OXFAM

Motorisation of Yelulu Water Supply System

REFERENCE NO.: 19/005/ARU-UG

BIDDING DOCUMENT

ANNEX VIII: Technical Specifications

January 2019

Technical Specifications

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1 GENERAL CLAUSES

1.1General

Chapters 1, 2, 3, 7, 8 and 10 are particular to the Contract and shall take precedence over Chapters 4, 5, 6, 9 and the 4th Edition of the Civil Engineering Specification for the Water Industry (CESWI) and the CESWI Appendix, which contain standard specification clauses.

Clauses refer to all Parts of the works unless specified otherwise.

1.2 Purpose and Location of the Works

The purpose of the Works is to motorise Yelulu Water Supply system, located in Arua District in West Nile region of Uganda, in the Republic of Uganda.

The Works will be in two Parts, as described below:

Part 1: Water Supply Pipe Laying

Supply and laying of new pipelines and associated fittings.

Part 2: Buildings, Reservoirs, and Mechanical -Electrical Works

The installation of a submersible borehole pump at Yelulu borehole DWD 57363; the respective power supply and construction of a pump house and guard/attendant's house, fences and a water service storage tank.

1.3 General Description of the Works

The bid is for the supply and installation of solar power supply, solar-powered submersible water pump, water pipes; the civil works for tanks, guard and pump houses; the supply and commissioning of mechanical and electrical plant for the pump; guard house, and pump house. The extent of the Works is specified in Chapter 2.

A brief description of the facilities to be provided under this tender in the three arts of the Works is given below.

Part 1 Water Supply Pipe Laying

Part 1 of the Works comprises the supply and laying of water pipes, as shown on the Issued Drawings, and will consist of the following items.

- Supply and laying of pipes and fittings;
- Supply and installation of bulk flow meters;
- Supply and installation of washouts, air valves and associated chambers;
- Supply and installation of consumer connections, and service pipes;
- Further details of the work to be undertaken are given in Clause 2.1.

Part 2 Buildings, Tanks, and Mechanical -Electrical Works

Part 2 of the Works comprises the civil, mechanical and electrical works for the pump station, pump house guard/attendant house and a water storage tank. The details are in the Issued drawings and summarised as follows: -

- Construction of a new pump station, pumping mains pipes and associated site works
- Construction of a 01No. new water storage tank, and associated pipe and site works
- Supply and installation of solar panel arrays with support structures, including pump controllers, high-capacity submersible solar-powered water pumps with accessories and electrical/mechanical works
- Supply and installation of lighting at the pump station
- Fencing of the pump station and the reservoir site
- Construction of a pump house and attendant's house s

Further details of the work are given in clause 2.2.

1.4 Other Contracts

No other contracts are foreseen.

1.5 Plant Design

Part 2

The whole of the Plant shall be designed and constructed to the best standard.

A manufacturer's standard design may be used for a Plant item where such a design is available and where it is at least equal to and compatible with that required by the Specification.

The Plant shall be new, of sound workmanship and robust design, and of a grade and quality suitable for the duty concerned and for the climatic conditions at the Site.

The Plant shall be designed to provide adequate protection against the entry of vermin and dust and to minimise fire risk and consequential fire damage.

All parts, which can be worn or damaged by dust, shall be totally enclosed in dust proof housings.
All equipment shall operate without excessive vibration and with minimum of noise.

All similar items of Plant and their components together with spare parts shall be made from the same materials and shall be fully interchangeable.

All manually operated Plant not located inside a building shall be provided with facilities for making it tamper proof. This is in addition to any requirements of the Specification for securing Plant under operational conditions.

The standards of workmanship and finish shall be uniform throughout and the final colours shall be designated by the Engineer.

Materials used in the Works which are or can be in contact with the untreated or treated water shall not contain any matter which could impart taste or odour or toxicity or otherwise be harmful to health or adversely affect the water conveyed. Approval by Technischer Überwachungsverein Germany or the National Water Council UK or the Uganda National Bureau of Standards will generally be regarded as satisfactory evidence of suitability.

1.6 Design Life

Parts 1 and 2
All materials and equipment shall be designed for long life and continuous operation during prolonged periods with a minimum of maintenance and the Contractor may be called upon to demonstrate this for any component either by the service records of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall, as far as possible, not require the services of highly skilled personnel.

The materials of construction of the Plant shall be selected, taking into consideration their location and duty, such that the economic life of the Plant is not less than 25 years.

Except for consumable items such as gland packing, carbon brushes etc. which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continual operation. Where major dismantling is required to replace a part, such life shall be not less than five years.

1.7 Regulations, Standards, Codes and Standard Specifications

The Contractor shall obtain at least one copy of each DIN, ISO, BS, CP or other approved standard and reference work which is referred to in the Specification, and of each other standards which applies to materials which are being supplied to, or workmanship executed on, the Works. These standards and reference works shall be supplied to the Engineer within 90 days of the Engineer's Order to Commence the Works and will be available to the Contractor at all reasonable times.

Parts 1 and 2
Wherever reference is made in the Contract to specific standards and codes to be met by the materials, plant, and other supplies to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the contract. Where such standards are national, or relate to a particular country or region, other authoritative standards, which ensure a substantially equal or higher performance than the standards and codes specified will be accepted subject to the Engineer's prior review and written approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's approval. In the event that the Engineer determines that such proposed deviations do not ensure equal or higher quality, the Contractor shall comply with the standards specified in the documents.

All standards used will be the current version. A Contractor proposing to use alternative versions of specified standards and codes shall submit the alternative version to the Engineer for approval in

accordance with the requirements outlined in the above paragraph.

All materials and workmanship not fully specified herein or covered by an approved standard shall be such kind as is used in first class work and suitable to the climate in the project area. Where the requirements of any such standard specification or regulation conflict with the requirements of this Specification or any item on the Drawings, then the Contractor should refer to the Engineer for clarification before proceeding with that section of the Works.

Materials, installation and testing of pipelines and their associated works shall be in accordance with the Civil Engineering Specification for the Water Industry, 4th Edition.

Part 2
Except where otherwise specified all materials and workmanship shall comply with current national standards provided that these standards are not less stringent than the equivalent German Standards, British Standards or Codes of Practice or provided that they comply with the requirements of the International Organisation for Standardisation (ISO) or the International Electro-technical Commission (IEC), as appropriate.
The electricity installation shall comply with all relevant statutory regulations and standards current at date of the bid, unless otherwise indicated within this Specification. Electrical installations shall, where relevant, be in accordance with the IEE Regulation for Electrical Installations, 16th Edition.

1.8 Drawings

Part 1
The Drawings comprise the following:

- Issued Drawings

The Issued Drawings as hereinafter described.

- Approved Drawings

Approved Drawings as hereinafter described. Installation of pipelines and other works for which Approved Drawings are required shall not begin until the appropriate Approved Drawings are available. The plant shall be installed in accordance with the Approved and Engineer's Drawings.

- Engineer's Drawings

The drawings issued from time to time by the Engineer.

- Other Drawings

Part 2
The Drawings comprise the following.

- Issued Drawings

The Issued Drawings as hereinafter described.

- Bid Drawings

The Bid Drawings as hereinafter described.

- Approved Drawings

Approved Drawings as hereinafter described. Manufacture of the Plant shall not begin, nor shall erection of the Plant commence, until the appropriate Approved Drawings are available. The Plant shall be manufactured and erected in accordance with the Approved and Engineer's Drawings.

- Engineer's Drawings

The drawings issued from time to time by the Engineer.

- Record Drawings

Record Drawings as hereinafter described.

- Other Drawings

1.9 Issued Drawings

These are drawings issued to the Contractor with the Bid Documents for the purposes of preparing a bid.

Such drawings shall be deemed to have been issued for the guidance of bidders, and shall be referred to for the interpretation of the Contract only where the drawings supplied by the Contractor at the time of bidding and incorporated in the Contract are insufficient.

1.10 Bid Drawings

The Bid Drawings are supplied by the Contractor for the purpose of illustrating his bid, namely:

- a layout of the whole scheme, scale 1 : 1000;

- drawings and technical details of the Plant in sufficient detail to illustrate that the several items of Plant are suitable for their intended purpose.

Where Bid Documents including Drawings show features not in compliance with this Specification, and where such features are not listed in the Technical Schedules then the requirements of the Issued Documents will be taken as the basis of the Contract.

1.11 Approved Drawings

With reference to Sub-Clause 1.25 of the General Conditions the Contractor shall submit, for approval, each drawing in the following categories and schedule.

Part 1

- Pipe Laying Drawings

For the installation of service connections, fittings, valves, pipelines and service pipes, these drawings shall include details of all service connections to be installed by the Contractor. Where water pipelines and service pipes are to be laid these drawings shall show the position, material, class, diameter, length and pipe invert and ground levels above mean sea level, other services to be encountered or crossed by the pipeline and any structures to be constructed along it including valve/meter chambers, manhole chambers, trench cut-offs and anchor blocks.

Parts 2 and 3

- Preliminary Layout Drawings
  - These shall be submitted within 1 month of the Commencement Date.
  - These drawings shall show locations of major structures and site layouts.

- Preliminary Civil Outline Drawings

These shall be submitted within 2 months of the Commencement Date.

These drawings shall include information to allow the structural design to commence.

These drawings shall inform the Engineer of the basic physical shape, including channel sizes, and positions relative to one another, of the structures, and confirm the hydraulic levels through the plant.

They shall indicate in broad terms the locations for plinths and pipelines (greater than DN 250 mm) through walls. Location, line and level of major equipment/structures shall be positioned to an accuracy of ±300 mm. They shall not detail final position for equipment and loadings or wall thicknesses and the like.

Loadings' accuracy for major plant shall not be less than final load nor greater than 120% of final load.

- Detailed General Arrangement Drawings

These shall be submitted within 3 months of the Commencement Date.

These drawings shall include information required to allow all major structural design and civil general arrangement drawings to be completed.

These drawings shall comprise:

- general arrangement drawings to scale of site plans showing each structure and building, principal routes for cables, pipes and chemical ducts and services;
- drawings of each building/structure shown in plan and elevation to show position of major items of plant.

- Final Civil Outline Drawings
  - These shall be submitted within 4 months of the Commencement Date.
  - These drawings shall include information to allow all major civil detail drawings to be completed.
  - These drawings shall include final positions and loadings and dimensions of major plant.

- Plant Drawings

These shall be submitted within 5 months of the Commencement Date and shall include but not be limited to:

- general arrangement drawings to illustrate the position of the Plant in relation to the appropriate part of the Works in sufficient detail to show all the principal dimensions, methods of support and other relevant information;
- drawings of the Plant in sufficient detail for the Engineer to satisfy himself that jointly and severally the items of the Plant are suitable for their intended purpose;
- sectional drawings of each major item of the Plant, with a parts list and a list of materials to be used for each part. General arrangement of electrical panels with foundation and cable access details;
- diagrammatic outline and detail drawings of all services to, from and between the several items of the Plant, including potable and process water supplies, pipework, connections and fittings, electrical single line and schematic diagrams, cable schedules and site cable layout, connections and fittings, and drainage pipework and fitting;

- requirements for incoming supplies, services etc and details of interface connections in respect of the Plant, particularly where such connections are at the limit of Contract;

- details of wastes, effluent discharges, etc. and details of interface connections in respect of the Plant, particularly where such connections are at the limit of Contract;

- detailed drawings of the Plant and data in sufficient detail as may be reasonably required for the Engineer to satisfy himself as to the stability, durability and safety of the works and for ascertaining of inspection of the Plant during construction that it is in conformity with the Contract;

- fully detailed installation drawings giving complete dimensions of pedestals, cuts, chases, bolt holes, ducts and other provisions to be made in the civil structures and on site of fixing the Plant.

1.12 Procedure for Approval of Drawings

Unless otherwise indicated within this Specification, preliminary copies of drawings for approval shall be submitted to the Engineer.

Any alterations required by the Engineer to be made to drawings submitted for approval shall be made by the Contractor without extra charge, or extension of time, provided such alterations are not consequential upon a change in the requirements of the Contract.

Drawings when approved will be stamped with the Engineer’s approval stamp and one copy of each such approved drawing will be returned to the Contractor.

Acceptance of Bid Drawings shall not be deemed to confer the Engineer's approval upon them.

1.13 Record Drawings

Parts 1, 2 & 3

The Contractor shall provide a set of as built drawings for the works. He shall submit four hard copies of the drawings, a soft copy (digital format), a print out of the co-ordinates of the fixtures (e.g. valves, bends, manholes, etc.) and an electronic copy of the co-ordinates. The Contractor shall agree the details of the electronic copies with the Engineer

Parts 2 & 3

A coloured and framed drawing showing all valves, pipe runs etc., together with detailed operating instructions for use in the pumping station and four full sets of Record Drawings will be required by the Employer on the completion of the work. The Drawings and one soft copy (digital format) shall be fully dimensioned, general arrangement and detail drawings together with electrical wiring diagrams. All drawings submitted for approval shall be included in the record drawings. Revised drawings shall be submitted within one month of any amendments made during erection. The record drawings shall be submitted with the operating instruction manuals as specified in Clause 1.21.

1.14 Contractor's Calculations and Technical Details

Parts 2 & 3

Within two months of the Commencement Date the Contractor shall submit to the Engineer design calculations and technical details of the Plant and structures further to those accepted with his Bid, in sufficient detail for the Engineer to satisfy himself that the items of the Plant and the structures are

jointly and severally suitable for their intended purpose.

The design calculations and technical details shall include design calculations, piping and instrumentation diagrams, hydraulic flow diagrams, technical details and schedules of major plant and structures.

The Contractor shall also provide such additional details and calculations and other data as may be reasonably required by the Engineer to satisfy himself to the stability, durability and safety of the works and for ascertaining and inspection of the plant and structures during construction that it is in conformity with the Contract.

The Contractor shall submit as part of his technical details, the magnitude and frequency of all out of balance forces of the plant to allow them to be considered in the structural design of civil and building structures.

1.15 Programme

Parts 1, 2 & 3

Before commencing the Works, the Contractor shall, submit to the Engineer for his approval a programme showing the order in which he proposes to carry out the Works. The programme shall be in the form of a bar chart, or any other form as may be agreed by the Engineer, and shall be co-ordinated to consider transportation and delivery times for the materials and for climatic and other conditions to provide for the completions of the Works in accordance with the Contract. The programme shall clearly indicate the following:

- the sequence of each activity, the proposed start and completion dates of each activity, the rate of progress and the cumulative quantity of percentage of work expected to be achieved on each activity by the end of each month;

- dates by which major drawings requiring the Engineer's approval will be submitted (a period of three weeks shall be allowed from date of receipt of these drawings for such approval);

- the time allocated for work by others, including those of the Employer and by utility undertakings.

Sufficient space should be provided in the programme for recording the actual progress against the programmed progress for each activity.

The programme shall be submitted with details of the following:

- a statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled workers to be employed on the Works;

- a list and type details of major Constructional Plant (including vehicles) which the Contractor proposes to employ on the Works;

- details of the Contractor's methods of working for all operations;

- a statement giving the proposals for location or locations and sizes of accommodation, offices, workshops and stores;

- details of the programme for the Works from the date of receipt of the Engineer's order to commence the Works including a complete resource allocation showing the number of units and

allotted times for each unit of Constructional Plant, materials and labour allocated to each part of the Works.

1.16 Progress Meetings and Reports

During the period of the Contract, the Contractor shall allow for all consultations with the Employer and the Engineer and his staff located in the project area, or elsewhere as necessary.

From the commencement of the work on Site there will be a series of monthly Site progress meetings to coordinate the civil and plant works. Representatives of the Contractor, approved by the Engineer, shall attend monthly progress meetings on Site or at the offices of the Employer. In addition, approved representatives of the Contractor shall attend further meetings in cases of emergencies or for other reasons when called upon by the Employer.

The Contractor shall submit to the Engineer each month a report on his progress in the performance of the Contract. The report shall include a copy of the approved programme with the current progress for each activity shown.

1.17 Organisation of Activities

Parts 1, 2 & 3

The Contractor shall organise his activities within the Contract Area in such a way as to minimise disruption to both the public, to water consumers and his sequence of working shall be clearly indicated in the Programme. The Contractor shall submit a fully detailed programme of work to the Engineer for approval.

1.18 Notice of Operations

The Contractor shall give full and complete written notice of all important operations to the Engineer sufficiently in advance of not less than 48 hours and in a form approved by the Engineer, to enable the Engineer to make such arrangements, as he may consider necessary for inspection or for any other purpose. The Contractor shall not commence any important operation without the written approval of the Engineer.

The Notice of Operation shall be followed by a Request for Inspection/Approval, in a form approved by the Engineer, in which the Contractor shall seek permission for executing any part of the Works.

Important works shall include all operations occurring on the site outside the following hours:

- Monday to Friday: 8:00 am to 5:00 p.m. These shall be the normal site working hours.

1.19 Public Holidays

The Contractor shall allow in his programme for the following 14 public holidays per calendar year as observed in the Republic of Uganda and upon which days the Contractor shall not be permitted to work:

(a) New Year's Day (1st January),
(b) NRM Anniversary Day (26th January),
(c) Janani Luwum Day (16th February),
(d) Eid al-Fitr,
(e) Women's Day (8th March),

(f) Good Friday,
(g) Easter Monday,
(h) Labour Day (1st May),
(i) Martyrs' Day (3rd June),
(j) Heroes' Day (9th June),
(k) Independence Day (9th October),
(l) Eid al-Aduha,
(m) Christmas Day (25th December),
(n) Boxing Day (26th December).

It is important for the contractor to note that from time to time the government may designate certain days as public holidays in addition to those listed above.

1.20 Site Management

The Contractor shall keep complete and accurate records, using a form approved by the Engineer, of Works and associated activities and events on Site. These records shall include, but are not limited to, details of the Works executed; delivery to Site of Materials, Plant and Contractor's Equipment; removal from Site of any item of Contractor's Equipment and weather conditions.

The Contractor shall prepare monthly progress reports and submit them to the Engineer in three copies. The first report shall cover the period up to the end of the first calendar month following the Commencement Date. Reports shall be submitted monthly thereafter, each within 7 days after the last day of the period to which it relates.

Reporting shall continue until the Contractor has completed all work which is known to be outstanding at the completion date stated in the Taking-Over Certificate for the Works.

Each report shall include

a) Charts and detailed descriptions of progress, including each stage of design (if any), Contractor's Documents, procurement, manufacture, delivery to Site, construction, erection and testing; and including these stages for work by each nominated Subcontractor,

b) Photographs showing the status of manufacture and of progress on the Site;

c) For the manufacture of each main item of Plant and Materials, the name of the manufacturer, manufacture location, percentage progress, and the actual or expected dates of:
    i) commencement of manufacture,
    ii) Contractor's inspections,
    iii) tests, and
    iv) shipment and arrival at the Site;
d) Records of Contractor's Personnel and Equipment;

e) Copies of quality assurance documents, test results and certificates of Materials;

f) Safety statistics, including details of any hazardous incidents and activities relating to environmental aspects and public relations; and

g) Comparisons of actual and planned progress, with details of any events or circumstances which may jeopardise the completion in accordance with the Contract, and the measures

being (or to be) adopted to overcome delays.

1.21 Packing and Protection

Before any item is despatched from a manufacturer's factory it shall be adequately protected and packed so as to arrive at the Site intact and undamaged. The Engineer shall be given at least 14 days' notice that packing will commence. The method of protection and packing must be suitable to withstand the conditions, which may be experienced in shipment and delivery to the Site. It should also be suitable to withstand long periods of storage out of doors.

No one crate or package shall contain items of Plant intended for incorporation in more than one part of the Works.

All items shall be clearly marked for identification against the packing list, which shall be placed in every crate or package and protected in a waterproof envelope.

All crates and packages shall be clearly marked with a waterproof pen and weather-proof material to show the weight and where the weight is bearing, and where the sling should be attached. They shall also be marked to identify the packing lists.

Bright parts and bearing surfaces shall be protected from corrosion by the application of a rust-preventive lacquer, high melting point grease or similar. A sufficient quantity of appropriate solvent shall be supplied with the Plant for the removal of this protection.

Each crate or package shall have a clear indelible and, as far as possible, indestructible unique identification cypher, also quoted on the packing list inside it. Three copies of the packing list shall be posted separately to the Engineer at the time of shipment.

All flanges and mating surfaces shall be protected by means of a wooden template or similar. The bolts for securing this template shall not be secured by the bolts, screws etc., which form part of the final installation.

1.22 Commissioning

The Contractor is required to provide suitable personnel, to be approved by the Engineer, to operate each section of the Works during commissioning, i.e. the setting to work and testing of individual components of the Works or the complete Works. This shall include Tests on Completion as more fully defined in Chapter 7. Commencing during the commissioning period the Contractor shall instruct the Employer's staff in the operation and maintenance of each section of the Works as specified in Chapter 8.

1.23 Operating Instructions

Parts 2 & 3

The Contractor shall provide five sets of instruction manuals for each of the sections of the Works to cover all items of the Plant and process. The manuals shall describe the installation and operation as a whole and give step by step procedures to enable the Employer to carry out any operations likely to be required during the life of the Plant including erection, commissioning, testing, operation, maintenance, dismantling and repairs. The instructions shall include the operation of valves, etc. existing or provided by others where the operation of these items is part of or associated with any aspect of the Plant operation.

The maintenance instructions shall include lubrication charts, testing and replacement procedures to be carried out daily, weekly, monthly, and at other intervals to ensure trouble-free operation. Where applicable, fault location charts should be included to facilitate finding the cause of imperfect operation or breakdown.

Sections of the manuals shall be devoted to each size and type of equipment with relevant detailed descriptions of construction, maintenance and operation with lists of parts and procedures for ordering spares.

The Contractor shall supply five sets of manuals and record drawings for each section of the Works to the Engineer two months before starting the tests on completed plant systems. Where appropriate preliminary draft copies of instructions shall be submitted during erection to facilitate erection and testing of equipment prior to Plant commissioning. Two complete sets of manuals shall be submitted to the Engineer for approval including certification of equipment, three months before the final submission described above.

The manuals shall be fully bound and indexed to A4 size with the name of the Employer, Contractor, the Contract number and name of the scheme clearly marked. A collection of manufacturer's descriptive leaflets will not be acceptable as an instruction manual.

1.24 Water and Electricity Supply

Parts 1, 2 & 3

The Contractor shall make his own arrangements for the supply of water and electricity for the purposes of the Works.

In the event of a reservoir or pipeline failing hydraulic tests, the Contractor shall be responsible for disposing of the test water to allow repairs to be carried out, and for costs of any water tankers required for supplying water for subsequent re-tests.

Water and wastewater derived from the construction, testing and completion of the Works shall be disposed of to the satisfaction of the Engineer so as to cause no damage or complaint.

The Contractor shall provide consumers whose water supply has been disconnected during construction works with potable water. The Contractor can bill for these services as provided for in the Bills of Quantities.

1.25 Contractor's Facilities

The Contractor shall provide all site facilities including offices, workshops, stores, accommodation, washing, sanitation etc. necessary for use by his own staff, for the execution of the Works.

The Contractor shall be responsible for making all arrangements for drainage from his site facilities and shall be responsible for payment of all charges in connection therewith.

1.26 Storage of Plant and Equipment

Parts 2 & 3

The Contractor shall be responsible for and bear all costs of securely storing the Plant and Equipment, both on and off site, in suitable environmental conditions to prevent deterioration of the Plant and Equipment until it is incorporated into the Works. The standard of storage to be provided by the Contractor for the Plant and Equipment shall be as follows.

All electrical Plant and Equipment and moving mechanical Plant and Equipment shall be stored by the Contractor in suitable wind and watertight buildings to be provided by the Contractor at his own expense. The stores shall be dust free and shall be adequately ventilated and heated by the Contractor at his own expense, to prevent condensation and deterioration of the Plant and Equipment. The heating shall be provided by a thermostatically controlled heating system. The stores shall also be adequately lit. The stores and its services shall be approved by the Engineer. The giving of such approval shall not relieve the Contractor of his liabilities for the safe and proper storage of the Plant and Equipment under the Contract.

All other Plant and Equipment shall be stored by the Contractor in secure compounds to be provided by the Contractor at his own expense. Such Plant and Equipment shall be protected as appropriate to prevent its deterioration while in store.

While the Plant and Equipment is in store the Contractor shall take all necessary precautions to maintain the Plant and Equipment in a serviceable condition and these precautions shall be to the approval of the Engineer. Such minimum precautions shall include, but not be limited to, the measures described below.

- Motors shall be stored under polythene with their heaters energised at all times. Packing strips shall be inserted in the air gaps to prevent rotors from resting on stator cores and bearings shall be removed.

- Circuit breaker panels, motor control centres and switchboards shall be stored under polythene and the heaters shall be energised at all times.

- Oil-filled transformers shall be pressurised with an inert gas.

- All flanges shall be closed off with metal caps and all small openings shall be stopped with plastic plugs or caps.

- All shaft exits from casing and bearing housings shall be sealed with Denso tape moulded into place. All closures shall be taped over and the tape painted with three coats of tretoplast to form a complete seal.

- All exposed ferrous non-stainless machined surfaces shall be coated with a bitumen solution.

- Thrust and journal bearings shall be removed from the pump and packed in the pump. Journal bearings shall be stored as a matched pair.

- Plant and Equipment shall be inspected every three months to ensure that the packing is intact and that the Plant has not been contaminated by the ingress of moisture.

- The Plant and Equipment shall be examined every six months and desiccants replaced. All rolling elements of Plant and Equipment shall be given 1.25 turns at each inspection.

Notwithstanding the above requirements, the Contractor shall be liable for the safe and proper storage of all Plant and Equipment under the Contract.

1.27 Level Datum

This was obtained by use of a combination of stationary GPS and Total Station, leading to measurement of traverses along the proposed water lines, as well as proposed water storage sites.

A report containing the co-ordinates of the points, the point description of reference benchmarks and the point description of new established traverse points will be handed over by the Engineer to the Contractor.

This notwithstanding, the Contractor has to check the points and will be fully responsible for the surveying works.

All levels stated shall be related to existing and temporary benchmarks and traverse points established during the design of the works.

1.28 Climatic Data and Location Level

The topography of the project area varies in elevation from 900 masl in the wetlands to about 2000 masl on the hill tops. The project areas are relatively flat.

The area experiences bi-modal rainfall with two seasons. The first rainy season is from March/April to June/July while the second rainy season is from August to October/November. The amount of rainfall ranges from 1000mm - 1200mm per annum. Rainfall intensity and distribution are erratic. Temperature ranges from a minimum diurnal range of 18˚ - 25˚C to a maximum range of 25˚C. - 40˚C.

The Contractor shall take account of the following site climatic conditions at the site of the Works both in the design and selection of all plant and equipment and the construction of the Works.

- Temperature ranges from a minimum diurnal range of 18 - 25 C to a maximum range of 25 C. -35 C.

1.29 Contamination of Water Supplies

Before any person is engaged on work involving a risk to the purity of potable water supplies or deemed to involve such a risk by the Engineer, he shall be tested to indicate that he is not a carrier of typhoid or other water-borne disease and he shall be informed of the dangers of contamination. The Contractor shall notify the Engineer of any person who has been certified by a doctor as suffering from an illness associated with looseness of the bowels, and no such person shall be employed on such work until the Employer's medical adviser is satisfied that it is safe for him to be so employed.

The Contractor shall comply with the provisions of `Safeguards to be Adopted in the Operation and Management of Waterworks' published by HMSO (UK).

1.30 Site Access and Boundary

It is the Contractor’s responsibility to make provision for any additional accommodation, any special or temporary way leave, or any tip for the disposal of surplus materials, or any borrow pit or quarry required by him outside the Working Areas to carry out the Works.

For the purposes of this Clause, ‘accommodation’ shall be deemed to include housing, offices including office accommodation for the Engineer, workshops, warehouses, and storage areas.

In the event of the Contractor making use of any special or temporary way leave or additional accommodation required by him or any tip for the disposal of surplus materials, or any borrow pit or

quarry, he shall obtain the written consent of the owner, occupier or authority having charge of the land in which such way leave, accommodation or tip is situated and shall make a record agreed by the owner, occupier or authority as aforesaid of the condition of the surface of that land before entering thereon.

The Contractor shall permit the Engineer and any person authorised by the Engineer access for the purposes of the Contract to any such special or temporary way leave or additional accommodation.

In the event of the Contractor making use of any special or temporary way leave or additional accommodation made available to him for the purpose of the Contract, the land in which such way leave or accommodation is situated shall be deemed to be part of the Site.

The extent of the site is indicated below. The Contractor shall not use the site for any purpose not required by the Contract.

Part 1
The site generally comprises Working Areas in each street or field sections where the various Works are to be constructed. Working Area boundaries will be as directed by the Engineer and will generally compose a strip extending not more than 5 metres from excavations under the Contract.

Parts 2 & 3
Access to the Site will be as follows:

Using new site roads or existing roads to be constructed as shown on the Issued Drawings.
The Contractor shall at all times confine his operations to those areas identified on the Issued Drawings as within the Site boundaries.

The Contractor shall execute the Works in such manner as to minimise interruption and interference with the operation of the existing facilities. Access to the existing facilities shall be maintained to the satisfaction of the Engineer at all times.

The Contractor shall apply to the Engineer in writing at least 28 days before starting any work which involves interference with existing structures, equipment, etc. or otherwise interferes with or interrupts the Employer's normal operation. The Contractor shall not execute such work until he has received permission to proceed in writing from the Engineer.

1.31 Use of Public Highways and Roads

The Contractor shall ensure that roads and thoroughfares used by him in any way are not dirtied as a result of such use and in the event of their becoming thus dirtied in the opinion of the Engineer, the Contractor shall take all necessary steps to clean them, at no extra cost to the Employer. The Contractor shall obtain all permits required for carrying out the Works on public roads and shall liaise with the appropriate authorities with regard to the timing and execution of the road works.

The Contractor shall be responsible for establishing and maintaining temporary road diversions for the duration of the roadwork. The road shall be kept open at all times during the road works period, and the work shall be carried out in such a manner as to minimise the disruption to traffic.

1.32 Private Property

The Contractor shall make a record, to be agreed by the Engineer, of the condition of the surfaces of any private property, private lands or of any public cultivated or maintained lands over which access to the Site lies before any work is commenced, to make them suitable for access. He shall keep such surfaces in a reasonable state of cleanliness and repair during the execution of the Works. On the

termination of the Contractor's use of such access he shall restore the surfaces to a condition at least equal to that existing before his first entry on them.

The Contractor shall not first enter any part of the Site in private lands without the prior permission of the Engineer and without first having obtained the consent of the owner of such lands. The Contractor shall give a minimum of two weeks' notice to the Engineer of his intention to begin works in any area.

The Contractor shall provide and maintain at all times, vehicular and pedestrian access to all properties, private and public, to the satisfaction of the Engineer, and not impede access to any properties.

1.33 Clearance of the Site

The Contractor shall clear the Site to the extent required by the Engineer for checking the setting out. Clearance of the Site shall also include the demolition and removal of all articles, objects and obstructions, which are expressly required to be cleared. The Contractor shall not clear the Site of any structure without the prior written permission of the Engineer. The Contractor shall remove the material arising from such clearance and dispose of it in a manner and at a location, on or off the Site, to the approval of the Engineer.

The Contractor shall fill and make good with appropriate materials those cavities and losses of soil, which result from clearing the parts of the Site not subsequently to be occupied by the Permanent Works.

1.34 Condition of the Site

The Contractor shall maintain the Site in a clean, tidy and healthy condition for the whole of such time as he is responsible for the care of the Works.

The Works shall be kept in a dry state and any water entering the Works from any source shall be collected and discharged in a safe manner approved by the Engineer.

1.35 Access for the Employer and Engineer

The Contractor shall permit the Employer and the Engineer and any person authorised by the Employer or the Engineer, including workmen of the Employer, other contractors or utility undertakings, access for the purposes of the Contract, or performing their normal duties, to all areas of the Site and to any additional accommodation or temporary way leave for the duration of the contract period.

1.36 Noise

The background sound level at any point along the boundary of the Site or Working Areas, arising from the operation of any mechanical equipment, with the exception of the diesel generators, shall not exceed 70 dB (A). The background sound level at any point along the boundary of the Site, arising from the operation of the diesel generators for standby generation shall not exceed 80 dB (A).

No item of Plant and Equipment, shall produce a sound pressure level exceeding 85 dB(A) when measured at a distance of 1 m from the reference surface of that item requirement of ISO 3746 `Acoustic Determination of Sound Power Levels of Noise Services - Survey Methods' or the equivalent ANSI SI.36.

Sound pressure levels shall be measured in dB (A), using a calibrated sound meter meeting the requirements of BS 5969 with the responses speed set to `slow'. The background noise level shall be at least 10 dB (A) below the operating noise level of the machine or other item of Plant and Equipment.

The Contractor shall produce certified evidence from the manufacturer that the appropriate tests have been carried out on all items of the same type which is in all relevant respects similar to the item to be supplied. Such relevant respects would include the running speeds, the power input under the loading conditions which would produce the most noise, the power input under normal operating conditions (if different from the foregoing), the number of stages (for rotary machines) or the number of cylinders (for reciprocating machines).

If an item in its standard build does not comply with the above requirement, the Contractor shall be required to reduce the sound pressure level by providing improved or additional silencers or fitting sound insulating materials to the item.

1.37 Temporary Works

The Contractor shall submit to the Engineer for approval full details of his proposals for temporary works at the Site, at least 14 days prior to the intended start of such work.

The Contractor shall not proceed with such work until he has received the Engineer's written approval of his proposals for the temporary works. Such approval shall not relieve the Contractor of his obligations and liabilities under the Contract.

1.38 Latrines

Throughout the period of construction of the Works the Contractor shall provide, maintain and clean suitable and sufficient latrines for use by his employees. He shall ensure that his employees do not foul the site but make proper use of the latrines. Cost for the provision and maintenance thereof shall be included in the Contract Price.

Where practicable the latrines shall be connected to the nearest sewer, or if this is not practicable the Contractor shall provide an adequately sized septic tank and soak away or alternative approved by the Engineer.

1.39 Photographs

The Contractor shall supply digital copies of photographs and un-mounted positive prints of not less than 250 x 200 mm of such portions of the Works, in progress and completed, as may be directed by the Engineer and specified herein. The digital copies and prints shall not be altered. The digital copies shall be the property of the Employer and shall be delivered to the Engineer with the prints. No prints or digital copies shall be supplied to any other person without the written permission of the Engineer.

If so directed by the Engineer, the Contractor shall supply transparencies and colour prints in lieu of colour digital copies and prints.

The photographs shall be in two categories:

(i) Progress photographs taken every two days and submitted on a monthly basis for all work aspects.

(ii) Record photographs taken at completion and supplied at the time of substantial completion and commissioning of the works.

Both categories of photographs shall be properly referenced to the approval of the Engineer and on the back of each print shall be recorded the date of the photograph, the direction in which the camera was facing, an identifying description of the subject and the reference.

Photographs taken for record purposes as ordered by the Engineer or as specified herein shall be supplied with three prints, having the reverse of one subscribed with the signatures of the Contractor and the Engineer (or their authorised representatives) for the purpose of attestation. If required, the Contractor may at his own expense have an additional print similarly attested for his retention.

The Contractor shall supply three CDs / DVDs containing the digital copies and three prints of each progress/record photograph ordered by the Engineer. He shall supply two additional prints of progress/record photographs selected by the Engineer for incorporation in albums. He shall supply two sets of albums, mount the prints, and title the prints and albums all to the approval of the Engineer.

The taking of photographs of the Works by the Contractor for any other purpose whether for use in Uganda or in any other country shall not be carried out without written approval from the Engineer.

The cost of taking, developing and supplying the photos shall be borne by the Contractor and should be incorporated in the rate for the preparation of the as-built drawings.

1.40 Setting out

Part 1

Final horizontal and vertical alignment of all pipelines shall be agreed with the Engineer prior to the commencement of works as detailed in Chapter 3 of this Specification.

1.41 Units of Measurement

All designs, drawings, specifications and manuals shall use SI (kg, m, s) units and all measurements, dimensions and performance data shall be quoted in those units.

1.42 Languages

All drawings, instructions, signs, notices, name-plates etc., for use in the operation and maintenance of the completed works shall be in English.

Warning signs shall be in English.

1.43 Contract Signboard

The Contractor shall supply and erect at least eight contract signboards at locations to be specified by the Engineer. The signboards shall be of substantial construction to the approval of the Engineer and the lettering shall be black on a white background. The layout and dimensions of the signboards shall be approved by the Engineer. The sign boards must be erected not later than four weeks after contract commencement.

1.44 Advertising

The Contractor shall not use any part of the Site for any form of advertising without the prior written approval of the Engineer.

1.45 Safety Regulations on Site

The Contractor shall comply with all statutory and other regulations concerning the safety of his site staff, operatives, staff of the Employer and Engineer and members of the public, as a result of his operations. He shall obtain copies of all regulations and shall make them available on Site for inspection by the Engineer.

Notwithstanding the above the Contractor shall ensure that the following primary site safety rules are adhered to at all times.

- All open excavations shall be fenced off with temporary fencing at all times, and shall be adequately lit at night.

- Excavating and earthmoving plant and equipment must not encroach on live carriageways at any time. The Contractor shall ensure that all items of plant working adjacent to live carriageways are accompanied by a Banksman at all times.

- Construction materials, bedding material and excavated material stored adjacent to the pipe trench must be safely and securely stored, and must not encroach onto the live carriageways, pedestrian footpaths, private or public access ways or watercourses, unless prior approval is given by the Engineer.

1.46 Protection of Existing Public and Private Services

The Contractor shall notify all public authorities, utility companies and private owners of proposed works, which will affect them not less than one week before commencing the Works.

The Contractor shall adequately protect, uphold, maintain and prevent damage to all services and shall not interfere with their operation without the prior consent of the public authorities, utilities, utility companies, private owners, or the Engineer as appropriate.

If any damage to services results from the execution of the Works, the Contractor shall immediately carry out the following:

- Notify the Engineer and appropriate public authority, utility company or private owner.

- Make arrangements for the damage to be made good without delay to the satisfaction of the public authorities, utility company or private owner as appropriate. The Contractor shall be liable for all costs for making good such damage.

The Engineer may issue instructions or make other such arrangements, as he deems necessary, to repair rapidly any essential services damaged during the execution of the Contract. Such arrangements shall not affect any liability to pay for making good the damage.

1.47 Permits

The Contractor shall be fully responsible for obtaining all necessary permits, licences and permissions required for the execution of the Works, prior to the commencement of the Works. Payment for the permits should be included in the contractor’s respective rates.

1.48 Insurance

The Contractor is required to maintain insurance for the Works in accordance with the Conditions of Contract, including insurance of all pipework, fixtures, fittings, valves and meters etc. supplied by others, for which the Contractor is solely responsible. In addition, the Contractor is required to maintain the value of his insurance cover and Performance Security in respect of the rise and fall of costs, in accordance with the Conditions of Contract.

1.49 Environmental Protection

The Contractor shall enforce environmental mitigation measures, as listed below. However, the Contractor shall not be limited to the listed mitigation measures.

Table 1.1 Mitigation Measures and Preliminary EMP during Construction

Construction Period		
Project Impact	Mitigation Measure	Responsible Party
General		
Soil degradation	Top soil should be stockpiled up separately from subsoil. After completion of work the top soil should be spread over those areas, which can be partially restored in order to facilitate natural regeneration of those areas	Site Management of the Contractor
Soil erosion	The enhanced erosion potential of the soil especially in areas with high relief energy induced by excavation activities may be reduced by sowing of grass. Extremely steep hillsides have to be protected by technical measures.	Site Management of the Contractor
Soil compaction	Restriction of the construction work to the construction area (minimising of space consumed);	Site Management of the Contractor
Excavation	Excavation material should be reused for re-filling of trenches or landscaping of all sites as far as possible.	Site Management of the Contractor
Clearance of vegetation	Protection of trees and roots, if damage to trees is unavoidable replanting of trees is required	Site Management of the Contractor
Loss of harvest	May be reduced to a certain extent by an appropriate activity schedule which considers the main harvest time. Compensation by cash	Site Management of the Contractor DWD
Dust generation (health)	During dry seasons moistening of excavation sites upon requirement, cover of haul trucks carrying excavation material	Site Management of the Contractor
Employment opportunities	Utilisation of local labour resources	Site Management of the Contractor
Security, health and safety of workers and the public	Provide warning signage where needed Provide information to the public Fencing and watchmen where needed	Project Management Site Management of the Contractor
Site Specific for Pumping Stations		
Degradation of the water quality due to increased turbidity	Monitoring of water quality and use of flocculants in treatment on requirement	DWD
Degradation of the water quality due to contamination	Material for construction of and coffer dam must be approved as harmless to aquatic environment and water quality Increased monitoring of water quality during construction period	Contractor, DWD
On animals depending on construction method	Selection of the best proposed method connected with appropriate consultation and expertise of nature protection agencies	DWD NEMA
Site specific for Pipeline network		

Construction Period		
Project Impact	Mitigation Measure	Responsible Party
Traffic congestions	Proper scheduling, planning of short-term deviations of traffic where necessary to avoid bottlenecks to the maximum extent feasible. Traffic control and safety signals and lighting should be in accordance with national and local regulations. Safe detours and walkways for pedestrians shall be implemented as necessary.	Contractor

Table 1.2 Mitigation Measures and Preliminary EMP during Operation

Operation Period		
Project Impact	Mitigation Measure	Responsible Party
Pollution of the environment at pump stations and reservoirs Health and safety	Proper storage facilities for materials at the respective sites will be designed Proper safety equipment for workers Protective and emergency response equipment required in chlorination facilities	DWD
Permanent loss of agricultural land	Compensation	DWD

2 GENERAL REQUIREMENTS OF THE WORKS

2.1Extent of the Works - Part 1

The Works to be executed by the Contractor shall include the following supply areas:

2.1.1 Pumping Mains

Supply, laying and commissioning of 3.3km of OD 90 HDPE PN16 pumping mains pipes and associated fittings, to the storage tank.

2.1.2 Distribution Network

Supply, laying and commissioning of distribution mains pipes and associated fittings, from the following storage tank:

- Supply, laying, testing and commissioning of 1.5km of OD32 PN6 HDPE distribution mains and associated fittings
- Supply, laying, testing and commissioning of 0.9km of OD40 PN6 HDPE distribution mains and associated fittings
- Supply, laying, testing and commissioning of 0.35km of OD50 PN6 HDPE distribution mains and associated fittings
- Supply, laying, testing and commissioning of 0.85km of OD63 PN6 HDPE distribution mains and associated fittings
- Supply, laying, testing and commissioning of 1.77km of OD75 PN6 HDPE distribution mains and associated fittings
- Supply, laying, testing and commissioning of 2.3km of OD90 PN6 HDPE distribution mains and associated fittings
- Supply, laying, testing and commissioning of 0.025km of OD100 PN6 uPVC distribution mains and associated fittings
- Supply and installation of 2No. bulk flow meters
- Making of 15 No. stand posts including associated fittings

2.2 Extent of the Works - Part 2

The Works to be executed by the Contractor shall include the following.

2.2.1 Civil Works for Pump Station

- Construction of a new well head, concrete platform around the well head and fittings
- Construction of pump station site works - pipework,
- Construction of 15.0 m^2 floor space for separate pump and guard houses
- Construction of site works including access road and parking pipework, fencing, drainage etc. for

the pump station and tank site

2.2.2 Civil Works for Water Supply Storage tanks

- Supply, installation, testing and commissioning of 01No. 75m^3 capacity steel panel tank on a 12m-high steel tower including foundation associated pipework and ancillaries

2.2.3 Mechanical / Electrical Works for Water Supply

- Installation and commissioning of a solar panel array (including array support structure, accessories and cabling) producing individual combined power supplies; solar-powered pump (including pump controller and specified accessories) with duty point for flow of 22.5m and head of 150m

2.2.4 Tools and Equipment for Water Supply

Supply to store tools and equipment for operation and maintenance of the water supply system including:

- Plumbing Tools and Equipment,
- Water Quality Test Kit,
- Miscellaneous Tools,

2.3 Work to be executed by others - Part 1

There is none foreseen at this point in time.

2.4 Work to be executed by others - Part 2

Work to be executed by UEDCL or UMEME

3 PARTICULAR SPECIFICATIONS

This chapter is divided into three parts, each corresponding to a part of the Works as defined in chapter 1. Clauses relating to Part 1, 2 and 3 of the Works are prefixed 3.1, 3.2 and 3.3 respectively.

References to clauses are to those of the 7th Edition of the Civil Engineering Specification for the Water Industry (CESWI), unless stated otherwise.

3.1 Part 1: Water Supply Pipe Laying

3.1.1 General Description of the Works

The works consist of pipe laying. The layouts of all the pipe works to be done are given in the Drawings as listed below:

Drawing YLU – GL - 100 series shows the general layout and the entire water system and the layout of Phase I and the details of the lines are contained in CHAPTER 2 of these specifications.

The pipelines shall be laid to the alignment shown in the drawings, and shall be tested, and disinfected as described in these specifications.

The Contractor shall lay intensification pipework at locations as directed by the Engineer, and make consumer connections as directed by the Engineer from the existing lines to the new lines. The new connections shall be made with new materials, of acceptable quality, and at the most convenient locations as agreed on site. The meter installations shall however be the existing installations but transferred to a location consistent with the location of the new connections. The Contractor shall lay service lines of adequate length to connect with the usable part of the consumers existing service pipe.

All abandoned service connections shall be sealed so as to be watertight.

3.1.1.1 Pumping Main

The pumping main shall be 3300m long, OD90 PN16 and, shall transmit water from the pump station to the storage tanks. The pumping main will be largely of either HDPE. The pumping main shall be to the alignment and detail given in the YLU - PM – 100 series of drawings

The contractor shall note the following:

a) Most of the lines run adjacent to existing roads. The programme for pipe laying in these locations shall be agreed with the Project Manager so as to result in the minimum of traffic flow disruption.
b) Part of the line may be laid across the country in fields where regular vehicle access is not available. The contractor shall arrange for his own access and the cost of this shall be deemed to be included in his rates. In addition, pipe markers shall be installed along the cross-country pipeline route as directed by the Engineer.

3.1.1.2 Distribution System

The layout of the distribution individual supply areas is given in the Drawings YLU – DM - series. The details of the distribution system are shown below

Diameter (mm)		HDPE	uPVC	Total
Outside	Internal			
20	16.2	277		277
32	28.2	953		953
40	35.4	552		552
50	44.8	1,106		1,106
63	55.4	40		40
75	66.4	1,770		1,770
90	79.8	2,299		2,299
110	103.6	0	24	24
Total		6,997	24	7,021

Source: Network Analysis

The alignment of the lines could change in light of new obstacles to pipe laying. The Contractor must give at least one week's notice before commencing work on any road crossings and the roads shall be reinstated to the satisfaction of the authority responsible for the roads.

3.1.1.3 Consumer Connections

The Project Manager will issue a list of properties and/or locations that may require consumer water connections to be made. The Contractor shall install these consumer connections complete with consumer meters, and including tapping the main lines and laying of the service pipes, on all these properties. The details of the meter installation shall be as given in the standard drawings. The bill of quantities contains provisional quantities of materials for service connections. The Project Manager will determine the final quantities required and direct the Contractor to order them. The Contractor shall therefore not order these materials without approval from the Project Manager.

3.1.2 Survey of Highways, Properties, Lands and Crops

The Contractor shall provide the Project Manager with the details of all the property that may be destroyed in the course of the execution of the works, four weeks prior to commencing works in the affected areas. This will allow adequate time for the Employer to compensate the owners of the property before the works commence. The Employer shall not be held liable for any delays in the works arising from late presentation of this information to the Project Manager or delays arising out of inaccuracies of the information presented by the Contractor to the Project Manager.

3.1.3 Accommodation for the Engineer

Not applicable.

3.1.4 Traffic Requirements

The Contractor shall comply with the provisions of the highway and road safety codes issued by the Government of the Republic of Uganda.

3.1.5 Surface Boxes and Guards

All valves, unless otherwise stated, shall be provided with surface boxes. The surface boxes shall be of

those types given in the Standard Drawings. The cover of the surface box shall be lockable and the cover shall be fixed to the base by a welded bolt.

3.1.6 Excavation

Trenches for all pipes laid in the road reserves or underneath roads shall have a minimum cover of 1.2 m over the crown of the pipe. Trenches for ductile iron pipes, or steel pipes or HDPE or uPVC pipes laid in open fields not subject to traffic loading shall have a minimum cover of 0.90 m above the crown of the pipe.

Scrub, hedges, debris and other obstacles such as huts, trees etc. along the routes of the pipelines shall be cleared to the satisfaction of the Project Manager. The Project Manager reserves the right to restrict the width of clearance due to the proximity of roots, houses, public utilities or other such permanent obstructions. All trees within 2 m of the pipeline centre lines shall be felled and the roots grubbed up. Trees with a girth of less than 0.5 m shall be deemed to be included in the clearance of scrub etc and shall not be paid for separately.

Before excavating across any public road, the Contractor shall give 10 days' notice in writing of his intention to excavate, shall satisfy the Project Manager, the Police and other traffic authorities, as to the precautions he proposes to take and the signs and lights to be provided and operated. The Contractor shall further give the Project Manager 24 hours' notice before excavating across any private road or track. The cost of providing all diversions, signs, signals, operations, flagmen and the like will be at the Contractor's expense, and shall be deemed to be included in the Contract, whether these are expressly billed or not.

All surfaces of roads, paths, fields, gardens, verges etc. whether public or private, which are disturbed during the execution of the Contract, shall be initially restored on a temporary basis by the Contractor. Permanent reinstatement shall commence only when the backfilled material has properly consolidated. The cost of restoration shall be deemed to be included in the Contract whether these have been expressly billed or not.

Permanent restoration shall not commence until the Project Manager has given written permission to proceed. It shall be carried out with materials similar to those which were used in the original surface and to the satisfaction of the Project Manager and/or the responsible owner or Authority.

Trenches, channels, and kerbs shall be reinstated to the condition in which they were before excavation was commenced. The final surface of the trench shall be flush with surrounding ground. The width of reinstated surfaces, due to be measured for payments, shall correspond to the specified width at that location.

For the purposes of the 4^{th} edition of the Civil Engineering Standard Method of Measurement, hereinafter referred to as CESSM4, the classification of excavation shall be as follows.

- Topsoil shall be regarded as any soil which, on visual examination, can be seen to have been broken down by agricultural cultivation, and/or is capable of supporting plant growth.
- Rock shall include any material which, in the opinion of the Project Manager, requires for its removal the use of explosives, sledgehammers and wedges, breaking tools or which cannot be removed by a 145 kW tractor with rear mounted heavy duty ripper.

Individual boulders, each greater than $0.2m^3$ in volume shall be included in this class when their nature and size are such that they cannot be removed without recourse to the stated methods. Where their aggregate volume is 50% or more of the total volume of material removed it shall be measured as rock throughout.

3.1.7 Pipe Bedding

The Contractor shall give notice to the Project Manager after completion of trenching of his intention to lay the pipeline. The Project Manager will jointly with the Contractor inspect the trenches and determine the type of bedding for various sections of the trenches as follows:

- Pipes which will be bedded on the original ground.
- Pipes which will be bedded on selected excavated material (depth as shown on Standard Detail SD 121).
- Pipes which will be bedded on imported material (depth as Standard Detail SD121).

3.1.8 Concrete Protection to Pipes

All pipes at public road crossings shall be provided with a class C15 concrete surround (see Standard Detail SD121). All pipes where the cover stipulated in clause 3.1.6 of the specifications is not achievable shall be provided with a class C15 concrete surround.

3.1.9 Completion of Pipe Surround

The Contractor shall give notice to the Project Manager after completion of trenching of his intention to lay the Pipe. The Project Manager will jointly with the Contractor inspect the trenches, and determine the type of pipe surrounds required for different sections of the trenches. The types of surrounds will be as follows:

- non selected excavated material other than the top soil, rock or artificial hard material;
- selected excavated material;
- imported granular material.

Indicative quantities of surrounds in the various categories have been included in the Contract. The final quantities shall be as determined on site.

3.1.10 Protection of Ferrous Pipes, Joints and Fittings

External painting of pipe fittings is not deemed adequate protection, and therefore shall not be permitted. The Contractor shall present to the Project Manager a sample of the material he intends to use for approval, prior to ordering fittings. Protections shall be provided to all fittings falling in this category, and the cost of so doing shall be deemed to be included in the Contract.

3.1.11 Marker and Indicator Posts

Marker posts for fittings and pipeline structures shall be of design as shown in the drawings, and shall be located within 3 m of the fittings, and to minimise the possibility of traffic/pedestrian damage, and damage from future pipe laying/fitting repair operations. Marker plaques shall be aluminium plates 150 x 150 x 3 mm inscribed in water blue permanent colour. They shall be engraved with the pipeline diameter and offset distance prior to installation in white colour.

3.1.12 Precautions Prior to Testing Pipelines

Pressure testing of pipelines against a closed valve shall be avoided. If the circumstances are such this is not avoidable, the Contractor shall seek the approval of the Project Manager prior to undertaking

such a test.

3.1.13 Testing of Pressure Pipelines

The pipelines shall be subjected to a hydrostatic testing prior to commissioning. The test pressure shall be:

- Water pumping line: Operation pressure or static pressure plus 5 bar, whichever is greater, but at least nominal pressure plus 5 bar.

- Distribution network: nominal pressure plus 5 bar,

- Thermoplastic pipes: as per the manufacturer's instructions or DIN.

The operation pressure includes the pressure of surge effects.

For concrete or cement-mortar lined pipelines, the section under test shall be filled with water to the required pressure and allowed to stand for 24 hours before the test procedure commences.

For the initial construction period the lengths of pipelines to be tested shall not exceed 0.5 km. At the discretion of the Project Manager this length may, as the Contract proceeds, be extended to a maximum of 1.5 km.

Before testing commences, all anchorages shall be in position, all concrete thrust blocks shall have attained their required strength and, where pipe joints are deflected to produce large radius curves, the backfill between the pipe body and the trench side shall be compacted to the final requirements. The Contractor shall provide for transmitting the unsupported end thrusts to solid ground.

The Contractor shall fill the pipe with water and shall steadily increase the pressure to the working pressure of the main. The pressure shall then be increased in increments of 1.0 bar, with a pause of one (1) minute between each increment until the specified test pressure is achieved. After a period of thirty (30) minutes, the quantity of water required to restore the pressure back to the test pressure shall be measured. This process shall continue for a minimum period of three (3) hours.

If the amount of make-up water in the three hours test exceeds the specified quantity, the Contractor shall locate and repair the leaks, then repeat the test all at his own expense. The test on each section shall be repeated until the specified degree of water tightness has been obtained.

3.1.14 Disinfection of Water Mains

The Contractor shall disinfect all new mains intended for conveyance of potable water before they are put into service.

Pipelines that are to convey potable water and have successfully passed the hydrostatic test, shall be scoured out until the wash water runs clear. They shall then be recharged with potable water containing at least 50 mg/l of free chlorine. The chlorine shall be derived from a 1% solution of calcium hypochlorite in water. The solution shall be added in a manner and rate approved by the Project Manager.

The pipeline shall then be allowed to stand for a period of at least 24 hours during which period all intermediate in-line valves shall be operated at least once. After this period, the residual free chlorine

shall be measured at the end of the pipeline furthest from the point of injection of the chlorine solution. If the free residual chlorine is less than 10mg/1, the sterilisation process shall be repeated until this value is achieved.

The Employer will supply sufficient potable water for one sequence only of the scouring, sterilising, re-charging and commissioning procedures as defined. The Contractor shall be deemed to have allowed in his rates the cost for the potable water and shall be also deemed to have allowed in his rates, for any re-sterilisation including the cost of potable water, deemed necessary by the Project Manager.

3.1.15 Survey of Pipeline Routes

The Project Manager has carried out a preliminary survey of pipeline and fixed the appropriate route as indicated on the Drawings.

The Contractor, in conjunction with the Project Manager, shall set out and agree the final pipeline route and shall undertake a detailed survey of the agreed route prior to the commencement of construction work. The Contractor shall submit the results of the survey to the Project Manager in the form of longitudinal sections and plans drawn to a scale to be decided by the Project Manager. They shall conform to the following.

- The length of the route shall be accurately measured and chainage markers (50 mm x 50 mm timber pegs or similar approved) fixed at 25 to 50 m intervals and clearly marked with the chainage at that point.

- Using modern survey equipment approved by the Project Manager, ground levels shall be taken at intervals agreed with the Project Manager. Generally a 25 m interval will be acceptable though this is to be reduced as necessary to ensure any abrupt changes in level are recorded.

- Levels shall relate to the datum given in Chapter 1 of this Specification, and permanent benchmarks shall be established, clear of the proposed pipeline, at intervals along the pipeline route.

The Project Manager will review the pipeline profile and amend it where necessary including any revisions to the number and position of air valves and washouts.

Route surveying shall be completed, and approved Pipe Laying Drawings issued and approved, before excavation and pipe laying begin. All submitted drawings shall be in print and AUTOCAD format.

3.1.16 Pipe Laying - Controlled and Non-Controlled Sections

The criteria for the level and gradient to which pipe shall be laid are divided into two categories as follows.

“Controlled Sections” comprise those sections of the pipeline where pipe gradients will be subject to the following.

- The cover above the crown of the pipe to ground level shall be a minimum of that stated in Clause 3.1.6.

- The upward gradient shall be steeper than 1 in 500 with flow, or steeper than 1 in 300 against the flow.

- The positions of the high and low points shall be determined from the Contractor's detailed route survey and shall be as far apart as ground levels permit, with the depth of the pipe being increased from the minimum by as much as 1,000 mm to avoid high points at small undulations.

The Contractor shall ensure that the required pipe levels and gradients along "controlled" sections comply with the above criteria.

"Non-Controlled Sections" shall comprise the remaining sections of the pipeline which shall be laid to stipulated cover as specified in Clause 3.1.5.

3.1.17 Pipeline Materials

All pipelines of size equal to or bigger than DN 80 shall be in uPVC or equivalent quality material in the distribution network. Pipes of smaller size have been specified as HDPE. However, any pipeline of equal or better quality will be acceptable. House connections shall be in HDPE.

The transmission pumping line shall be in HDPE/uPVC/ductile iron/steel according to the Contract agreement. Material specifications are given below:

3.1.17.1 Pipes of Ductile Cast Iron

- Standards and Codes of Practice

The latest editions of the following Standards and Codes of Practice shall apply:

Standards:

- ISO 2531
- DIN 28600
- DIN 30674, Part 1

Codes of Practice:

- DVGW GW 5
- DVGW GW 6
- DVGW W 342

- Descriptions for Straight Pipes

- Coefficientk=9

- Centrifugally cast
- Automatic joints with synthetic ring seals (TYTON or equivalent)
- Internal coating: Blast furnace cement mortar lining for

DN 200 3.0 mm

DN 300 3.0 mm

According to DVGW W 342 or equivalent

- External coating: The pipes and parts shall receive external protective coating as follows:

  Bituminous coating acc. to. DVGW GW 5 pp., class GA 2.2 for tropics and Polyethylene-

  coating of extra thickness acc. to DIN 30674, Part I

- Flanges

Dimensions acc. to ISO 2531, Items 25 pp are valid

- Standard Fittings and Specials

For nomenclature and all other details, ISO 2531, Items 25 pp are valid. External and internal coatings as above

Coefficients K = 14, 12 as specified

- Welded Specials

  - Welded tees shall be used only for blow-offs, air vents, etc. In both cases a short pipe of 4.0 m length shall be fitted out with a welded-on flanged spigot. Welding shall be carried out in the manufacturer's plant with welding method and materials to be approved by the Project Manager.
  - Branches of eccentric tees for blow-offs shall be welded to the through-pipe at an angle of 11¼^{o} to the tangent.
  - Branches for air vents shall be on the crest in symmetrical position.
  - Otherwise all provisions of ISO 2531 are valid and all foregoing specifications.
  - External and internal protective coatings as above.

3.1.17.2 Steel Pipes (DIN Specifications for Steel Water Pipes)

- Standard of Manufacture

Steel water pipes will be delivered in accordance to the requirements of DIN 2460 (Specification for

Steel water pipe). Pipes themselves will be manufactured and tested according to DIN 1626.

- Selection of Steel Grade, Minimum Thickness and Working Pressure

The nominal pressure of the pipeline, trench depth, type of pressure loading (static or pulsating) shall be advised to the manufacturer. The wall thickness and steel grades for steel pipes shall be selected from Table 3 of DIN 2460 reproduced below to suit the working requirements of the system if the following conditions apply:

- Trench depth does not exceed 6m for DN 500 and below, and 4m for above DN 500
- Vehicle loading imposed by SLW 60 load according DIN 1072
- Internal pressure is predominantly static (not pulsating)

			Pipeline Pressure Rating PN (bars)				
Size DN	Outside Dia., da	Thickness	St37.0 Vn=0.9	St37.0 Vn=0.9	St52.0 Vn=0.9	St37.0 Vn=1.0	St52.0 Vn=1.0
mm	mm	mm	Test Report 2.2	Cert. 3.1B	Cert. 3.1B	Cert. 3.1B	Cert. 3.1B
80	88.9	3.2	63	80	125	100	125
100	114.3	3.2	50	63	100	63	100
125	139.7	3.6	50	63	80	63	100
150	168.3	3.6	40	50	63	50	80

Should the trench depth exceed the above values or the internal pressure is fluctuating than wall thickness should be checked according to DIN2413 for suitability and adjusted if necessary.

- Pipe Ends

Pipe shall be furnished with either of the following ends:

- Bevelled for joining by butt welding according to Clause 4.2 of DIN2460 and Clause 4.10.5 of DIN 1626, I.E bevel angle 30deg. +5/-0 AND ROOT FACE 1.6MM +/- 0.8 for wall thickness, s >&=3.2mm
- With Spigot and Sockets for welding Clause 4.3 0f DIN 2460
- With Socket and Spigot with Rubber Gasket Push In Joints Clause 4.3 of DIN 2460

- Lengths, Dimensional Tolerances and Visual Inspection

Pipes shall be delivered in 12 m specified lengths from 323.9 mm and above, and 6 m specified lengths for below 323.9 mm. Tolerance on length will be in accordance with Table 5 of DIN 1626 reproduced as follows:

	da < & = 500	da > 500
Up to 6 m length	+10/-0	+25/-0
6 to 12 m length	+15/-25	+50/-0

Tolerance on diameters and ovality shall be in accordance Table 6 of DIN 1626 reproduced as follows:

Outside diameter, da	Diameter Tolerance at ends and on body	Diameter Tolerance over 100 mm from ends by agreement	Ovality Tolerance
< 200	**+/-** 1% da (up to +/- 0.5 mm permitted in all cases)	+/- 0.5**%** da (up to +/- 0.3 mm permitted in all cases)	Within permissible deviations on diameter
200 to 900	+/- (0.5% da + 1) mm	200 < & = da <300; +/- 1.0 mm 325 < & = da <1000; +/- 1.6 mm	2%; not guaranteed if da/s > 100
1000 & >	+/- 6 mm	By agreement	Ditto

Ovality shall be calculated as 200 x (da_{max} - da_{min}), in % where da_{max} and da_{max} is the greatest and smallest measured outside diameter respectively.

Thickness tolerances shall be in accordance to DIN 1626 Clause 4.10.2.2:

Thickness, s	Tolerance
Up to 3 mm	+ 0.30/ -0.25 mm
Over 3 mm to and including 10 mm	+ 0.45 mm/ -0.25 mm
Over 10 mm	- 0.5 mm, upper limit by mass deviation

Thickness shall be measured at pipe ends with suitable instruments.

Straightness: straight to the eye as in DIN 1626 Clause 4.10.3.2, but special requirements may be agreed.

Weld reinforcement height tolerances shall be in accordance with Clause 4.10.4 of DIN 1626:

Thickness, s	Tolerance
< & = 8 mm	< & = 2.5 mm
Over 8 mm up to and including 14 mm	< & = 3.0 mm
Over 14 mm and including 40 mm	< & = 4.0 mm

Visual Inspection and defect removal (DIN 1626 Clause 5.3.4.2):
Besides the above dimensional checks, all tubes shall be inspected internally and externally visually for surface appearance. Slight manufacturing surface irregularities such as raise or depressed areas or

grooves allowed so as the minimum wall thickness tolerance is not exceeded (DIN 1626 Clause 4.7.2). Defects may be removed in a proper manner so long as minus wall thickness tolerance not exceeded (DIN 1626 Clause 4.7.3).

- Testing

Hydrostatic Testing (Clause 5.5.6 of DIN 1626)

All pipes shall be hydrostatically tested. Works Test Pressures shall be 50 bars unless the hoop stress induced exceeds 90% of the minimum yield stress of the steel calculated in accordance with DIN 2413 in which case the latter resulting test pressure shall be complied with. The results of all hydrostatic tests shall be recorded on a pressure-recording chart. All test pressures must be held for 5 seconds.

Non-Destructive Testing (Clause 5.3.3 of DIN 1626)

All welds shall be subjected to non-destructive testing. The test may be ultrasonic flaw detection or radiographic means.

Destructive Testing (Table 7 of DIN 1626)

- Chemical Composition

The pipe manufacturer shall carry out a chemical analysis of each heat of steel supplied. The test may be done on finished tube or the sheet steel or strip at the manufacturer's discretion.

- External Coatings of Pipes and Fittings

Pipes and fittings will be coated externally in fusion bonded epoxy powder (EP Powder) to DIN 30671 (Specification for Thermoset plastic coatings for buried steel pipes) to a minimum thickness of 350 microns. Pipes and fittings will be coated only in factory conditions.

Prior to external and internal lining, all Pipes and Fittings will be blast cleaned to DIN 55928 Part SA 2.5 quality with a surface profile of 38 - 102 microns. All blasting cleaning machines will be fitted with air-wash systems to remove dust and fines from the surfaces during grit blasting. All surfaces will be cleaned of dust by compressed air prior to coating.

The following tests shall be done by the pipe manufacturer or coating applicator during pipe coating operations:

- Standard of cleanliness of blast cleaned surface as per Clause 4.1.1 of DIN 330671
- Surface coating thickness measurement as per Clause 5.3 of DIN 30671
- Freedom from imperfection by spark detection test as per Clause 5.4 of DIN 30671

The following tests shall be done on pipe sections or steel plate specimens coated with epoxy powder by the epoxy manufacturer once every three years:

- Impact Strength
- Indentation resistance
- Flexibility
- Coating resistivity
- Flexibility
- Adhesion

- Heat reversion
- Cathodic disbondment

The epoxy powder used will be Basepox PE50 – 1080 manufactured by BASF AG.

- Cement Mortar Linings for Pipes and Fittings

All pipes and fittings will be lined internally in cement mortar to DIN 2614 Type N.

Prior to cement mortar lining, the surfaces of all pipes and fittings surfaces shall be checked to ensure they are free of rust, scale, loose weld beads, grease, oil, and other impurities. Slight rusting from hydrostatic testing is permitted (DIN 2614 Clause 6.2).

Application Procedure: Cement mortar linings shall be applied by centrifugal spraying with stationary pipe and subsequent rotation as in Clause 4.1.2 of DIN 2614 (Procedure II). Where the shape of the fittings are such that application by centrifugal lining is precluded, linings will be manually applied as in Clause 4.1.3 of DIN 2614 (Procedure III).

Cement: Portland cement shall conform to DIN 1164 Part 1.

Sand grading size: A sieve analysis will be carried out a minimum of twice a year on sand use according to ISO 3310 Part 1. Fines of up to 0.125 mm in size shall not exceed 10 %. Maximum particle size shall not exceed 2 mm and 1.5 mm for sand used in pipefittings linings respectively.

Mixing water used shall be potable and have a conductivity of less than 2000 uS/cm and a $KmnO_4$ consumption of less than 10 mg/l when tested according to DIN 36404 Part 8 and DIN 38409 Part 4 respectively.

The maximum sand to cement ratio for pipes and fittings will be 2:1 by weight and shall be checked once each week of lining application according to Clause 7.4 of DIN 2614. The water to cement ratio shall also be checked once each week of lining application Clause 7.4 of DIN 2614.

Lining thickness of pipes shall be in accordance with DIN 2614 Table 4

Pipe DN	Min. Single Value	Max. Single Value
<&=150	3	6
200 – 300	4	7
350 – 600	5	8

Lining thickness of fittings shall be in accordance with DIN 2614 Table 5.

Pipe DN	Nominal	Min. Single Value	Max. Single Value
<&=300	5	3	10
350 - 600	7	5	10

Lining Thickness shall be measured on each pipe and fitting using a hardened graduated steel spear for wet linings or with an electromagnetic or magnetic measuring instrument for dry linings. The average of thickness readings taken from 4 points spaced at 90 degrees along any cross sectional plane at least 50 mm from the pipe ends shall be calculated and this average shall fall within the tolerances above.

Compression and Flexural Tests on Mortar prisms prepared from mortar. Mortar being used in lining operations shall be tested according to DIN EN 196 Part1 and shall have a minimum compressive and

flexural strength of 50 N/mm^2 and 5 N/mm^2 after 28 days. Tests will be carried out twice a year per cement mortar type; each type being identified by a particular mixing ratio and materials.

Curing Period: Pipes and fittings shall be kept damp for a minimum of 7 days at ambient temperatures of greater than 5 degrees C. Pipes shall be dispatched only after the periods stated below are met and only if under the following conditions:

	5 – 15 degrees C ambient	> 15 degrees C ambient
<&=DN600	14 days	7 days
> DN 600	14 days	days

Cracks in Linings DIN 1624 Clause 6.5: Single cracks shall not exceed 2.5 mm. Expansion cracks as a result of transport or in service use wider than 1.5 mm shall be repaired unless it can be demonstrated to the satisfaction of the purchaser that cracks will heal autogenously under constant soaking of water.

Condition of Linings (DIN 2614 Clause 6.5): Linings of pipes shall be as smooth as possible without surface irregularities exceeding 1 mm in depth determined by measuring the distance from a 30 mm straight edge placed on the lining in the direction of the pipe axis. Localised irregularities of up to 2.5 mm in depth are allowed on fittings.

Cured linings shall not have loose sand particles. Protruding, firmly embedded sand grains shall be permitted.

Hydraulic roughness, ks, shall not exceed 0.1 mm.

3.1.17.3 Pipes of Unplasticised Polyvinyl Chloride for Pressure Systems

- Standards and Codes of Practice

The latest editions of the following Standards and Codes of Practice shall apply:

Standards:

- ISO 161
- ISO 2441
- DIN 8061
- DIN 8062
- DIN 8063
- DIN 16451
- DIN 16929
- DIN 19532

Codes of Practice:

- DVGW W 320
- DVGW W 323/1
- DVGW W 325

- Descriptions for Straight Pipes

Geometric properties shall be as follows (for PN 10):

DN (mm)	D external (mm)	Thickness (mm)	Chamfer Length (mm)
50	63	3.0	4.5
80	90	4.3	6.5
100	110	5.3	8.0
150	160	7.7	11.5
200	225	10.8	16.0

Wall thickness of pipes shall not be less than above mentioned figures.

- Pipes shall be manufactured by extrusion method.
- Permissible working pressure at different temperatures shall be acc. To DIN 8062 as follows:
-
-

Class No.	PN	Permissible working pressure [bar] at		
		$20^{o}C$	$40^{o}C$	$60^{o}C$
3	6	6	4	-
4	10	10	6	1
5	16	16	10	2.5

- Colour shall be dark-grey

- Pipe materials shall conform to the following data:

specific weight 1.40g/cm^3
tensile strength not less than 50 N/mm^2

coefficient for thermal expansion approx. 80 x 10^{-6}/K
modules of elasticity 3000 N/mm^2
thermal conductivity approx. 0.15 W/m.K
chemical resistance acc. to DIN 16929
impact strength acc. to DIN 8061

- Pipes shall have automatic socket and spigot joints with synthetic ring seal, spigot ends shall be chamfered as mentioned above.

- The pipes shall be designed so as to withstand the load of a heavy truck (load of axle 140 kN) at 0.80 m soil cover under specified bedding conditions.

- Flanges

Dimensions shall be acc. ISO 2441.

- Standard Fittings and Specials

Specials and fittings shall be of uPVC acc. to DIN 8063 or of PVC-coated cast iron acc. to DIN 16451, and form part of the pipe manufacturer's original program.

3.1.17.4 Pipes of Unplasticised Polyethylene for Pressure Systems

- Standards and Codes of Practice

The latest editions of the following Standards and Codes of Practice shall be apply:

Standards:

- ISO 161
- ISO 3607
- DIN 8074
- DIN 8075
- DIN 16932
- DIN 16933
- DIN 16934
- DIN 19533

Codes of Practice:

- DVGW W 320
- DVGW W 323/1
- DVGW W 325

- Descriptions for Straight Pipes

Geometric properties shall be as follows (for PN 10)

DN (mm)	D external (mm)	Thickness (mm)	
50	63	5.8	straight pipes of standard lengths or from coil
80	90	8.2	
100	125	11.4	straight pipes of standard lengths
150	180	16.4	
200	225	20.5	
300	235	32.3	

- Pipes shall be manufactured by extrusion method.
- Nominal pressure shall be defined at 20oC. Permissible working pressures shall be according to the table listed below.
- Colour shall be black
- Pipe material shall conform to the following data:

specific weight 0.95 g/cm^3
coefficient of thermal expansion 2 x 10^{-4}/K
modulus of elasticity 900 N/mm^2
thermal conductivity 0.41 W/(m.K)
chemical resistance acc. to DIN 16934

- Permissible working pressure at different temperatures shall be according to DIN 8074, Part 1 as follows:

Class No.	PN	Permissible working pressure [bar] at temperatures equal or lower than		
		20^{o}C	30^{o}C	40^{o}C
3	4	4	2.5	1.6
4	6	6	3.2	2.0
5	10	10	6.0	4.0

- Pipe joints shall be for butt-end-welding for pipes of sizes equal to or greater than DN 80 and either butt-end-welding or screwed quick-release couplings for pipes of sizes equal to or less than DN50.

- The pipes shall be designed to withstand the load of a heavy truck (load of axle 140 KN) at 0.80 m soil cover at specified bedding conditions.

- Flanges

Dimensions acc. to ISO 2441, Welding necks shall be of uPE. Counter-flanges shall be of uPE.

- Standard Fittings and Specials

Specials and fittings shall be of uPE acc. to DIN 19533 and form part of one supplier's original program

3.1.18 Connections to Existing Water Supply

Some of the pipelines laid under this contract may involve replacements to existing pipelines, which will subsequently be abandoned.

When the Contractor is instructed to work on an existing main, he shall give at least two weeks' notice of his intention to start the work, and obtain the agreement of both the Engineer and the District or Town Council authorities to his proposed programme of work. In formulating his programme, the Contractor shall take into account the desirability of reducing to a minimum the time during which the existing main is shut down and the existing supply interrupted. During this time the Contractor shall supply the population at selected points indicated by the Engineer.

The Contractor shall make all necessary arrangements to deal with any discharge of water from the existing mains when exiting the Works. Any tees, valves and other pipework used to make the connection shall be sterilised to the satisfaction of the Engineer. Pipes that have been emptied during the execution of the Works shall only be refilled under the supervision of the Engineer.

3.1.19 Service Connections

Some of the pipelines laid under this Contract will be replacements to existing pipelines that will subsequently be abandoned. In such cases, the Contractor shall locate and transfer all good service connections, as directed by the Engineer to the new pipelines. He shall provide all the necessary fittings into the new pipeline, and provide all the pipework and fittings to connect the new tapping to the existing consumer service pipe. Consumer connections in bad condition shall be replaced by new connections.

3.1.20 Consumer Meters

All consumer meters shall be Kent PSM, SOCAM, or similar approved by the Project Manager and suitable DWD operation & Maintenance needs and to BS5728. They shall be multi-jet type and equipped with non-return valves and serviceable screens.

3.1.21 Installation of Gate Valves

Gate valves shall be installed at locations specified in the drawings or as directed by the Project Manager. The Contractor shall install epoxy coated gate valves, complete with chambers and their associated epoxy coated pipework and fittings, in accordance with Standard Detail Drawing SD111.

3.1.22 Installation of New Hydrants

New hydrants shall be installed at locations as in the drawings complete with chambers and their associated pipework and fittings.

3.1.23 Installation of New Service Pipe Connections

New service connections shall be installed at locations as directed by the Project Manager. The Contractor shall install a service connection complete with stop tap, gate valve, consumer meter and associated pipework and fittings.

3.1.24 Replacement of Service Pipe Connections

Replacement of service connections to any existing distribution pipes shall be installed at locations as directed by the Engineer. The Contractor shall disconnect and plug the existing service connection at the ferrule and remove the existing above ground pipework and fittings to the operator's store at a location in the Project Area as directed by the Engineer. The Contractor shall install a replacement service connection, complete with stop tap, consumer meter and associated pipework and fittings.

3.1.25 Quality of Work

All replacements of and repairs to service connections, fire hydrants, gate valves and pipes are to be of a high quality of workmanship. All installations are to be capable of withstanding a constant pressure of 16 bar (160 metres head of water) without leakage.

3.1.26 Appurtenances and Accessories for Pressure Mains

3.1.26.1 Standards

The latest edition of the following Standards shall apply:

- DIN 1952
- DIN 3202
- DIN 3230
- DIN 3352
- ISO 2441

3.1.26.2 Factory-Tests and Markings

All items shall be duly factory-tested prior to delivery according to DIN 3230, Parts 3 and 4. Test-certificates shall be submitted with each set of delivery.

All items shall be duly marked as follows:-

- Nominal diameter
- Nominal pressure
- Material of body
- Direction of flow
- Manufacturer's trade mark
- Maximum temperature of liquid
- Permissible working pressure
- Quality control mark
- Serial number
- Year of manufacture
- Stamp of acceptance
- Hydraulic coefficients
- Number of standard

3.1.26.3 Flanges

Flanges shall be according to ISO 2441 or equivalent standard

3.1.26.4 Coating

Protective coatings for appurtenances and accessories shall, if not otherwise mentioned, be as follows:

For buried items:

- internal: Approved epoxy-resin coating of minimum thickness 300 micron

- external: Same as internal

For items installed in manholes or valve chambers or in plants:

- internal: Approved epoxy-resin coating of minimum thickness of 300 micron

- external: 1 primer and 2 finish coats of approved epoxy-resin

Pigments shall be to the approval of the Project Manager. Colours acc. to the Project Manager's instruction.

3.1.26.5 Manufacturer

All valves and accessories except for fire hydrants shall be from the same manufacturer. All valves and accessories shall be used for transmission mains and distribution mains as well as for central works, such as tanks, pumping plant, etc.

3.1.26.6 Gate Valves

Gate valves shall be of advanced design according to DIN 3202 and DIN 3352, Parts 1 and 4, or equivalent standard for free flow with rubber-coated wedge. Nominal pressure shall be as indicated. Valves shall close clockwise with non-raising spindle and shall be provided with maintenance-free stuffing-box. Design shall be such as to allow buried installation. Drive nut shall be square of size 27 x 27 mm. Body and wedge shall be of epoxy coated nodular cast iron, spindle of stainless steel, rolled thread, roll-polished shaft, spindle nut of brass or nodular cast, stuffing-box seal of approved plastic.

3.1.26.7 Butterfly Valves

Butterfly valves shall be such that the basic body (a) can be equipped with different elements as follows:-

- Standard spindle gear

- Standard spindle extension

- Standard hand wheel

- Standard electric servo-motor

- Standard gravity drive with standard hydraulic lift cylinder and attenuation (incl. Oil tank)

- Flow interceptor with mercury balance and trigger mechanism.

Hence, the family of butterfly valves shall be worked out such as to minimize variety of types and spares to be held.

The elements are specified as follows:-

- Butterfly valve

Shall be of advanced design with eccentric shaft and continuous ring seal. Design shall permit adjustment of seal without dismantling the disk. Flanges shall be provided for the drive mechanism. Design must be such as to allow buried installations.

Body and disk shall be of nodular cast iron, seat in body shall be of nickel built-up welding, seal ring of approved synthetic rubber, clamping segments shall be of nodular cast iron and screws of stainless steel, shafts shall be of stainless steel and bushings of nodular cast alloy, ring seals of synthetics and screws of stainless steel.

- Standard spindle gear

Spindle thread shall be rolled-on, close clockwise, non-rising. Design shall be such as to allow installation of approved spindle extension of Subsection 10. Drive nut shall be of size 27 x 27 mm for DN up to 400. Gear box shall be watertight with annular gaskets, 0-rings shall tighten the drive-end bushing. Axial drive-end bearing shall be self-lubricating ball-bearing.
Gear-box shall be of cast iron, spindle of stainless steel with rolled-on thread, spindle-nut of nodular alloy cast.

- Standard spindle extension

Refer to Sub-section 9.

- Standard hand wheel

Refer to Sub-section 9.

- Standard electric servo-motor

Refer to Sub-section 19.

3.1.26.8 Spindle Extensions and Surface Boxes for Gate Valves

Spindle extension for buried valves shall be made up of the following parts:

- 1 drive nut 27 x 27 mm of nodular cast or steel,

- 1 shaft extension, of epoxy coated carbon steel,

- 1 coupling, of nodular cast,

- 1 protective pipe, of PVC or equivalent,
- 1 surface box with lockable cover, and the cover shall be fixed to the base by a bolt,
- All parts to receive one primer bituminous coat,
- One key shall be supplied for every 50 units, but 5 keys at least per contract.

3.1.26.9 Spindle Extension and Surface Boxes for Butterfly Valves

Same as Sub-section 9, but including:

- 1 indicator, of nodular cast or brass or stainless steel or approved synthetics
- 1 protective pipe, of ductile cast
- One key shall be supplied for every 25 units, but 5 keys at least per contract.

3.1.26.10 Hand Wheels

Hand wheel shall have dimensions as follows:

For Gate Valves

of DN	Diameter (mm)	Square Nut (mm)
50	165	14
80	200	17
100	220	19
150	285	19
200	340	24
300	445	27

Hand wheel of nodular cast with approved plastic coating.

For Butterfly Valve drive

of DN	Diameter (mm)
150	150
200	250
300	250
400	250
500	400
600	500

Hand wheel of nodular cast with approved plastic coating.

3.1.26.11 Void

3.1.26.12 Check Valve of Butterfly Type

Basic design criteria of this valve shall be same as of Sub-section 8 above, but eccentric position of shafts relative to pipe centre-line and metallic sealing surfaces. This check valve shall only be for installation in manholes and shall be equipped with a drive weight fixed to a lever, adjustable position.

Materials as per Sub-section 8 above, except metallic seal surfaces, all nickel-plated, lever of welded carbon steel, drive weight of nodular cast.

3.1.26.13 Air Vents

Air vents shall have 2 chambers, the bigger one shall act when the pipeline is filled or blown off, the smaller one during normal operation. A stop valve incorporated in the body shall permit easy maintenance.

Body shall be of epoxy coated nodular cast, gaskets, of approved synthetics, bolts and nuts of cadmium-plated steel.

3.1.26.14 Venturi Meters

Venturi meters shall comprise the following elements:

- Venturi pipe to the pressure rating of the pipe
- Connecting pipes with globe valves
- Mechanical flow indicator

The particular elements are specified as follows:

- Venturi pipe to the applicable pressure rating shall be designed conforming to DIN 1952, short length. Body of grey cast, ring-chamber of brass or of grey cast. Maximum differential pressure 0.25 bar.
- Connecting pipes to the applicable pressure rating including drain valves and ventilation valves of globe valve type. Pipes and fitting of copper 12 mm x 1.0 mm. Globe valves of brass, joints for soldering or with thread.
- Mechanical flow indicator, scale: indicating 1 l/s max. 500 l/s, linear, at rated differential pressure of 0.25 bar. Mercury gauge for differential pressure, linearisation of p/Q by specially shaped mercury containment. Indicator suitable for incorporation of an integrating meter for 6 digits to be powered by a synchronous motor. Materials: Approved synthetics and stainless steel.

3.1.26.15 Inlet Strainers

Strainers shall have flanges and a net inlet area of at least 3 x area of DN. The strainer shall be fixed to the flange by bolts.

Body of epoxy coated nodular cast iron strainer of stained copperplate, bolts of stainless steel.

3.1.26.16 Pressure Reducing Valves / Safety Valves

A pressure-reducing valve shall consist of the main valve and a control valve, including pressure gauge. Valve shall be designed to work at pressures less than 16 bar. Control valve shall be installed in by-pass.

Valve body and bonnet shall be of epoxy coated grey cast iron, with chromium-plated sliding planes, stem of gun metal, spring of special steel, packing of approved synthetics; Spindle shall be of carbon steel. The same material shall be applied for the control valve. Pipes and fittings, including strainers shall be of copper and brass, respectively.

3.1.26.17 Pressure Gauges

Pressure gauges shall be of minimum Diameter 100mm and all be designed for PN 16 and have metric scale for not less than 15 bar, subdivided into intervals of 0.2 bar, have 3/8" male thread with hexagonal nut. It shall be accompanied by a globe valve with 2 female threads.

Body of gauge shall be of brass or stainless steel, scale of white enamelled plate with black figures and graduation. Membrane shall be of stainless steel, all other parts of stainless steel and/or brass, bronze, and approved synthetics.
Acceptance test for pressure gauges shall be a calibration in the presence of the Project Manager.

3.1.26.18 Electric Servo-Motors

A complete set shall include:

- 1 Electric motor, IP 44, 127/220 V, Hz
- 1 Worm gear
- 1 Drive wheel for manual operation, self-declutching
- 2 Limit switches for monitoring
- 1 Set of control switches as follows:
    - for gate valve: path-length control for opening (counter-clockwise) and torque moment control for closing (clockwise)

- for butterfly valves: path-length control for opening (counter-clockwise) as well as for closing (clockwise)

Electric motor shall be of squirrel-cage type, completely enclosed, suitable for installation in moist places. Ball bearings shall be maintenance-free and self-lubricating.

Gearbox shall be of injected cast iron or welded steel. Worm gear shall be of steel / bronze.

3.1.26.19 Flap Valves

Flap valves for outlets shall be with flange PN 10 or socket as required. Body, flap of epoxy coated nodular cast, axle of bronze, bolt of steel or bronze; seal of rubber.

3.1.26.20 Pipe Expansion Joints

Pipe expansion joints shall be used for flexible connections between buried pipe sections and sections suspended underneath bridges; these expansion joints shall allow for axial movement in the pipe system due to differential movements between the bridge abutments and the bridge itself, as well as for lateral movement in the pipe system due to vibrations of the suspended pipe section. Pipe expansion joints shall be of the axial type, allowing for lateral movements by bellows-section.

Joints shall be of the multiple-wall type, of high grade steel No.1.4541 acc. to DIN 17007. Their physical properties like nominal diameter, nominal pressure, joint length, etc, shall be determined on the basis of an analysis of kinematical and strength conditions, and in correspondence with those of the adjacent system parts, such as to achieve a good functioning of the complete system.

Internal protection pipes shall be provided for pipe expansion joints in sanitary sewerage and storm water drainage lines.

Installation shall be in such a way that no undue strain in place on the pipe/joint system.

3.1.27 Gabions and Mattresses for Pipe Protection

3.1.27.1 Materials for gabions and mattresses

All units shall consist of woven steel wire mesh boxes of approved module and be of the sizes stated on the Drawings.

- Mesh: Mesh openings shall be hexagonal in shape.
- Mesh joints: All joints shall be flexible and consist of not less than one and one half full turns.
- Galvanising: All wire used shall be galvanised to BS 443, or equivalent, prior to weaving of the mesh.

- **Binding wire:** 3.4 mm diameter selvedge shall be incorporated along the edges of the wire mesh.

3.1.27.2 Stone Filling

Filling material shall be selected rock fill graded between 100 mm and 250 mm.

3.1.27.3 Construction of Gabions and Mattresses

- Prior to assembly, the units shall be opened out flat on the ground and stretched to remove all kinks and bends. The units shall then be assembled individually, by raising the sides, ends and diaphragms, ensuring that all creases are in the correct position and that the tops of all four sides are even. The four corners shall be laced first, followed by the edges of the internal diaphragms to the sides.

- In all cases lacing shall commence at the top of the unit by twisting the end of the lacing wire around the selvedge. It shall then be passed round the two edges being joined, through each mesh in turn and securely tied off the bottom.

The end of all lacing wires shall be turned to inside of the unit on completion of each lacing operation.

- Only assembled units or groups of units shall be positioned in the structure. The side or end from which work is to proceed shall be secured either to completed work, or by rods or stakes driven into the ground at the corners. These shall be secured and reach at least to the top of the unit. Further units shall then be positioned in the structures as required, each being securely laced to the preceding one at all corners, and diaphragm points.

- Final stretching of gabion boxes shall be carried out using a wire strainer or which of at leach one tonne capacity firmly secured to the free end of the assembled gabion boxes shall be securely laced along all edges (top, bottom and sides) and at diaphragm points to all adjacent units).
- Filling shall be carried out only whilst the units are under tension. Filling shall be placed by hand to produce a net face and line, with a minimum of voids. Vertical bracing wires at 500 mm horizontal centres shall be used in the top layer of unit. These bracing wires shall be wrapped around two mesh wires and extend from top to bottom so positioned to ensure a neat face and line free of bulges and depressions on completion to the satisfaction of the Engineer.

- Tension on the units shall be released only when sufficiently full to prevent the mesh from slackening. Units shall be overfilled by 20 to 50 mm above their tops to allow for subsequent settlement 100 mm filling materials may be used for this purpose.

- Closing and wiring down of lids shall proceed immediately after filling operations. Lids shall be stretched tight over the filling with bars and wired down securely through each mesh along all edges, ends and diaphragms. The end of all tying and bracing shall be turned into the unit on completion of all lacing operations.

Particular care shall be exercised throughout construction to ensure lightness of mesh, stone to be well packed with minimum of voids and secure lacing. The exposed faces of completed work shall

present a neat face and line free of bulges and depressions.

3.2 Part 2 - Buildings, Reservoirs, and M & E Works

3.2.1 Pump Station Civil Works

The water supply system has boreholes as the source of water. The location of the borehole sites is shown in drawings XXX - PS - 100 and XXX - PS - 200 series respectively

All the works shall be carried in a manner that will be able to provide adequate water and achieve the drinking water standards of the Government of Uganda. The system components are as follows:

- Pump Station
- Pumping Main
- Storage Tank
- Distribution pipe network
- Office/workshop buildings,
- General site works, pipework, drainage, road works, fencing etc.

The drawing OWS – GL - 100 gives the layout of the works.

3.2.1.1 Water Supply Source Locations

A pump station will be located at Yelulu where a borehole DWD 57363 was recently drilled sites with particulars listed in the table below.

Supply Area	Location	DWD No.	Drilled Depth (m)	Drillers yield (m^3/h)	Static water level (m)	Discharge (m^3/h)
Yelulu	Yelulu	57363	63	24	10.7	22.5

3.2.1.2 Pumping Station

The details of the pump stations are given in the PS – 100 series of drawings.
The pump station shall contain the following:

- Water well, well head and pump
- Pump house and Guard house
- Fencing and civil works
- Compound lighting

3.2.1.2.1.1.1 Borehole and Well head

The bore of the wells at the site is six inches (152 mm internal diameter from the drilling logs),

therefore, the pumps have been sized with this in mind. The well depth is 63m. The well pipes will be surrounded by a reinforced concrete slab and with be exposed to the elements of the weather.

3.2.1.2.1.1.2 Pump house and Guard house

The Contractor shall construct the pump control house and guard house as detailed in the drawings. The pumps will be vertical submersible centrifugal pumps with all the controls embedded in the controller box.
The suction pipes will vary from DN 80. The pump will be set a depth of 50m in the well.
The pump house will contain the following:

a) Pump motor control centre panel, cabling, and other electrical works for the pump;
b) Associated pipework and fittings i.e. Bulk flow meters, non-return valves, pressure switches, valves,
c) Floor drainage channels and cable ducts

Any plinths shall be in concrete and shall have independent foundations from the pump house floor. The plinth construction shall ensure no ground water leakage into the pump house. All works to ensure this shall be deemed to have been included in the cost of the plinths.

The pump house shall be provided with adequate ventilation, and shall be provided with a wide industrial type door to deliver and remove equipment.

Only indicative pipework is provided in the drawings. All the internal pipework shall be designed by the equipment supplier to the approval of the Project Manager, and their cost shall be deemed to be included in the pump supply and installation.

3.2.1.2.1.1.3 Fencing and Civil Works

This will involve civil works for the site and fencing the pump station with chain-link and installation of a gate

3.2.1.3 Pumping Main

The pumping main shall be in the range of DN80 HDPE and shall be located as shown in drawings PM – 100 series. The contractor shall note that established vehicular access to parts of the route MAY not available for part of the pipe length, and he shall be deemed to have allowed for it in his rates.

3.2.1.3.1 General Building Furnishings

The following general furnishings shall apply in addition to those contained in the drawings:

- Toilets and washrooms shall have the walls and floors tiled with ceramic tiles of approved colour.
- The ceiling shall be in celotex and painted with approved colour.
- All the external windows and doors shall be made burglar deterrent to the Project Managers satisfaction.
- Hard wood skirting, architraves and cornices shall be provided.

- The whole building shall be painted and decorated.

3.2.1.3.2 Plumbing and Drainage

Appropriate plumbing for the washrooms shall be provided. Cold water supply shall be installed from the site cold water supply system. A local elevated storage shall be provided. There shall be a 400-litre tank for general site use. Drainage to drain all the wet areas shall be installed discharging into a septic tank system.

3.2.1.4 Wash Water Disposal Field

The wash water shall be disposed of through percolation into the ground and evapo-transpiration. An irrigation field, planted with fast growing plants shall be constructed as instructed by the Engineer.

3.2.1.4.1 General Building Furnishings

The following general furnishings shall apply in addition to those contained in the drawings:

- Toilets and washroom shall have the walls and floors tiled with ceramic tiles of approved colour.
- The ceiling shall be in celotex and painted with approved colour.
- All the external windows and doors shall be made burglar deterrent to the Project Managers satisfaction.
- Hard wood skirting, architraves and cornices shall be provided.
- The whole building shall be painted and decorated.

3.2.1.5 Pump Station Site Works

The site layouts are shown in the Drawings XXX – PS – 100 and XXX – PS – 200 series.

Included in the general site works are the following:

- the earthworks necessary for the works
- the inter-connecting pipework and channels
- water supply connection for the guard house
- drainage
- fencing
- road works
- other site structures e.g. retaining walls, etc.

These are described below:

3.2.1.5.1 General Conditions

The pump stations are to be built at new sites. The Contractor shall note that any existing facilities shall be kept in the state it was found in unless instructed otherwise by the Project Manager. This means that throughout the construction period, the employer's staff will have unimpeded access to the site. Where there is interference with the present facilities from the new construction operations, the Contractor shall provide temporary facilities to maintain continuity of operation of the facilities. The Contractor shall be deemed to have allowed for these working conditions and shall be deemed to have allowed for that in his rates.

3.2.1.5.2 Earthworks

The Contractor shall strip the topsoil from areas where structures, roads, and other works are to be located. The Contractor shall excavate for the structures to the extent of the formation levels given in the drawings. All excavation works below the formation levels are included in the cost of the structures.

The areas within the fencing shall be landscaped as directed. This shall include digging up the area, removal of weeds, raking it level and grassing the area. In case a fill is necessary, this shall be with excavated material. The grass shall be of type that will grow in the climatic conditions at respective site of the Project area.

The Contractor shall level out and appropriately landscape the southern parts of the site as

All the fill material shall be from excavated material unless specified or directed otherwise by the Project Manager. The unused excavated material shall be disposed of off-site at the contractors cost.

3.2.1.5.3 Drainage

Drainage pipework shall be provided to take all the drainage of the site and houses. The drains shall be laid to evenfall, and shall ensure a velocity of at least 1m/s. The manholes shall be finished at least 0.3m above the general ground. Pre-cast manholes have been called in the Bills of Quantities. The Contractor may use in-situ concrete if he so desires, as long as this is at no additional cost to the Employer.

Surface water drainage channels have been included in the Bills of Quantities. These shall be concrete lined and constructed to a grade of at least 3%. The Engineer shall decide their final locations on site.

All the provisions specified in Part 2 of these specifications shall apply to the drainage works.

3.2.1.5.4 Other Site Structures

The Contractor shall provide a pre-cast concrete paved walkway 0.7 - 1 m, walkways within the pump stations site as directed by the Engineer. The paving shall be of quality and bedded as provided for in the General Specifications.

3.2.1.5.5 Road Works

The Contractor shall construct an access road to the site, and to the major delivery areas within the site, as shown on the drawings. Parking spaces shall be constructed at the office block, at the chlorine

house, and, at the staff housing area.

The roads shall be constructed on firm ground base where possible. Where an imported sub-base is required, this shall be compacted as provided for in the general specifications. The works shall be laid out to enable rapid drainage of run-off, and at the appropriate location drainage channels and culverts shall be provided. The culverts shall be at least DN900 and shall be in concrete or galvanised steel.

Kerb stone shall be constructed as provided for in the General Specifications.

3.2.1.5.6 Fencing

The Contractor shall erect a perimeter fence around the entire works, to include the pumo and gate houses. The extent of this is indicated in the drawings. The sites shall be provided with gates at the locations indicated in the drawings or as directed by the Project Manager.

3.2.2 Reservoirs

3.2.2.1 Storage Reservoirs

The details of the reservoir are given in the TK – 100 series drawings.

The storage reservoir for this water supply will therefore be 100 m^3 elevated storage tank on a galvanised steel tower 12m high.
The new reservoirs will be made of square cold pressed galvanised steel panels of length 1.22m. The reservoirs shall be provided with inlet, overflow, outlet, and drain pipe work. The following fittings shall also be provided for the reservoirs:

i) Internal ladder of galvanised steel,
ii) Wall mounted level indicator,
iii) Vents on the tank roof,
iv) Roof level access cover of galvanised steel.

The access covers shall be at least 100 mm above the finished level of the roof and shall be lockable. The roof vents shall be similarly set out and shall be fitted with vermin proofing and mosquito proofing fabric.

3.2.2.2 Reservoir Site Works

The site works at the reservoir consists of the following:

i) The general earthworks,
ii) The site pipe work,
iii) The site drainage,
iv) Miscellaneous works.
v) The outlet from the reservoir shall be fitted with a new bulk flow meters.

The detail specifications for pipework and drawings provided for in Part 1 and 2 of these specifications shall apply for the site pipework.

The Contractor shall excavate the site to the extent of the formation level of the tank. The ordinary excavated material and topsoil shall be reserved for filling within the site, and the balance disposed of. The Contractor shall identify his own disposal sites.

A "Woltman" Helix Type Bulk Flow Meter shall be installed on the reservoir outlet. The bulk flow meter installed shall be of a design to accept flow and pressure data loggers.

The drains and overflow from the new reservoir shall be connected to acceptable outfalls.

The Contractor shall erect a chain link perimeter fence around the entire works housing the reservoir. The fence shall be erected on a dwarf wall that shall partly serve as a flood protection wall with three lines of barbed wire fixed to the top of the fence. The site shall be provided with a double leaf gate at the location directed by the Project Manager.

3.2.3 Mechanical Works for Water Supply

3.2.3.1 Pump

The following equipment shall be supplied and installed:

3.2.3.1.1 Submersible Borehole Pumps

The pumps shall operate as one duty and they shall deliver a combined flow and heads as specified for each individual site and have components as follows

Pump Efficiency: minimum 80%.
Motor: 6“- high efficiency 3-phase 380 V AC motor – 25 to 55 Hz operation; speed: 1,400 to 3,080 rpm – depending on pump end; Insulation class F; Enclosure class IP68; Maximum installation depth- 300m

Pump End: Multi-stage centrifugal pump with premium materials, AISI 304 stainless steel, non-return valve, dry running protection

The pump shall be complete with pump, electric motor, assembly parts for stationary installation, pressure gauge at inlet and outlet, electric and control cables to connect to the Motor Control Centre and all accessories.

Each pump shall include all pipe-work including connecting to manifold, inlet butterfly valve, outlet butterfly valve, check valve, compensators, bends, air valve and all accessories.

3.2.3.1.2 Cabling

Cabling shall be executed according to Clause 4.32. It shall include all cables necessary for proper functioning, such as the following cable connections:

- From transformer to metering box and from metering box to MDB 16x1core x 240 mm² XLPE-I Copper

3.2.3.1.3 Lighting and Small Power

The lighting system shall comply with Clause 4.45 and shall include light fittings with bulbs and tubes, switches, power plugs, cables from control cubicle to the fittings and all fixing material and conduits. Conduits shall be G. S. fixed on the surface.

The lighting and small power is indicated in the drawings and BOQs.

3.2.3.1.4 Earth

The buildings shall be provided with an earth system as specified under Clauses 4.32.3 and 4.35.

Instead of rods a loop of copper wire min 95 mm² can be installed below the foundation before concreting with 4 connections to be connected later on to the earth ring of the building. For connections of the copper conductors brazed pressure clamps shall be used.

3.2.3.1.5 Lightning Protection

Lightning protection shall be provided for the highest building, consisting of a copper tape with minimum 70mm² cross section installed along the ridge of the roof, with a copper spike peak surpassing the building heights by approx. 50 cm.

The connection to the earth copper ring shall be executed by using brazed screws and washers avoiding direct contact of galvanized steel with copper.

3.2.3.2 Solar power Supply

The solar panels supplied shall be to the solar pump manufacturer's specification and direction for installation.

3.2.3.3 Pump Control Centres

3.2.3.4 Cabling

Cabling shall be executed according to Clause 4.32. It shall include all cables necessary for proper functioning, such as the following cable connections:

- Cabling between the Transformer and the Main Distribution Board by 4 x 1Core x 70mm^2 x LPE Copper
- Cabling from Main Distribution Board to pump controller shall be according to the pump manufacturer's specifications

And others.

3.2.3.5 Lighting and Small Power

The lighting system shall comply with Clause 4.45 and shall include light fittings with bulbs and tubes,

switches, power plugs, cables from control cubicle to the fittings and all fixing material and conduits. Conduits shall be G. S. fixed on the surface.

The lighting and small power is indicated in the drawings and BOQs.

3.2.3.6 Earth

The buildings shall be provided with an earth system as specified under Clauses 4.32.3 and 4.35.

Instead of rods a loop of copper wire min 70mm² can be installed below the foundation before concreting with 4 connections to be connected later on to the earth ring of the building. For connections of the copper conductors brazed pressure clamps shall be used.

3.2.3.7 Lightning Protection

Lightning protection shall be provided for the highest building, consisting of a copper tape with minimum 70mm² cross section installed along the ridge of the roof, with a copper spike peak surpassing the building heights by approx. 50 cm.

The connection to the earth copper ring shall be executed by using brazed screws and washers avoiding direct contact of galvanized steel with copper.

3.2.3.8 Office and Workshop

The following electrical equipment shall be supplied for the Office:

3.2.3.8.1 Distribution Board (DB3) for Small Power and Lighting

DB3 shall contain the following:

- 100A TPN Main Incomer Isolator.
- 2No 32A TPN Type C MCB
- 1No 63A SPN Type C MCB
- 3No 32A SPN Type C MCB
- 3No 20A SPN Type C MCB
- 3No 10A SPN Type C MCB
- Surge suppression unit of appropriate capacity as made by FURSE of UK.

3.2.3.8.2 Small Power and Lighting Equipment

- 12No twin-tube 1200mm fluorescent light fittings with electronic starters with 2 x 40 W tubes.
- 8No single-tube 1200mm fluorescent light fitting with electronic starters with 1 x 40 W tubes.
- 3No metal-clad 13A 240V power sockets for the control room
- 2No 32A 240V single-phase industrial power sockets with plugs, and 2No 32A 415V 3-phase industrial power sockets with plugs.
- 2No Ball type fittings for toilets
- 1 No 5 litre pressure type water heater under sink in laboratory complete with cabling.

3.2.4 Drawings, Documents and Maintenance Scheme

3.2.4.1 Contract Drawings

- The Contractor shall submit to the Project Manager in triplicate the following drawings for approval:

    - Electrical Drawings: On the basis of the simplified documents, the Contractor shall prepare the following planning records as supplements to the VOB DIN 18382 Standards:

Wiring diagram and construction plans and drawings, installation plans, complete cable lists, clamping plans, etc. as well as lists of parts, clearly indicating material and type of proposed equipment.

This also applies to the control and signal circuits are well as interlocking and interrelated control of other technical sectors. A clear illustration according to pertinent standards is imperative.

A complete documentation (lists of parts, descriptions, maintenance and operating instructions, test reports and certificates, etc.) shall be submitted, in five copies each, prior to the commencement of installation.

    - Copies of proposed panel layouts.

- Two copies will be retained for record purposes whilst one copy will be returned to the Contractor stamped "APPROVED" and/or supplement with any necessary modifications or revisions. The Contractor shall provide four further copies of finally approved drawings.

3.4.6.2 Record Drawings

- Within a period of three weeks following the issue of the "Take-over" Certificate the as-built drawings shall be provided. One set shall be reproducible on plastic (or equivalent) and three sets shall be prints of:
  - Works and general plant layout,
  - As-constructed drawings,
  - Comprehensive diagrams for the control panel showing scheduled functions and diagram of connection,
  - Overall mechanical/electrical and control schedules for the Works with details of interconnections between the various units of the plant,
  - Actual (not typical) section drawings where applicable,

3.2.4.2 Operating and Maintenance Manuals

- Comprehensive operating and maintenance manuals in English language covering all items of Plant and including all manufacturer's instruction, references, lists, etc. shall be compiled. The manuals have to cover the pumping station.

- The manuals shall be submitted in five copies and shall cover the testing, operation, control, maintenance, dismantling and repair of all the Plant provided in the Works. All information shall be supported by:
  - Catalogues and brochures,
  - Dimension drawings,
  - Data sheets,
  - Descriptive text,
  - Comprehensive drawings, sketches, plans, sections as required.

The greatest importance shall be drawn to the completeness and clearness of presentation.

- It is emphasized that a collection of standard pamphlets of general nature unaccompanied by drawings and descriptive matter will not be acceptable. In particular, information supplied by Sub-Contractors and manufacturers employed by a Contractor shall be co-ordinated in the comprehensive manual. Cross-references of descriptive texts, drawings and spare part lists must be complete.

- The Contractor shall deliver to the Project Manager in duplicate loose leaf copies of draft operational and maintenance manuals for the Plant two months before start-up of the works. The manuals shall be divided into several volumes (e.g. function, operation, maintenance, overhaul) and shall fully and clearly set out the Contractor's own recommendations and instructions for the satisfactory operation, maintenance and overhaul of the Plant as applicable to each of the installations and devices supplied.

- The text or accompanying diagrams shall in addition show the electrical wiring, handling and erection instructions. Draft manuals shall, during the testing and commissioning of the Works, be carefully checked by the Contractor and updated and modified to ensure that they are fully descriptive and applicable to the final lay-out of plant and process under operational conditions.

- The draft manuals may include manufacturer's standard literature but the Contractor shall fully supplement the literature by his own descriptive text, drawings, tables, figures, characteristic curves and the like.

- The final approved manuals for the Works shall be submitted prior to the commencement of the Period of Maintenance. They shall be securely bound in A4 sized loose-leaf binders, clearly titled, index linked and cross referenced.

- The final manuals shall incorporate instructions, recommendations and advice for the operation of the entire process covering the full range of flow and shall include advice on the joint operation and control of the water supply system. No section of the Works will be certified by the Project Manager as completed unless this requirement has been met. The contents of the final manual may be subdivided into the following sections:

    - Basic data of the works,
    - Description of the different units of the Works including supporting sketches,
    - Setting to work procedures,
    - Normal operation,
    - Taking out of service procedures
    - Emergency operation (electricity failure etc.)
    - Water quality monitoring programme including sampling schedule and sampling locations, draft of quality reporting forms according to DWD Standard and description of standard methods used for analysis.

- If during the Period of Maintenance, the Contractor or the Project Manager has found that the manual should require modification or enlargement as a result of subsequent operational and maintenance experience in the Works, the Contractor shall provide the approved modification for each manual.

- The manuals shall include explanations of the function and purpose of each item supplied and the operational, mechanical and electrical procedures for:

    - Lubrication, checking, calibration (including charts), testing adjustment of each item,
    - Attention at daily, weekly, monthly or other intervals to ensure reliable trouble-free operation,

- Complete overhaul, dismantling and reassembly, testing and re-commissioning,
- The identification and selection of suitable lubricants standardized throughout the Works, identifying equivalents of local manufacturer's
- Defect locating charts to facilitate tracing of the cause of malfunction or breakdown,
- Routine and emergency safety precautions, procedures and recommendations,
- Cleaning of the Plant and its components.
- Guidelines for conservation of equipment in case of taking the equipment out of service,
- Maintenance of protective coating,
- Operational maintenance of the system, performance and treated water quality monitoring and reporting procedures.

- The instruction manuals shall describe the installation as a whole and shall give a step-by-step procedure for any operation likely to be carried out during the whole life of the Plant.

- A separate section of the manual shall be devoted to each size and type of equipment and to each system of Plant. The various sections shall be grouped into separate volumes relating (as appropriate) to functions like operation, maintenance, overhaul etc. The appropriate volume shall contain also a list of spare parts and the required procedure and addresses for ordering them. A list of recommended spare parts to be stored shall be supplemented each item of equipment.

3.2.4.3 Maintenance Scheme

- The operation and maintenance instruction manuals shall be supplemented by the supply of a comprehensive yearly maintenance programme for the water works operation and maintenance staff.

- A wall chart or charts shall be provided, covering a period of one year with coloured markers. It shall have vertical divisions in weeks and horizontal divisions for each item of Plant. A fitter's card system shall be provided with at least one card for each item of Plant. The cards shall detail the maintenance required with the relevant spaces for work done, parts required and the like, in order that for each task or day's work, the electrical works and mechanical maintenance staff may be presented with the card for routine work completion and signature.

- The markers shall be arranged with standard colours to indicate work required, parts outstanding, work completed and the like.

- The maintenance scheme shall be provided complete at the time of handing over of the Works. It should have sufficient space for extension to include any further routine work, which may be required.

3.2.5 Tools and Equipment

3.2.5.1 General

- The Contractor shall furnish each of the new water offices with the tools and equipment listed hereunder.

- The tools and equipment shall be complete in all respects and be installed, calibrated and connected to the electric supply, if applicable.

- All tools shall be of high quality material (chromium-vanadium and high quality tool steel respectively) and shall be in accordance with the latest standard.

3.2.5.2 Specifications of Workshop Tools and Equipment

The equipment shall be provided according to the following technical requirements. It shall be of an approved quality and finish. These will include:

- Plumbing Tools and Equipment
- Water Quality Test Kit,
- Miscellaneous Tools

4 STANDARD SPECIFICATION FOR MECHANICAL AND ELECTRICAL PLANT

4.1Introduction

Plant and Equipment includes all mechanical and electrical equipment and associated services and equipment as specified herein, or as listed in Schedules or shown on Drawings, and includes all materials and ancillary equipment required or which may reasonably be inferred to be necessary for the proper performance of the Works.

This chapter of the Specification sets out the standards of materials, workmanship and design to be used by the Contractor for mechanical and electrical plant and reference to any specific material or equipment does not necessarily imply that such material or equipment is to be included in the Works.

All component parts of the Works shall, unless otherwise specified, comply with the provisions of this chapter or be subject to the approval of the Project Manager.

4.2 Safeguarding of Machinery

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this Specification shall remove the Contractor's obligation from drawing the attention of the Project Manager to any feature of the Works which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs, which would increase the safety of the Plant.

The installation layout and plant design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of hot pipes, air vents and rotating machinery.

All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

4.3 Rating Plates, Name plates and Labels

All equipment, apparatus and Plant shall be clearly labelled or fitted with nameplates and rating plates generally as follows:

4.3.1 Indoor Type Labels

- Labels for the outside of equipment shall be of a rigid type laminated and engraved plastic material, with black block capitals on a white background. The labels shall be fixed by non-rusting screws, or similar approved.

- Labelling inside equipment shall be as above except that a flexible self-adhesive type labelling may be used if suitable for the ambient temperatures and if not less than 12 mm in width.

4.3.2 Weather-proof Labels

These labels may be vitreous enamelled or brass. Plastic labels will not be accepted unless proof can be given that the labels can withstand the environmental conditions found at Site.

Vitreous enamelled labels shall be secured by brass or non-rusting roundhead screws, with brass and fibre washers in contact with the enamel front and back to prevent damage.

4.3.3 Name and Rating Plates

Each main and auxiliary item of Plant shall have permanently attached to it in a conspicuous position a nameplate and a rating plate. Upon these shall be engraved the manufacturer's name, type and serial number of Plant, details of the loading and duty at which the item of the Plant has been designed to operate, and such diagrams as may be required by the Project Manager. All indicating and operating devices shall have securely attached to them or marked upon them, designation as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes as indicated on the Record Drawings. Details of proposed plates, labels and inscriptions shall be submitted to the Project Manager for approval before manufacture.

4.4 Lubrication

A complete schedule of recommended oils and other lubricants shall be furnished by the Contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Project Manager for approval before incorporation in the instruction manuals. In the case of grease-lubricated roller bearings for electric motors a lithium-based grease is preferred.

Where grease is the lubricant, preference shall be given to a pressure system which does not require frequent adjustments or recharging. Where necessary for accessibility, grease nipples shall be placed at the end of extension piping and, when a number of such points can be grouped conveniently, the nipples shall be brought to a battery plate mounted in a convenient position. `Hydraulic' button-head type nipples, in accordance with BS 1486, shall be used for normal grease and all grease nipples shall be of the same size and type throughout the Plant as far as possible. Arrangements shall be provided to prevent bearings being overfilled with either grease or oil.

The Contractor shall supply grease-gun equipment for each type of nipple provided. Where more than one special grease is required a grease-gun for each special type shall be supplied and permanently labelled.

Oil containers shall be supplied complete with oil-level indicators of the sight glass type, or where this is not practicable, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The normal, maximum and minimum levels shall be clearly visible to an operator standing on the normal access floor to the particular item of Plant. The sight glasses shall be easily dismantled for cleaning.

4.5 Initial Charges of Oil etc.

The initial charges of oil, grease, electrolyte and similar materials necessary for the correct setting to work and operation of the Plant shall be included in the appropriate Plant item.

4.6 Welding

Welding procedure specifications shall be prepared and submitted to the Project Manager. They shall detail steel grades; joints design; material thickness; welding process; consumables; principal welding positions; working/pre-heating temperature and post-weld heat treatment.

Welding shall be carried out only under the direction of an experienced and competent supervisor.

No such welding shall be carried out before the Project Manager or Inspection Authority has approved the details proposed. No alteration shall be made to any previously approved detail of welding preparation without prior approval of the Project Manager. Welders shall be qualified in accordance with the requirements of BS 4872 or BS 4871 as applicable.

The welding plant shall be capable of maintaining at the weld the voltage and current specified by the manufacturer of the electrodes. The Contractor shall supply instruments for verifying voltage and current as and when required by the Project Manager.

Unless otherwise described in the Specification, metal-arc welding shall comply with SII 0192-78, or BS 5135, or ASTM A-671, as appropriate. Tack welds and temporary attachment shall follow the procedures laid down in BS 5135. The position of welds for temporary attachment shall be agreed by the Project Manager.

Radiographic examination, which may be required of highly, stressed fusion welds shall comply with the provisions of BS 2600 or BS 2910 or other equivalent standard, except where otherwise specified or ordered by the Project Manager.

Mechanical and other non-radiographic tests, if required, shall be carried out in the presence of the Project Manager, or the Inspection Authority.

4.7 Castings

The structure of the castings shall be homogeneous and free from non-metallic inclusions and other defects. All surfaces of castings which are not machined shall be smooth and shall be carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 0.25 mm in depth or 12.5% of total metal thickness whichever is less and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The Project Manager shall be notified of larger defects and no repair welding of such defects shall be carried out without his prior approval.

If the removal of metal for repair should reduce the stress-resisting cross-section of the casting by more than 25%, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25%, then that casting shall be rejected.

Castings repaired by welding for major defects shall be stress-relieved after such welding or as otherwise instructed in writing by the Project Manager.

Non-destructive tests may be required for any casting containing defects whose effect cannot otherwise be established, or to determine that repair welds have been properly made.

Unless otherwise specified castings shall be produced to the following standards or equal:

Grey-iron	BS 1452	Grade 220
Carbon steel	BS 3100	Steel alloy
Stainless steel	BS 3100	Steel 316C16
Copper and copper alloy	BS 1400	Group A grade LG 2
Group B grade CT1, AB2		
Group C grade G1		

4.8 Forgings

All major stress-bearing forgings shall be made to a standard specification, which shall be submitted to the Project Manager for approval before work is commenced. They shall be subject to internal examination and non-destructive tests for the detection of flaws, and shall be heat-treated for the relief of residual stresses. The name of the manufacturer and particulars of the heat treatment proposed for each such forging shall be submitted to the Project Manager, who may decide to inspect such forgings at the place of manufacture.

4.9 Non-metallic Materials

Fabrics, cork, paper and similar materials, which are not subsequently to be protected by impregnation, shall be treated, with an approved fungicide. Sleeving and fabrics treated with linseed oil varnish will not be permitted.

The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or other approved hardwood, which is resistant to fungal decay and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insect, bacteria or chemical attack, unless it is naturally resistant to all these. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings on wood shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types, which are impervious to moisture and fungus growth. Synthetic resin cement shall be used for joining wood.

4.10 Engineering Hardware

Nuts, bolts, studs and washers for incorporation in the Works shall conform to the requirements of the appropriate British, DIN or other approved standard. Nuts and bolts for pressure fittings shall be of the best quality steel machined on the shank and under the head and nut.

Bolts shall be of such a length that one thread shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of such a diameter that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices and anti-vibration fittings shall be provided where necessary to ensure that no bending stress is caused in the bolt.

Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material under all conditions.

All bolts, nuts and screws that are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel.

The Contractor shall supply all holding down, alignment and levelling bolts complete with anchorages, nuts, washers and packings required to attach the Plant to its foundation, and all bedplates, frames and other structural parts necessary to spread the loads transmitted by the Plant to concrete foundations without exceeding the design stresses.

Unless otherwise necessary to meet special requirements all thread shall be of preferred metric sizes with standard coarse threads.

ISO metric black hexagon bolts, nuts and screws shall comply with SII 0589-81, or ISO 885, ISO 888, ISO 898-1 and -2.

ISO metric precision hexagon bolts, nuts and screws shall comply with ISO 272, ISO 4759-1, ISO 885, ISO 888, ISO 898-1 and -2 or ASTM F-593, ASTM F-468 M, strength grade 8.8.

The dimensions of ISO metric countersunk head bolts screws, and hexagon nuts shall comply with ISO 225, or ISO 888, ISO 898-I.

Plain steel washers for use with ISO metric bolts shall comply with ISO 887 or ASTM F-844.

Taper steel washers shall comply with ASTM F-844 and ASTM F-436.

4.11 Instruments

Unless otherwise specified, any indicating and recording instruments supplied under the Contract shall be of the flush-mounted pattern with dust- and moisture-proof covers and shall be suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks.

Indicating instruments shall be of the dial type and shall be provided with a readily accessible zero adjustment.

Dials in general shall be white with black markings and not subject to fading. Scales shall be of such material that no peeling or discoloration will take place with age under humid conditions.
The use of iron and steel screws shall be avoided in instruments and electrical relays wherever possible.

Steel screws, when used, shall be zinc, cadmium or chromium-plated, or where plating is not possible due to tolerance limitations, shall be of stainless steel. All wood screws shall be of dull nickel-plated brass or of other approved finish. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be non-rusting materials, e.g. phosphor-bronze or nickel-silver, as far as possible. Pivots and other parts for which non-ferrous material is unsuitable shall be of stainless steel.

4.12 Spare Parts

The Contractor shall supply all spare parts necessary for the continuous operation of the Plant for a minimum period of two years, and shall describe such spare parts in the Schedule of Spares.

The spare parts shall comply with the Specification and be new, unused and readily interchangeable with the parts for which they are replacements.

Spare parts shall not be packed with any items of Plant for erection or installation.

Each spare part shall be clearly marked with its identification reference and a detailed list shall be enclosed in each package containing spares.

They shall be treated and packed to afford adequate protection during transit and for an extended period of storage at the Site. All containers shall be clearly marked `SPARE PARTS' together with

sufficient information to allow complete identification of the spares and date of supply or packing.

Electrical and mechanical spares shall be packed and crated separately. Spares for different items of Plant shall not be mixed in the same container.

All cases, containers or other packages are liable to be opened for examination as the Project Manager may require, and packings shall be designed to facilitate opening and subsequent repacking.

4.13 Special Tools and Test Equipment

The Contractor shall supply a complete set of special tools and test equipment necessary for maintenance or testing of any part of the Plant to be carried out during the life of the Plant, whether of an electrical, mechanical or any other nature.

The tools and test equipment shall not be used for the erection of the Plant and shall be handed over in a new and unused condition excepting that the Project Manager may call upon the Contractor to prove their effectiveness.

The tools and test equipment shall be boxed separately in suitable containers marked or labelled with their contents.

All cases, containers or other packages shall be designed to facilitate opening and subsequent repacking.

When specified, tools and test equipment for internally sited Plant shall be mounted in suitable cabinets with lockable doors. Racks or clips shall be provided for individual items with outline markings and labels showing which tools or equipment are missing. The cabinets shall be wall mounted with best quality finish and appearances.

4.14 Centrifugal Pumps

Centrifugal pumps shall have head/quantity characteristics, which fall continuously from the maximum pressure at closed valve conditions and which are steep in order that variation in head shall have a minimal effect on the quantity discharged.

The preferred design speed of pump is 1,500rpm. Pump motor ratings shall exceed the maximum pump power consumption over the operational range of the pump by at least 10%.
Waterways through the pump shall be smooth in finish and free from recesses and obstructions. Impeller passageways shall be as large as possible. The leading edges of the impeller vanes shall be rounded and smooth.

Water velocities in the suction or delivery branches of a pump shall not exceed 8 m/s when the pump is operating within its specified duty range and within this working range there shall be no discernible noise due to hydraulic turbulence or cavitation within either the pump or its associated pipework and valves.

The NPSH requirements of the pumps, based on the 3% output drop criterion shall be at least 2 m less than the NPSH available at every working condition.

The pump shaft shall be of alloy steel forgings compatible with the impeller and the impellers and shaft sleeves shall be secured to the shaft by means of a key or keys. The impeller retaining nut shall be fitted with a locking device.

All parts exposed to wear shall be adequately protected by means of renewable sleeves, bushes, wear rings e.t.c. which shall be arranged for easy inspection, adjustment, or replacement without removal of the pump casings, pipework e.t.c., or the need to disturb the drive shaft alignment.

The pump thrust shall be taken by a combined thrust and radial type bearing assembly capable of taking the weight of the moving parts and the hydraulic loads under all conditions of operation with a minimum life of 100 000 hours.

Bearing cooling arrangements if used shall be designed on the closed-circuit principle; open discharge of cooling water into the pumping station drainage system is not permissible.

The pump casing and other parts of the pump subject to pressure shall be hydraulically tested by the manufacturer to at least one and a half times the maximum working pressure.

Integral inlet and discharge flanges shall be provided and integral lifting lugs shall be incorporated.

Facilities shall be provided for the removal of air during priming and for draining.

Glands may be fitted with mechanical seals or conventional soft packing. The gland arrangement shall be designed for easy adjustment and removal of the seal.

When soft packed glands are used suitable means shall be provided for collecting and preventing splashing of the gland leakage water.

Drainage and gland leakage water shall be piped into the building drainage system.

The shafts of pumps fitted with conventional packed glands shall be fitted with removable gland sleeves.

The rotating element of the pump and the motor shall be readily removable from the pump casing without the need to disconnect the adjoining pipework.

Rotating assemblies of pumps of 100 mm diameter inlet and over shall be statically and dynamically balanced and shall be designed so that the first critical speed is at least 50% greater than the maximum operating speed.

Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

On pumps of 75 mm inlet and over, tappings shall be provided at both the suction and discharge flanges of suitable size for pressure gauges.

4.15 Vertical Mixed Flow Bowl Pump

Not Applicable

4.16 Sump Pumps

Not Applicable

4.17 Pump Performance Guarantees

The pump performance guarantee shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's work.

The pump shall operate at its design point within acceptance tolerances for flow rate and total head laid down in Clause 9.4.1 of BS 5316: Part 2 (= ISO 3555).

Each pump shall be tested at the manufacturer's factory in accordance with BS 5316: Part 2 (ISO 3555) or other relevant standards in conjunction with one of the contract motors.

This test shall be carried out on at least one pump set using the flexible coupling and contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.

Where similar drive shaft arrangements have been installed by the Contractor and have been proven satisfactory in service this requirement may be withdrawn subject to the approval of the Project Manager.

A test shall be carried out of the performance from closed valve to the maximum quantity that can be delivered under abnormally low discharge heads.

Sufficient readings shall be taken at each test to produce accurate curves of the heads, flow, pump speed and power required at pump coupling throughout the operating range of the pump.

Vibration and noise dB(A) levels shall be measured and shown to be acceptable. The Contractor shall provide acceptable test certificates, showing the NPSH requirement for the pump is at least 2 m less than the NPSH available under all working conditions.

In the absence of the approved test certificates the supplier shall carry out a test on one pump of each type to verify the NPSH requirement based upon the 3% output drop criterion.

Test Certificates in duplicate shall be submitted to the Project Manager immediately following each of the tests mentioned above. Performance curves shall also be incorporated in the Operation and Maintenance Manual.

(a) Single Pump Operation

Head/quantity curve
Motor kW input/quantity curve
Overall efficiency/quantity curve
NPSH required/quantity curve

(b) Parallel Pump Operation

Head/quantity curves

4.18 Electric Motors

4.18.1 General

Electric motors shall comply with BS 4999 and BS 5000 and rated on the basis of duty type S1

(maximum continuous ratings).

Motors shall be suitable for two starts in succession from hot under the specified duty conditions of load torque and inertia and shall also be suitable for six equally spaced starts per hour under similar conditions.

Motor starting currents shall not exceed 6 x full load current as determined by the locked rotor test.

Motors shall be designed to operate continuously within the voltage range of 94% and 106% of rated voltage and between the frequency range 95% and 102% of nominal frequency.

Motors shall be capable of operating under conditions of three phase supply imbalance where the negative and zero phase sequence components of the voltage do not individually exceed 2% of the positive phase sequence components.

The motor shall be designed for the method of starting as follows:

- Designate N for direct on-line starting;
- Designate NY for star-delta starting;
- Designate D for direct on-line starting with reduced starting current.

4.18.2 Construction

Motor construction shall provide a degree of protection as follows:

- IP 44 - internal general industrial and pumping duty;
- IP 54 - external use or applications in dusty environments;
- IP 55 - external use in exposed locations.

Motor mounting arrangement shall be to suit application.

The motors shall be tropicalized.

Motor cooling shall be in accordance with ICO 141 (totally enclosed fan cooled) or ICO 661 (forced ventilation). Other forms of ventilation may be used with the approval of the Project Manager.

Motor bearings shall be provided with facilities to add additional lubricant. For grease lubricated bearings grease nipples shall be provided and a grease relief feature incorporated. Oil lubricated bearings shall be provided with site glasses which provide an accurate indication of bearing oil level when the motor is in use.

Motors shall be designed for normal sound power as defined by BS 4999.
Windings shall be insulated to class F as defined by BS 2757.

Where specified motor windings shall incorporate:

- thermistors (PTC type), or,
- resistance thermometers (PT 100).

In each instance the temperature detecting devices shall be in close thermal contact with each phase of the stator windings. All thermistors shall be connected together to provide a single electrical circuit for connection to an external relay, which will be capable of tripping the motor.

Motors shall have the direction of rotation clearly indicated on the driving end.

Each resistance thermometer shall be connected separately to an external monitor relay, which shall offer alarm and trip settings.

Thermal protection shall be Class I or Class II for sizes of motor of 75 kW and below and Class II above 75 kW. Anti-condensation heaters shall be fitted to motors rated 11 kW and over. A warning label, red letters on a white background shall be fitted to indicate that the heater may be energised. Heater terminals shall be shrouded. On larger motors a separate terminal box shall be provided.

Anti-condensation heaters shall be sized to raise the temperature inside the motor several degrees above the dew point temperature. The heater surface temperature should not exceed $20^{O}C$.

Heaters shall be automatically disconnected when the motor is switched on.

4.18.3 Cable Terminations

Cable termination boxes shall be suitable for air termination of cables. They shall be sealed with a neoprene gasket to provide dust and weather protection.

Cable boxes for voltages in excess of 1 000 V shall be treated with anti-tracking varnish.

Phase segregated terminal boxes shall be used for voltage of 11 kV and above.

4.19 Submersible Pumps

Submersible pumps shall be of the single entry design supplied complete with boltless self-aligning duck-foot assemblies giving automatic connection to the discharge pipework. The pump casing shall be manufactured from close grained grey iron to BS 1452.

An oil filled casing shall separate the electric motor from the centrifugal pump. Mechanical seals shall be fitted to the pump shaft, which shall prevent water from entering the oil casing, and oil from entering the motor casing. A moisture detection system shall be provided to initiate an external alarm.

The motor housings shall be impregnated to protect the ingress of moisture.

The shaft bearings shall be sealed and lubricated for life.

Each pump shall be provided with its own galvanised steel guide rails, fittings and all necessary support brackets. A suitable lifting chain shall be attached to each pump to enable the pumps to be raised and removed from the wet well without the necessity for personnel entering the well. The lifting chain shall comply with BS 1663 or BS 3113 and BS 4942.

The submerged cable shall be a multi-core flexible cord, vulcanised rubber insulated with tough

rubber sheath and outer PCP sheath to BS 6500.

Where both thermal protective and moisture-sensitive devices are incorporated within the pump, both devices shall be brought out via separate conductors within the motor cable, although one such conductor may be common.

4.20 Pipework and Layout - Pumping Stations

In general all pipes and fittings shall be steel or ductile iron with flanges to BS 4504.

Where steel and cast flanges are mated together the steel flange shall be machined over its full face, after welding to its respective pipe is completed.

Flexible joints shall be provided to facilitate installation and removal and/or differential movement of plant. Where required, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipework as a whole.

The pipework shall be laid out and designed such as to facilitate its erection, painting in-situ, dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum loss in head. Where steel pipework is used the number of flanges is to be kept to a minimum with the size of each unit of pipework determined by the ease of handling, installation and general appearance of the completed pipe system. Positions of flanges shall take into account any necessary concrete pipe supports or thrust blocks.

Facilities shall be provided for draining the pipe system. Where a pipe passes through a wall, retaining wall or is subject to thrust it shall incorporate a puddle flange, which shall conform to the dimensions stated in BS 4504 but remain undrilled.

Unless otherwise specified, nuts, bolts and washers for pipework shall conform to the requirements of BS 4504.

Bolts shall be of sufficient length that one thread shall show through the nut when in the fully tightened condition.

4.21 Gaskets and Joint Rings

Joint rings shall be manufactured to conform to BS 2494 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80^{O}C.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any constituent soluble in water of the quality stated in the Specification, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

4.22 Steelwork

The ladders, platform, covers and handrails to be supplied and fixed under this Contract are indicated on the Drawings or detailed in the Specification.

Any small areas of chequer plating or similar covering that are necessary to cover gaps between items of Plant and the surrounding structure, and any access ladders, platforms and handrails that must be attached to items of Plant to facilitate operation, inspection or maintenance, shall be supplied and erected by the Contractor.

The Contractor shall include in his Contract for providing adequate means of access to all hand wheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance.

Handrails shall consist of double ball forged steel standards with tubular rails, hot dip galvanised in accordance with BS 729.

Chequer plating shall be of `Durbar' or other non-slip pattern, not less than 4.5 mm thick (exclusive of pattern) and hot dipped galvanised after fabrication in accordance with BS 729.

Aluminium alloy flooring may be offered as an alternative, manufactured in accordance with BS 1470, material H30 TB.

4.23 Pressure Gauges

Pressure gauges shall comply with BS 1780 and shall not be less than 100 mm in diameter.

Unless otherwise specified, scales shall be calibrated in metres head of water, with zero representing atmospheric pressure. The lettering shall be in black.

Compound gauges shall read at least 5 m below atmospheric pressure using red lettering.

Where the working fluid is of a corrosive or dirty nature the pressure gauge shall be protected from the working fluid by a diaphragm or similar arrangement.

Each pressure gauge shall be fitted with a stopcock immediately adjacent to the gauge and all pressure gauge piping shall be fitted with an isolating valve at the point of connection to the main system.

Where pressure gauges are mounted within or on a panel a suitable connection for a test gauge shall be provided.

4.24 Surge Vessels and Equipment

Vessels shall be designed, constructed and tested to BS 5500. As a minimum requirement, but not limited to, the vessel shall include:

- Saddle supports and legs complete with holding down bolts;
- Drilled and tapped or flanged facings for and including the following fittings:
    - Pressure relief air valve rated for not less than 150% working pressure and to pass 200% maximum flow into vessel.
    - Adequate access to afford inspection of the inside of the vessel and to the top of the vessel by means of a ladder.
    - Calibrated level sight glass of the reflective type covering the full range of water level in the vessel and having top and bottom shut-off cocks and hinged safety glass and pressure/level calibrations carried on a substantial engraved plate.
    - Air vent and inlet valves.
    - 150 mm diameter pressure gauge and isolating cock.
    - Lifting lugs to enable handling of the vessel on Site without damage to the painted surfaces.
    - Flanged inlet and outlet branch.
    - Drain valve.
    - Level control signals will be provided by a magnetic float switch with a mouse running up and down the external sights. The float switch shall be fitted with low/high level setting for air compressor control and low/high levels for alarms. Controls and alarms shall be timed out during transient conditions.

The Contractor will be required before ordering the equipment to submit detailed computer calculations done by the pump supplier for the Project Manager's approval. These shall show the maximum and minimum pressure developed in the protected and unprotected states.

The Inspecting and Regulating Authority will be Lloyds, TÜV (TECHNISCHER ÜBERWACHUNGSVEREIN) or equivalent regulating authority approved by the Project Manager.

4.25 Compressors

Not applicable

4.26 Air Blowers

Not applicable

4.27 Electrodes

Electrodes shall be stainless steel rods with PVC coating and housed in appropriate enclosures. Means shall be provided for adjusting the length of each electrode by a minimum of 75mm without cutting. External enclosures shall be totally weather-proof to IP 55 with tapped cable entries.

Holders, subjected or liable to flooding shall have gaskets placed between cap and body and fitted with a sealed external terminal for connection with the electrodes.

Electrodes for alarm, or level control of surge vessels shall have robust, water and airtight heads fitted to the top of the vessel. Suitable arrangements shall be provided for the withdrawal of the electrodes, without the need for access to the inside of the vessel.

In all applications a separate electrode shall be provided for the earth return circuit.

Each alarm or control signal shall be initiated from a separate single electrode unit. Multi- electrode units will not be accepted.

The relay control box shall be totally weather-proof to IP 55 and suitable for wall mounting.

The relay control box shall include a hand-off-auto switch, in line fuses and neon lamp indicating the relay condition.

The alarm and control contacts in the relay box shall be set for `fail safe'. In the event of the electrical supply to the relay box failing or the signal cabling being damaged, the alarm and control circuiting will be initiated.

The sensitivity shall be adjustable between 100 and 20 000 ohms and the switching differential better than 5% of sensitivity setting.

The supply voltage shall be 240 V, 50 Hz. The electrodes circuit shall be 25 V maximum open circuit, 30 mA short circuit. The relay contacts shall be rated for 5 A and 220 V, 50 Hz inductive load.

4.28 Electromagnetic Flow meters

Flow meters shall be of the fully submersible electromagnetic type suitable for fitting in a chamber outside the pump station, in accordance with BS 5792 with protection to IP 67.

Flow meters installed in steel pipelines, which are to be cathodically protected, shall be provided complete with insulating flanges, continuity bonding, earth, etc.

Flow meters shall be flanged and rated to suit the delivery pipework and provided with a detector head and associated equipment to provide a linear 4 to 20 mA dc output, proportional to the rate of flow. Any equipment required to operate in conjunction with the flow meter shall be fully submersible or mounted in a location not subject to flooding.

The calibrated accuracy shall be better than ±0.5% of actual flow from full scale flow rate to 50% flow rate increasing progressively to ±1% of actual flow rate at 10% flow. Flow meters shall be installed in accordance with the manufacturer's instructions and with a minimum of five diameters straight pipe upstream and two diameters downstream.

4.29 Adjustable Weir Plates

Not Applicable

4.30 Stop Gates and Stop Logs

4.30.1 Stop Gates

Stop gates shall be of epoxy coated welded steel construction, with a vertical skin plate supported on a series of horizontal beams connected to vertical end members.

The gate shall be arranged to seal at the sides, top and bottom against water pressure acting from the upstream side of the gate.

Resilient seals shall be secured to the gate. The seals shall be adjustable and seal fixing bolts and nuts shall be of a corrosion resisting material to facilitate seal replacement.

Guide rails, lintel and sill shall be epoxy coated mild steel or 316 stainless steel and provided with adjusting and fixing devices to enable them to be accurately positioned and suitable for sealing in either direction.

Stop gates shall incorporate pressure equalising valves to enable the gate to be lifted under balanced hydraulic conditions.

Stop gates shall be fitted with lifting hooks and one stop gate lifting frame shall be supplied for each installation.

4.30.2 Stop Logs

Stop logs shall be constructed from steel rectangular hollow sections and epoxy coated, complete with inter-log sealing strips and lifting hooks.

Stop logs shall be supplied with epoxy coated mild steel or 316 stainless steel guide rails for wall or channel mounting, as required, and complete with fixing bolts. Resilient seals shall be securely fixed to the guide rails by corrosion resistant materials to facilitate seal replacement.

A stop log lifting frame shall be supplied for each installation.

4.31 Standby Generator Set

Not applicable

4.32 General Requirements for Switchboards

4.32.1 Construction

Switchboards for the control of equipment rated at 3.3 KV or above shall conform to BS 162, 5227 and IEC 298.

Switchboards for the control of equipment rated at 415 volts shall conform to BS 5486 (IEC 439).

All switchgear, distribution boards, motor control centres, and other panels shall comprise factory built assemblies of the multi-cubicle type.

Panels shall be free standing, of uniform height, flush mounted, and totally enclosed to not less than IP 42 in accordance with BS 5420:1977 (IEC 144:1963). When size of starters and other components does not justify this type of construction, wall-mounting patterns may be used.

The base of the panel shall be effectively sealed against the ingress of vermin and termites, and all equipment shall be rated for continuous operation in a tropical climate.

Any ventilation louvers shall be backed by brass fine mesh gauze to exclude termites.

Framework for the panels shall be of welded construction, and panels shall be fabricated from mild steel sheet of 2mm minimum thickness, folded and braced where necessary to provide a rigid structure.

All metal work shall be treated in accordance with Part 4 of this Specification. All bolts, nuts, screws, hinges, handles, etc. shall be corrosion resistant.

Interiors shall be finished white, and the exterior shall be finished to a light grey shade except the plinth, which shall be black.

Cabling access shall be from the rear by means of gusseted bolt-on plates.

Access to the cubicles or cubicle compartments for all normal routine maintenance shall be from front by hinged and lockable doors fitted with neoprene gaskets (all gaskets shall be termite resistant) and chromium plated lockable tee type handles. All doors shall be electrically bonded to the main frame, using adequate flexible conductors, protected against mechanical damage. All locks on a given part unit shall be operated by the same key.

Each multi-compartment control panel shall comprise an assembly of individually constructed cubicles. These shall be assembled to include a metallic sheet between adjacent cubicles.

In each multi-compartment panel at least one empty compartment shall be provided for future use.

In single unit panel, enough space shall be available for the addition of at least 10% more components for future use.

Panel shall be readily capable of extension at either end, within the bus-bar rating.

Where panel size is excessive easily handled sections shall be supplied for site assembly. Sections shall be fitted with eyebolts, which after positioning of the panel, shall be removed and replaced with plated bolts and washers.
Bases shall be of rigid construction capable of withstanding stresses during replacement, such as those imposed by moving the sections on rollers.

4.32.2 Bus Bars

All bus-bars shall be of electro tinned HDHC copper, and shall be of uniform section throughout the length of the panel.

They shall be run in separate screened compartment, divided with barriers into as many compartments as there are cubicles in the panel. Access to individual compartments shall be via bolt-on cover plates, each bearing the legend in White on a Red background:-

"DANGER - LIVE BUS-BARS", also the Red Arrow symbol denoting danger from electric shock.

The neutral bus-bars shall be not less than half the cross-sectional area of the phase bars. Phase bus-bars shall be colour coded Red Yellow and Blue: the neutral shall be black.

4.32.3 Earth

Each panel shall be equipped with a copper earth bar running the full length of the panel rated to withstand without damage, the thermal and dynamic effects of earth fault currents. Minimum size shall be 25 x 3mm.

Vertical tee-offs shall serve all compartments in each cubicle, all connections shall be bolted and bolted faces shall be cleaned.

The Contractor will be responsible for ensuring that all components, sub-assemblies, gland plates, etc., are solidly bonded to earth using green/yellow PVC insulated copper conductors of not less than 2.5 mm^2 cross-sectional area. Reliance on metal-to-metal joints for electrical continuity will not be accepted.

4.32.4 Control Circuits

Control circuits shall be protected by M.C.B.

4.32.5 Over and Under-Voltage; Phase Failure and Phase Sequence Protection

The main incoming 415 volt switchboards and control panels shall be equipped with high or low voltage, phase failure and phase sequence protection, if specified under detailed specifications.

The Lovato Electronic Voltmeter Relay type RVT manufactured by the Officine Electromeccanica Lovato of Italy meets the requirement for this application. Alternatives may be offered for the approval of the Project Manager.

4.32.6 Surge Voltage Protection

All solid-state control or electronic devices, which may be located within the panel, shall be individually protected by surge arresters.

4.32.7 Small Wiring

All small wiring shall be 600/1000 volt grade multi-stranded copper wires, complying with BS 62311:1978, and of minimum cross section 1.5mm^2. PVC insulation shall be used up to 70oC for temperatures in excess of this, (e.g. for final connections to heaters) fire resistant cable such as Pirelli FP 200 or equivalent shall be used.

Wiring looms shall be neatly bunched using proprietary straps and cleats. Alternatively plastic ducting may be used. Self-adhesive fixings are not acceptable.

All wires shall be fitted at each end with insulated pin type crimped terminations, to avoid splaying of the strands, and shall additionally be identified at each end, in line with the schematic diagram.

Identification ferrules shall be of the interlocking ring type, engraved black on white. Colour coded types will be accepted only if they are also number engraved. 'C' type or Adhesive markers are not acceptable.

Earth wires shall be green/yellow. Wiring shall not obscure components or labels, nor interfere with access to components, and shall be protected against damage by the use of grommets where necessary.

Terminations shall be made leaving sufficient length to allow making off again, if this proves necessary.

Identification ferrules shall be arranged so that wiring can be easily traced from the front of the compartment.

4.32.8 Terminals

Terminal board insulation shall be polyamide or equivalent. Melamine types are not acceptable.

All connectors shall be of brass or bronze, with screws of similar material. Contact between dissimilar metals is not acceptable. No steel screws plated or otherwise, shall be used. Insulating barriers shall be fitted between supplies at different voltages.

All terminal screws shall be captive.

Maximum two conductors shall be connected to each terminal. Multiple connections shall be effected using links.

Main power terminals shall be stud and nut types, with plain and locking washers. Conductors terminating on these shall be fitted with insulated crimped lugs. Rail mounted terminals for cables in excess of 35 mm^2 cross-sectional area are not acceptable.

4.32.9 Gland Plates

Adequately sized blank gland plates shall be provided below each outgoing terminal section to accommodate the requisite glands.

Suitably sized compression-type cable glands shall be provided for all cables. Glands used for armoured cable shall include provision for sealing the armour wires to protect them from corrosion and to prevent ingress of moisture into the cable.

Brass lugs shall be provided for connection of the cable armouring to earth.

4.32.10 Anti-Condensation Heaters

Heaters shall be fitted in every compartment, and controlled via an adjustable thermostat.

Heater locations shall be selected to avoid damage to components and wiring, and they shall operate at black heat.

Each heater shall be separately fused, and the final 100mm of wiring shall have heat resistant insulation. (see Clause 4.32.7).

Heater supplies shall be derived via compartment isolators. Heater switches shall be labelled “ON” and “OFF”.

4.32.11 Door and Desk Mounted Components

All indicating instruments shall be moving iron type with a quadrant scale of minimum length 75mm and conform to IEC 51. Their accuracy shall be to class 1.5 or better.

All instruments and protective relays shall be flush mounted and effectively sealed against ingress of moisture, dust and insects.

Where connected in motor circuits, ammeters shall have ‘overload’ scales capable of withstanding starting inrush current.

Hours run counters shall be flush mounted cyclometer type, scale 99,999.9 hours.

Control and selector switches shall have their positions clearly labelled, and additionally shall each have a separate label to indicate the switch function. Labels shall correspond with the associated schematic diagrams.

Interlocks of a substantial mechanical type shall be provided on each cubicle between door and the circuit breaker or fuse switch such that the door cannot be opened unless the circuit breaker or fuse switch is in the OFF position. On/Off switches and circuit breakers shall be padlock-able in the "OFF" position.

Pushbuttons and indication lamps shall be selected from a matching range and they shall be colour coded in compliance with IEC 73 as follows:-

Indicating Lamps	Colour
On	White
Off	Green
Fault	Red
Alarms	Yellow
Heaters	Blue

Push Buttons	Colour
Start	Green
Stop	Red
Alarm accept	Black
Emergency stop	Red

Each indicating lamp shall incorporate a push-test feature. Alternatively a test push button shall be provided which activates all lamps simultaneously via a contactor. Lamp fittings shall be capable of re-

lamping from the front of the panel, and shall be positively locked against rotation.

Fault indicating lamps shall remain on until the associated trip relay is reset or the fault is corrected. Should there be an interruption to the electricity supply, all fault indicating lamps will again be illuminated on reconnection of the supply, until the fault is cleared or the trip relay is reset.

All exposed terminals on the rear of door-mounted components shall be shrouded to prevent accidental contact when the panel doors are open.

4.32.12 Labels

All labels shall be engraved on laminated plastic sheet, (Traffolyte or approved equivalent) and shall be fixed using non-ferrous screws or rivets.

Designatory or advisory labels shall be of White/Black/White laminate, while warning labels shall be Red/White/Red, or White/Red/White.

Adhesive labels of any kind are not acceptable.

Component labels shall also be of laminated plastic and shall show the reference by which it is identified on the schematic diagram.

On the front of each starter compartment a special label shall be attached on which shall be given particulars of the load including, for example:

- Motor voltage
- Motor FLC
- Pump total head
- Pump discharge

Adhesive labels of any kind are not acceptable.

4.32.13 Rubber Mats

Each floor mounted panel shall be supplied complete with a rubber mat, manufactured in accordance with BS 9921:1976.

Mats shall be 6mm thick (minimum) x 600mm wide and longer than the panel at each end by 600mm.

4.33 Fault Levels

The following prospective symmetrical fault levels are to be assumed for initial design considerations.

11 KV	UEDCL/UMEME overhead supply line	200 MVA rms
415 Volt	bus-bars (secondary terminals of LV supply transformers)	30 MVA rms

It shall be the responsibility of the Contractor to ascertain the true fault levels.

4.34 Lightning Protection

The installation shall be in accordance with the recommendations of the British Code of Practice as set out in BS 6651.

To ensure an effective system, particular attention shall be paid to the quality of the materials used which shall be electrically sound and provide good corrosion resistance in a tropical environment.

Each structure shall be provided with air terminations, down conductors and earth terminations, together with all necessary joints, bonds and earth electrodes, including test joints.
Each down conductor shall be provided with a suitable test joint not less than 0.5m and not more than 1.5 m above ground level

4.35 Earth

The installation shall be in accordance with the recommendations of the British code of Practice.

Earth terminations shall be constructed using copper rods driven into ground to a depth of at least 1.5m. In order to achieve the necessary earth impedance, rods shall be combined in groups with a separation between rods not less than the length of the rods.

Concrete inspection pits shall be installed above each earth rod complete with copper bars to which bolted connections can be made to link earth rods together to form an integrated network. To this bar shall also be connected all other earth connections

A substantial wall mounted copper earth bar shall be provided in each building for which an earth electrode system is installed. This bar will act as a terminal strip to which connections can be bolted from switchgear earth bars, the casing of electrical equipment and any other metal structures, which require bonding to earth. All such connections shall be sized in accordance with the IEE Wiring Regulations.

A separate earth system shall be provided for lightning protection.

Earth termination networks, which incorporate lightning protection, shall have a resistance to earth of less than 1 ohm.

Earth termination networks not incorporating lightning protection shall have a resistance to earth determined by the maximum earth fault loop impedance (as defined by the IEE Wiring Regulations) which is acceptable for the correct operation of the overcurrent protection devices, which have been installed.

4.36 Site Lighting

The principal roads and access areas on the Site shall be illuminated by suitable discharge lamps mounted on lighting columns or wall brackets on buildings.

The control of the lights shall be by means of an electro-mechanical timer having adjustable contacts

and capable of operating for a minimum of 48 hours after interruption of the main power supply. The lighting control relay shall be located in the main MCC and shall switch all the site lighting simultaneously via contactors.

Unless there are existing luminaires on site which can be matched by similar units, each luminaire shall comprise a lantern and gear for High Pressure Sodium lamp with protection to IP 54. The Thorn Beta Seventy-nine range meets the requirements of BS 4533 and IEC 598 but similar types of alternate manufacture will be considered.

The Thorn QC3 column and GCBS 534 bracket complies with BS 3489. Similar alternatives will be considered.

The lighting columns shall be set in concrete blocks cast in situ with suitable conduit for cable entry.

4.37 Power Factor Correction Capacitors

Capacitors shall be installed within the panel, and shall comply with BS 1650.

They shall contain a biodegradable non-toxic dielectric impregnant. The use of polychlorinated biphenyl (P.C.B.) is not acceptable.

Discharge resistors shall be fitted to the capacitors in all cases such that 1 minute after disconnection; the terminal voltage shall not exceed 50 volts to earth.

4.38 Utility Electricity Supply

4.38.1 11 KV Systems

The existing high voltage supply at 11 KV consists of a 3-phase overhead transmission line system.

The present policy of the utility is to provide dropout fuses at high voltage for transformers up to, and including, 500KVA. They will also provide and install the HV cable between overhead line and transformer. It shall be the responsibility of the Contractor to provide the low voltage cable and protection equipment.

Provision shall also be made for the installation of utility metering for the incoming supply comprising the following:-

- KW max. Demand indication
- KWHr integrating meter
- KVAmax. Demand
- KVAr max. Demand

The necessary C.T.'s and V.T.'s for metering shall also be provided and these shall comply with the relevant utility DCL standards, which are currently as follows:-

- Current transformers shall be ratio 100/50/5 A for use at 50 Hz having a burden of 15 VA at Class 'C'.

- Voltage transformers shall be of ratio 11000/110 volts for use at 50 Hz having a secondary burden of 100 VA per phase at Class 'B'.

A suitable battery and battery charger shall be installed in the 11 KV sub-station for switchgear tripping duties.

4.38.2 11 KV Switch Gear

If necessary, a cubicle shall be provided for the metering equipment. In addition to the meters already specified, an ammeter and a voltmeter shall be mounted on the front of the panel to read the current in one phase and the voltage between two phases, together with all necessary fuses.

Anti-condensation heaters shall be provided in all cubicles together with a control thermostat and isolation switch.

Padlocking facilities are required for all access doors.

The degree of protection of the cubicles shall be to IP 44 or better.

4.38.3 Over-Current and Earth Fault Protection

The overcurrent and earth fault protection shall comprise an integral system. The characteristics of the relays and other protection devices shall be selected so that acceptable discrimination is obtainable from the source (UEDCL high voltage supply) to the pump motors.

The Contractor shall show to the satisfaction of the Project Manager that the system proposed shall provide an entirely satisfactory installation for the operation of the plant and the safety of the personnel working there.

The Project Manager shall approve the proposal upon submission by the Contractor of curves illustrating the time/current characteristics and discrimination of all protective elements.

Relays shall be suitable for use with current transformers having a 1A secondary output. They shall be of the electromagnetic type and shall be contained in dust protected cases to IP 50 and fully tropicalized.

4.38.4 Battery and Charger

A suitable battery and battery charger shall be supplied for 11kV switchgear tripping duties.

The capacity of the battery shall be determined by the Contractor and shall have a nominal output of 30 volts DC.

4.38.5 Transformer Protection (1000 KVA Rating)

A double-float Buchholz relay and a winding temperature indicator with alarm and trip settings shall be included with the transformer fittings. Indication of both alarm and trip shall be given by a four-

element plug relay, which shall be mounted on the same panel as the overcurrent and earth fault relay

4.39 Transformers

4.39.1 Control Transformers

Control transformers shall be liberally rated and conform to BS 3535. The windings shall be fully tropicalized and one pole of the secondary winding shall be connected to earth via a test link.

4.39.2 Current Transformers

Current transformers when used for operation of meters, relays or instruments shall comply with BS 3938. They shall be rated for 1 A output except for the utility See also, Clause 4.38.1.

Polarity of primary and secondary windings shall be clearly indicated in accordance with BS 158. One pole of the secondary windings shall be connected to earth via a test link.

Separate C.T.'s shall be used for metering and for protection purposes.

4.39.3 Voltage Transformers

Voltage transformers shall comply with BS 3941 Class I and be either mineral oil filled or encapsulated and shall be complete with HRC fuses on both the primary and secondary side. See also UEDCL specification for metering V.T.'s, Clause 4.38.

V.T.'s can be single phase or three-phase, nominal ratio 11 kV/110V, 199 VA per phase.

4.39.4 Power Transformers

Power transformers shall comply with BS 171 and shall be connected delta/star in accordance with vector group Dyn 11. They shall be double wound on a core of cold rolled, grain orientated sheet steel.

They shall be suitable for out-door use, oil immersed, natural air-cooled. (type ONAN).

The following fittings are required for all transformers:-

- Diagram and rating plate
- Lifting lugs
- Earth terminal
- Conservator with drain plug
- Oil level indicator
- Drain valve (To be used also for oil sampling)
- Oil filler hole with plug
- Dehydrating (silica gel) breather
- Jacking lugs

4.40 415 Volt Equipment

The attention of the Contractor is drawn to the relevant Parts of Clause 4.32, General Requirements for Switchboards.

4.40.1 Main Switchboard

This shall incorporate the main circuit breaker(s) for the incoming supply, as well as distribution switchgear for all other 415 volt panels on the site. In addition, it will house various motor starters for equipment installed in the principal buildings, relays and contactors.

The switchboard shall be a floor-mounted panel comprising sectional steel cubicles with protection to IP 4X.

The preferred type of switchgear for the main incomers is MCCB but switch fuses will be acceptable if it is impossible to integrate the protection characteristics of the MCCBs into the overall overcurrent protection scheme.

The following equipment will be housed in the panel:-

- Ammeter, Voltmeter and selectors for incoming supply
- Main incoming circuit breakers
- Distribution switchgear
- Motor starters
- Control supplies

4.40.2 Control Panels

These shall generally be wall mounted and incorporate an incoming Circuit Breaker for supply isolation. In addition to motor starters, the panel shall include the following:-

- Set of ammeters for incoming supply
- Voltmeters
- Selector switch(s) for duty/stand-by drives
- Control circuits
- Small Power and lighting circuits

4.40.3 Emergency Diesel Generator Supply

At certain locations, it is desirable to have a stand-by generator permanently installed to provide all or part of the electricity requirements of the Works. Alternatively, provision shall be made for a mobile generator to be connected in place of the normal utility supply.

The specification for the installation of the diesel generator is fully covered in Clause 4.31.

An incoming circuit breaker shall be included in the 415 volt main M.C.C. panel for the generator, and this shall be mechanically interlocked with the circuit breakers for the utility supply, so that both supplies cannot be connected simultaneously.

In the case of a mobile generator, it shall be possible to couple the generator into the system of the main 415 volt board. Terminals shall be provided for the cables from the generator.

4.40.4 Motor Control Equipment

4.40.4.1 Contactors and Control Relays

Contactors shall comply fully with IEC 158, 337 and 292 with duty to AC 3.

Main contacts shall have a rated operating current as AC 3 duty of at least twice the FLC of the motor.

Starting contactors shall incorporate where appropriate thermal type overload relays which shall be ambient temperature compensated and also provide single-phasing protection. The thermal overload relay should be selected so that the motor FLC lies in the middle of the range of settings.

There shall be space and facility for fitting add-on auxiliary contact blocks to the contactor.

Control relays shall comply fully with IEC 337 with duty to AC 11.

Contactors, thermal overload relays shall be selected to comprise a comprehensive system of motor control.

4.40.4.2 Fuses, Links and M.C.B.'s

All circuits shall be protected either by fuses or by M.C.B.'s but wherever possible M.C.B's shall be used in preference to fuses.

All fuses shall be HRC type to BS 88. Fuse bases and carriers shall be GEC Red Spot or equivalent approved by the Project Manager, and all live parts shall be fully shrouded. Fuse carrier shall be coloured Black, link carriers shall be coloured White.

All M.C.B.'s shall be type 2 to BS 3871. They may be single double or triple-pole as required and rail mounted.

M.C.B.'s fuses and links shall be grouped where appropriate according to their functions ad shall be clearly marked both on panels and the associated wiring diagrams with their reference number.

The minimum rating of any fuse or M.C.B. shall be 5 A, unless it is essential to use a lower rating.

4.40.4.3 Isolators

All isolators and main switches shall be padlock-able in the "OFF" position, and shall be interlocked such that the door to the compartment cannot be opened with isolator in the "ON" position, except when otherwise specified. In such cases, such metalwork as may be live shall be adequately shrouded, and warning notices fitted.

4.40.5 Motor Starters

The method of starting motors shall be as follows:-

- Motors up to (and including) 10 kW - D.O. L.
- Motors 12 kW and over - Star/Delta or Auto Transformer

All motor starters must be suitable for a minimum of 15 starts per hour (up to 22 kW) or 10 starts per hour (30 kW and over).

4.40.5.1 D.O.L. Starters

Each starter shall be equipped with:-

- Line contactor
- Thermal overload/phase fault relay
- Over-temperature relay for use with thermistors embedded in the motor windings
- Current transformers for ammeter (if necessary)

On the door will be mounted the following:-

- Ammeter
- Start and Stop push buttons
- Overload reset push button
- Over-temperature reset push button
- Hours run indicator
- Indicating lamps and labels as necessary

4.40.5.2 Star/Delta or Auto-Transformer Starter

Each starter shall be equipped with the relevant items from the following:-

- Set of main contactors for automatic start sequencing including time delay relays
- Thermal overload/phase fault relay
- Over-temperature relay for use with thermistors
- Current transformers for ammeter (if necessary)

On the door will be mounted the following:-

- Ammeter
- Start and Stop push buttons
- Overload reset push button
- Over-temperature reset push button
- Hours run indicator
- Indicating lamps and labels as necessary

4.40.6 Emergency Stop Push Button

Every motor, which forms part of a fixed installation, shall be provided with an emergency stop push button adjacent to the equipment.

It shall be of the “lock-off” pattern with one normally open and one normally closed contact. The unit shall comprise a heavy-duty, weather proof box mounted on a substantial up stand and at a height of 1 m above floor level.

4.40.7 Small Control Stations

These shall be housed in sheet steel enclosures suitable for wall mounting and equipped either with a hinged lid or screw/on cover, to IP 42 or better.

The size of enclosures shall be such that adequate room is available for components, wiring and labels, and for easy access for maintenance purposes.

All components and their installation shall conform to the requirements detailed in other sections of this Specification.

Anti-condensation heaters will be required, but not the provision of rubber mats.

4.40.8 Consumer Units and Distribution Boards

These shall be of the multi-pole MCB type, suitable for combinations of TPN, TP, DP, and SP MCB’s and shall comply with BS 5486.

Where distribution boards are integral with motor control centres or switchboards they shall be fed from the bus-bars via suitably rated MCB’s.

Residual current circuit breakers (Residual current devices) shall be included to give added protection against earth faults in compliance with Regulation 413 of the IEC wiring Regulations.

Each consumer unit and distribution board shall be provided with an internal circuit designation chart. These shall be securely fixed, and equipped with perspex or similar covers, and shall have space for each outgoing circuit to give clear identification. Unprotected paper labels will not be accepted.

4.40.9 Control Desks

Control desks shall comprise a sheet steel enclosure and hinged lid. The lid will be set at an angle to facilitate operation of the controls, which are mounted on it. The index of protection shall be IP 42 or better.

Rear access will not be available but either hinged doors or screw-on panels shall be provided at the front.

All components and their installation shall conform to the requirements detailed in other sections of this Specification.

An anti-condensation heater will be required complete with adjustable thermostat and isolating switch, but rubber mats will not be required.

4.41 Electric Motors

All motors shall comply with BS 4999 and BS 5000, (IEC 34 and 72) and shall be cage type, TEFV with enclosures to IP 44 (unless otherwise stated).

They shall be continuously maximum rated and wound for a voltage of 415 volts at 50 Hz. The insulation shall be class F or better but shall be designed for a maximum temperature rise of 80deg.C in an ambient of 40deg.C.

The preferred motor speed is 1500rpm.

The rating of the motors shall provide an excess of power not less than 10 per cent over the maximum demand made by the mechanical load connected to them. Where necessary the motor shall be rated to take into account the effect of the altitude at which it will be operating.
Anti-condensation heaters shall be incorporated in all motors over 4 kW. They shall be suitably rated and designed for connection to a 240 volt, single phase A.C. supply.

The windings of all motors shall have embedded P.T.C. thermistors.

All six ends of motor windings and heater leads etc., shall be brought out to a terminal block or blocks contained within a terminal box or boxes. The terminal box or boxes shall each be suitable for the reception of the requisite number of PVC/SWA/PVC or XLPE/SWA/PVC cables, of suitable voltage grade.

Motors other than submersible shall be fitted with grease lubricated ball and/or roller bearings. Bearing housing shall be fitted with grease nipples incorporated relief valves. Bearings shall be chosen to give an operating life of at least 80,000 hours.

4.42 Cables and Wires

All cables shall have multi-strand copper conductors, unless otherwise specified. PVC over-sheaths shall be impregnated with repellents to deter vermin and termites. All grades shall be suitable for operation under tropical conditions.

- PVC cables shall comply with BS 6346
- XLPE cables shall comply with BS 5467

The minimum size of conductors for power cables shall be 2.5mm2.

Joints in cables are to be avoided, except where cable lengths exceed drum lengths. In such circumstances, joints shall be made and tested under supervision, and their location indicated by a proprietary concrete marker.

Positions of joints shall be accurately recorded for incorporation on “as built” drawings.

4.42.1 Buried Cables

Where cables are laid in the ground, they shall be bedded on 50mm of graded sand, and after laying shall be covered, prior to backfilling, by another 50mm of graded sand.

Laying depth shall be a minimum of 500 mm below final grade, and all cables in the ground shall have a separation of at least one cable diameter and shall have a polythene warning tape installed below it:-

The warning tape shall be coloured yellow/black stripes and bear the following legend, in bold black capitals, at regular intervals:-

"CAUTION - ELECTRIC CABLE BELOW". It shall be laid at a depth of 200 mm below final grade.

Concrete marker posts shall be erected at intervals at intervals of 25m or at changes of direction of cable trenches. A plate shall be fixed to the post stating "BURIED CABLES" and their position marked on the final "AS-BUILT" drawings.

At road crossings, ducts shall be provided for protection of the cables against mechanical damage. These shall be a minimum of 100mm diameter, of steel or PVC. Each duct shall be provided with a nylon drawing-in rope.

Adequate numbers of ducts shall be provided at points of entry into buildings. These shall be in the form of easy sweep bends, having a bending radius appropriate to the size of the largest cable but in any case not less than 10 times the cable diameter.

After installation and final test, all cable ducts shall be sealed using fire resistant materials to the satisfaction of the Project Manager, to prevent ingress etc. into buildings of water vermin, termites etc.

4.42.2 Cables in Ducts

Cables shall be installed on heavy-duty return flange trays of proprietary design or by means of individual cleats. Trays shall be hot dip galvanised and the cables shall be installed using fixings such as nylon or PVC straps.

Single cable fixings shall be made using either aluminium or plastic cleats either fixed directly on to the sidewall or mounted on proprietary galvanised steel channel. BICC 'Leprack' steelwork and cable fittings or other approved type shall be used.

Where ratings permit, trefoil cleats may be used.

Trays shall be fixed to the wall using hot dipped galvanised standoff brackets.

Due regard to the current loading of cables shall be made but not more than two layers of cable shall be installed on cable trays and the separation between single or trefoil cables shall be a minimum of one cable diameter or equivalent.

It will not be acceptable to lay unsecured cables on the bottom of the duct.

4.42.3 Building Services

Other than in residential buildings, cables shall be run either in covered floor ducts, or on heavy duty return flange, hot dip galvanised cable trays. Trays shall be fixed to the wall using hot dip galvanised standoff brackets, and shall be covered with hot dip galvanised capping. (Small wiring may be run in conduit or ducting. See (Clause 4.43).

Cables shall be fixed by using nylon or PVC straps.

Each cable shall be labelled with its reference, (per the cable schedule) at each end, using proprietary cable markers. These markers shall be easily legible and firmly fixed. Clip-on or adhesive markers will not be accepted.

The blank gland plates within each panel shall be removed and drilled to accommodate the requisite glands, which shall be supplied under this Contract.

4.42.4 Cable Terminations and Glands

Cables shall be colour coded at the terminals by means of coloured sleeves as follows:

- Phase : red, yellow, blue
- Neutral and D.C. negative : black
- Earth : green or green/yellow
- D.C. positive : red

The individual cores of cables shall be made off to their respective terminal boards. Each core shall be fitted with insulation pin or lug type crimped terminations, as appropriate.

Each core shall be identified with interlocking ring type ferrules, to correspond with the fixed wiring on the other side of the terminal board. Adhesive types shall not be used.

Glands shall comply with the relevant British Standard and shall be of cadmium plated brass. They shall be of weather proof pattern incorporating an armour clamp and an earth lug or tag. After installation, PVC or neoprene shrouds shall be fitted over each gland.

At all termination sufficient slack cables shall be left to allow for future trimmings, stripping back and reconnecting to the terminals.

4.42.5 Cabling Details

The Contractor shall submit a schedule of all cables, detailing the following for each cable proposed:

- Reference Number
- Type
- Cross Sectional Area
- Number of Cores
- Origin
- Destination
- Cost per metre installed
- Cost for each termination (glanding and making off)
- Route Length

- Operating Voltage
- Estimated Current
- Percentage Voltage Drop

Rates (for cables) and (terminations) shall be used to assess costs in the event of any agreed route length variation.

The Contract price shall include all cables required for a fully operational installation.

4.43 Conduit and Trunking

Other than in residential buildings all conduit and trunking shall be surface mounted or, in the case of trunking for lighting cables and fittings, may be suspended using proprietary fixings.

All cabling in conduits and trunking shall be multi-strand, PVC insulated and not less than 1.5 mm^2 conductor cross-section.
All surface conduits shall be heavy gauge hot dip galvanised screwed tubing all accessories shall be hot dip galvanised.

Tubing and fittings shall comply fully with BS 4568:1970 Parts 1 and 2.

Minimum size shall be 20mm diameter and newly cut threads shall be painted without delay, using zinc rich paint.

Conduits shall be fixed using spacer saddles and brass screws at intervals not less than 1.2 meters on horizontal runs, and 1.5 metres on vertical runs.

Trunking shall be of galvanised cold rolled steel designed for lighting applications and shall be of robust construction and suitable for use in a tropical industrial environment. It shall be suitable for suspension and allow continuous unobstructed runways for cables. Luminaires shall be themselves suspended from trunking or fixed directly to it.

In locations where it is not possible to make direct connection by conduit due to vibration or difficult route, it will be acceptable to use flexible conduits. This shall be approved by the Project Manager and shall be of robust construction and suitable for use in a tropical environment.

4.44 Junction Boxes

Junction boxes shall be manufactured from hot dipped galvanised steel and shall be fitted with the requisite numbers and sizes of DIN rail mounted terminals. Cable cores on each side of the terminal boards shall be identified using ring type interlocking ferrules. Boxes shall have an ingress protection of IP 54, and all cable entries shall be from below, wherever possible.

4.45 Lighting and Small Power

Other than in residential buildings consumer units or distribution boards shall be provided in every building for internal lighting and small power supplies. They shall be single-phase or three-phase as necessary and shall comprise RCD's and MCB's. Re-wirable fuses are not acceptable. (See Clause 4.40.8).

Luminaires for general lighting shall be single or twin tube fluorescent fittings fixed directly to ceilings

or trunking or suspended by hangers to give optimum illumination.

The following minimum levels of illumination shall apply at a height of 1m above floor level:

- Laboratory 400 lux
- Offices, control rooms and workshop 300 lux
- Pump houses, machinery rooms and operational areas 200 lux
- Entrance halls and storage areas 100 lux

All light switches shall be surface mounted and of robust industrial type suitable for conduit connections. They shall be rated at not less than 5A but the steady state load shall not exceed 50% of the switch rating.

The mean mounting height of single switches or the bottom row of a multiple switch unit shall be 1.4m above floor level

Switched socket outlets for general purposes use shall be surface mounted and of robust industrial type suitable for conduit connections. They shall be rated at 13 A to BS 1363 and installed 0.5m above floor level.

4.46 Emergency Lighting

At power supply failure a basic lighting shall be provided. As far as possible, fluorescent bulbs with electronic converters shall be used. If not suitable small halogen light fittings shall be provided.

4.47 Flood Lighting

For operational purposes certain areas may require to be floodlit. Such as:-

- Pump Station

They shall be controlled by individual switches at a convenient location.

The luminaire shall be selected from the flood lighting range offered by Thorn Lighting or Philips Lighting or other approved manufacturer. They shall be mounted on lighting columns or wall brackets.

4.48 3-Phase Plugs and Sockets

The plugs and sockets shall be 5-pin suitable for 415 volts, 3.phase, 50 Hz with separate neutral and earth pins. They shall comply with BS 4343 and IEC 309 and be protected to IP 44 or better.

The plugs shall be of polycarbonate material but the sockets shall be of aluminium alloy, suitable for conduit connections. The socket shall be surface mounted at a height of 1.25m above floor level.

4.49 Extractor Fans

Extractor fans shall unless otherwise specified, generally be installed at high level within the wall of the building so that they project a minimum distance into the building. Air operated louvres shall be positioned over the fan opening on the outside of the building as a weather shield.

The fan motors shall be fully tropicalized and protected to IP 54 or better.

Fans shall be tested in accordance with BS 848.

4.49.1 Fan Control

The fan motor shall be suitable for 415 volts, 3-phase, 50 Hz and shall be controlled either manually or automatically by means of a wall-mounted thermostat. The thermostat shall be adjustable and shall be fixed at a height of 1.5m above floor level.

4.50 Level Controls

Level control relays shall be installed within the appropriate MCC and shall be activated by remote electrodes installed in the associated wet well or by pressure gauges.

Connections to electrodes shall be made at the electrode holders, the latter being fitted on proprietary brackets. The electrodes shall be used to provide a signal at specific depths for control purposes. They shall comprise an earth (or reference) electrode, together with as many other electrodes as are necessary for the application.

The electrodes shall comprise rods or tubes which shall be hot dip galvanised or of material resistant to corrosion. They shall have a minimum diameter of 15mm. Joints in electrodes will not be accepted.

Where electrodes exceed 2.0 metres in length or are immersed in fast flowing liquids, insulated support brackets shall secure them.

Electrodes shall be as those made by Hawker Electronics Ltd, such as HAWKER HPE8 or E12 or any similar approved type.

4.50.1 4.51 Tests on Completion

Testing on completion shall be carried out to demonstrate compliance with the IEE wiring Regulations.

The following tests shall be carried out: -

- Verification of polarity (dc and single-phase circuits)
- Phase rotation
- Resistance to earth of earth system
- Insulation resistance. (Phase/phase and phase/earth)
- Earth loop impedance
- Operation of over current and earth fault relays by injection tests
- Operation of all other protective relays and devices
- Levels of illumination
- Correct sequencing of all control equipment

The Project Manager shall be given full opportunity to witness all tests and shall approve all test results.

The Project Manager shall have the right to ask for specific tests to be repeated.

5 STANDARD SPECIFICATION FOR PAINTING AND PROTECTION

5.1General

The preparation, application and conditions for work shall comply with the recommendations of BS 5493 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.

Paints, primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use.

No site painting shall be carried out unless the surface to be painted is dry, the air temperature above 4oC and the relative humidity less than 85%. The Project Manager shall approve the methods for removing all dirt, oil, grease, etc., before Site painting commences.

Test plates carrying finishes from the actual coating used may be required by the Project Manager for inspection and test purposes.

To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white.

Priming to two mating surfaces shall be applied prior to assembly.

All items of Plant shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance. Such painting shall be carried out within one month of successful acceptance trials for the Plant.

All paint thicknesses shall be checked using an Elcometer or equivalent instrument, supplied by the Contractor, for each layer of paint, to the reasonable satisfaction of the Project Manager.

5.2 Surface Preparation

Surface preparation for the various substrates shall be as follows unless otherwise specified under Detailed Paint Systems:

5.2.1 Steelwork

All steelwork including structural steel and steel doors and frames shall be prepared by blast cleaning in the Shop. Blast cleaning shall be to a visual standard in accordance with SIS 05 59 00 standard Sa $2^{1}/_{2}$ at the time of painting (equivalent to 2nd Quality BS 4232).

Only dry abrasive blast cleaning techniques shall be employed. Abrasives shall be expendable copper slag or re-usable iron and steel grit or shot. All surface defects, including cracks, surface laminations and deep pitting, likely to be detrimental to the protective painting system shall be removed as laid down in BS 4360. All fins at saw cuts, burrs, and sharp edges shall be similarly removed. Where

extensive grinding has been necessary, the dressed areas shall be re-blasted to remove all rust and provide an adequate paint key.

After blast cleaning, before the surface has time to re-rust, and in any case within 4 hours of blast cleaning (2 hours for outdoor blast cleaning) the first coat of primer shall be applied.

5.2.2 Metal Sprayed Coatings to BS 2569 : Part 1 (Zinc)

The metal deposition shall be coated at once with two pack zinc chromate etch primer, and the first coat of the paint system shall be applied within 1 to 4 hours.

5.2.3 Galvanised and Non-ferrous Surfaces

Surfaces shall be cleaned of dirt and building debris. All grease and handling marks shall be removed by the application of zinc chromate etch primer thinners.

The clean dry surfaces shall then be primed with two pack zinc chromate etch primer followed by the first coat of the paint system within 1 to 4 hours.

5.3 Detailed Paint Systems

The exposed plant shall be painted white gloss to BS 00E55, unless otherwise stated or instructed by the Project Manager.

Equipment out of sight in rooms that are normally locked, i e HV switchgear and transformers shall be white gloss or manufacturers standard colour.

Penstocks shall be black, epoxy coal tar except for headstocks and hand wheels which will match the actuator colour or be white gloss.

Diaphragm valves shall be black.

Motive water pumps shall be blue.

Chlorine equipment and drums shall be yellow.

Cranes and ancillary equipment shall be yellow.

5.2.4 Structural Steelwork

5.2.4.1 Shop applied - Apply Overall:

1 coat high build alkyd zinc phosphate primer to a minimum dry film thickness of 75 microns followed by 1 coat phenolic / alkyd coating containing micaceous iron oxide to a minimum dry film thickness of 50 microns.

5.2.4.2 Site Applied:

Any damaged areas to be prepared as for the shop coats and made good with the original shop coats to the specified dry film thicknesses.

5.2.4.3 Apply Overall:

1 coat phenolic/alkyd coating containing micaceous iron oxide to a minimum dry film thickness of 50 microns followed by 1 coat alkyd decorative enamel to a minimum dry film thickness of 40 microns.

5.2.5 Steel Doors and Frames

5.2.5.1 Shop Applied:

1 coat high build alkyd zinc phosphate primer to a minimum dry film thickness of 75 microns followed by 1 coat alkyd based undercoat to a minimum dry film thickness of 40 microns.

5.2.5.2 Site applied:

1 coat alkyd based undercoat to a minimum dry film thickness of 40 microns. 1 coat decorative alkyd enamel to a minimum dry film thickness of 40 microns.

5.2.6 Steelwork in Contact with Water

5.2.6.1 Shop applied:

Hot dip galvanising to BS 729.

5.2.6.2 Site applied:

Any damaged areas to be thoroughly cleaned of rust and surface deposits and painted with 1 coat of epoxy zinc phosphate to a minimum dry film thickness of 75 microns followed by 1 coat of epoxy micaceous iron oxide undercoat to a minimum dry film thickness of 100 microns followed by 1 coat of epoxy micaceous iron oxide to a minimum dry film thickness of 60 microns.

5.2.7 Pipework and Valves

All pipework and valves above ground, unless otherwise specified, shall be treated as described herein for pumping station steel pipework. All pipework and valves in chambers shall be treated as described in Chapter 6 for buried pipework.

5.2.8 Mechanical and Electrical Equipment

Paints, including primers and undercoats, shall be obtained from the same manufacturers and shall, except where application has to be made within a limited time of mixing, be ready mixed for use and compatible with one another. Only paint that is delivered in sealed containers, bearing the name of the manufacturers and properly labelled as to its quality and instructions for use, will be acceptable.

The manufacturer's proposed paint and protection systems for all mechanical and electrical equipment shall be submitted to the Project Manager for approval at the time of submission of shop drawings.

All surfaces of Plant shall be protected against corrosion and/or erosion with the exception of stainless material and rotating gland or bearing surfaces.

Where dissimilar metals are in proximity and where the possibility of electrolytic or similar corrosion exists the mating surfaces shall be insulated.

Test plates carrying a sample of the actual coating used may be requested by the Project Manager for test and inspection purposes.

All items of Plant shall be delivered to Site with their protective paint finish applied and, except where otherwise specified or instructed by the Project Manager, shall be given further coats of final paint finish, at Site, of sufficient thickness to give uniform colour and appearance. Site painting shall not be carried out unless the surface to be painted is completely dry, the air temperature is above 20oC, and the surface temperature is at least 3oC above the dew point. Immediately before site painting all oil, grease, etc. shall be removed from the surfaces to be painted and all damage to the factory applied finish made good.

Unless otherwise specified or approved by the Project Manager (eg where the Contractor's normal protective finish is of a special nature giving equal or better protection) or where the material of construction has an inherent corrosion resistant property, the Plant shall be protected in accordance with the following:

- Component parts which may be in direct contact with water (excluding the pumping station steel pipework)

    - blast clean in accordance with the requirements of Swedish Standard SIS 05 59 00 Sa 21/2.
    - Ferrous metal:

within 4 hours of (a) above apply zinc metal spray to a thickness of 0.1 mm or greater in accordance with BS 2569.

or

within 4 hours of (a) above apply sufficient coats of polyamide cured epoxy zinc rich primer containing at least 90% of zinc in the dry film to give a minimum dry film thickness of 30 microns.

    - Non-ferrous metal:

within 4 hours of (a) above apply sufficient coats of polyamide cured epoxy etch primer to give a minimum dry film thickness of 50 microns.

    - thoroughly clean and degrease previous finish and within 2 hours apply sufficient coats of tar or pitch epoxy resin to give a minimum dry film thickness of 250 microns.

- Steel pipework:

- fettle to remove all flash, weld spatter, sharp and rough surfaces.
-
- blast clean in accordance with the requirements of Swedish Standard SIS 05 59 00 Sa 21/2.
- within 4 hours of (b) above apply one coat epoxy polyamide primer to give a minimum dry film thickness of 25 microns.
- apply second and third coat amine adduct cured epoxy, each coat to give a minimum dry film thickness of 125 microns.

- Exposed plant, not coming into direct contact with the water, excluding diesel engines:
  - blast clean in accordance with the requirements of Swedish Standard SIS 05 59 00 Sa 21/2.
  - within 4 hours of (a) above apply sufficient coats of polyamide cured epoxy primer containing red oxide or zinc phosphate to give a minimum dry film thickness of 50 microns.
  - thoroughly clean and degrease previous finish and within 2 hours apply sufficient coats of polyamide cured epoxy with inert durable pigments to give a minimum dry film thickness of 125 microns.
- Plant installed inside buildings excluding electrical panels and the pumping station steel pipework:
  - thoroughly clean surfaces to remove rust, scale, dirt, loose paint, etc. and degrease by the use of solvents which are compatible with the paint finish to be applied.
  - within 4 hours of above apply sufficient coats of polyamide cured epoxy or alkyd resin based primer to give a dry film thickness of not less than 40 microns.
  - thoroughly clean and degrease previously applied finish and within 2 hours apply sufficient coats of polyamide cured epoxy or alkyd resin based undercoat and gloss finish paint to give an even and uniform colour and covering.
- Ferrous nuts, bolts, washers, etc. and other small component parts shall be either hot dip galvanised to BS 729 or zinc electroplated. They shall be given further coats of site applied protective finish when the plant is undergoing site painting.
- Electrical panels installed within buildings shall be finished with sufficient stove dried enamel primer and gloss finish to give a dry film thickness of not less than 50 microns or alternatively a single coat of polyester sprayed powder where this is the manufacturer's standard finish.
- Electrical panels installed in exposed positions or in damp conditions shall receive a surface preparation containing zinc prior to stove enamelling. Electrical panels shall not be site painted, however, each item of plant shall be supplied with touching up paint and any damage shall be satisfactorily repaired.
- Electrical panels shall not be site painted, however, each item of plant shall be supplied with touching up paint and any damage shall be satisfactorily repaired.

5.3 Colour Coding and Labelling of Pipes and Equipment

All pipes and equipment shall be colour coded to a schedule to be agreed with the Project Manager before any site painting starts, or earlier if necessary to suit manufacturing procedures. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment.

All pipelines shall be identified by stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one piece removable liners. Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Project Manager. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.

Pipes smaller than 22 mm outside diameter shall be labelled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel.

Titles shall also be provided on all equipment in locations and in sizes to be approved by the Project Manager.

6 STANDARD SPECIFICATION FOR PIPEWORK AND VALVES

6.1General

The pipework shall be laid out and designed so as to facilitate its erection, painting in situ, dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum loss in head. Where steel pipework is used the number of flanges is to be kept to a minimum with the size of each unit of pipework determined by the ease of handling, installation and general appearance of the completed pipe system.

Flexible joints shall be provided on pressure pipes where necessary to facilitate installation and removal of Plant or to allow for differential movement. Where required, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipework as a whole.

Wherever possible, standard fittings shall be used in preference to fabricated or special fittings.

Valves, strainers and other devices mounted in the pipework shall be supported independently of the pipes to which they connect.

All metal brackets, or other forms of support, shall be rigidly built up of steel by bolting or welding in preference to the use of castings.

Facilities shall be provided for draining the pipe system and releasing air. The period for drainage shall not exceed 30 minutes and there shall be suitable means of disposal for the drained fluid.

6.2 Marking and Protection of Pipes and Fittings for Shipment

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

6.3 Storage of Pipeline Materials

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500 mm diameter or over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Flexible pipes shall be stored in sheds or covered areas.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Project Manager and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers, which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers, which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

6.4 Transportation of Pipes and Fittings

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Project Manager may cause damage to the pipes shall be discarded.

Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

6.5 Inspection of Pipes and Fittings

Before incorporating into the Works each pipe shall be brushed out and carefully examined for soundless. Damaged pipes, which in the opinion of the Project Manager cannot be satisfactorily repaired, shall be rejected and removed from Site.

Damage to pipe coatings or linings shall be repaired to the satisfaction of the Project Manager.

6.6 Built-in Pipework and Other Plant

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipework and other Plant is in accordance with the requirements of the programme.

Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall be to BS 4504 but shall be

undrilled. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the Works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

6.7 Materials

Each pipeline shall be constructed in a material compatible with the fluid conveyed through that pipeline, ie the materials used in the pipes which are or can be in contact with the untreated or treated water, shall not contain any matter which could impart taste or odour or toxicity or otherwise be harmful to health or adversely affect the water conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

Pipework and valve materials for the following duties shall be as follows or equivalent to the approval of the Project Manager:

- Alum solution - rigid PVC-U
- Chlorine:

Drum connections - cadmium plated 70/30 copper nickel CN 107, BS 2871 : Part 1:

Chlorine gas or liquid - flanged or welded carbon steel, CAF flanged joints.

Chlorine gas lines below atmospheric pressure - polyvinylidene fluoride (PVDF) with solvent welded or flanged joints.

Chlorine solution - Class E PVC-U in concrete covered dusts outside building. Inside building and in exposed areas, rubber lined carbon steel.

Valves shall be globe type with forged steel bodies, monel spindles, stainless steel seats and PTFE gland packing or carbon steel, monel plug, PTFE sleeved plug.

- Sulphuric Acid:

Concentrated acid - flanged carbon steel and Hastaloy for diameters less than 50 mm.

Dilute acid - Polyvinylidene fluoride (PVDF) with solvent welded or flanged joints.

- Lime:

Lime slurry transfer pump suction pipework - steel, ductile iron or rigid PVC-U.

Lime slurry transfer pump delivery pipework - EPDM covered, reinforced, natural rubber line tube, approved for use with potable water and with chemical resistance to chlorine solution (35 g/l) and sulphur dioxide solution (3.5 g/l) with quick release couplings.

Saturated lime dosing pipework - steel, ductile iron or PVC-U.

- Water:

Raw water, backwash water, dirty wash water, - steel or ductile iron.
supernatant and treated water

Service water - steel, ductile iron or PVC-U.

- Air:

Air scour - steel or ductile iron.

6.8 Ductile Iron Pipes and Fittings

Ductile iron pressure pipes and fittings shall comply with clause 3.1.17

6.9 Steel Pipes and Fittings

Steel pipes and fittings shall comply with clause 3.1.17.

6.10 Grey Iron and Cast Iron Drain Pipes and Fittings

Grey iron and cast iron drain pipes and fittings shall comply with BS 4622 and BS 437, respectively. Pipes shall be protected to the same standards and have the same type of joint as ductile iron pipes.

6.11 Unplasticised PVC Pipes and Fittings

Unplasticised polyvinyl chloride pipes, fittings and specials shall be to clause 3.1.17

Where PVC pipes, fittings and specials are to be connected to cast iron, stainless steel or steel pipes, `Viking Johnson' type flange adaptors or stepped couplings shall be used.

6.12 Polyethylene Pipes

Polyethylene pipes shall comply with Clause 3.1.17

6.13 Rubber Hosing

Rubber hosing shall conform to BS 5119, Type 2. It shall be capable of handling chlorine and sulphur dioxide solutions at a working pressure of 12 bar.

6.14 Copper Tubes and Fittings

Copper tubing and fittings for work above ground level shall comply with BS 2871 and BS 864: Part 2 respectively and be jointed with capillary joints. For underground location the copper pipe shall be to BS 2871: Part 1.

6.15 Flanged Joints

All flanges shall comply with Clause 3.1.17 or Clause 6.9 for steel pipes. The nominal pressure rating for particular flanges shall be at least equal to the highest pressure rating of the pipes or fittings to

which they are attached, but with a minimum nominal pressure of PN 16. All flanges shall be provided with all necessary nuts, bolts, washers and gaskets. In general, valves shall have flanged body ends.

All flanged joints that are buried or in chambers shall be protected with Densomastic and Densotape wrapping, applied in accordance with the manufacturer's instructions.

Flanges shall be installed on the pipes in the factory and field welding of flanges shall only be allowed with the approval of the Project Manager.

Where pipework outside pumping stations and surge vessel chambers is cathodically protected, an insulated flange shall be incorporated at the first flange inside the structure. These flanges shall be tested to ensure that electrical insulation is achieved.

6.16 Gaskets and Joint Rings

Joint rings shall be manufactured to conform with clause 3.1.17 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80^{O}C.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any soluble constituent, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

6.17 Welded Joints for Steel Pipes

Welding of joints in steel pipes shall be carried out manually by the metal arc welding process complying with AWWA Standard C206.

Before starting the welding of pipe joints in the Works the Contractor shall submit for the Project Manager's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength and arrangements for air testing of individual joints.

Welding shall only be carried out by welders approved by the Project Manager pursuant to the provisions of Clause 6.18 and each welder shall identify his work by means of a stencilled mark.

Welded joints other than for closing lengths shall be of the spherical spigot and socket type. For pipes of 675 mm diameter and smaller the pipe joint shall be welded externally. For pipes larger than 675 mm the pipe shall be welded internally and a sealing weld made externally.

All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by

means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld run when it is completed. Pipes manufactured with longitudinal or spiral welds shall be lined up before jointing so that these welds are at least 15^{O} apart around the joint circumference.

For pipes larger than 900 mm diameter a triple run convex fillet weld shall be used. For pipes of 900 mm diameter or less a double run convex fillet weld shall be used. The minimum leg length of the fillet as deposited is to be equal to the full thickness of the pipe wall. The actual throat depth shall not be greater than 9/10th and not less than 7/10th of the minimum leg lengths as deposited. The depositing of the weld metal shall be carried out in such a manner as to ensure that all the welds have adequate root fusion and are of good clean metal free from cracks, gas holes, slag inclusions and all other impurities. The surface of the weld shall have an even contour with regular finish and shall indicate proper fusion with the parent metal. All slag shall be thoroughly removed after depositing each run of welding by light hammering with a chipping hammer followed by wire brushing. Any welds showing cracks or other cavities or in which the weld metal tends to overlap on to the parent metal without proper fusion or containing any other defects whatsoever shall be cut out and rewelded to the satisfaction of the Project Manager at the Contractor's expense.

At closing lengths where two plain-ended pipes are to be joined by a welded joint the gap between the two ends shall not exceed 75 mm. An external steel sleeve collar, of a thickness not less than that of the pipe itself and approximately 300 mm in length shall be placed centrally over the two ends to be jointed and the end of each pipe shall then be fillet welded to the sleeve collar in accordance with the above procedure.

No weld or adjacent parts of the pipe shall be painted prior to inspection by the Project Manager.

6.18 Welder Performance Test

The Contractor shall submit for the Project Manager's approval the names of persons whom he proposes to employ as welders with evidence that, as a minimum preliminary qualification, they have passed the qualifying tests prescribed in Clause 11 of BS 2633 and possessed certificates from an independent testing authority. The Project Manager may further require any such person to perform satisfactory test welds under Site conditions and on pipes similar to those for use in the Works, before approving his employment as a welder. The Contractor shall maintain an up-to-date list of welders approved by the Project Manager and if ordered by the Project Manager he shall remove from the approved list any welder whose workmanship, as demonstrated by the results of air pressure tests on individual welded joints, is below a reasonable standard of quality of consistency in the Project Manager's opinion.

6.19 Testing of Welded Joints

Where directed by the Project Manager welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and rewelded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

6.20 Flexible Couplings and Flange Adaptors

Flexible couplings and flange adaptors shall be of the Viking Johnson or similar approved pattern and be assembled in accordance with the manufacturer's instructions and protected, if buried or in chambers with Densomastic and Densotape wrapping applied in accordance with the manufacturers' instructions. Flexible joints shall be harnessed or tied where necessary.

6.21 Pressure Reducing Valves

Pressure reducing valves shall be capable of maintaining a constant downstream pressure from a higher constant or variable upstream pressure and they shall be drop tight under no flow conditions.

The valve operation shall be achieved by the interaction of the inlet pressure, outlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the outlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

Body ends shall be flanged and drilled to BS 4504.

The materials for the valves shall be as follows:

Cast iron body and cover. Internal valve, gunmetal with bronze liner, cups and facing rings in leather. Relay valve, bronze with stainless steel spindle and nylon valve face. Diaphragm, reinforced synthetic rubber. Loading spring, if employed - spring steel. Cylinder and weights, if employed - cast iron. Lever, steel with gunmetal pins and links. Connecting pipework to cylinder - copper. Cylinder, mild steel epoxy lined with internal working parts gunmetal bushed.

6.22 Pressure Relief Valves

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurised in excess of a preset maximum allowable pressure. The valves shall be drop tight under no flow conditions.

The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

Body ends shall be flanged and drilled to BS 4505.

The materials for pressure relief valves shall be as specified for pressure reducing valves in Clause 6.21.

6.23 Gate Valves

Gate valves shall comply with BS 5150, BS 5163 with Clause 3.1.32

Certain clauses of BS 5150 are amplified as follows:

Clause 14 Operation

Manually operated valves shall not require a force of greater than 20 kg on the outer rim to operate with balance pressure across the valve, unless otherwise specified. To achieve this, gearing may be used in which case the time required to operate the valve under normal working conditions shall not exceed 20 minutes.

Clause 14.4 Indicators

Indicators showing both OPEN and SHUT positions shall be supplied.

Bypasses

Bypasses for valves 400 mm and over shall be fitted with integral bypasses as follows.

- 400 mm nominal diameter valve - 50 mm diameter bypass
- 500 mm nominal diameter valve - 80 mm diameter bypass
- 800 mm nominal diameter valve - 100 mm diameter bypass

Body ends shall be flanged and drilled to BS 4504

All valves shall be manually operated unless specified otherwise or to suit the system operation.

6.24 Butterfly Valves

Butterfly valves shall comply with BS 5155 or Clause 3.1.32

Body ends shall be flanged and drilled to BS 4504.

All valves shall be manually operated unless specified otherwise or to suit the system operation.

6.25 Check Valves

Check valves shall in general comply with BS 5153 or Clause 3.1.32

Certain clauses of BS 5153 are amplified as follows:

Clause 4 Type Swing type for either vertical or horizontal use.

The valve design shall ensure closure in the shortest possible time following deceleration of the water column, ideally reaching its seat without slamming at the instant forward motion of the column ceases.

Where specified the position indicators initiated by microswitches shall be provided to show when the gate is OPEN or SHUT, and provision made for initiating the operation of remote indicator lights and alarms.

Body ends shall be flanged and drilled to BS 4504.

For use with clean water and air duo-check type valves may be used and shall be of the flangeless type.

6.26 Diaphragm Valves

Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS 4504.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions shall be supplied and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional `O' ring seal of nitrite rubber or other approved material.

Diaphragms shall be composed of moulded reinforced, flexible material attached by studs to the compressor. Diaphragm materials shall, where required, be composed of corrosion resistant material.

6.27 Penstocks and Flap Valves

Rising spindle penstocks shall be provided with headstocks and foot brackets as required. Guide brackets as necessary shall be included with the penstock. The handwheel with gunmetal rotating-nut shall have adequate diameter for the duty required and shall have cast on it the direction of closing which shall be clockwise.

Hand operated weir penstocks shall be lockable at any position.

Penstocks gates and frames shall be of cast iron and constructed of material of at least Grade 180 of BS 1452.

Seating faces shall be gunmetal or bronze, hand scraped, and securely fixed to the frame or door.

Frames shall be manufactured from continuously welded stainless steel Grade 316 S16. All frames shall be suitably reinforced and include corner gussets. All fasteners shall be stainless steel Grade 304 S16.

Anchor bolts shall be in stainless steel.

Non-return flap valves shall be designed to suit the hydrostatic conditions at a particular location so that they will automatically open when the downstream level falls below the upstream level and will close when the water levels equalise.

Flap valves shall be heavy pattern type with body and flap of close-grained grey iron, watertight faces of cast iron or non-ferrous rings securely riveted on, machined and hand scraped to a watertight finish. The flaps shall be double hung with non-ferrous hinge pins. Frames shall be drilled for bolting to concrete or to suit flanged ends of pipework.

6.28 Headstocks

Mechanically remote operation of gate or butterfly valves shall be by the use of headstocks, or headstocks with operating spindle extension. Headstocks for direct connection to valves shall be for

use with non-rising stem valves. They shall be of cast iron or fabricated carbon steel and fitted with a position indicator and hand wheel, or bevel gear and hand wheel to conform to the operational requirements. Stem bearings shall be gun metal bushed.

Where headstocks are structurally mounted above a valve chamber, or otherwise distant above a valve, then operating spindle extensions shall be used between the valve and headstock. These shall be suitable for length adjustment during assembly on Site and where necessary shall be fitted with universal couplings adjacent to the valve and to the headstock. Universal couplings need not be fitted on sluice valves. The two couplings shall be so orientated as to give a linear transmission of rotational movement between headstock and valve stems.

6.29 Air Relief Valves

Air relief valves shall be of the Apex type manufactured by Glenfield Neptune, Kilmarnock or equivalent approved.

6.30 Electric Valve Actuators

Actuators shall incorporate a motor, integral reversing contactor starter, local control facilities and terminals for remote control and indication.
Actuators shall be sized to ensure valve operation at the maximum differential pressure. The safety margin of motor power available for seating and unseating the valve shall be sufficient to ensure torque switch trip at maximum valve torque with the supply voltage 10% below nominal.

Motors shall be 3 phase squirrel cage, Class B insulated with a time rating of 15 minutes at 40^{O}C or twice the valve stroking time, whichever is the greater, at an average load of at least 33% of maximum valve torque. Overload protection shall be provided by a direct sensing thermostat embedded in the motor windings.

The gearbox materials shall be suitable for the ambient temperature and enclosure protection shall be suitable for non-submerged outdoor use.

For butterfly valves the worm and quadrant gearing shall be housed in a robust iron gear case with `O' ring seals. Adjustable mechanical stops shall be provided to cater for $90^{O} \pm 5^{O}$, these shall be designed to take the rated torque output of the actuator. The input and output drive mechanisms shall fully cater for resultant radial and axial loads. The assembly shall be grease packed for life.

For sluice valves and penstocks the gearbox shall be of the totally enclosed oil bath lubricated type suitable for operation at any angle and provided with appropriate filling and drain plugs. The drive shall incorporate a lost motion hammer blow feature. The output shaft shall incorporate thrust bearings of the ball or roller type. The design shall permit the gear case to be opened for inspection or dismantling without releasing the stem thrust or taking the valve out of service.

The gearbox shall be painted in the same colour as the actuator.

A hand wheel shall be provided for manual operation, engaged when the motor is declutched by a lever. The drive shall be restored to power automatically by starting the motor. The hand wheel drive must be mechanically independent of the motor drive and any gearing shall be such as to permit emergency manual operation in a reasonable time. Clockwise operation of the hand wheel shall give closing movement of the valve. The effort required for manual operation shall not exceed 250 N.

Actuators shall be provided with open and close torque and/or position limit switches as required by

the type of valve plus two additional limit switches at each end of travel for remote indication and interlocking. A mechanical latch shall be provided to prevent the open torque switch tripping while the initial unseating hammer blows are applied. Space shall be provided for two additional sets of limit switches consisting of three switches per set. Each set shall be independently adjustable to any valve position. Switch contact ratings on inductive circuits shall be 5 A ac up to 400 V, 50 W dc up to 25 V.

A mechanical dial indicator shall be provided to show valve position fully open (red), fully closed (green) and intermediate (white). The mechanical dial shall show continuous valve movement. A sealed potentiometer shall be provided for continuous remote position transmission.

The reversing contactor starter and local controls shall be integral with the valve actuator, housed to prevent breathing and condensation buildup. The starter shall be suitable for 60 starts per hour, and shall comprise electrically interlocked reversing contactors of appropriate rating to the motor size. The primary winding of the control transformers shall be separated from the secondary by a grounded screen and shall be protected by two easily replaceable cartridge fuses. Secondary windings shall also be protected by cartridge fuses.
Local controls shall comprise a pushbutton switch for open close and stop and a local/remote selector switch padlock-able in any one of three positions.

- Local control only.
- Off - No electrical operation.
- Remote control with local stop.

It shall be impossible to operate both open and close pushbuttons simultaneously. Stop push-buttons shall be mushroom headed `Stay put' type.

Each actuator shall incorporate the following:

- Easily resettable phase discriminator to prevent starting with an incorrect phase rotation or dead phase.

- Plug-in interposing relays with dust covers for open/close/stop control from a specified remote dc supply.

- Plug-in relay with normally open contacts coil energised from a control transformer only when local/off/remote switch is in the remote position to show the actuator is electrically operable by remote control.

Internal wiring shall be tropical grade PVC insulated stranded cable of 5 A minimum rating for control circuits and appropriate size for the motor 3 phase power. Each wire shall be clearly number identified at each end. The terminal compartment shall include a moulded `transfer back' terminal block of the study type, the 3 phase power terminals being segregated by a separate insulating cover. The terminal compartment shall include a double O-ring seal to provide a watertight barrier to the electrical enclosure so that electrical components are protected from moisture ingress while the terminal cover is removed.

The actuator enclosure shall be watertight IP 67.

All actuators shall be inspected and witness tested at works fitted to the appropriate valve or penstock. Test certificates shall be provided.

6.31 Pneumatic Valve Actuators

Pneumatic actuators shall be of compact reliable construction and shall be sized to guarantee valve operation at maximum possible differential pressure.

Actuators shall be double acting with an adjustable air cushioning device to prevent piston slam.

The barrel shall be of cold drawn chrome plated steel, the piston rod of precision ground steel, and the piston head of aluminium alloy or malleable iron.

Fixing bolts shall be of high tensile stainless steel.

Valves shall be provided with facilities for manual operation.

6.32 Valve Operators

Valves for operation shall be so geared that under the operating conditions as specified herein, the maximum force on the rim of the hand wheel, crank, or other necessary for operation shall not exceed 20 kg and the maximum torque shall not exceed 5.5 kg/m. A spur, bevel, or worm gear reduction unit, if required, shall be attached to the pinion shaft of the operating mechanism.

The reduction gears shall be made of steel with machined teeth and unless otherwise provided, they shall be enclosed in a cast iron or fabricated steel sealed housing with oil seals, and shall operate in an oil bath. The pinion shaft and screw stems shall be made of alloy steel. The pinion shaft shall be provided with bronze sleeves.

The thrust bearings at each end of the pinion shaft shall have external fittings to permit lubrication with grease. The screw stem shall have a thrust bearing of the ball or roller type, which can be lubricated with grease through an external fitting.

7 TESTING

7.1General

Testing will be required in the following two categories.

7.1.1 Works Tests and Inspection

These tests and inspections shall be carried out at the manufacturer's premises.

7.1.2 Tests on Completion

These tests shall be carried out on site and shall include:

- Tests on site during erection;
- Tests on completed plant systems;
- 30-day operation test.

7.1.3 Further Tests

These tests are described more fully in the following sections and in other chapters of the Specification as detailed below.

7.2 Works Tests

All items of the Plant shall be liable to works inspection at all reasonable times by duly authorised representatives of the Project Manager or the Employer and the factory performance tests on completed units listed below shall be subject to witnessed testing. The Project Manager or his representative reserves the right to carry out pre-shipment inspection of the Plant.

Tests on the pumps shall, as a minimum, comprise the following:

- A performance test on one pump of each duty, the pump shall be driven by its electric motor and be complete with intermediate shafting etc.;

- A performance test on all pumps not tested in (a) above.

The electrical equipment to be supplied shall be in tested in accordance with the requirements of the Specification and in accordance with the relevant BS, DIN or other applicable standard and any other tests as required by the Project Manager to ensure that the Plant fully complies with the Specification requirements.

Complete performance tests are to be carried out on the motors as detailed in BS 4999 or equivalent. Motors shall be tested for temperature rise at full-load. For identical motors only the first motor for each type and rating need be tested as above, other motors may be subject to routine testing.

Routine and type tests shall be carried out on transformers to BS 171, IEC 214 or equivalent. Routine tests shall include:

- Insulation resistance;
- Ratio, polarity and phase relationship;
- Measurement of winding resistance on all tap positions and phases;
- Impedance voltage;
- Over-voltage withstand;
- Load loss;
- Noise level.

Low voltage switchgear shall be type tested to IEC 157 or equivalent. High voltage circuit breakers, vacuum contactors and earth devices shall be type tested to IEC 56 and IEC 470 or equivalent.

Routine tests shall be carried out on all high voltage circuit breakers, and vacuum contactors, including power frequency voltage tests, millivolt drop test and operational tests. Routine and operational tests shall be performed on all 415 V switchgear. Tests shall demonstrate that all control, protection and interlock systems operate satisfactorily.

High voltage cables shall be subjected to high voltage tests and insulation resistance tests. The dc resistance of the conductor shall be measured.

LV cables shall be routine tested in accordance with the relevant BS, DIN or national standard.

Miscellaneous items of electrical plant not specifically mentioned above but provided under the terms of the Contract shall undergo routine tests at the manufacturer's works, unless written approval is given by the Project Manager.

Any additional witness testing resulting from non-compliance of the equipment on initial testing shall be carried out at the Contractor's own expense.

Three copies of all pump and motor test certificates and pump performance curves shall be sent to the Project Manager within two weeks of the completion of the tests, whether the tests were witnessed or not.

The Project Manager will inspect the packing for shipment and confirm that this complies with the minimum standard called for in BS 1133.

Visual inspection shall include:

- Compliance with the Specification and the Contractor's undertaking in respect of description, quality and quantity;

- Standard of painting and corrosion protection;

- Standard and suitability of packing.

Where not otherwise specified, performance tests will be limited to those required by the appropriate British or equivalent International Standard Specification. Witness testing of small and standard plant will normally be waived.

Copies of all test certificates and graphs shall be supplied within two weeks of completion of any tests. Where standard equipment is used type test certificates may be supplied and the particular plant item not tested.

Each consignment of Plant delivered to the Site shall have been tested at the manufacturer's works or other approved place in accordance with the appropriate British or other approved Standard (such test being referred to herein as Works Tests). The Contractor shall provide the Project Manager with the manufacturer's test report for each such consignment before delivery to Site.

7.3 Tests on Completion

7.3.1 Tests on Site Erection

Tests shall be carried out on individual items of plant and equipment during erection on site in order to confirm their suitability for the intended purpose. These tests shall include but not be restricted to the following.

7.3.1.1 Mechanical and Electrical Equipment

- A general inspection to check for correct assembly and quality of workmanship;
- Earth electrode resistance;
- Insulation levels;
- Voltage drops;
- Earth loop continuity and impedance;
- Overload and protection relay settings;
- Operation of protective devices;
- Motor running currents under no load and normal operating conditions;
- Security of all covers, fittings, conduits, trunking, cable fixings, etc;
- Security of earth terminations;
- Correction function of the plant;
- That all equipment is installed in accordance with the manufacturer's instructions;
- All installations generally as detailed in the IEE Wiring Regulations, 16th Edition. Test certificates shall be provided by the Contractor;
- Water, oil and air tightness of all services at or near maximum working pressure;
- Adequacy and security of fixing arrangements for machinery and pipework;
- Damp-proofing, rust-proofing and vermin-proofing and whether there are any unforeseen flood risks from failure to seal apertures between Plant and building structures (such as in pressurised floors and apertures for float rods, control systems and wiring).

The Contractor shall fully document the tests carried out and readings taken and submit to the Project Manager for approval.

Following the above inspections and tests, a 24-hour running test shall be carried out on each machine to prove:

- Correct functioning;
- Absence of fluid leaks;
- Correct bearing temperatures;
- Absence of undue vibration or noise.

During this test a check on the performance of the Plant shall be made, as far as site facilities will allow, to compare its site performance with the official factory tests and to identify any constraints on performance due to site conditions.

7.3.1.2 Pressurised Components

Any enclosed systems including gas-holding components shall, as required by the Project Manager, be tested for mechanical strength and leakage at a pressure not less than 1.5 times the maximum operating pressure of the system, or the pressure called for in the appropriate British Standard. Any resulting damage or leakage shall be rectified by the Contractor at his own expense and the system shall be retested by the Contractor at his own expense.

Pipelines which are designed for internal pressure shall be hydraulically tested in accordance with this clause.

Gauges used for testing pressure pipelines shall either be of the conventional circular type, not less than 300 mm diameter, calibrated in metres head of water, or shall have a digital indicator capable of reading increments of 0.1 metre head. Before any gauge is used, the Contractor shall arrange for it to be checked independently, and a dated certificate of its accuracy shall be provided.

Before testing, valves shall be checked and sealed, the sections of main filled with water and the air released. After having been filled, pipelines shall be left under operating pressure for the period specified in the Contract, so as to achieve conditions as stable as possible for testing.

The pressure in the pipelines shall then be raised steadily until the specified test pressure is reached in the lowest part of the section, and the pressure shall be maintained at this level, by pumping if necessary, for a period of one hour. The pump shall then be disconnected, and no further water shall be permitted to enter the pipeline for a further period of one hour. At the end of the period the original pressure shall be restored by pumping and the loss measured by drawing off water from the pipeline until the pressure as at the end of the test is again reached.

Pressure testing against closed valves or air valves will not be permitted. The Contractor shall provide and install all necessary temporary caps and blank flanges and thrust blocks.

The test on a pressure line shall be considered satisfactory if there if no leakage after the specified time period for maintaining the test pressure.

7.3.1.3 Unpressurised Containers

Reservoir tanks and other liquid containers not to be subjected to pressure shall be tested for leakage after installation. The completed structure will be tested by filling with water and measuring the water level. For concrete structures testing will only commence after the concrete has attained its design strength.

The following procedure based on BS 8007.will be used:

a) The structure will be slowly filled to its normal operating level. The rate of filling should be uniform at a maximum of 2m depth in 24 hours. To cater for moisture loss/gain due to evaporation and rainfall a control can shall be securely inserted in the water in the structure and also filled with water to a set mark. The water in the can is subject to the same gain/loss as the structure.

b) Once filling has been completed, a stabilising (soakage) period of a minimum of 7 days will be observed. The level should be read daily at the same hour; the drop in level should reduce each

day so that at the end of the initial 'soakage' period of 7 days, the recorded 24 hour drop should not exceed about 2 mm. This may be extended to 10 or 14 days before relative stability is achieved.

c) The 7-day test period should then be started by recording the water level in the structure and in the can used to record the loss/gain due to evaporation/rainfall. Both levels should be recorded every day at the same hour. The level in the structure should be recorded at four different positions.

d) The acceptable drop in water level should not exceed 1/500 of the average water depth or 10 mm, whichever is greater.

e) If the drop in level over the 7-day test period does not exceed the acceptable drop and there are no signs of seepage on any of the exposed surfaces, the structure can be assumed to have passed the test.

Any leakage shall be rectified by the Contractor at his own expense and the tank or container re-tested by the Contractor at his own expense.

7.3.1.4 Tests on Completed Plant Systems

Following the successful completion of individual testing of each item of plant in a plant system, each plant system shall be tested for satisfactory operation through the full range of service duties. Tests shall include all anticipated duty under both automatic and manual control as appropriate.

7.4 30 Day Operation Test

When all testing under Clauses 7.2 and 7.3 have been completed and accepted by the Project Manager, the Contractor shall operate each section of the Works as a whole for a minimum period of 30 days. This operation shall be at the maximum capacity of the section of the Works, or lesser rate if required by the Project Manager for certain periods.

Daily reports shall be prepared on the operations that comprise of the amount of water in the system, hours in use, etc., as directed by the Project Manager. These shall be submitted to the Project Manager and shall form part of the Employer's operation and maintenance manuals and As-Built drawings.

Training of the Employer's staff shall take place as described in Clause 8.06 during the operation period.

During the 30 days described above, the Contractor shall demonstrate that the Plant can produce consistently the specified quality of water at the design range of outputs. A comprehensive record shall be made of all aspects of the plant operation during this time and the results provided to the Project Manager in the form of a commissioning report.

7.5 Further Tests

Further tests may be required by the Project Manager during the Defects Liability Period to determine the performance of the Plant under raw water conditions different from those prevailing during the 30 day operation period. Should the Plant fail the test by not meeting the requirements of the Specification, the Plant shall be made good and re-tested by the Contractor at his own expense.

8 OPERATION AND MAINTENANCE TRAINING

8.1General

The Contractor shall carry out full operation of the water supply system for 30 consecutive days. Daily reports shall be prepared on the operations that comprise of the amount of water in the system, hours in use, at least 6No off site detailed water quality tests etc., as directed by the Project Manager. These shall be submitted to the Project Manager and shall form part of the Employer's operation and maintenance manuals and As-Built drawings. Training of the Private Operator's staff in basic operation and maintenance procedures of all plant and equipment shall be in this period.

The Contractor shall provide comprehensive training for the Employer's operation and maintenance staff and operators as part of the Pumping System (including borehole pump house and System Control) and the Distribution System (Reservoirs and Pipe Network Control). Training shall be provided in the following categories.

- Training in the operation of individual items of equipment.
- Training before issue of the Taking-Over Certificate.
- Training after issue of the Taking-Over Certificate.

These categories are described more fully in subsequent sections of this chapter.

8.2 Staffing Schedule

The Employer will provide all the necessary operating staff and maintenance personnel to carry out the 30 day operation, for each section of the Works, under the Contractor's direction and to take over the plant operation after the 30 days operation.

8.3 Operating Instructions

The Contract requirements concerning Operation and Maintenance Manuals are given in Clause 1.21 of the Specification. Two draft copies of the manuals are to be submitted for approval 2 months prior to the commencement of Tests on Completed Plant Systems (Clause 7.3 of the Specification). The draft manuals will be used during the training period and any amendments required will be communicated to the Contractor by the Project Manager before submission of the final version.

8.4 Training for Individual Items of Plant

Training in the maintenance, installation and operation of the following categories of plant and equipment is to be given to the Employer's staff prior to the hands-on training during the 30-day operation period for each of the sections of the Works:

- Utility grid supply
- Solar panel array
- Submersible Borehole pumps;
- Water supply system control;
- Steel reservoir tanks flow control,
- Electrical switchgear.

8.5 Formal Lectures

The Contractor shall not be expected to give formal lectures; training is expected to be of a practical nature.

8.6 Training after Completion

Instruction shall be given to the Employer's operators and supervisory staff in the form of hands-on training throughout the 30 day operating period for each of the sections and parts of the Works. This training will be given as an integral part of the operation and shall be continuous during the 30 day period for each of the sections of the Works. All aspects of the plant operation shall be covered and the Contractor shall provide sufficient training personnel to cover all the necessary aspects fully.

8.7 Training after Acceptance

Following formal acceptance of the plant or part thereof by the Employer, the Contractor shall continue to provide training in an advisory capacity, while responsibility for the normal operation shall lie with the Employer. Training during this period shall include the provision of advice and assistance when required by the Employer.

8.8 Training and Advisory Personnel

The Contractor shall provide the following personnel to achieve the training requirements of the contract.

8.8.1 Training Expert

The training expert is to be experienced in operation and maintenance and in training unskilled operators in all aspects of the management and operation of the works which are being provided under this Contract. This shall be demonstrated by the submission of the Contractor's nominee's curriculum vitae to the Project Manager and the latter's approval to his appointment prior to the commencement of the training services. The training expert shall be fluent in English. The total duration of the training expert's input shall be a minimum of two months which may be split into a number of visits.

8.8.2 Operations Engineer

There shall be an operations engineer on the Site two weeks prior to the start of the first 30 day operation period. During the 30 day operation period for each of the sections of the Works he shall be fully responsible for the direction of the Employer's operating staff and for the correct operation. During the Defects Liability Period he shall act in an advisory capacity to the Employer. During both periods he shall be fully authorised to act on the Contractor's behalf to obtain necessary spares, materials and equipment to ensure the correct functioning of the Plant. The Contractor's nominee shall be subject to the Project Manager's approval and his linguistic abilities shall be similar to those of the training expert.

The numbers and durations of inputs of the training and advisory personnel are to be regarded as a minimum: the Contractor shall provide sufficient personnel to provide an operation, training and advisory service acceptable to the Project Manager.

8.9 Programme

Three months prior to commencement of the training the Contractor shall provide the Project Manager with a detailed programme of the various phases of the training, showing in particular when the different staff and operators will be required to attend.

9 STANDARD SPECIFICATIONS FOR BUILDINGS

A. GENERAL

9.1 Introduction

- This Part of the Specifications indicates the requirements of the Contract in respect of building and appurtenant works.
- Throughout the Drawings, and in this Specification, all reference to British Standard Specifications shall be deemed to be the latest edition of the British Standard to which the Clause refers at the time of tendering.
- The Specification is to be read in conjunction with other Parts covering the entire Works.
- Details on Drawings and in the Bills of Quantities and instructions given on Site by the Project Manager will take precedence over the Specifications given herein.

9.2 Earthworks

The Contractor shall keep a photographic record of surfaces to be reinstated, before the commencement of the works, and after completion of the reinstatement. Before the commencement of works that will damage surfaces, and will therefore need reinstatement, the Contractor shall inform the Project Manager in writing, one week in advance of date of carrying out the works and the anticipated date of reinstatement.

B. CONCRETOR AND MASON

9.3 Sand

All sand for making mortar shall be clean, well graded siliceous sand of good, sharp, hard quality equal to samples, which shall be deposited with and approved by the Project Manager. It shall be free from lumps of stone, earth, loam, dust, salt, organic matter and any other deleterious substance, sieved through a fine sieve and washed if so directed.

9.4 Lime

Lime for mortar shall be non-hydraulic or semi-hydraulic quicklime or hydrated lime in accordance with BS 890, Class B.

Quicklime shall be run to put it immediately after delivery to Site in a pit dug on the Site or in an approved container. The water to be first run into the pit or container and the lime to be added, until it is completely submerged, and stirred until all lumps are disintegrated. The resulting milk-lime shall then be run through a 3 mm square mesh sieve and into a pit or other container and kept clean and moist for not less than 4 weeks before use.

Hydrated lime shall be added to water in a clean receptacle, thoroughly mixed to the consistency of thick cream and allowed to stand, and be kept clean and moist, for not less than 16 hours before use.

9.5 Cement Mortar

Cement mortar shall be 1:5, composed of 50.0 kg of Portland cement to 0.15 cu metres of sand, measured in specially prepared gauge boxes and thoroughly mixed in an approved mechanical mixer or mixed dry on clean and approved mixing platforms, with water added afterwards, until all parts are completely incorporated and brought to a proper consistency. Re-tempering of wholly or partially set mortar will not be allowed.

9.6 Gauged Cement Motor

Gauged cement mortar shall be composed of 50.0 kg cement to 0.085 cu metres of lime to 0.34 cu. metres of sand, measured in specially prepared gauge boxes and thoroughly mixed dry on clean and approved mixing platforms, with water added afterwards, until all parts are completely incorporated and brought to a proper consistency. No partially or wholly set mortar will be allowed to be used or remixed.

9.7 Gauged Lime Mortar

Gauged lime mortar shall be composed of 2 parts by volume of lime putty to 9 parts by volume of sand, measured in specially prepared gauge boxes and mixed dry on clean and approved mixing platforms, with water added afterwards, until all parts are completely incorporated and brought to a proper consistency.

The mortar shall be mixed 7 to 10 days before it is required for use and shall be stacked in a neat heap well smoothed off, covered with wet sacks and allowed to mature.

Immediately before use, 1 part by volume of Portland cement shall be added to 9 parts by volume of lime mortar, the whole being remixed, with the addition of extra water, until all parts are completely incorporated and brought to a proper consistency.

The gauged mortar must be used within 45 minutes of being mixed. Re-tempering of wholly or partially set mortar will not be allowed.

9.8 Protection

All walling shall be properly protected while mortar is settling, as the Project Manager shall direct.

9.9 Setting out Rods

The Contractor shall provide setting out rods and set out all work on same for courses, openings, heights, etc. and shall build the walls, piers, etc. to widths, depths and heights indicated on the Drawings. Setting out rods to be gauged to allow an average height of 22.5 cm for each course.

9.10 Bonding of Block work and Stone Walling

Blocks or stone for general walling shall be bedded and jointed as described, properly bonded together in such manner that no vertical joint, in any one course, shall be within 125 mm of a similar joint in the courses immediately above or below. All walling of 300 mm thickness or less shall be built in single thickness of blocks or stone.

Walling exceeding 300 mm in thickness shall be built in two thicknesses of blocks or stones with through blocks or stones no more than 1.0 m (approximately) apart in each course as directed by the Project Manager.

Alternate courses of walling at all angles and intersections shall be carried through the full thickness of the adjoining wall. All walling shall be built entirely solid in blocks, without voids and all perpends, reveals and angles built strictly true and square. The walling shall be flushed up and grouted solid as the work proceeds.

Stone blocks shall be wetted before being laid and the walling kept wet while the mortar is setting. The top of walling, where left off, shall be well wetted, before recommencing work, as the Project Manager shall direct.

All putlog holes shall be not less than one course deep and carefully filled with concrete block or stone, cut to fit the size of opening, with beds and joints filled with mortar, well tamped in, after scaffolding is removed and, if in faced wall, to match facings.

9.11 Pargeting and Coring

All flues shall be pargeted and cored in lime and sand mortar (1:4)

9.12 Quarry Tile Sills

Quarry tiles for sills shall be throated, red, size 150 x 150 mm in accordance with BS 2871 type A. The tiles shall be set sloping and bedded in cement mortar (1:3) and neatly flush pointed with cement and sand grout (1:1) tinted to match tiles.

9.13 Damp Proof Course

The bituminous felt sheet for damp proof courses shall be three-ply approved membrane in accordance with BS 743, weighing not less 0.5 kg per square metre. The sheeting is to be lapped 150 mm at running joints and the full width of walls at angles. Only the net area covered is measured and the Contractor shall allow in his prices for all cutting and waste and extra material in laps as joints, angles, etc.

9.14 Reinforced Walling

Walls of less than 200 mm thickness shall be reinforced with one row of 20 gauge hoop iron, minimum 20 mm wide, built into every third course, well lapped at junctions and joints and carried at least 125 mm into abutting walls at intersections.

9.15 Fixing of Timber Door Frames

All door frames are to be bedded, and pointed in mortar and are to be securely fixed to reveals means of 25 mm mild steel cramps 300 mm long, bent and screwed to backs of frames, with a flanged end built 225 mm into joints of walling, three cramps to each side frame of each door. Where the door is provided with fanlights, four cramps are to be used to each side frame.

9.16 Holes for Timbers in Walling

Holes for timber built into or passing through a wall shall be squared out to suit the timber size and

line with 3 ply roofing felt cut flush to finished wall surfaces.

9.17 Concrete Block work Walling

Concrete blocks shall be solid, hard, true to size and shall have sharp arises in accordance with BS 6073 Type "A" and be approved by the Project Manager.

They shall be obtained from an approved manufacturer or manufactured on Site in an approved block making machine. The mix used shall be not less than (1:9) by volume and the maximum size of aggregate shall not exceed 1.2 mm.

All concrete blocks used in walling must be capable of withstanding a crushing pressure not less than 0.280 kg/mm^2 after 28 days.

The blocks, on removal from the machine, shall be carefully deposited, on edge on racks under sheds, erected by the Contractor, and left for 3 days, during which period they shall be kept constantly wet. After this period, they shall be placed on edge, in the open on racks and protected by sacking, or other approved covering, and kept wet for a further 5 days. Thereafter, the blocks shall be left in the same position without wetting for a further 20 days.

No blocks will be allowed to be used in the work until 28 days old and until samples have been taken and approved by the Project Manager.

They shall be laid dry except for the top surface, which shall be wetted immediately before mortar is applied. After laying no further water shall be applied.

The concrete blocks shall be 225 mm high to bond in satisfactorily with all other walling.

Except where plaster finish is required internally, the internal faces of wall shall be finished fair with beds and joints neatly flush pointed as the work proceeds.

All walls to be plastered to have the joints raked out 12 mm deep as keys for plaster.

The concrete blocks shall be bedded and jointed in gauged lime mortar, as described, with beds and joints not more than 12 mm or less than 6 mm thick, all flushed up and grouted solid as the work proceeds, or pointed as required.

9.18 Hollow Clay Partition Blocks

Hollow clay partition blocks are to be hard, well burnt, true to size and shape, with sharp arrises and keyed faces and joints in accordance with BS 3921. They are to be equal in every respect to a sample to be deposited with and approved by the Project Manager.

Hollow clay partition blocks shall be laid in courses 225 mm high to break joint in alternate courses and shall be bedded and jointed in cement mortar as before described.

9.19 Stone Walling

The stone for walling shall be sound and hard throughout, free from all defects, and shall be obtained from a quarry approved by the Project Manager. It shall be chisel dressed into true rectangular blocks, with each surface even and at right angles to all adjoining surfaces.

Stone blocks for general walling shall nominally be 225 mm high and 100 mm, 150 mm, 225 mm, or 300 mm thick as required for the work, the maximum permissible variation of any of the foregoing dimensions being 1.0 cm.

Stones shall not be less than 450 mm long but a proportion of 20% will be permissible in lengths between 300 mm and 450 mm long. Samples shall be submitted to the Project Manager for approval when so approved shall become the standard for the work.

The stone blocks shall be bedded and jointed in cement mortar, as described, with beds and joints not more than 12 mm or less than 6 mm thick, all flushed up and grouted solids as the work proceeds, or pointed as required.

9.20 Brick Walling

The brick shall be 225 x 115 x 75 mm (nominal) and shall be sound, hard, square, well burnt and of uniform size, shape and colour with sharp straight arrises. The bricks shall comply with BS 3921 and shall produce a clear ringing sound when struck against one another. No brick shall absorb more than twenty per cent of its dry weight during twenty-four hours immersion in water.

The Contractor shall be responsible for the transportation of the bricks to the Site in good condition and for ensuring that they are carefully unloaded and stacked on the Site. On no account will bricks be tipped from the vehicles. No broken or damaged bricks will be permitted to be used in the work.

All brickwork shall be built in English bond, consisting of alternate courses of headers and stretchers, all as detailed. Half brick walls shall be built in stretcher bond.

All bricks shall be well soaked with water immediately before being laid. Joints shall be not more than 10 mm thick and shall be bedded and jointed in cement mortar as described. All joints shall be solidly flushed up as the work proceeds. Bats shall not be used except where required for bond.

All brickwork shall be set out and built to the respective dimensions, thicknesses and heights specified or shown on the Drawings, and shall be built in a uniform manner, no one portion of two being raised more than 1.00 m above the other, at any one time, and, in such cases, the joints between the portions shall be in long steps to prevent cracks arising. All courses shall be truly horizontal and all perpends, quoins, jambs etc. shall be kept strictly vertical and square. All junctions of walls, etc. shall be formed in the correct bond as the work proceeds.

When walls are to be faced, only selected and approved facing bricks shall be used, the facing bricks shall be kept perfectly clean and no rubbing down of brickwork will be allowed. Walls must be protected against splashing caused by rain, paints or other causes.
All putlong holes shall be formed by leaving out headers in header courses or stretchers in stretcher courses as required, carefully filled up with headers or stretchers, as necessary, with beds and joints filled with mortar, well tamped in, after scaffolding is removed.

9.21 Precast Concrete Air Bricks

Unless otherwise stated precast concrete airbricks are to be 225 mm wide, 150 mm high and 40 mm thick of approved pattern.

The air bricks shall be fixed double, one flush with the outer face of the wall and having approved copper mosquito gauze cut to size and fixed by folding over the edges of air bricks before building in.

The other brick fixed flush with the inner face of the wall. Include for rendering around sides, top and bottom of brick opening in cement and sand mortar (1:4).

9.22 Built-in Services

Particular care shall be exercised by the Contractor to ensure that all pipes, ducts, drains, conduits, junction boxes, anti-static installations, etc., are laid before the concrete for the floor and roof slabs is poured, and the Contractor will be held responsible for the cost of any additional cutting etc., and making good which becomes necessary through his failure to make proper arrangements for all work to be done in close cooperation.

9.23 Precast Concrete

The mixes for precast concrete units shall be as follows unless otherwise stated on the Drawings.

UNIT	CONCRETE
Lintels	C20-20 mm nominal aggregate
All other Units	C20 – 12 mm nominal aggregate

9.24 Entrance Steps

Entrance steps, as required, to suit ground and floor levels shall be formed in concrete (C15/20), with suitable foundations as directed by the Project Manager. Treads shall be not less than 250 mm wide and risers not more than 175 mm high. All exposed surfaces shall be finished in cement and sand rendering (1:4), trowelled smooth with a wood float, 18 mm thick on treads and 12 mm thick on risers and finished with Carborundum dust on treads.

9.25 Concrete Apron

To all buildings where directed, provide a 50 mm thick concrete (C20/12) apron, 1.0 metre wide around the perimeter, laid on a 100 mm bed of hard-core, shall be provided.

9.26 Savings

Where required, these shall be size 600 x 600 x 50 mm thick of vibrated (C20/12) concrete finished on top with a wood float, clean cut edges and free from all cracks, chips or broken corners. The slabs shall be laid on a 75 mm thick consolidated bed of sand or stone dust, laid to falls where necessary and jointed and pointed in cement mortar (1:4).

The jointing mortar to be worked well down into the joints and the pointing to be key drawn and all excess mortar cleaned off.

9.27 Concrete Shelves

All suspended precast or in-situ concrete shelves, pot slabs, etc., shall be reinforced with B.R.C. Ref. NO. A252 or other equal and approved fabric reinforcement.

C. CARPENTER AND JOINER

9.28 Quality of Timber

The qualities of timber are stated hereinafter:

- All timber described as “sawn podo” shall be Grade 11 (Select Grade) sawn podocarpus.
- All timber described as “wrot podo” shall be Grade 1 (Prime Grade) wrot podocarpus.
- All timber described “cedar wrot” shall be first (Prime Grade) wrot cedar.

All Musharagi, Mvule, Mahogany, and all other hardwoods, shall be selected quality, kiln seasoned or air dried and, when delivered to Site, shall have a moisture content of not more than 14% of its dry weight.

All timber for permanent work in the building shall before use, be approved by the Project Manager for quality in accordance with the foregoing specification for its respective grade.

9.29 Treatment of Timber

All structural timber used in the Works shall be treated with an approved preservative. Such timbers shall be impregnated under pressure before fixing with Tanalith, Celcure, or other approved medium, toxic termites, crypotermes and other timber pests. All cut end of timber so impregnated are to be treated with two coats of “B” crystals or other approved method.

9.30 Tolerance of Scantlings

Variations from specified dimensions of scantlings shall not exceed the tolerance agreed with the Project Manager. Boards 25 mm thick or less shall hold up to the specified sizes. All timber shall be as long as possible and practicable to eliminate joints.

9.31 Sizes and Thickness

Sizes and thickness of wrot carpentry and joinery are nominal, that is to say a 3 mm reduction off specified sizes will be allowed for each wrot face, except where described as finished sizes in which case no reduction from the stated thickness or size will be permitted.

9.32 Insulation Board

Insulation board shall be 12.5 mm thick “CELOTEX”, or other equal and approved fibreboard, in accordance with BS 1142. Insulation board ceilings shall be fixed to a symmetrical pattern in each room.

9.33 Soft Board

This board is similar to insulation board but having high moisture absorbing properties.

9.34 Block Board

Block board shall be of approved local or imported manufacture, to BS 3444, softwood or hardwood faced, as specified, equal to a sample to be deposited with the Project Manager for approval and which, when so approved, shall form the standard for the work.

9.35 Plywood

Plywood shall be of approved local or imported manufacture, in accordance with BS6566, and of approved first or second grade softwood faced, unless otherwise described. "Exterior Quality" plywood shall be exterior moisture resistant type.

9.36 Hardboard

Hardboard shall be suitable for painting, in accordance with BS 1142 and shall be used, prepared and fixed strictly in accordance with the manufacturer's printed instructions.

9.37 Chipboard

Chipboard shall be approved, or local softwood, faced in accordance with the manufacturer's printed instructions.

9.38 Plastic Sheets

Laminated plastic sheeting shall be "Formica", or other equal approved, in accordance with BS 3794 of the type and grade specified. It shall be used, prepared and fixed strictly in accordance with the manufacturer's printed instructions.

9.39 Wood Wool Slabs

Wood wool slabs shall be approved Normal Quality to BS 1105 and fixed in accordance with the manufacturer's printed instructions.

9.40 Defects

Should any of the carpentry or joinery shrink, warp, wind or develop any other defects within six months after the completion of the work, the same shall be removed and new fixed in its place, together with all other work, which may be affected thereby, all at the Contractor's cost and expense.

9.41 Carpentry

All carpentry work shall be left with sawn surface except where particularly specified to be wrot. Scantlings and boarding shall be accurately sawn and set out, in strict accordance with the Drawings, and shall be framed together and securely fixed in the best possible manner with properly made joints. Provide all beads, nails, screws, etc. as necessary and directed and approved.

9.42 Wall Plates

Wall plates are to be bedded on walls in cement mortar and secured with 12 mm diameter bolts, 300 mm long at 1.00m centres, built 225 mm deep into walling. Plates to be in long lengths, halved and spiked at joints and angles.

9.43 Valley Rafters

Valley rafters to be fixed double and bolted or spiked together as directed or shown on the Drawings.

9.44 Gang Boarding

Gang boarding 25 mm thick, butt jointed and securely nailed to ceiling joists, shall be provided to form an access floor 450 mm wide between ceiling opening and water storage cisterns unless otherwise specified.

9.45 Fascia and Barge Boards

Fascia and bargeboards shall be in wrot cedar or as specified and according to detailed Drawings.

9.46 Bat Proofing

The underside of projecting eaves to buildings with ceilings shall be bat proofed by means of 50.0 x 25.0 mm wrought podo framing filled in with stout galvanised coffee tray mesh.

The framing shall be nailed on one edge to ends of rafters to butt up against fascia board and, on other edge, 50.0 x 25.0 mm sawn podo bearers plugged to wall.

9.47 Building in of Timbers

Timbers such as purlins, etc., required to be built into or through inner and outer walls, shall have 12 mm air space between same and walling.

9.48 Joinery

All joinery shall be executed with workmanship of the best quality and in strict accordance with the detailed Drawings. All mouldings shall be accurately run and all work planed, and papered and finished to the approval of the Project Manager. All finishes shall be slightly rounded. All framed work shall be cut out, properly tongued, shouldered, etc., and framed together, as soon after the commencement of the work as is practicable, but should not be wedged up until required for fixing in position. Any portions that warp, wind, develop shakers, or other defects, shall be replaced with new ones.

As soon as required for fixing in position, the framing shall be glued together with best quality glue and properly wedged or pinned, etc. as described.

Oval or round brads or nails shall be used for fixing all face work. All heads shall be properly punched in and puttied.

The quality of all workmanship shall conform to Part 11 of BS 1186.

9.49 Plugs

All fixing for joinery etc. shall be approved and plug fixed into holes of a recommended size. The holes shall be drilled with special masonry drills and not cut with a cold chisel and hammer. Under no circumstances will wooden plugs be permitted. The expression “plugged” shall be taken to mean fixed with and including plugs as last described to stone or concrete.

9.50 Protection

Any fixed joinery which, is liable to become bruised or damaged in any way, shall be properly cased and protected by the Contractor until the completion of the work.

9.51 Setting out of Joinery Work

All joinery work shall be accurately set out on boards to full size, for information and guidance of artisans before commencing the respective work, with all joints, ironwork and other items connected therewith fully delineated. Setting out will be required to be submitted to the Project Manager and approved before the respective work is commenced. All joinery work shall be wrot unless otherwise described.

9.52 Ceiling Joists

Where ceilings are shown on the Drawings, ceiling joists shall be fixed at 600 mm centres and around walls and the undersides shall be perfectly level.

Brandering is to be 50 x 50 mm, fixed to and level with the underside of ceiling joists, at 600 mm centres, maximum, in both directions. The Contractor shall include for cutting and fitting at trusses.

9.53 Ceilings

Where shown on the Drawings, ceilings to all rooms shall be formed of approved insulation board not less than 12 mm thick

Ceilings shall be fixed to brandering in a symmetrical pattern with edges chamfered to form “V” joints, all to the approval of the Project Manager.

9.54 Priming of Woodwork

Where intended to be in contact with stone, concrete blocks, concrete, cement or plaster, the backs and other surfaces of all door, window or other frames and linings, posts, architraves, skirting, fillets and fascias, and cornices etc. shall be treated with one coat of aluminium priming paint applied before fixing.

9.55 Cornices

The Contractor shall provide 100 x 25 mm cedar moulded cornices, securely fixed to rafters and brandering, at the junction of walls and fibreboad ceilings in all rooms or provide 75 mm wide strips of insulation board, planted on to the junction of walls and fibreboard ceilings, as shown on the Drawings.

9.56 Doors, Frames and Finishing

9.56.1 Flush Doors

Flush doors shall be in hardwood and obtained from an approved local manufacturer, sizes of members and method of construction shall be to the approval of the Project Manager.

9.56.2 Framed, Ledged and Braced Doors

Framed, ledged and braced doors shall be 5.0 cm (nominal) thick 830 x 2,030 mm overall, or to size specified on the Drawings, and shall consist of 100 x 25 mm stiles and top rail, 225 x 25 mm lock and bottom rails and 100 x 25 mm diagonal braces filled in with 25 mm tongued, gooved and "V" jointed both sides boarding, in matched width, and shall include chamfers on edge of stiles and adjacent boarding to form "V" joints.

9.56.3 Ledged and Braced Doors

Ledged and braced doors shall be 50 mm (nominal) thick 830 x 2,030 mm overall, or to sizes stated on the Drawings, and shall consist of 100 x 25 mm top rail and diagonal braces, 225 x 25 mm lock and bottom rails and covered on one face with 25 mm thick tongued, grooved and "V" jointed both sides boarding in matched widths.

9.56.4 Door Frames

Door frames shall be in rebated and moulded cedar 100 x 75 mm. Wardrobe door frames shall be in rebated cedar 75 x 50 mm. Cupboard doorframes shall be in rebated cedar 75 x 38 mm.

9.56.5 Wardrobe and Cupboard Doors

Wardrobe and cupboard doors shall be 25 mm thick flush doors constructed of approved blockboard and hardwood lipped on all edges.

9.56.6 Architraves

The finishing of doorframes to all doors shall consist of 75 x 20 mm wrought cedar splayed architraves plugged to walling and mitred at all angles. When the doorframe is set against the face of the wall or where there is insufficient room for the architrave, the finishing shall consist of a 20 mm wrought cedar quadrant moulding planted on the frame.

9.56.7 Door Stops

40 mm diameter rubber doorstops shall be provided to all door and securely plugged and screwed to floors with screws 40.0 mm long.

9.57

9.58 Shelves

Slatted shelving shall consist of 50 x 25 mm wrought podo slats 20 mm apart screwed to bearers.

All board shelving exceeding 225 mm wide shall be cross-tongued.

Blockboard shelving shall be 25 mm thick with hardwood or softwood veneer, as stated or shown on the Drawings, with 132 x 25 mm softwood or hardwood edge strip to match, tongued in on all edges and the shelving screwed bearers.

9.59 Pelmets and Curtain Track

Pelmets shall be in cedar and mm bearers plugged and screwed to concrete lintol or stone wall. The whole to be formed of 100.0 x 25.0 m twice rounded at front and ends. The top, 125.0 mm rounded,

screwed to 50.0 x 25.0 properly tongued, grooved, glued and screwed together, fitted with, and including, approved curtain track cut to length, and screwed to pelmet and fitted with 4 no. rollers per 300 mm run and all fittings.

9.60 Window Boards

Window boards shall be formed in cedar and shall be 25 mm thick, rounded on edge to project 40.0 mm beyond jambs, notched at ends and plugged and pelleted to walling under.

9.61 Trap Doors

Where shown, or directed, in fibreboard ceilings, the Contractor shall trim ceiling, joints and brandering for and form access door size overall 1000 x 850 mm. At hanging side of opening provide and fix 75.0 mm splayed frame and plant 75.0 x 50.0 mm stop on top of trimmer. Form the door with 50.0 x 25.0 mm frame covered with fibreboard to match ceiling and hang on pair of approved strong 75 mm steel butts and finish around opening with 40 x 25 mm rebated fillet screwed to trimmers to form stop.

9.62 Panelling to Bath

The bath casing shall be provided with a removable access panel 300 x 450 mm of approved tempered hardboard, fixed to 38.0 mm x 38 mm sawn podo framing plugged to concrete floor and walls.

D. METAL WORKER

9.63 Ironmongery

All ironmongery shall be of the description and manufacture described and shall be fitted and fixed in an approved manner. All locks shall be provided with two keys and shall have a sufficient number of differs to ensure that no two external locks may be opened with the same key. The Contractor shall include for all cutting, sinking, boring, mortising, fitting and for supplying all necessary and suitable matching screws. The Contractor shall also include for removing door furniture, during painting operations, and afterwards refixing and for labelling all keys with door references and handing to the Project Manager on completion. Master keys shall be provided and properly labelled where directed. Face plates with all locks shall match the door furniture.

All locks, springs and other items of ironmongery with movable parts shall be properly tested, cleaned and adjusted where necessary to ensure they are left in perfect working order by the Contractor.

Samples of all ironmongery specified shall be submitted to the Project Manager for approval, and the approved samples shall thereafter be regarded as the standard for the work. Ironmongery which in the opinion of the Project Manager, does not conform to this standard , shall be removed from the Site.

Alternatively, ironmongery of an equal standard will be acceptable provided samples are submitted to and approved by the Project Manager before orders for such ironmonger are placed.

9.64 Structural Steel and Metal work

Mild steel shall be sound, of approved manufacture and comply with the requirements of BS 4360 and have full threads to all screw works. With welds neatly executed, filled smooth and left clean. Prices

for all mild steel shall include for removing all rust and scale and applying one coat of red oxide or other approved priming paint to all surfaces before fixing. Cast iron shall be best quality cast clean and sharp and free from all cracks, vents, holes and other defects.

9.65 Galvanised Sheet Iron

Galvanised sheet iron shall be No.24 B.W. gauge of approved manufacture, free from all defects and hold up to the gauge as specified.

Flashings, gutters etc. shall be lapped 75 mm minimum and riveted and soldered at joints where required.

Where applied to walls, the side overlaps shall be seam bolted at 300 mm centres maximum with 6 mm diameter seam bolts 19mm long, each with diamond shaped bitumen washer, galvanised steel washer and galvanised steel nut.

9.66 Burglar Deterrents

All windows, external doors and openings shall be made with burglar deterrent. Mesh window guards shall be provided to all ground floor bedroom windows. Window guards shall be galvanised "Weldmesh", or other equal, of approved welded steel with 50 mm square mesh with No.8 gauge galvanised wires in each direction.

Burglar deterrent bars, which shall be provided to all but bedroom windows, shall consists of 19 x 5 mm high yield steel flats or hollow sections as directed by the Project Manager, behind the line of the glazing bars to the casements, with the ends of the bars welded to metal or sunk into the timber frames, whichever is applicable. Louvre windows and openings shall be provided with an external grill of 20 mm twisted high yield bars or hollow sections as directed by the Project Manager, built all round into the walling at intervals not exceeding 0.12 m. The bars shall be welded at 150 mm centres horizontally and 450 mm centres vertically.

External doors shall be provided on the outside with similar grills hinged to 50 x 50 mm angle iron frames built into the walling as previously described. One pair of butt hinges shall be used and hinge pins welded, after fixing the grill, so that the grill cannot be lifted off the hinges. The grill shall, on the inside, be provided with a 20 mm barrel bolt, welded to a 5 mm thick backing plate, 200 mm square, and secured by an approved padlock with hardened steel shank. The grill and frame shall further be provided with staples at the top and bottom to accommodate additional padlocks if required.

9.67 Metal Windows

Metal windows shall be of standard type of approved manufacture with plastic or bronze fittings, lugs, glazing clips and other accessories all in accordance with BS 6510. Windows shall be delivered to Site after correct selection of the windows, with red oxide dipped finish. Care shall be taken in the transportation, handling, storing and building into their requirement positions. Special attention to the care of the various window accessories shall also be given as no badly fitting, damaged or incomplete windows will be accepted by the Project Manager. All such windows and accessories shall be replaced at the Contractor's own expense.

9.68 Louvre Windows

The vertical side members for louvre windows shall be profiled from 18-gauge aluminium strip to BS 1470. Blade holders and operating components shall be of injection-moulded polypropylene, or similar

approved, with the blade holders sized to accommodate 152,4 mm (6 in) deep glass louvre blades, and pivoted on the vertical side members at centres of blades. They shall be linked together by 18-gauge aluminium section, specially profiled to form weathering links when the louvres are closed. The louvres should be capable of being locked in any position by means of plastic knob and steel bolts used in conjunction with a quadrant or in any other approved manner. Head and cill stops shall be either of 20 gauge aluminium or of suitable wood.

For louvre windows, glass to BS 952, with exposed edges bevelled, shall be used as follows:-

- Glass widths not exceeding 600 mm: 4.0 mm clear sheet glass
- Glass widths from 600 to 750 mm: 5.0 mm polished plate glass
- Glass widths from 670 to 1000 mm: 6.5 mm polished plate glass

9.69 Open Mesh Steel Flooring

Open mesh flooring shall be to BS 4592 and shall be painted black in accordance with the Specification. Kicking plates, 100 mm high shall be provided around all openings unless otherwise stated.

9.70 Ladders

Ladders shall be galvanised mild steel, with 20 mm diameter solid rungs and 75 mm by 10 mm stringers turned over at top and bottom, flanged and drilled for 12 mm diameter rag bolts.

Rungs shall be set at 230 mm centres and stringers shall be 420 mm apart. Stays shall also be of mild steel, heavily galvanised, 75 mm by 10 mm with length to suit, bent to shape, drilled for 12 mm diameter bolts for fixing to stringers and walls etc, with maximum distances between fixing points of 2.5 m. Ladders shall generally conform to BS 4211 “Steel Ladders for Permanent Access”.

9.71 Hand railing

Hand railing shall consist of 25 mm internal diameter water tubing, galvanised after being cut to length. The standards shall be of best quality forged steel, heavily galvanised after manufacture, 900 mm high, having two 80 mm balls drilled to suit the tubing and position of standard. The shanks of the standards shall be 30 mm diameter and of a type suited to their position. The movable hook bars 750 mm long shall be 25 mm diameter solid mild steel round bars heavily galvanised, with suitable hooks and eyes, complete with appropriate fixings to standards and walls. Hand railing shall generally conform to BS 499.

9.72 Rolling Shutters

These shall be in galvanised steel, slatted, manually operated, with a locking device and prime coated. Frame size, type and fixing details shall be to the Project Manager’s approval.

9.73 Fencing

Galvanised chain link fencing shall comply in all respects with BS 1722 Part 1.

Boundary fencing shall be 1.8 m high, topped by three strands of best quality barbed wire. The fencing shall comprise steel or precast concrete straining posts 2.6 m or 2.67 m long respectively, topped by a cranked extension piece 450 mm long, and set 750 mm in the ground in concrete Class C15/40 with all necessary struts.

Straining posts, intermediate posts and struts shall all be of either steel or precast concrete, corresponding to fence type LS 72A Table 4 or LC 72A Table 3 respectively of BS 1722 Part 1.

The chain link cladding shall be 50 mm mesh by 3 mm dia., complete with three strands of 3.5 mm galvanised iron write, to which cladding shall be secured, at 150 mm centres on the top line wire and 450 mm centres on the middle and bottom line wires.

Straining posts shall be provided at all ends, corners, junctions and changes in direction, and at intervals not exceeding 45 m on straight stretches. Intermediate posts shall be provided at intervals not exceeding 3 m.

9.74 Gates

Gates to boundary fencing shall be constructed at 25 mm dia. galvanised mild steel pipe frame, with rounded corners and covered with wire mesh. Each gauge shall be complete with all hinges and ironmongery.

Keeps for drop bolts shall consist of 25 mm diameter galvanised pipe, 250 mm long, embedded 150 mm deep in Class C 15/40 concrete.

9.75 Wrought Iron Gates

The manufacturer, pattern, locking devices and fixings shall be approved by the Project Manager.

9.76 Reservoir Roof Vents

Roof vents for reservoir shall be doubled swan-neck type, manufactured from fibreglass or stainless steel. The vent internal diameter shall be 50 mm and corrosion resistant wire mesh guards shall be fitted to cover the ventilator openings. The vent shall project no less than 500mm above the reservoir structural roof level and shall be cast in the positions indicated on the Drawings.

9.77 Reservoir Access Covers

Access covers for reservoirs shall be hinged, lockable, single seal, light duty manufactured from fibreglass or stainless steel. The clear access opening provided when the cover and frame are in position shall be as indicated on the Drawings. The seals shall be filled with non-toxic grease on commissioning of the reservoirs.

9.78 Reservoir Level Gauges

Level gauges shall be fitted externally to all reservoirs. Where reservoirs are covered by earthen embankments, gauges shall be fitted to roof slabs. The gauges shall be float operated with an external pointer travelling along a calibrated scale to read the depth of water in the reservoir at 100 mm intervals. Pointer and float shall be connected by nylon or corrosion-resistant cables. Calibrated gauges shall be fabricated from suitably treated mild steel components with each 100 mm depth point.

E. PLASTERER AND TILER

9.79 Plaster and Rendering

All surfaces to be plastered or rendered shall be brushed clean and be well wetted before the plaster is applied. All plaster and rendering shall be kept continuously damp for seven days after application.

All arrises shall be finished true and slightly rounded, except where otherwise stated, and shall be run at the same time as the adjoining plaster. No partially or wholly set plaster or rendering will be allowed to be used or re-mixed.

The Contractor shall prepare samples of the plastering and rendering, as directed, until the required quality, texture and finish is obtained and approved by the Project Manager, after which, all plastering executed in the Works shall conform to the respective approved samples.

The Contractor shall cut out and make good all cracks, blisters and other defects and leave the whole of the work perfect on completion. When making good defects, the plaster or rendering shall be cut out to a rectangular shape, with edges undercut to form a dovetailed key, and finished flush with the face of the surrounding plaster or rendering. “Gypsum”, or other equal and approved plaster, shall be used when remedying defective work.

Gauged plaster internally shall consist of a first or rendering coat composed of one part cement, two parts lime, and nine parts sand and a finishing coat composed of one part cement, three parts lime, and six parts sand. The first or rendering coat shall be laid to a uniform surface, finished with a wood float, well scored and allowed to dry out for at least seven days before applying the finishing coat. The second or finishing coat shall be thoroughly worked and finished hard and smooth with a steel trowel.

Great care shall be taken in applying the finishing coat to obtain uniformity of the surface, smoothness and hardness. The total finished thickness of plaster shall be not less than 12 mm.

Cement plaster internally shall be composed of one part cement to five parts sand applied in two coats, the first coat well scratched to form a key and allowed to dry out at least 24 hours before applying the second coat. The second coat shall be finished with a steel trowel. The total finished thickness of plaster shall not be less than 12 mm.

Where the wall plaster is carried over wall plates, a strip of expanded metal shall be spiked to the wall plate to form a key.

Particular care shall be taken to ensure that plaster is made good around plumber’s water, soil and waste pipes and around electrician’s conduit, fittings and switches.

The Contractor shall include in his rates for dubbing out as necessary in cement and sand (1:7), hacking concrete to form a key and for all internal angles, arrises, other labours and for making good up to windows, door frames or other openings.

9.80 Wall Tiling

Glazed wall tiles shall comply with BS 6431, be free from all blemished and defects and true to size shape and colour. Wall tiles shall be obtained from an approved manufacturer and shall be supplied in 150 x 150 x 6.5 mm units of an approved design and colour.

The bedding for wall tiles shall be a 12 mm thickness of 1:3 cement sand mortar rendering finished to a true plumb surface. Before it has hardened, this surface shall be scratched to provide a key for the tile bedding. Tiles shall be set on the rendering in a bed of parian cement or alternatively an approved

adhesive. Joints between tiles shall be uniform in width and exactly in line and these joints shall be pointed up with parian cement.

The rates shall include for all radi-used and special tiles and for cutting and fitting around doors, reveals and pipes.

9.81 Floor Finishes

Cement and sand pavings and finishings shall include for finishing surface perfectly smooth and hard, with a steel trowel, dead level or to true falls if so described, all temporary rules and formwork, to stop pavings at openings or edges as required; all knife edges, or slightly rounded arrises, for preparing concrete beds to receive paving by thoroughly brushing surface clean with a steel wire brush, well wetting and painting the same with cement and sand (1:1) grout immediately before paving is laid, for any additional thickness of paving required, beyond the thickness specified, due to irregularities in the concrete bed, and for keeping paving damp for at least 7 days after laying.

At the junctions of different floor finishings, fix in position 3 x 25 mm plastic or aluminium jointing strips cut to lengths bedded in and finished flush with pavings. All pavings shall be laid with joints set out in accordance with a detailed pattern approved by the Project Manager.

The Contractor shall protect the floor finish with heavy quality building paper, sheeting or sawdust, to the satisfaction of the Project Manager, as each area is completed.

9.82 Terrazzo Flooring

The Contractor shall arrange for the terrazzo work to be executed only by experienced personnel.

Before commencing the application of these finishings, the surface to receive the same, shall be thoroughly cleaned by wire brushing and left free of all dust, oil, grease, or any other deleterious substances, well wetted and painted with cement and sand (1:1) grout immediately before work commences.

All terrazzo finish shall conform in every respect to the colour and texture of a sample of the work, which must be approved by the Project Manager.

The rates for terrazzo finishes shall include for surfaces perfectly smooth, dead level or to true falls as specified, for all temporary rules, formwork to stop pavings at opening and edges, all knife edges, or slightly rounded arrises as required, and for any additional thickness beyond that specified or required due to irregularities in the surface to receive such finish.

Terrazzo work shall be polished to an approved texture by mechanical means. The floors shall be first thoroughly washed clean and then rough polished and all holes etc. filled in with an approved filler and left for a 24 hour period. Finally the work shall be washed down and given a final polish to the texture approved by the Project Manager.

All skirting, corners, working round pipes, door frames and sanitary fittings etc. shall be thoroughly hand polished to a similar texture by Carborundum block.

F. PLUMBER AND DRAIN LAYER

9.83 Eaves Gutters and Rainwater Pipes

Eaves gutters and rainwater pipes shall be made from No.24 B.W. gauge galvanised sheet iron. The eaves gutters shall be lapped and soldered at joints, have beaded edges and be fixed to falls with approved 25 x 6 mm galvanised iron brackets, with a galvanised sheet iron clip, riveted on outer edge and bent around the beaded edge of the gutter, 900 mm apart, bent to the shape of the gutter and each screwed to fascia boards or rafters with two stout steel screws. The gutters shall be half round and 150 mm diameter.

The rainwater pipes to be 100 mm diameter and have beaded shoulders, 100 mm distant from the lower ends, and fitted so that each length rests on the pipe section below. The upper part of the 100 mm long shoulder to be wrapped in hemp or yarn and coated with linseed oil putty to form a tight sealed joint with the length below. Any surplus putty is to be neatly cleaned off. 150 mm diameter ball gratings are to be fitted at gutter outlets.

All rainwater pipes to be fixed 40 mm clear of the extreme outer face of walls with strong, galvanised, malleable iron holderbats having a 120 mm long ragged tail and circular strap, in two pieces to form galvanised bolted connections.

The rainwater pipes are to be fixed in locations as shown and, unless otherwise stated, provided with 3.0 m length of open concrete drain channel. The Contractor shall provide proper purpose made swan neck bends, plinth bends, shoes, stoppered ends, etc., where required.

9.84 Flashings, Aprons, Valleys etc., in Galvanised Sheet Iron

Cover flashings, cover turn up of gutter linings, etc. to be 150 mm wide, minimum, lapped and soldered at angles, bent and turned into chases in walling 25 mm deep, wedged with metal wedges at not more than 150 mm centres and pointed in cement mortar (1:3).

Apron flashings to be 250 mm wide, minimum, dressed over roof coverings, turned up chimney stacks, lapped, soldered and turned into chases all as last.

Valley linings to be 600 mm width minimum, lapped not less than 150 mm and soldered at joints, dressed to shape of boarding and turned up 25 mm minimum, dressed over splayed tilting fillets, both sides, laid loose on boarding to allow for free movement in expansion and contraction.

9.85 Pipe Material and Installation

Galvanised mild steel tubing shall be of medium thickness in accordance with BS 1387.

Fittings for the same shall be galvanised malleable iron in accordance with BS 4609. Joints are to be screwed and socketed and put together in approved jointing compound. Long screws and any other un-tapered threads shall have yarn as well as jointing compound incorporated in the joints or be jointed with PFTE tape.

Polythene tubing for cold water services shall be normal or heavy gauge, as required or specified in accordance with BS 6572 and 6730. Joints and fittings shall be in accordance with the manufacturer's printed instructions.

All brass work and fittings shall be in accordance with BS 1010 for draw off taps and stop valves and BS 1212 for ball valves. Plastic float valves to be in accordance with BS 2456, and high or low pressure as directed by the Project Manager.

Soil, waste and vent pipes and their fittings shall be coated medium grade cast iron spigot and socket

pipes. Pipes, fittings and accessories shall be in accordance with BS 16. All joints shall be made with P.C.3 compound or other similar and approved jointing compound.

Where directed, pies shall be fixed in chases in walling and secured with approved holderbats built into walls, not more than 1.30 metres apart.

All surface fixings, unless otherwise specified herein, shall be carried out in “Philplug” or “Rawlplugs”. The fixing holes shall be drilled with special masonry drills and not cut with a chisel. Under no circumstances will wooden plugs be permitted. Lavatory basin brackets shall be fixed to solid walls with 6 mm diameter bolts 100 mm long with head nut and washer.

Tubing for hot water services, waste and overflow pipes, etc. shall be galvanised mild steel.

The Contractor shall make arrangements with the water undertaking for connection to the existing water main including supplying all fittings and paying all dues.

9.86 Plumbing

Pipes and tubes shall be cut by hacksaw or other method, which does not reduce the diameter of the pipe or form a bead or feather, which might restrict the flow of water. Bends shall be formed on an approved machine and in no case to an internal radium of less than eight times the outside diameter of the pipe. Elbows may only be used on pipes of 12 mm and 19 mm diameters and not on hot water systems of any description. All tubing, exposed on faces of walls, shall be fixed at least 25 mm clear of adjacent surfaces with approved holdbacks built into walls not more than 1.30 metres apart. Polythene tubing must be supported throughout its entire length in horizontal positions as directed.

Pipes fixed in roof spaces or to joinery shall be fixed with approved clips screwed to timber members, not more than 1.30 metres apart. Easy bends in the line of piping shall be made with an approved bending machine. No fire-bends will be permitted. Where elbows are allowed, they will be of the rounded pattern.

9.87 Cold Water Storage Tank

The cold water storage tank shall be by an approved manufacturer and shall conform with the requirements of Class A cisterns to BS 417.

It shall be of the capacity shown on the Drawings. Where tanks are required to sit on concrete slabs, 25 mm timber boarding must be provided under the tanks.

9.88 Hot Water Storage Tank

Connect expansion pipe to water heater and run through ceiling to discharge over cold water tank in roof including all necessary fittings etc. as detailed on the Drawings, or as directed by the Project Manager.

Connect to cold water storage tank and run cold supply to water heater and make connection hereto. Provide low pressure gate valve at a point immediately before the cold supply enters the hot water cylinder or water heater.

9.89 Connection of Pipes and Tanks

Each connection of tubing to cold water storage tanks shall be made by drilling a hole in the tank side

and using a long screw union and two back nuts all well screwed up in red lead. Joints of tubing to glanded and bossed connections of hot water cylinders or boilers shall be made with a long screw, union and backnut screwed up in red lead.

Connections to sanitary fittings shall be made with a 450 mm length of copper tubing bent to shape as required, with copper to iron couplings at each end, and red lead joints to union of fitting and tubing.

9.90 Sanitary Fittings

The descriptions entered in the Bills of Quantities, intended to outline the scope of the work and drawings indicate the general arrangement and approximate sizes and locations of equipment, piping and outlets. Where Site conditions require reasonable changes in indicated locations and arrangements, these shall be made without extra cost.

The Contractor shall submit, for approval by the Project Manager, a complete schedule of all sanitary fittings he proposed to supply and install. The schedule shall name and describe each item and the name of the manufacturer.

Once the schedule has been approved, no departures from it may be made without the written consent of the Project Manager. No orders for sanitary fittings shall be placed until the schedule has been approved.

9.91 Stop Cock Pit

Construction stop valve pit size 250 x 250 x 600 mm deep internally consisting of 100 mm thick concrete sides, 75.0 mm concrete base size 600 x 600 mm, precast concrete cover slab size 450 x 450 x 50 mm thick reinforced with 75 mm mesh, no. 10 gauge “Weldmesh” or other equal and approved fabric reinforcement, with two 10 mm diameter mild steel rod lifting handles cast in the cover slab. Allow for holes through the sides for pipes.

9.92 Concrete Drain Pipes

Concrete drain pipes shall be spigot and socket pipes of approved manufacture in accordance with BS 5911 and be totally immersed in water for at least 3 hours immediately preceding laying.

The joints, for concrete drain pipes shall be made by first wrapping three turns of cement slurried yarn to the end of the socket, then caulking well home so that the consolidated width of the yarn does not exceed one quarter of the depth of the socket. The yarn shall be best quality, white spun, long staple yarn, soaked in water for 24 hours before use and inserted in the joint while still wet.

The remaining portions of the socket shall be filled solidly and homogenously with cement mortar (1:2) and finished with a neat cement fillet on the outside at an angle of 30 degrees. Immediately after jointing, a tight fitting wad or scraper shall be drawn several times through the bore of the pipe to ensure it is left clean and free from obstruction. The joints shall be protected from injury until they have set hard.

9.93 Pitch Fibre Drain Pipes

Pitch fibre pipes, coupling and fittings shall be of approved manufacture in accordance with BS 2760 for pitch impregnated fibre drain and sewer pipes. The laying, cutting and jointing of pitch fibre pipes, and the jointing to pipes of other materials, shall be carried out strictly accordance with the

manufacturer's printed instructions.

9.94 Cast Iron Pipes and Fittings

Cast iron drainpipes shall be coated spigot and socket pipes of approved manufacture in accordance with BS 437. All joints shall be made with P.C.3, or other similar and approved jointing compound, in accordance with BS 5292.

Cast iron soil fittings shall comply in all respects with BS 416. Those of spigot and socket type for drains to BS 437 and will be used as drain connectors to manholes.

9.95 Step Irons

Step irons shall be provided to manholes and septic tanks and shall be approved malleable galvanised cast iron to BS 1247.

9.96 Concrete Beds and Surrounds

All drain pipes shall be laid on a concrete bed, or blinding, as directed by the Project Manager.
Beds shall first be laid to correct falls and levels with recesses formed for the pipe sockets so that the whole of the soffit of the pipe barrel bears evenly on the bed. When the concrete has set, sufficient mortar (1:5) shall be spread on the bed to receive the pipe barrel, and ensure a surplus is squeezed out when the pipe is laid and finally adjusted to level. After jointing, the recesses around sockets shall be filled with concrete of the same mix as the bed and the haunching or surrounding completed.

Where pipes are laid under driveways and parking areas, the pipes shall be bedded and surrounded with concrete if the cover on the pipe is less than 1.0 m.

9.97 Laying of Pipes

Pipes shall be laid in straight lines to even gradients and to the required depths commencing at the lowest end.

Before each pipe is laid, it shall be examined to ensure that the barrel is clean and all foreign material removed. Any cracked or damaged pipes shall be rejected.

9.98 Gulleys

Gulleys shall be approved 100 mm salt glazed stoneware or cast iron trapped gulleys with 150 x 150 mm cast iron gratings to receive the wastes from waste fittings. Bed the gulleys on and surround with concrete (C15/20) 100 mm minimum thickness, carried up to form 75.0 x 75.0 mm curb, with all exposed surfaces finished in cement and sand (1:2), trowelled hard and smooth and all angles rounded. Make good cement joint to drain pipe and run drains to adjacent manholes.

9.99 Manholes

Manholes shall be constructed in stone, concrete, or concrete blocks in the positions and to the depths shown on the Drawings or as directed by the Project Manager. Construction in stone and concrete blocks is only allowed to depth of 1.5 m.

Cast iron manhole covers and frames shall be provided to all manholes, and shall be manufactured in accordance with BS 497 and approved by the Project Manager, size 60.0 x 45.0 cm single seat,

minimum 23.42 kg weight, as shown on the Drawings or as directed by the Project Manager. Where wheeled traffic is liable to pass over the manholes, the Contractor shall provide medium or heavy-duty covers and frames as directed by the Project Manager.

Covers shall be bedded in grease and sand in the rebates and painted with two coats or black bituminous paint on completion.

Internal rendering to manhole walls and benching shall be 12 mm thick minimum, composed of one part of Portland cement to two parts of sand.

The surface is to be trowelled hard and smooth, coved at all internal angles and rounded on all arrises. The Contractor is to include for all coves, rounded angles, making good to pipes etc. and all other labours. The rendering to benching is to be applied whilst the concrete is green.

9.100 Testing

Each length of drain and manhole shall be tested, as described hereinafter, and approved by the Project Manager before any backfilling of the trench takes place.

Testing shall not be carried out until at least 12 hours have elapsed after jointing takes place.

The test shall be as follows:-

- The lower end of the pipe and all junctions shall be securely stoppered and the whole length under test filled with water.

- When full, a further stopper shall be inserted at the top leaving a pipe attached to the drain plug. This pipe shall be bent through 90 deg., and shall terminate in a header tank 150 mm square. The vertical distance between the centre line of the drain plug and the top of the header tank shall be not less than 900 mm.

- Water shall then be poured into the header tank, which shall be kept full for a minimum period of 3 hours to allow absorption to take place. At the expiration of this period, the header tank shall be topped up and the testing of the drain commenced. If, after a further period of 30 minutes, the water level in the header tank has not fallen by more than 12 mm the test will be considered satisfactory.

- In the event of a pipeline failing to withstand the test, the point of failure shall be completely surrounded, at the Contractor's expense, with concrete 1:3:6, using 19 mm aggregate, so there is a minimum cover of 15.0 cm in all directions. The length shall then be retested.

- Immediately a length of drain has been approved, the trench shall be backfilled for a depth of at least 30.0 cm above the top of the pipes.

- Air testing of drains may be used with the approval of the Project Manager.

G. ELECTRICIAN

9.101 Electrical Installations

All work in connection with the electrical installations shall only be carried out by an experienced and approved personnel.

All wiring shall be single core P.V.C. insulated copper conductors. Standard colour codes must be adopted viz: Red - Live, Black - Neutral, Green - Earth. The wiring shall be carried out by looping cables from point to point. No tee joints or any other joints shall be permissible.
Cables shall be drawn after installation of the conduit systems and any plaster has dried. Cross entry of cables and more than 6 cables in a conduit shall not be acceptable. Draw wires shall be threaded in at the time of installation of the conduits.

All electrical installations shall comply with UEB Regulations, with fittings of a type readily available in Uganda and approved by the Project Manager.

9.102 Conduits for Electric Cables

Best quality unplasticised, rigid, heavy gauge Class “A” P.V.C. conduits shall be used everywhere. The conduits shall be suitable for plain connections. On wooden trusses the conduits shall be secured at intervals of not more than 3 metres. Deformed, misshaped and bent conduits must not be used under any circumstances. At all bends and curves, the effective cross sectional area shall not be reduced below the normal cross sectional area. Conduits less than 19 mm nominal diameter shall not be used.

All conduits shall be laid in straight horizontal and vertical lines. In case of straight runs of conduits exceeding 50 m, suitable inspection boxes shall be placed at intervals of not more than 15 m. No more than 4 easy bends and 2 right angle bends shall be allowed between two such inspection boxes. The conduits shall be secured to reinforcement bars at intervals of not more than 3 m.

H. PAINTING AND GLAZING

9.103 Glazing

All glass shall be of approved manufacture, in accordance with BS 952, free from flaws, bubbles, specks and other imperfections, cut to size to fit the opening for which it is intended, with not more than 1.6 mm play all round.

The glass for glazing generally shall be clear and flat drawn and shall be Ordinary Quality (O.Q) sheet glass of the required thickness to suit the size of sheet and position. 5 mm semi obscured glass shall be fitted to windows of toilets and bathrooms. Glass louvre blades shall not exceed 750 mm in length.

Putty for glazing shall be tropical putty of approved manufacture suitable for glazing to metal or wood frames as appropriate. Putty shall be delivered to the Site in the original manufacturer’s sealed cans or drums and used directly therefrom with the addition only of pure licensed oil if necessary. No mineral or other oils be used.

The rebates of all windows shall be painted one under coat before puttying.

The putty shall, within 14 days, dry and harden without wrinkling of the surface or caking and shall adhere satisfactorily to the surface of the glass and the frame.

All glazing to wood frames shall be sprigged and to metal frames fixed with clips. All glass shall be

properly back - puttied, and the front putty finished neatly and cleanly in line with back putty. Glass to glazed doors shall be fixed with glazing beads, secured with brass screws.

The Contractor shall clean all glass inside and out, remove all paint and putty marks replace any broken scratched or cracked panes and leave all glazing sound and perfect at completion.

9.104 Painting and Decorating

Before commencing the painting work, the Contractor shall submit to the Project Manager, for approval, a list of all the brands of paints and finishing including the necessary primers and undercoats to be used. Immediately upon being approved orders shall be placed and the total requirements obtained for the work. Once approved, no other brand of materials shall be used without the permission of the Project Manager expressed in writing.

All materials shall be delivered to the Site intact in the original containers and shall be mixed and applied strictly in accordance with the manufacturer's printed instructions. No addition will be allowed to be made locally without the permission of the Project Manager.

The priming, undercoats, and finishing coats shall each be of different tints. The priming and undercoats shall be the correct brands and tints to suit the respective finishing coats, in accordance with the manufacturer's instructions. All finishing coats shall be to the colours and types specified by the Project Manager.

The Contractor shall include for the preparation of surfaces, rubbing down between each coat, stopping, knotting and all other work as previously described and as necessary to obtain a first class finish.

Plaster, finished with a steel trowel and fair face concrete surfaces, shall be well rubbed down, filled and made good as necessary, and thoroughly cleaned down, immediately before decoration is applied.

Cast in-site concrete, with a rough textured surface, shall be made good as necessary, and thoroughly wire brushed clean, immediately before decoration is applied.

Insulation board or similar surfaces shall be filled, and made good as necessary and lightly brushed down to remove all dirt, dust and loose particles.

Metal work to be painted shall be scaled clean and thoroughly wired brushed and wiped clean with white spirit (using rag or brush) to ensure that all loose particulars of rust and scale are removed completely.

Galvanised surfaces shall be treated with approved calcium plumbate primer applied strictly in accordance with the manufacturer's printed instructions.

Aluminium and other non-ferrous metal shall be primed with an approved zinc chromate primer.

Ironwork coated with bituminous solution shall receive an isolating coat of aluminium metal primer.

All exposed cast iron or asbestos cement, waste and vent pipes shall be primed with two coats approved aluminium metal primer before further treatment.

Woodwork to be painted shall be well rubbed down and primed with aluminium wood primer well

brushed into the wood. All knots shall be covered with good shellac knotting before priming and all defects shall be filled with a hard stopping after priming.

Plywood to receive finishes other than paint shall have all stains removed, be well rubbed down and have all defects levelled up with hard stopping of a colour to match the adjoining surfaces.

After each coat, the work shall be allowed to dry and shall then to be well rubbed down with fine glass paper on blocks, or other means as required for the particular work, before the next coat is applied. The paintwork shall be finished smooth and free from brush marks.

All door furniture and other ironmongery shall, during painting operations, be removed and afterwards re-fixed.

9.105 Distemper and Lime wash

Distemper shall be oil or case in bonded and washable. It shall be thinned only with petrifying liquid made by the manufacturer of the approved distemper to be used, and in accordance with the printed instructions.

Lime-wash shall consist of slaked lime and coarse salt mixed in the following manner:

To 25.0 kg of slaked lime add water into which has been dissolved one kilogram of coarse salt. Add clean water until the required consistency is obtained.

All materials for external use shall be of exterior quality recommended by their manufacturers for such use.

9.106 Covering up

Sweep clean and cover up all floors, etc. with dust sheets when executing all painting and decorating work.

Paint splashes, spots and stains, shall be removed from floors, woodwork, etc. Any damaged surfaces shall be touched up and the whole of the work left clean and perfect upon completion.

10 INSPECTION AND TESTING OF WORKS AND EQUIPMENT

10.1 Testing Of Earthworks

10.1.1 General

The Contractor shall furnish all equipment and materials necessary for collecting samples and carry out field laboratory tests on materials for earthworks. Laboratory equipment shall be housed in a suitable building on site, which shall also incorporate space for the storage of field test equipment.

10.1.2 Main Tests and Standards

The Contractor shall carry out all tests in accordance with ZTVE-STB 94 or equivalent ASHTO or BS standards. For the various tests the following DIN standards shall apply:

DIN18121	Moisture Test	DIN18125	Density Test for Soils (including voids)
DIN18122	Consistency Test	DIN18127	Proctor Test
DIN18123	Grading Tests	DIN18134	Loading Test
DIN18124	Density Test (solid volume without voids)		

10.1.3 Compaction of Soils

The Contractor shall carry out the compaction to safely achieve the specified dry density and control soil compaction during backfilling and filling operation.

Where the sub grade or layers of soil material require being moisture conditioned before compaction, the Contractor shall uniformly apply water to the sub grade or layer of soil to attain the optimum moisture content required. The application of water shall be carried out in a manner to prevent free water appearing on surface during compaction operations.

The Contractor shall replace soil material that is too wet for compaction to the specified densities.

10.1.4 Testing of Compaction

The Contractor shall inspect, perform and report all testing and retesting as to ensure that the works conform to the specified requirements. In order to test the degree of compaction, the Contractor shall carry out field density tests in accordance to DIN18127 or B.S. 1377.

For each compacted backfill of trench the required number of field density tests to ensure compliance with specification shall not be less than three passing tests between each 2 manholes or 100 linear meters (whichever is smaller) of filled and compacted trench.

If, in the opinion of the ENGINEER, the sub grade, backfill and fill layers have been placed and compacted to densities below the specified limits, the Contractor shall provide additional compaction and testing until satisfactory results are attained or remove certain sections of the work and reconstruct them according to the Specifications at his own expense.

All holes made for the purpose of tests shall be restored by the Contractor to conform to the characteristics of the adjacent layers. This work shall be conducted at the Contractor’s expense.

The compaction required for various fills shall be as follows:

Item of Works	Materials Prescribed	% of Max. Density
Backfill for over-excavation	Granular material	100
Formation and bedding layers	Fine granular material	95
Crushed stone supporting layers	Crusher runs	95
Final backfill of trenches under roads	Fine granular material	100
Backfill of trenches in general	Fine granular material	98
	Sandy material	95
	Clayey material	93
Backfill below structures	Fine granular material	100

10.2 Inspections And Testing Of Civil Works

10.2.1 Inspection Prior to Commencement of Works

Buildings and other structures in close proximity to the construction Site that might be damaged by excavation or other work shall be inspected before work is commenced.

All parties concerned shall be invited by the Contractor to participate in the inspection.

The Engineer and the Contractor shall make the inspection jointly and the Contractor shall, at his own expense, set out an inspection report, including “preconstruction photos” as described in Chapter 2.3.7.

The report shall describe the conditions of the buildings, roads, footpaths etc. in question.

Any failure or damage caused by excavation or other works, shall be repaired and maintained by the Contractor at his own expense without any delay.

10.2.2 Testing of Concrete Works

10.2.2.1 Concrete Works, Test Certificates

Unless otherwise directed by the Engineer, the Contractor shall supply and submit to the Engineer:

Manufacturers test sheets with each consignment of cement and admixtures certifying the compliance with the relevant standards.

Certification of the calibration of weighing and dispensing equipment on the batch mixing plant.

The certified test results for all tests carried out on aggregates, water fresh and hardened concrete.

In case of doubts, new tests shall be executed upon the Engineer’s direction at the Contractor’s expense.

10.2.2.2 Concrete Works, Inspections

No concrete shall be placed until the Engineer has inspected and approved the surfaces upon which the concrete is placed the formwork and the reinforcing steel.

If requested by the Engineer to do so, the Contractor shall institute a "pour card" system in which a card is made out for each lift of concrete and is initialled by the Contractor and the Engineer confirming that the inspections have been carried out.

The "pour card" shall include spaces to identify the concrete being placed and to signify the completion of the inspections by the Contractor and the Engineer in regard to:

- Preparation of surfaces on which concrete is to be placed;
- Formwork;
- Reinforcement;
- Readiness for concrete placing;
- Striking time of formwork
- Inspection after removal of framework (remedial work directed);
- Curing procedures
- Completion of remedial work (if any)

10.2.2.3 Sampling and Testing of Aggregates

The Contractor shall sample and carry out mechanical analysis of the fine aggregates and each normal size of coarse aggregate in use, employing the method described in DIN4226 at least once a week when concreting is in progress and at such more frequent intervals as the Engineer may require.

The grading of all aggregates shall be within specified limits. Should the fraction of aggregate retained on any sieve differ from the corresponding fraction of aggregate in the approved mix by more than 5% of the total quantity of fine and coarse aggregate, the Engineer may instruct the Contractor to alter the relative portions of the aggregates in the mix to allow for such differences.

10.2.2.4 Sampling and Testing of Concrete

The Contractor shall provide the equipment necessary to determine the compacting factor of freshly mixed concrete at each place where concrete is being prepared and shall determine the compacting factor of the freshly mixed concrete by the method described in DIN1048 on each location where a set of test cubes is made and not less than once a day or as the Engineer may direct.

Unless particularly specified, for each grade of concrete works test cubes shall be made whenever required by the Engineer but not less frequently than one set of cubes per 25 m^3 or part thereof concreted per day.

Each set of cubes (six cubes per set) shall be made from a single sample of a concrete batch taken by random. Each three cubes shall be tested 7 and 28 days after manufacture.

When requested by the Engineer, additional set of cubes shall be made for testing 3 days after

manufacture. Test reports shall be submitted to the Engineer in duplicate.

10.2.2.5 Compliance with Specified Requirements

The concrete shall be deemed satisfactory provided that:

The average 28 days strength f_{cm} determined from every group of four consecutive test cubes must be f_{ck} + 8 N/mm² and the minimum strength of each cube must be f_{ck}, i.e. for grade C 20/25 concrete the average value must be 28 N/mm² and the strength of each cube must be 20 N/mm² minimum.

Each individual test result shall be greater than 85% of the specified characteristic strength.

If one cube result fails to meet the second requirement, the result may be considered to represent only the particular batch of concrete from which the cube was taken, provided that the average strength of the group satisfies the first requirement.

If more than one cube in a group fails to meet the second requirement or if the average strength of any group of four consecutive test cubes fails to meet the first requirement, then all the concrete in all the batches represented by such cubes shall be deemed not to comply with strength requirements.

10.2.2.6 Non-Compliance with Specified Requirements

When the average strength of four consecutive test cubes fails to meet the first requirement, no further concrete from that mix shall be placed in the work and the Contractor shall establish the cause of the failure and apply such remedies as are necessary.

The Contractor shall demonstrate by trial mixes and test cube results that the revised mix is in accordance with the specified requirements.

The Contractor shall, within 24 hours of the date of testing, make proposals for agreement with the Engineer about actions to be taken in respect of any concrete represented by the test cubes which fail to meet either of the requirements. These proposals may include, but shall not be limited to, cutting and testing cores.

Concrete, which is ultimately not found to comply with any of the requirements of the Specification, shall be broken out and replaced or otherwise dealt with as agreed by the Engineer at the expense of the Contractor.

Furthermore, the Engineer may order additional cement to be added to the mix immediately. The mixes used may also be changed whenever, in the opinion of the Engineer, such change is necessary or desirable to secure the required workability, density, tightness, surface finish and strength, and the Contractor shall not be entitled to additional compensation because of such changes.

10.2.2.7 Cutting and Testing of Core Samples

As and where directed by the Engineer, cylindrical core samples shall be taken normal to the surface of the hardened concrete for examination and testing.

The procedure for drilling, examination, measurement and testing shall be in accordance with DIN1048.

Prior to the preparation for testing, the specimen shall be made available for examination by the Engineer.

If the crushing strength of the specimen determined in accordance to DIN1048 is less than the characteristic strength at 28 days for the grade requirements in other aspects, that concrete in that part of the works of which it is a sample shall be considered not to comply with the specified requirements.

10.3 Inspection And Testing Of Pipes And Mains

10.3.1 Testing at Place of Manufacture

The manufacturer shall, at the place of manufacture, test all type of pipes, fittings and pipeline appurtenances listed in the Quantities, including all necessary jointing material and mark them. The Contractor shall submit the certificates prescribed by the respective Standard Specifications.

The Engineer may witness such tests without incurring any responsibility for the materials.

10.3.2

10.3.3 Tests of field welds

All field welds at main diameters exceeding DN 300 or PN10 shall be subject to an ultrasonic test.

10.3.4 Pressure Testing of Mains

The Contractor shall submit a systematic procedure for testing and method of filling and draining all mains and pipework for approval to the Engineer. The pressure drop method shall be applicable as set forth by EN805 Chapter 11.

Test pressure of the mains shall be 1.5 times the operating pressure of the mains but not less than stated in the following table. The test pressure always applies to the lowest point of a test section.

System test pressure STP		
Kind of main	Class = PN	System Test pressure STP
Local main	PN6, PVC-U	11bar = 6 bar + 5 bar
Principal main	PN10, ductile iron	15bar = 10bar + 5bar
Trunk main	PN16 ductile iron	21bar = 16bar + 5 bar
	PN25 ductile iron	30 bar = 25bar + 5 bar

The Contractor shall perform the hydrostatic test, on all complete piping, prior to field coating of welds and fittings and prior to backfilling of the joints.

The Contractor shall provide and fit any test heads required, and the Engineer shall be informed in

time to make a final check of each section to be tested before test heads are connected. The Contractor shall ensure that any necessary bosses on the test heads or pipework are included as required for filling and venting during site testing. Fill and vent points in the pipe shall be closed afterwards. Thrust blocks shall be provided and removed after testing. Tests shall not be performed against valves but against blank flanges and test heads exclusively. .

Calibrated manometers of class 0,6 ∅ 160mm shall be used for testing and be placed at the lower end of the test section.

Water filling may start after opening valves or hydrants from existing system if approved by the Engineer or from tanker trucks. Before start of test, air must be completely removed from the test section as its presence falsifies the test results.

If visible leaks have to be contemplated in the test section, the test has failed irrespective of the recorded pressure drop. Pressure drop shall not exceed 20kPa = 0,2bar during 2 hours of main test, otherwise the test has failed

10.3.5 Testing of Water Meters for House Connections

Water meters for house connections shall be tested and calibrated at the factory in accordance with test certificates shall be issued and submitted to the ENGINEER for approval. The meters shall bear the seal of the calibration bank. The certificate shall include precise information on the test and calibration processes applied.

Tests shall be conducted with 10 meters out of 1000 but not less than 5 per each size. Test pressure shall be 16 bar during 15 minutes. Meters shall show no of leakages of body and seals. The hydraulic parameters shall be determined and compared to the requirements of the standard. If two or more meters do not pass the tests, the batch shall be rejected.

10.3.6 Pressure test for headers, manifolds and other pipework in plant.

The prescriptions of 10.2.1shall apply accordingly.

10.3.7 Tightness test of water tanks and reservoirs

Tightness test shall be carried out before any backfill around the tank subject to test takes place. All outside surfaces of the tank walls must be cleaned, smoothened and be completely visible and accessible. Each tank of a multi-tank reservoir shall be subject to a separate test.

Filling of a tank shall take place during daylight to allow for continuous inspection during filling. Tanks shall be filled up to high water level as indicated on the drawings or as otherwise instructed by the Engineer.

For tanks completely or partially made of concrete, the Contractor shall maintain a tank subject to test full over a period of 7 consecutive days prior to the test to achieve saturation of the concrete exposed to water.

For tanks completely made of steel such saturation period is not required, and the Contractor shall maintain the tank full one day prior to start of test.

A visual check of all concrete wall surfaces shall then take place. If such inspection does not identify visible leakages or wet spots, the test can continue. If such inspection however identifies leakages and

wet spots, the test will be terminated and the Contractor shall proceed with repairs of the respective parts as instructed by the ENGINEER. Thereafter the procedure shall be repeated. Reference: DVGW W311 12 (1988).

After having successfully passed the visual inspection of the external surfaces, the main test shall be undertaken. The main test shall last 48 hours. During that period of 48 consecutive hours all ventilation hoods and accesses shall be tightly closed and sealed. Water level shall be measured at the beginning and end of the main test period. If water level drop does not exceed one (1,0) cm or 3/1000 of storage height, whichever is less, the test is passed successfully.

Water for the successful tightness test shall be supplied free of charge by the Employer through the connected mains. The Contractor shall pay to the Employer the water for any unsuccessful test at the rate for industrial bulk users.

10.3.8 Monitoring of settlements

From start of filing until completion of the test, the Contractor shall monitor the settlements of the tanks through precision levelling on the benchmarks grouted into the concrete as directed by the Engineer, particularly at the four corners of rectangular tanks and every 90° at the circumference of round tanks.

Frequency of levelling and recording formats shall be as instructed by the Engineer.

10.4 Tests at Completion

Tests at Completion shall be carried per each hydraulic system separately upon request of the Contractor. The Contractor shall prepare for each system a detailed program for the test runs. These tests shall be carried out under the direction of the ENGINEER and shall demonstrate that all mechanical, electrical control systems work satisfactorily an integral functional system.

The program shall be elaborated in such way as to provide tests for each individual element but also for the entire system as a whole. The program shall provide for simulation of normal as well of all extreme operating conditions, in particular to simulate the performance of limit switches or alarms at low and high water level. Surges shall be simulated by sudden shutting off of pumps. The Contractor shall provide measuring equipment to monitor peak pressures during surges.

For complete transmission systems the tests at completion shall serve to determine the actual capacities of the various elements through the full rangs of possible operations.

In case that at the time of tests at completion requested by the Contractor connections to the public power supply have not been completed by the Power Corp., the tests shall be carried out with power generated from the stand-by generating sets.

For mains the pressure test shall be deemed to constitute part one of the test at completion, subject to a successful test at normal operating pressures which shall constitute part two of the test at completion of mains. During this second part, the satisfactory function of valves, in particular air valves, washouts, hydrants, shall be tested.

11 PROJECT MANAGER/ENGINEER'S REQUIREMENTS

Not applicable