºC
- Powder shall be of non toxic during handling and applications and shall be dry and durable for at least 5 years.

309. HEATING VENTILATION & AIR-CONDITIONING

309.1 GENERAL

309.1.1 Technical clauses

Equipment and material shall be of good quality and stored under the best conditions (protected from temperature, sunlight, corrosion...). They shall be stored and sheltered from adverse weather conditions, such as humidity and temperature variations, dirt and dust, or other contaminants.

Transport costs shall be borne by the Contractor. Before ordering, he shall submit samples and catalogues for approval. Equipment shall be installed taking into consideration the manufacturer recommendations to ensure proper access, operation, and maintenance.

Subject to approvals, shop drawings may be modified to meet the requirements of the manufacturer. Materials which are not approved or found not easily accessible for maintenance shall be rejected, replaced and reinstated by the Contractor at his own expense.

309.1.2 Civil works

The Contractor shall be responsible for the coordination of all requirements of other Sections works namely, those of civil engineering and electricity, regarding the provision of openings in masonry or concrete works. In default, he shall perform upon the approval of the Engineer, all piercing, fixing and closing works. Where the Engineer refuses any such work, the Contractor shall not have right to claim for indemnity. Before closing the openings, all ducts, shafts and sleeves shall be covered with an approved resilient material.

309.1.3 Nameplates

Equipment shall have a nameplate that identifies the manufacturer’s name, address, type or style, model or serial number, and catalog number.

309.2 DESIGN CRITERIA

309.2.1 Design conditions

Outside conditions in summer:

92° F (33° C) Dry-bulb temperature
82° F (28° C) Wet-bulb temperature

Inside conditions in summer:

75° F (24° C) Dry-bulb temperature
50% Relative humidity

Outside conditions in winter

40° F (4° C) Dry-bulb temperature

Inside conditions in winter

68° F (20° C) Dry-bulb temperature

The noise level from evaporation machines and air extractor, measured at 1.5 m from any grille should not exceed 40 dBA.

Where this level is exceeded, sound attenuators shall be installed by the Contractor at his own expense.

Windows shall be 6 mm thick single-glazed or double glazed as per the project requirements.

309.2.2 Design cooling capacities

Air Cooled A/C equipment must give the required duty when the air temperature entering the condenser is equal to the specified design outside summer dry bulb temperature unless the specifications call for higher temperature for special applications. In addition, the equipment shall continue to function satisfactorily withou tripping or overheating at a maximum outside dry bulb temperature 40° C.

309.2.3 Accepted standards

The following standards are accepted for ACHVR services provided that necessary corrections and provisions are made to suit local climatological and design conditions, power supply system and other required codes.
ASHRAE: American Society of Heating Refrigeration and Air Conditioning Engineers (U.S.A)

IHVE : The Institute of Heating and Ventilation Engineers (U.K.)
ASME : American Society of Mechanical Engineers.
ARI : Air Conditioning Refrigeration Institute (U.S.A.)
ASTM : American Society for Testing and Materials.
AWS : American Welding Society.
UL : Underwriter Laboratories (U.S.A.)
SMACNA: Sheet Metal and Airconditioning Contractors National Association, Vienna.
HVCA : Heating and Ventilation Contractor's Association, U.K.

ADC 1062:GRD (1984) Test Codes for Grilles, Registers and Diffusers

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 210	(1985) Laboratory Methods of Testing Fans for Rating
AMCA 300	(1985; REV 1987; errata) Reverberant Room Method for Sound Testing of Fans
ASTMD1654	(1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASHRAE 52	(1968; R 1976) Air-cleaning Devices Used in General Ventilation for removing Particulate Matter
ASHRAE 68	(1986) Laboratory Method of Testing

Other International Standards may be considered provided they meet with the above standards as a minimum.

309.3 EQUIPMENT AND INSTALLATION

309.3.1 Split system heat pump

309.3.1.1 General

Air conditioners shall be of split system heat pumps type. The evaporators shall be installed on the mezzanine and/or on the roof. Condenser units shall be roof mounted.

309.3.1.2 Evaporator

It shall include:

- Heat exchanger with copper tubes and aluminium fins tested under 21 bars at the factory
- Expansion valve
- Balanced centrifugal fan, multi-speed installed on life-greased bearings
- washable metalic 25 mm thick filter, 90% arrestance of all particles down to 3 microns with an outside lable indicating danger of inflammability.
- Insulated stainless steel drain tray (sloped toward drain pipe) to receive condensates.

The system shall be installed in a metallic casing of thick sheet steel protected with two coats of baked paint and internally lined with fibreglass of suitable thickness.

309.3.1.3 Condensing unit

It shall include:

- Hermetic compressor with stop valve at the suction and the discharge, mounted on antivibration pads in a technical enclosure. The compressor shall be of gas suction cooled type

- Condenser coil made of drawn copper tubes, with aluminium fins and a liquid line solenoid

valve. Aluminium fins shall be treated by cataphoresis: scouring, rinsing, deoxydation then rinsing, phosphate crystal coating, bonderising, black or grey electrolytic cataphoresis paint, ultra filtering rinsing with demineralized water

- Expansion valve
- Fan with protection grille
- Shock resistant bottle.

The assembly shall be installed in a perforated casing. The metal jacket shall be of galvanized sheet treated with phosphate, and of suitable thickness. It shall be protected with two coats of baked paint.

Motors winding shall be thermally and electrically protected and weatherproof.

Control circuit shall include a time-delay relay and an electric protection for the compressor, a phase failure detector (loss of one phase or reverse phasing) for the three-phase motor, high and low pressure switches, a relay for the fan and a relay for the evaporator.

309.3.1.4 Refrigerant pipes

Refrigerant pipes between the evaporation and the condenser shall be hard copper, L type, insulated with Isoflex expanded synthetic rubber. Refrigerant pipes shall be soldered by nitrogen. Length of refrigerant pipes shall be carefully selected in relation with the units.

309.3.1.5 Control and electric connection

Cables and electric equipment shall be installed as specified in their relevant sections.

Control and electric connections shall include:

- A seasonal winter/summer thermostat with a selector switch: ON-OFF-VENTILATION. Thermostat shall be of remote bulbs type
- A circuit-breaker
- A control circuit between the evaporator and the condensing unit. Control cables shall be multicores, NYM type or equivalent
- All equipment shall be fitted with double insulated transformer allowing supply of the control circuit. The main power supply shall be three-phase. The Contractor shall be responsible for the installation of electric cables starting from the circuit breaker.

309.3.1.6 Installation

The evaporator shall be mounted on neoprene anti-vibration pads installed on U bars secured to the ceiling.

The condenser shall be mounted on neoprene anti-vibration pads. The drain pipe shall be PVC with a P-trap with 50 mm high waterseal.

The blower shall be connected to the duct by a 20 cm wide thick flexible duct.

Blower noise level shall not exceed 40 dBA when measured at a distance of 1 meter from the supply and return grilles. Blowers shall be fitted at the discharge with sound attenuators.

Roof-mounted evaporators shall be installed in a 150 cm high room. The room will house all supply and return ducts. Openings of supply and return ducts in the roof slab shall be accessible and weatherproof.

Free surface as per manufacturers recommendations shall be arranged around the evaporator for maintenance.

Waterproofing shall be ensured around ducts with metallic filler band.

309.3.2 Decorative air conditioners

309.3.2.1 General

Decorative air conditioners shall be of split system heat pump type. Evaporators and condensing units shall be wall mounted.

309.3.2.2 Evaporator

It shall include:

- Heat exchanger with copper tubes and aluminium fins tested under 21 bars at the factory

- Fan with tangential turbine with directional radial flow. Motor shall be of the silent type mounted on elastic suspensions and fitted with internal protections

- Air cartridge filter mounted on sliding guides and accessible from the front panel: 90% arrestance of all particules down to 3 microns

- Supply grille consisting of an adjustable multi-directional deflector

- Insulated stainless sheet steel drain tray to receive condensates

The casing shall have a polystyrene front and a stove enamelled steel backplate.

309.3.2.3 Condensing unit

The condensing unit will house the refrigerant compressor, the condenser, the moto-fan group, the expansion valve, as well as the electrical equipment.

- A hermetic compressor, mounted on antivibration pads in a technical compartment, fitted with a shock resistant bottle of gas suction cooled type. Stop valves shall be placed at the suction and at the discharge.

- A condenser coil made of drawn copper tubes with aluminium fins and fitted with a liquid liner solenoid valve.
  Aluminium fins shall be treated by cataphoresis: scouring, rinsing, deoxydation then rinsing, phosphate coating, bonderising, black or grey electrolytic cataphoresis paint, ultra filtering rinsing with demineralized water.

- A helicoidal fan with axial flow and low rotating speed and fitted with a protection grille, a motor of the silent type and shall be thermally and electrically protected.

- The casing shall be weatherproof and the compressor shall be placed in a soundproof compartment.

- Control circuit shall always include high and low pressure cutout switches, a relay for the fan, a relay for the evaporator and a time-delay relay for the compressor.

309.3.2.4 Refrigerant pipes

Refrigerant pipes between condensing unit and evaporator shall be precharged and delivered with the unit.

Refrigerant pipes shall have ends fitted with automatic wedge coupling. Length of refrigerant pipes shall be considered when selecting the units.

309.3.2.5 Control and electric connection

Cables and electric equipment shall be installed as specified in the relevant Seciton “Electrical Installations”.

Control and electric connections shall include:

- A seasonal summer / winter thermostat with a selector switch: ON-OFF-VENTILATION-COLD-HOT

- A three position velocity controller

- A circuit-breaker

- A control circuit between the evaporator and the condensing unit. Control cables shall be multicore, NYM type or equivalent

- Equipment shall be fitted with a double insulated transformer for the supply of the control circuit

- The main power supply shall be single-phase

- The Contractor shall be responsible for the installation of electric cables starting from the circuit-breaker.

309.3.2.6 Installation

The condensing unit shall be installed on neoprene antivibration pads and supported by a metal frame.

PVC drain pipes shall be used.

Operating noise level of evaporator shall not exceed 40 dBA when measured at a distance of 1 meter from the unit.

309.3.3 Roof top packaged A/C unit

309.3.3.1 General

The units shall be of the horizontal airflow with 40° C and 4°C in cooling as standard from the factory for all units. Cooling performance shall be as shown on drawings. All units shall be factory assembled, internally wired, fully charged with R-22 and 100 percent run tested to check cooling operation, fan and blower rotation and control sequence, before leaving the factory. Wiring internal to the unit shall be colored and numbered for simplified identification.

309.3.3.2 Casing

Unit casing shall be constructed of zinc coated, heavy gauge, galvanized stee. All components shall be mounted in a weather resistant steel cabinet with a painted exterior. Cabinet construction shall allow for all maintenance on one side of the unit. Service panels shall have lifting handles and shall be easily removed and reinstalled providing a water and air tight seal. The indoor air section shall be completely insulated with fire resistant permanent, odorless glass fiber material. The base of the unit shall have provisions for forkliff and crage lifting.

309.3.3.3 Filters

Two inches metalic washable filters on filter rack.

309.3.3.4 Compressors

A minimum of two compressors, shall be direct drive hermetic, reciprocating type with separate centrifugal oil pump providing positive lubrication to moving parts, motors shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage. Crankcase heater, internal temperature and current-sensitive motor overloads shall be included for maximum protection. Compressors shall have internal spring isolation and sound muffling to minimize vibration transmission and noise. External high pressure cutout, discharge temperature limit, winding temperature limit and compressor overload shall be provided.

309.3.3.5 Refrigerant Circuits

Two independant refrigerant circuit each shall have independent fixed orifice expansion devices, service pressure ports and refrigerant line filter driers factor installed as standard. An area shall be provided for replacement suction line driers.

309.3.3.6 Evaporator and Condenser Coils

internally finned 3/8" copper tubes mechanically bonded to configured aluminum plate fin shall be standard. Coils shall be leak tested at the factory to ensure the pressure integrity. The evaporator coil and condenser coil shall be leak tested to 200 psig and pressure tested to 450 psig.

309.3.3.7 Outdoor fans

The outdoor fans shall be direct drive statically and dynamically balanced, draw through in the vertical discharge position. The fan motor(s) shall be permanently lubricated and have built-in thermal overload protection.

309.3.3.8 Indoor fan

Units shall have belt driven, FC centrifugal fans with adjustable motor sheaves and adjustment of fan belts and motor sheaves. All motors shall be thermally protected units shall be capable of providing 1" esp at nominal unit cfm.

309.3.3.9 Controls

Unit shall be completely factory wired with necessary controls and contactor pressure lugs or terminal block for power wiring. Units shall provide an external location for mounting fused disconnect device. Microprocessor controls shall be provided for all 24 volt control functions. The resident control unit shall make all cooling and/or ventilating decisions in response to electronic signals from sensors measuring indoor and outdoor temperatures. The control unit maintains accurate temperature control, minimizes drift from set point and provides better building comfort. A centralized Microprocessor shall provide anti-short cycle timing and time delay between compressors to provide a higher level of machine protection.

309.3.3.10 Electric heaters

Electric heat modules shall be available for installation within basic unit. Electric heater elements shall be constructed of heavy-duty nickel chromium elements internally wye connected for 400 volt. Staging shall be achieved through the unitary control processor (3 stages). Each heater package shall have automatically reset high limit control operating through heating element contactors. All heaters shall be individually fused from factory. The unit shall be equiped with a remote type control box installed as shown on drawings at 1.5 m above flow level having a thermostat. OFF/FAN/COOL and speed selection switch.

309.3.4 Electric convector heaters

Electric convector heaters shall be suitable for domestic and commercial application and shall be fabricated from a self-extinguishing material. They shall be fan assisted and suitable for wall or floor mounting. They shall be protected by a thermal overload device. Their controls shall include a 24 hour timer, frost thermostat (4°C) and variable heat settings.

309.4 AIR FANS

309.4.1 General

Fans shall be tested and rated according to AMCA 210. Fans may be connected to the motors either directly or indirectly with V-belt drive. V-belt drives shall be designed for not less than 150 percent of the connected driving capacity. Motor sheaves shall be fixed pitch as defined by ARI Guideline D. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance. Motors for V-belt drives shall be provided with adjustable rails or bases. Removable metal guards shall be provided for all exposed V-belt drives, and speed-test openings shall be provided at the center of all rotating shafts. Fans shall be provided with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Fan and motor assemblies shall be provided with vibration-isolation supports or mountings. Vibration-isolation units shall be standard products with published loading ratings. Each fan shall be selected to produce the capacity required at the fan static pressure indicated. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated.

309.4.2 Axial Duct Mounted Fans

309.4.2.1 General

Fan Casing shall be cylindrical in construction, with matching metric spirally wound ductwork. Manufactured in heavy gauge galvanized steel with corrosion resistant fixings used throughout. Flanges to be quickfit type.

309.4.2.2 Fan/Motor assembly

Impeller to be of high performance aerofoil type comprising a cast aluminum hub with either aluminum alloy or polypropylene blades. Motors to be manufactured to BS 5000 with class F insulation and sealed for life bearings. Motors to be pre-wired to an external terminal base through flexible conduit.

309.4.2.3 Accessories

Unit to be complete with two mounting pads, four adjustable feet, foot fixings, two quickfit matching flanges and single bolt self sealing clamping collars, two flexible connectors, matching electronic speed controller, pair of wall mounting brackets, inlet cone and wire guard, antibackdraught damper, converter from quickfit to bolted flanges.

309.4.3 Centrifugal In Line Duct Mounted Fans

309.4.3.1 General

Fan Casing shall be rectangular In sections, manufactured from galvanized steel to BS 2982 1982, of rigid constructions with cut edges turned inward for safety. Circular ruged spigots shall be fitted to both ends of the case. The unit shall be supplied with easy installations fixing brackets attached to the unit by means of a single set screw.

309.4.3.2 Fan/Motor assembly

The Fan assemblies shall in coorporate a directly driven, backward curved centrifugal impellers, powered by single phase 200-240 V 50 HZ motors, and balanced with VDI 2060 class Q2.5 to give quiet and vibration free running. Motor shall be rated for IP55 with insulation to class F. Motor shall have integral thermal overload protection, sealed for life bearings and designed to run at any angle. Fan/Motor assembly shall be able to be withdrawn from its casing and turned through 150° to change air flow direction even after duct connection.

309.4.3.3 Accessories

Unit to be complete with two mounting pads, four adjustable feet, foot fixings, two quickfit matching flanges and single bolt self sealing clamping collars, two flexible connectors, matching electronic speed controller, pair of wall mounting brackets, inlet cone and wire guard, antibackdraught damper, converter from quickfit to bolted flanges.

309.4.4 Kitchen Fume Fans

309.4.4.1 General

Kitchen fume fans shall be either axial or centrifugal duct mounted type suitable for extracting fumes and steam, efficient, and designed for low sound level. Fan shall be complete with flexible duct connectors, backdraught and lower shutters, external grille, electrical speed controller, worm drive clips, vibration isolators.

309.4.4.2 Hood

Kitchen hood shall be of Aluminum with V type grease trap washable filter of 50 mm thick

designed for maximum face velocity of 1m/s complete with oil drainage facility and shall be to the engineer approval.

309.4.5 Window / Wall Fans

309.4.5.1 General

Window / wall fans shall be of the axial type that can be installed on window or wall, easy to install, esthetic and very silent, made of injected moulded plastic and rated class II electrical insulation.

309.4.5.2 Motors

Single phase motor, shaded pole type, suitable for 220-240 V, 50HZ, low consumptions fitted with internal thermal protection.

309.4.5.3 Accessories

Speed controller operable throug cord and remote fan switch, back draught shutters, wall fixing Kit, extended duct, and wall grille.

309.4.6 Special Application Axial Flow Fans

309.4.6.1 General

Ventilation fans used in water treatment plant such as in dewatering, chlorination, RAS and primary sludge pumping stations shall be belt driven axial fans suitable for flanged duct mounting for industrial application and extraction of high temperature gas up to 150° C, and corrosive and explosive gases.

Casing shall be made of rolled and electro-welled steel plate. The motor support shall be fitted outside the casing and the impeller support is welded inside. A steel sheet case protects the belt and the bearings. The whole assembly is furnished with gray epoxy paint. The casing is fitted with a spigot port.

309.4.6.2 Impellers / motors

Impellers shall be made in die-cast aluminum in one piece, with airfoil profile fixed blades, dynamically balanced according to ISO 1940 and finished with red epoxy paint. Impeller shall be driven by vee-belt drive. Motors shall be induction asynchronous according to IEC 34-1, 4 poles IP55, class F insulation, ball bearings greased for life, and cooling fan mounted externally on the fan.

309.4.6.3 Accessories

All duct work shall be flanged type complete with gasket sealant, flages, nuts, bolts, and washers, made of corrosive resistant steel coated with gray paint.

309.4.7 Roof Cabinet Twin Fans

309.4.7.1 General

Rectangular unit housing to be manufactured in aluminum allory and to contain a removable fan assembly comprising a directe driven centrifugal fans. Exhaust to discharge vertically through high velocity outlets protected by hinged birdguards, which automatically open under pressure. Units shall be fitted with two fans / motors: one runs, the other standby. Units to be provided with internal isolator and control prewired box. Motorst and fans shall be easily acceassable by removing the top cover sewred into the frame with bolts. Waterproof Frame finished in polyester powder paint.

309.4.7.2 Fan / motor

Fan blades shall be manufactured in aluminium alloy with asymetrical blade spacing, to be dynamically balanced. Motors, manufactured to BS 5000, TEFC, IP55, class F insulation incoorporating greased for life bearings, two speed motor.
Resilent mounting shall be supplied to support the fan and motor assembly on the baseplate to minimise machanical noise and vibration.

309.4.7.3 Accessories

Unit shall be supplied with flanged duct flexible connections on the suction side. Antivibration pads for external mounting of the unit on the concrete base.

Twin Fans Microsave control system utilising extra low voltage interface system. Controller to comprise a control module fitted to the twin fan unit which shall interface with the interface control panel (CP) via (24V) 4 core screened signal cable (0.55 mm^2) PVC coated (240V outer insulation). The ICP shall have a touch sensitive switch to select the fan mode and shall incoorporate coloured L.E.D.'s to in dicate fan and control status and is to include an "OFF" position. The I.C.P. shall be the same size as a surface mounted double gang power socket and the facia plate incoorporating electronics suitable for recessing into a plastic double gang power outlet. I.C.P. shall be manufactured in Fire retardant ABS plastic (VO rated) and installed as shown on drawing (REAF-S).

309.4.8 Roof Axial Cowl Fans

309.4.8.1 General

Fans shall be suitable for roof mounting on purposed made upstand as shown on general standard drawings designed to extract air with a horizontal discharge and with the motor shaft in the vertical position. Housing shall be made in polyester with fiberglass.

309.4.8.2 Impellers / Motors

Impellers made of injection moulded plastic reinforced with chemically anchored fiberglass and or cast aluminium protected with epoxy paints, and dynamically balanced in accordance with ISO 1940.

Motor shall be 4 pole, 2 speed asynchronous squirel cage in die cast aluminium in accordances with IEC 34-1: 220-240 V/ 50HZ single or three phase, class F, IP55 complete with thermal overload protection incoorporated in the winding with connections to the terminal base and greased for life ball bearings.

309.4.8.3 Accessories

Motors shall be provided with backdraught shutters preventing air entry when the fans are switched off.

Remote fan switch room mounted as shown on drawings (FEAF-S).

309.4.9 Centrifugal type power roof ventilators

Fans shall be V-belt driven with backward inclined, non-overloading wheel. Motor compartment housing shall be hinged or removable and weatherproof, constructed of heavy gauge aluminum. Fans shall be provided with birdscreen, disconnect switch, backfraft dampers and roof curb. Motors enclosure shall be explosion-proof type. Lubricated bearings shall be provided. All interior fan components shall be coated with a minimum 5-mil thick of Air Dray Phenol.

309.4.10 Air Filters

Air filters shall be listed according to requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP test method shall be as listed under the Label Service and shall meet the requirements of UL 586.

309.4.11 Factory painting

Units which are not of galvanized construction according to ASTM A 123 OR ASTM A 525 shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphatised and coated with a paint finish which has been tested according to ASTM B 117, ASTM D 1654 and ASTM D 3359. Evidence of satisfactory

paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 1/8 inch. Rating of the inscribed area shall not be less than 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint according to MS MIL-P-21035.

309.5 AIR DISTRIBUTION DUCT SYSTEM & DAMPERS

309.5.1 Duct works

All sheet metal ductwork shown on the drawings, specified required for various ventilation systems shall be fabricated and furnished from best quality cold rolled, close annealed, plain finished not salted, galvanised mild steel sheets of soft bending quality specially suitable for air conditioning works. Ducts shall be fabricated, assembled and connected in accordance with following table (applicable to galvanised ducts).

Dimension of Largest side mm	Sheet thickness mm	Transfer Between Joints	Reinforcing At Joints
Up to 400 mm	0.6	Not required	Drive slip
600	0.8	Not required	Pocket lock at 90 cm
800	0.8	Not required	Pocket lock at 90 cm
1000	0.8	40 mm x 40 mm x 4 mm at 90 cm	Pocket lock at 90 cm
1250	1.0	40 mm x 40 mm x 4 mm at 90 cm	Pocket lock at 90 cm
1600	1.0	40 mm x 40 mm x 4 mm at 90 cm	Pocket lock at 90 cm

Note: Sheet metal thicknesses are net minimum acceptable after accounting for manufacturing tolerances and should be as measured on site by a micrometer. Otherwise the next higher thickness indicated shall be provided in order to meet the specified thickness. Exhaust air duct from kitchen shall be manufactured from aluminium sheet with thcikness two gauges heavier than galvanised duct.

All bracing and reinforcement angles shall be made of black steel, properly cleaned from rust and painted with 2 prime coats of antirust red paint prior to installation. Angles shall be carried around all four sides of ducts.

Guiding vanes and deflectors shall be installed as shown on the drawings and where required for good air flow. Unavoidable pipe crossing with ducts, conduits, or structural members, shall be approved by the Engineer before erection.

The penetration shall be through a streamlined tight galvanized sheet sleeve of aerodynamic shape without reducing the cross section area.

All bends shall have a radius equal to 1.5 times the width of the duct. Otherwise, bends shall be right angled with streamlined double deflecting vanes.

Good workmanship air tightness and system cleanliness shall be foremost considerations. The interior of all ducting systems shall be clean before erection and all open ends, which are left as the work progresses, shall be temporarily sealed to prevent the ingress of dirt. Mastic type sealing compound shall be used to make duct joints airtight.

All ducting systems shall be adequately supported and all fittings shall be manufactured and installed in accordance with good practice to minimize air turbulence, noise generation and friction loss. Particular attention shall be paid to the selection and location of an adequate number of dampers of suitable type for flow regulation. Consultation with the system designer is recommended to ensure that the regulating procedures to be carried out at commissioning stage may be achieved.

Sufficient thermometers, test points and access doors shall be provided for commissioning and for operating and maintenance purposes.

Provision shall be made for the possibility of dismantling ducting connections and equipment for servicing/removal and suitable precaution shall be taken to prevent transmission of vibration.

Ductwork shall be adequately braced and stiffened to prevent 'drumming'. Where insulation incorporates a vapour seal, special care shall be taken to ensure the continuity of that seal and to prevent any damage before hand-over.

All dampers shall be checked to ensure that they are properly installed and that the blades and linkages move freely. Where tight shut-off is required checks shall be carried out to ensure there is no undesirable leakage around damper frames or through the assembly in the closed position.

309.5.2 Volume control dampers (VCD)

Manual volume control dampers shall be provided as shown on the drawings or as required additionally for balancing purposes. The dampers shall have sturdy corrosion resistant construction.

Damper quadrants shall be cast metal type with words 'OPEN' and 'SHUT' clearly marked in raised letters. All dampers shall have multi-leaf, double skin aerofoil section opposed action blades. Individual blades should not exceed 1200 mm in length or 175 mm in width. Double skin blades shall be made out of minimum 22 gage galvanised steel sheet. Damper frames shall be made out of 16 gage galvanised steel sheet.

Single blade dampers with single skin blade section may be used for damper size upto 300 x 300 mm. Single skin blades shall be fabricated from 18 gage galvanised steel sheet.

The blades shall be securely bolted/riveted to plated steel spindles, the ends of which shall be extended to the outside of the damper frame, each with a groove in line with the blade. Spindles shall be carried in brass or nylon bearings. The control linkage shall be outside the air stream. Shut-off dampers shall incorporate rubber blade edges to minimise leakage past the dampers.

Final position of the quadrant handles after balancing the air system shall be clearly marked.

The location of all concealed fire dampers and volume control dampers shall be indicated.

309.5.3 Fire dampers (FD)

Fire dampers shall be of curtain blades outside airstream dampers are designed to stop the spread of fire through ducts, walls and floors and shall be supplied to exact requirements.

The damper blades shall be precision roll-formed and then interlocked to provide a 'curtain' with an angular, heat deflecting construction. All dampers shall be supplied with two constant force stainless steel closure springs and locking ramps to ensure positive closure. Dampers shall be supplied as standard, with an easy maintenance fusible link for ease of testing and resetting dampers. The link is set to operate at 72°C unless otherwise stated.

The fire dampers shall be manufactured as standard from corrosion resistant galvanised mild stee. Should offers superior fire performance characteristics.

The fire dampers shall be designed in accordance with BS476 Part 8 (2 hour rating) and tested and approved.

Units of this type are factory assembled ready for site installation. They shall be supplied complete with installation frames.

309.5.4 Grilles and diffusers (SCD/RCD/ECD/SWG/RWG/EAG)

Grilles and diffusers shall be of rugged construction and made of anodized aluminium with removable cores, turning vanes and volume control dampers for final fine control.

Prior to installation, their location shall be approved by the Engineer and shown on shop drawings.

They shall meet the following requirements:

- noise level shall not exceed 40 dBA when measured at a distance of 1 meter from the grille
- air velocity in the occupied zone shall not exceed 0.25 m/s.

Grilles and diffusers shall be installed by concealed hooks. Junctions between ducts shall be as shown on the drawings.

Wall mounted grilles shall be fitted with a wooden frame to be secured before rendering works.

Grilles shall have manually adjustable sheet steel fins, 1 mm thick, easily accessible from the exterior.

309.5.5 External air louver (EAL)

Extract and fresh air external louvers shall include:

- A frame made of angle iron to be fixed to the wall
- A frame with rainproof fixed fins and bird screen grille.

Louvers shall meet the following requirements:

- Velocity of air : 500 FPM maximum
- Head loss : 5 mm water column maximum

309.5.6 Bird screens and frames

Bird screens shall be installed on all fresh air inlet louvers and shall conform to FS RR-W-360, Type I, Class 1, 2 by 2 mesh, 0.063 inch diameter aluminum wire or 0.031 inch diameter stainless steel wire. Frames shall be removable type or stainless steel or extruded aluminum.

309.5.7 Air filters

Filters shall be provided for fresh air and for mixed fresh and return air.

For both the applications, the filters shall be 50 mm thick permanent metallic washable type. Filter media thickness shall be not less than 45 mm. (Synthetic or natural washable filter media

may be used with prior approval. Self cleaning inertia type fresh air filters may be necessary for large installations.

Filters are normally placed upstream of the main supply fan and the cooling coil. Apart from producing clean room air, this protects cooling coils and other apparatus from deposition of dust. The system shall be arranged to provide an even velocity distribution across the filter face.

Where extra clean contamination free air is required, high efficiency filters, normally used in conjunction with prefilters, are placed down stream of the fan and shall be the last item of equipment before the discharge point. This ensures that any air leakage is outward and that contaminated air is not drawn into the system, also that any contamination from air handling equipment (e.g. carry-over of dust particles from humidifiers) is captured by the final fiter. Prefilter construction shall be as described above.

309.5.8 Fresh air intakes (FAI)

Fresh air intakes shall be as remote as possible from concentration of surface or roof dirt and positioned to avoid intake of fumes or odours. Inlet grille or wire mesh bird/insect screen and volume control damper shall be fitted ahead of fresh air filters. In some cases the fresh air intake may need acoustic treatment to reduce noise from or into the system. Air inlets shall be positioned at least 1.2 m above ground level. Goose neck connections shall be provided to prevent ingress of rain water. sand traps may be required in areas which experience high incidence of dust.

Adequate access to facilitate servicing of the filters shall be provided and access doors, ladders, electric lighting included where necessary.

All ducts shall be clean and free from builder’s rubble and dust before filters are installed. The correct flow direction shall be observed. The frame holding the filter media, when in position, shall form an effective seal so that no air bypasses the filter.

309.6 THERMAL INSULATION

309.6.1 General

Insulation shall be carried out neatly and to high standard by skilled workers, experienced in the trade.

The thermal insulation shall be non-corrosive to the metal, water repellant and fire retardant.

All metal surfaces shall be thoroughly cleaned and treated with approved corrosion inhibitor before applying insulation. Inhibitor coating would not be required for galvanized surfaces.

All duct flanges, stiffeners and inspection doors etc. should be insulated in accordance with the recommended practices and to the Engineer's approval. Strainers, valves (size 80 mm and above) and other fittings which require opening for maintenance/repairs shall be provided with insulated boxes. Inspection door insulation thickness shall match the surrounding ducts.

All openings in roof slabs and walls for passing ducts and pipes should be suitably weather proofed. Metal sleeves should be provided where ducts or pipes pass through masonry walls or partitions. All openings in roof, ceiling or walls made for the purpose of ACHVR installation shall be sealed to prevent ingress of rodents, insects, dust, moisture and water. Openings in equipment casings shall be sealed likewise.

All duct and pipe insulation shall be covered with cotton canvas/fiberglass cloth and vapour sealed. The cloth shall be soaked in approved weather proofing compound and wrapped carefully to provide a smooth surface, free from wrinkles and gaps. There should be at least 50 mm overlap at transverse and longitudinal cloth joints. Second coat of vapour seal shall be

applied after drying of the first coat. This vapour barrier finish shall be carried over the load bearing inserts at location of supports or hangers without discontinuity or punctures.

The vapour seal material shall be fire resistant, non-toxic, weather resistant and anti-fungus quality. Bitumen based products shall not be used.

309.6.2 Rectangular ductwork insulation

All rectangular supply and return duct work shall be insulated with rigid fiberglass slab covered with reinforced aluminium foil. The slabs shall be free from shot or coarse and have density of not less than 48 kg/m^3 and thermal conductivity not more than .037 w/m °C. The slabs shall be fixed applying approved adhesive material of high quality to entire surface of both the duct-work and insulation slabs and fixed in place immediately. (The adhesive shall be applied to both the edges of the slab also). All joints shall be sealed using 75 mm wide self adhesive tape. Minimum time should be permitted to lapse between applying self adhesive tape and applying vapour barrier to insulated surfaces.

All duct work external to the building shall be insulated with 50 mm thick fiberglass slab and covered with fiberglass cloth of 200 gm/sq.m quality.

All duct work within the building, except plant rooms, shall be insulated with 25 mm thick

fiberglass slab and covered with high quality canvas of 200 gm/sq.m quality.

Fresh air and exhaust air ducts shall be suitably insulated wherever possibility of external or internal condensation exists.

Hardwood battens shall be provided between the ducts and the supports. Wood shall be treated for protection from fungus and termite.

Plastic insulation hangers shall be provided as additional support to the insulation of rectangular ducts with a side dimension in excess of 600 mm. Hangers shall be fixed to the bottom and sides of the ducts using blind rivets spaced 300-400 mm apart.

309.6.3 Circular ductwork insulation

Circular supply and return air ductwork shall be insulated with flexible fiberglass blanked of density 24 Kg/m^3 covered with reinforced aluminium foil. Blanket thickness shall be 50 mm compressed to 25 mm during application for internal ducts and 100 mm compressed to 50 mm for external ducts. Method of application of insulation shall be same as for rectangular ducts. In addition, 25 mm wide aluminium bands shall be provided at 500 mm centers.

Sectional treated hardwood rings or approved plastic inserts shall be provided between the ducts and the supports.

Vapour sealing over the insulation shall be carried out in the same manner as for the rectangular ducts. Additional protection shall be provided for exposed insulated circular ducts, if specified.

Preinsulated flexible ducts shall be subject to the approval of MEW. Insulation density shall be not less than 16 Kg/m^3. Insulated flexible duct connections to grille/diffuser plenums shall be covered with canvas and vapour sealed as per the rest of the air ducts.

309.6.4 Drain pipe insulation

All condensate drain pipes within plant room or other internal areas subject to damage or sweating shall be insulated using 25 mm thick glassfibre or 10 mm foam rubber insulation applied and vapour sealed as for duct insulation.

309.6.5 Refrigerant pipe insulation

Refrigerant suction lines shall be insulated using 19 mm thick foam rubber or 50 mm thick rigid fiberglass and vapour sealed in the same manner as duct insulation. Refrigerant suction lines of small split air conditioners (upto 2.5 Ton nominal capacity) may be insulated using 10 mm foam rubber and vapour sealed. Refrigerant suction lines within packaged equipment shall be insulated with at least 19 mm rubber foam with protective paint. Metal cladding over insulation may be specified for large evaporator shells.

309.7 SOUND AND VIBRATION CONTROL EQUIPMENT

309.7.1 General

Care shall be taken in the selection and location of mechanical and electrical equipment to ensure that the noise or vibration that it produces does not cause annoyance to occupants within the building where it is located or to people in surrounding areas (either indoors or outdoors). Particularly careful consideration shall be given to the sitting of outdoor equipment, including cooling towers, if required, air cooled condensers, remote condensing units, externally mounted fans. Specialist advice is essential when large machines are to be mounted on roof or intermediate floors.

Proper consideration shall be given to the sitting of supply and exhaust louvers on the building exterior to prevent problems owing to unwanted sound passing outward (or inwards) through these openings.

309.7.2 Sound attenuators

Sound attenuators and lining materials in duct work systems, and anti-vibration devices for equipment, shall be located strictly in accordance with design requirements and manufacturer's recommendations.

Installation of specially designed sound attenuators shall be preferred over duct lining.

The material employed for sound absorption within attenuators, mixing boxes and room terminals and ductwork lining are generally susceptible to physical damage and to severe

deterioration if exposed to rain or water. It is essential that adequate protection is provided not only during storage and installation, but at all times upto system handover.

309.7.3 Antivibration devices

Anti-vibration devices include compression materials and rubber in sheer isolators. These materials may be damaged physically, or by liquid such as oil, and adequate precautions are therefore essential.

Packaged units, installed at ground level, indoor free standing units and air handling units shall be mounted on anti-vibration units in the form of multilayer rubber pads. Equipments installed on the roof may be mounted on rubber pads or springs suitably selected and approved by the manufacturer.

Multi layer pads shall be composed of rubber sheets, preferably with square grid pattern on both sides, and steel sheet inserts of 16 gauge. The composite pad thickness shall be selected to suit the equipment, but shall be not less than 32 mm.

AV pads for small packaged units, air handling units, condensing units, fans, etc. shall contain counterbored holes and fitted with suitable rubber grommets to permit free passage of foundation bolts without making contact with the equipment.

Spring type vibration isolators shall be fitted with limit stop to prevent excessive movement and there shall be a compensating pre-setting.

Care shall be taken to prevent any anti-vibration devices being loaded beyond their safe limits during erection of machinery.

309.7.4 Flexible duct

Flexible duct joints shall be provided at inlet and outlet of each fan, air handling unit and packaged unit. The joint material shall be flame retardant.

309.7.5 Others

Flexible electrical conduits shall be provided for final connection to chillers, pumps, air handling units, fans and any other vibrating equipment.

Care shall be exercised to ensure that antivibration mounts are not “bridged-out” by direct contact between the equipment and building structure through foundation bolts, hangers, rigid pipe or cable connections, rigid clamping of equipment body to any element of the building or through bottomed mounting springs. All shipping bolts and stoppers must be removed before commissioning.

309.8 INSTRUMENTATIONS

309.8.1 Test points for air distribution system

Adequate test hole fittings shall be provided in the air ducts to facilitate accurate measurement of air flow using pilot tube traverses. Test hole fitting shall have at least 25 mm dia bore complete with an effective removable seal. Location of test points should be clearly marked on the insulation surface.

Test points shall be provided at the following locations :
- At all fans 9in the straightest section of duct near to the outlet).
- At main branches.
- After regulating dampers.
- After cooling coil and heating batteries.
- At any other position indicated on the drawings or necessary for balancing the air system.

309.8.2 Manometers

U-tube type manometers shall be installed to measure the pressure drop across filters. The manometer shall have coloured fluid for easy readability and the tube shall be protected by a metal or plastic casing.

Manometer shall be installed at the following locations :

- Across fresh air filters of large air handling units.
- Across fresh air filters of air handling units for 100% fresh air applications.
- Across mixed fresh and return air filters of air handling units and packaged units for normal air conditioning.
- Across all high efficiency filters.

Inclined tube manometers may be used for special applications.

309.8.3 Smoke detectors

A smoke detectors suitable for duct mounting shall be installed in the main returns air duct adjacent to each packaged unit. The smoke-detector shall be photoelectric obscuration type and shall be interlocked with the motor to stop it in the event of smoke detection. It should operate on 240 volts with two volt free contacts and shall be manual reset type.

309.9 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during

construction, and new filters shall be installed after all construction dirt has been removed from the building. System shall be maintained in this clean condition until final acceptance. Bearings

shall be properly shall be properly lubricated with oil or grease as recommended by the manufacturer.
Belts shall be tightened to proper tension. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

310. GAS CHLORINATION

310.1 GENERAL

Gas chlorination equipment for installation at pumping stations, reservoirs and water treatment works and other locations on the system generally come under one of two categories.

a) Gas chlorination feeding into pressurised and gravity lines at locations where an electricity supply is available.

b) Gas chlorination at those locations, such as water catchment works, outlets from reservoirs etc where there is no electricity supply.

This specification cover both categories.

The Contractor is responsible for the safe design, provision and installation of the chlorination dosing system and associated safety equipment. The safety equipment required varies from site to site depending on site location, quantity of chlorine stored or dosed and type of equipment supplied. The contractor shall access the requirements of each installation with respects to the following points:

- ventilation system
- leakage detectors
- audio and/or visual alarms
- automatic shut down systems
- personal protection equipment
- procedures and training.

The equipment called for in this section are nominal requirements, and shall be supplemented with required system per manufactures recommendation for safety and operation.

310.2 SCOPE OF WORKS

The scope of works for the provision of chlorination equipment includes, as appropriate to the particular category above:

1. Supply and transport to site of all equipment including chlorinators, centrifugal booster pumps, chlorine bottles, and all other material and equipment necessary for the installation.
2. Installation of chlorination equipment and fittings, pumping equipment, metering, pipework and valves, control and protection equipment to form an effective and fully operational installation.
3. All necessary civil and building works.
4. Testing commissioning and putting into service all equipment.

310.3 VACUUM CHLORINATION OF PRESSURISED WATER SYSTEM

This system is applicable at pumping stations, water catchment works etc where the water to be treated is under pressure and electricity is available.

A centrifugal booster pump shall be provided to supply pressurised water to the chlorinators.

Where specified the rate of chlorine injection shall be controlled by flow metering and valving as a function of the water flow rate.

Equipment Characteristics

Injection of chlorinated solution shall be by vacuum type chlorinator, the vacuum being achieved by pressurised water and injector.

The chlorinator may be either wall mounted or mounted directly on the head of the chlorine bottle. It shall include:

- Pressure reducing valve
- Flow control valve
- Injection device
- Pressure relief valve to act in case of surge pressure of chlorine or loss of suction.
- Pressure gauges up and downstream of the booster pump.
- Non return valve downstream of the chlorinator.

The injection service pressure (bar) and chlorinator capacity shall be calculated by the Contractor and designed from information in the particular specification for each installation.

The Contractor shall supply all necessary equipment and fittings for operation, control and maintenance in accordance with the following list.

The list is indicative and by no means restrictive.

Water Circuit

a) Motor Driven Pumpset
An electric motor driven pumpset shall be provided to achieve the discharge rate and pressure for chlorinator operation.
The booster pump discharge rate and pressure shall be as the chlorination equipment manufacturers specification. The pump assembly shall comprise a three phase 380V electric motor with a minimum protection class IP55 and maximum speed of 3000 rpm., and a centrifugal pump mounted on a common base plate.

b) Non return valve downstream of the pump.

c) PVC or bronze valves (Upstream and downstream of the pump)

d) PVC or bronze control valve downstream of the pump.

e) Bronze strainer (1mm) upstream and downstream of the pump.

f) 10 or 25 bar pressure gauges as appropriate upstream and downstream of the pump.

g) Piping, treated against or resistant to corrosion.

Chlorine Circuits

a) Chlorine resistant non-return valve.

b) Anti-siphon system

c) Chlorine resistant chlorinated solution injection device.

d) Chlorine resistant pipework for chlorinated solution injection.

e) Chlorine resistant pressure relief piping for release of gaseous chlorine in the event of over pressure, to a maximum length of 8m.

f) Piping between chlorinator and injection device, complete with fittings, all of chlorine resistant material.

310.4 CHLORINATION OF PRESSURISED AND GRAVITY SYSTEMS IN THE ABSENCE OF ELECTRIC POWER SUPPLY

This system is for use where there is no power supply available, for example supply and delivery lines at reservoirs, catchment areas and headworks.

The chlorination process shall cease immediately in the event of lack of water.

a) Chlorination under low pressure

Use of low pressure chlorinators shall only be used where use of vacuum types is impossible due to insufficient line pressure.

The chlorinator shall be either wall mounted or directly assembled to a gaseous chlorine bottle, the latter providing pressure for operation of the chlorinator. A chlorine resistant piping connection shall link the chlorinator to a diffuser. In the case of a reservoir a spring loaded check valve shall be installed at the point of chlorine injection.

A nozzle injector rather than a diffuser shall be used for injection into a pipeline.

Where injection is into the pipeline pressure in the line shall always be more than 0.1 bar (g) and shall not exceed 0.7 bar (g). Partial vacuum in the pipe must be prevented.

In the case of a reservoir the level of water in the reservoir shall always be at least 1m above the diffuser.

The size of the piping between the chlorinator and the injection point will be a function of both dose rate and distance between the points.

b) Chlorination by Vacuum Chlorinator

Chlorination under vacuum only applies to reservoir gravity supply lines, the latter associated with a minimum hydraulic pressure of 0.5 bar. A hydro ejector shall achieve the required hydraulic pressure for injection provided a pressure drop is produced downstream of the hydro ejector feed point (By a valve or diaphragm).

The Contractor shall optimise the locations of feed and injection points in such a way as to achieve a minimum hydraulic pressure of 0.5 bar upstream of the hydro ejector. The capacity of the chlorinator shall not exceed 200 gr/hr at a hydraulic pressure of 0.5 bar or 300 gr/hr at a pressure of 1 bar, unless otherwise specified.

Chlorination shall cease immediately in the event of lack of water in the line.

c) Chlorination Dosing Pump

Disinfection shall be achieved by injection of chlorinated lime or sodium chloride (Javel water), by means of a dosing pump proportionally to the rate of flow of water. The chlorinated solution shall be stored in corrosion proof tanks.

The operation of the dosing pump shall be controlled by a flow meter equipped with a pulse transmitter. A control system receiving the transmitted pulses, shall regulate the dosage of chlorinated solution.

Supply of power shall be by:

A low leakage, self discharge, maintenance free battery with no water addition required.

A battery charging solar panel complete with either a charge regulator or an electronically controlled battery charger housed in a class IP55 box equipped with LED indicator. The contractor shall supply and install such other equipment as may be necessary for the operation of the system.

310.5 CONTROL SYSTEMS BASED ON FLOW RATE OF WATER

310.5.1 General

The control system shall comprise a chlorine injection regulating system. It shall include:

a) A chlorinator for use with pressurised water systems.

b) A water flow meter with an output signal proportional to the rate of flow to be treated.

c) A motorised chlorine flow control valve with feedback signal to the control system, the signal to be proportioned to the chlorine injection rate.

d) A feed back control system with signal comparator. In the case of signal discrepancy the control valve servomotor shall be actuated to adjust the injected dose of chlorine.

e) The injection nozzle and/or hydro ejector.

f) If specified the facility to receive a signal from a residual chlorine analyser which will adjust the chlorine/water ratio.

310.5.2 Requirements of the above Control Systems

a) Chlorine Flow Control Valve

The motorised control valve shall be functionally compatible with the chlorinator. It shall achieve automatic control of the chlorination process as a function of the rate of flow of water to be treated.

The supply voltage shall be 220V, 50 Hz with a two pole circuit breaker equipped with adjustable thermal trip.

The valve capacity shall not exceed 10 kgf (gaseous chlorine)/hr. It shall receive and transmit a 4-20 mA signal to the chlorinator. The valve can either be incorporated in the chlorinator or installed separately in the system.

b) Water Meter

The water flow meter which may be of the turbine, magnetic flow, diaphragm or ultrasonic type, shall control the operation of the motorised control valve. It shall have the following characteristics.

a) Be suitable for fluids with up to 80 mg/l solids particle content. It shall be designed for a range of water velocities from 0.5 to 3.0 m/s and shall transmit a 4-20 mA signal.
b) Operate on a supply voltage of 220V or 110V - 50 Hz.
c) Be equipped with a rate of flow indicator.

310.6 CONTROL SYSTEMS BASED ON RESIDUAL CHLORINE METERING

310.6.1 General

The system shall include:

a) A vacuum chlorinator injecting into a pressurised water system.
b) Chlorine injector flow control valve actuated by a converter to a residual chlorine analyser with signal transmission to the control valve of a signal proportional to residual chlorine concentration in the treated water.

The residual chlorine analyser shall be equipped with an electronic transmitter, and shall be one of two types.

310.6.2 Type "A" (with reagent)

The residual chlorine analyser shall be of the amperometric type for measurement of residual chlorine in water.

It shall include:

1. Measuring cell.
2. Suitable reagent to allow measurement of the concentration of total and/or free residual chlorine.
3. Amplifying circuit and converter with 4-20 mA output signal. The above to be incorporated in the analyser bar.
4. Zero point and scale adjustment features with automatic temperature compensation feature, to compensate for errors due to temperature fluctuation of the sample.
5. Direct reading indicator.
6. All components to be installed in a corrosion resistant box. The characteristics shall include:

    - Scale range 0-0.5, 0-2.0 mg/l
    - Water sample temperature range 0-50°C.
    - Output signal 4-20 mA
    - Supply voltage 220v - 50 Hz with 2 pole circuit breaker with adjustable thermal trip.
    - Indicator: located on front of analyser.
      Direct reading in mg/l
      Accuracy ±2% of scale range.

310.6.3 Type "B" (Dry Type)

The analyser shall consist of a potentiometric cell fitted with three metallic electrodes that shall generate a current directly proportional to the concentration of free residual chlorine.

It shall be equipped with a potentiometric amplifier and a converter to transform the current to a 4-20 mA signal.

The circuitry shall include a zero point and scale adjustment feature as well as automatic temperature compensation feature (Thermistor) in order to compensate for errors due to temperature fluctuations of the sample.

It shall have a direct reading indicator and be installed in a corrosion resistant box.

- The characteristics shall include:
- Scale ranges 0-0.5, 0-2 mg/l

- Water sample temperature range 0-50°C
- Output signal 4-20 mA
- Supply voltage: 220V - 50 Hz with 2 pole thermal magnetic circuit breaker.
- Indicator: located on front of analyser
  Direct reading in mg/l
  Accuracy ±2% of scale range.

310.7 AUXILIARY EQUIPMENT FOR CHLORINATION AND STORAGE

310.7.1 General

Where electric power is available the chlorination room shall be equipped with an extractor fan roof mounted cowl typetop discharge (10m static pressure), suitable for chlore extraction. The fan shall be connected to a PVC pipe of 100mm bracketed off the internal wall of the rroms. The pipe shall run vertically inside the rooms and be fitted with a mosquito net and weather cowl at the inlet. The fan shall give twenty air changes per hour and shall have a control switch located outside the building. A sign shall be fixed outside on the door "Danger, Toxic Gas - Access for authorised personnel only".

These shall be available at each chlorination building 2 No gas masks consisting of an integral mouth piece and wide view visual piece covering the entire face, complete with flexible breathing tube and filter cartridge with hipstraps.

2 No additional filter cartridges shall be supplied with each mask. The masks shall be kept in a dedicated wall mounted cupboard in the control room or attendants room. The cupboard door shall have affixed to it a label stating "Chlorine gas masks. Fit new cartridge before use"

The filter shall be effective in neutralising gaseous chlorine.

A emergency eye wash and shower system shall be fitted to the wall immediately outside the chlorination room for emergency use. It shall have a chain operated valve.

When specifically called or deemed necessary, the chlorination room shall be fitted with an orange windsock of airport quality mounted on the top of the building. The sock shall be made of nylon and shall be chemically treated and ultraviolet dyed to prevent fading. The sock shall be mounted on a frame specially made for this application that does not lock up and shall be visible from the entrance door of the chlorine building.

310.7.2 Chlorine Bottles

2 No chlorine bottles shall be supplied with each chlorinator. They shall be 50 kgf capacity each unless specified otherwise.

Each bottle shall be equipped with:

- An isolating valve, which shall be provided with a protective cap during transport.
- Where specifically called for, an automatic chlorine supply change over to a standby bottle on depletion of the duty bottle. The system shall be wall mounted and shall be functionally compatible with the chlorinators. It shall function on partial vacuum and shall be complete with all accessories and fittings The change over switch should include an indicator showing the cylinder in service.
- A bottle rack and chain support.
- Where specifically called for, a permanent weighing device shall be provided beneath the

bottle in service to continuously monitor the rate of chlorine consumption.

310.7.3 Chlorine Detector

Where specifically called for or deemed necessary, gaseous chlorine detector units shall be fitted. The gas leak detector shall be used in conjunction with an alarm which shall be actuated if the gas concentration arises above 1 ppm or 3 mg gas/cu.m of air.

The detector may be one of two types:

310.7.3.1 Type A (Dry Cell)

The gas detector shall consist of an independent tank and detection cell located outside the tank. The tank capacity shall be sufficient to give 6 months operation. The detection cell (sensibility 1mg/cu.m) shall be connected to an electronic measuring device located in a wall mounted box. In the presence of an oxidising gas the detection cell shall generate a current proportional to the gas concentration.

The box shall have an electronic indicating device and shall give continuous monitoring.

When gas concentration reaches its maximum permissible limit the detector shall activate visual and acoustic alarms, and shall trigger the operation of a remote alarm, where fitted, the operation of the extractor fan and closure of the supply line valves.

A test push button shall be provided to allow the operation to be checked.

310.7.3.2 Type B (Wet Cell)

The detector shall have live electrodes under constant supply voltage, immersed in an electrolyte that shall conduct current in the presence of an oxidising gas. The generated current shall be amplified and converted to a signal.

310.8 LEAK DETECTION, RESIDUAL, FREE RESIDUAL AND TOTAL RESIDUAL MEASUREMENT

A bottle of liquid ammonia for chlorine vapour leak detection purposes and a measuring kit for quick determination of the concentration of the following shall be provided with every chlorination equipment installation.

- Free residual chlorine
- Residual chlorine
- Total residual chlorine

Details of the equipment to be provided, which shall include all auxiliaries, shall be provided with the tender.

310.9 MONITORING AND CONTROL

The chlorination system shall have interface signals for the monitoring and/or control by a central computer station as specified.

As a minimum requirement, the chlorination system shall acquire the flow measurement analogue signal and provide the following outputs:

- RS 485 interface output for data exchange with computer based systems (PLCs, Monitoring station, etc.)
- Residual chlorine analogue signal where specified.
- Booster pumps status (ON/OFF/FAULT).
- Chlorine leak detection alarm.
- Vacuum switch alarm. This switch shall be integrated or fitted to the chlorometer to signal high or low vacuum level to the plant control system. The alarm shall be visual and audible. The switch contacts shall be set at manufacture as required by the particular site at which the chlorinator is to be installed.

310.10 INSTALLATION OF EQUIPMENT

The location of the chlorine bottles in the store shall be away from direct sunlight at all times. During transportation of bottles the contractor shall ensure that gas bottles are not overturned and that safe handling procedures are adopted at all times.

Gaseous chlorine piping connections between system components shall follow the shortest and most direct route possible and shall be laid to falls.

Water and other piping shall not be laid immediately alongside gaseous chlorine piping in order to prevent cooling and condensation.

Only grease or other lubricant as recommended by the equipment manufacturer shall be applied to all removable fittings.

Where the chlorinator is installed remote from the gas bottle the distance apart shall not exceed 10 metres.

The chlorinator vapour vent pipe shall be extended to outside the building away from inhabitated areas. The vent pipe outlet shall be covered with a mosquito net.

Chlorination equipment piping shall be secured to the wall by brackets with a minimum clearance of 100mm off the walls for painting and maintenance purposes.

310.11 SYSTEM START-UP

The procedure for putting chlorination equipment into service shall include:

- A bacteriological and physico-chemical analysis of the water to be disinfected.
- Determination of the chlorine demand of the water to be disinfected based on break point method.
- Adjustment of the chlorinator capacity to achieve, after 30 mins of chlorine to water contact a residual concentration of 0.5 mg/l. A check shall be made by measurement of the concentration of free chlorine in water at a pre-determined location in the water distribution system.

In the case of a chlorinator controlled by an automatic residual chlorine measuring device, the indicated concentration shall be checked against the result of an analysis of residual chlorine in the water sample.

310.12 DISINFECTION CONTROL

Following start up of the chlorination system the contractor shall take five samples of disinfected water at five different locations situated at representative distances from the chlorination point so as to achieve effective control of the quality of disinfected water. The following tests shall be undertaken.

- Measurement of free chlorine (Type b1)
- Measurement of free chlorine in water.

310.13 SITE PROCEDURES AND TRAINING

310.13.1 General

Training should be carried out with emphasis being given to safety precautions and methods of dealing with emergencies. Particular attention should be given to the following aspects:

(a) the hazards and characteristics of the material;
(b) safe methods of plant operation, including handling of the connection to supply systems;
(c) methods of maintenance;
(d) special operations; for example, plant shut down and start-up, methods of isolation and preparation of equipment for periodic maintenance and inspection;
(e) the location and operation of emergency shut-off valves;
(f) the procedures to be followed if releases occur;
(g) training in the use of all personal protective equipment supplied.

310.13.2 Operating Instructions

The operating instructions should cover each process operation. Written operating instructions are required, in English and Arabic, for all routine and emergency operations, ranging from guide cards for simple operations to complete manuals.

Copies of the instructions, which should include a flowsheet and indicate valves to be closed in an emergency, should be available in the working area for operators.

310.13.3 Emergency Arrangements

The emergency procedure should include how gas releases may be dealt with safely by site personnel. The procedure should cover various degrees of emergency and should be either supplied in written form or made available to employees so that they know the steps they are required to take. This procedure should include first aid and evacuation arrangements.

310.14 TESTS ON COMPLETION

The tests on completion of the chlorination system shall include the following:

1. Injection rate
2. Injection pressure
3. Absence of leaks
4. Injected concentrations
5. Compliance with specification
6. Safety criteria
7. Such other tests as the Engineer may determine.

310.15 NEUTRALIZATION CHAMBERS

Where specifically called or deemed necessary, a neutralization chamber shall be provided. For safety considerations a chlorine leak detection and neutralization system shall be provided with a capacity to treat the chlorine fumes of the largest full chlorine container present at the site.

The neutralization system shall have adequate absorption stages operating under negative pressure (vaccum) including all ducting. It shall consist of the following:

1. A fan to extract the chlorine-laden air;
2. A neutralization tower with contact rings, mist eliminator, and vent system;
3. Necessary neutralization and water recirculating pumps, nozzles, sprayers, piping, valving, etc...
4. A storage tank for the neutralization solution and required chemicals;
5. Necessary ducting, piping, valves, fans, and miscellaneous appatenances;
6. Electric and Mechanical auxiliaries for monitoring instrumentation and control.

The neutralization system shall be capable of treating chlorine gas release at a rate of 45Kg/min with an overall efficiency performance of 99.998 percent removal of the chlorine vapor in the vent discharge.

The scrubber system shall run until the gas concentration in the chlorine storage room is reduced to 1 ppm in less than an hour.

The leak detector and the extractor fan inlets shall be positioned at floor level in the storage premises. The chlorine storage units, the evaporator-chlorinator assembly, and the leak neutralization tower shall be located in separate rooms. In the event of a chlorine leak in the premises where the chlorine cylinders are located, a chlorine leak detector shall sound an alarm lock up the ventilation fans and automatically start the fan that extracts the air from the polluted places to the neutralization tower. The chlorine laden-air flows shall go through the mass of contact rings in the opposite direction to the neutralizing solution. The chlorine neutralization system shall be capable of neutralizing the volume of the largest full chlorine container present at the site.