BIDDING DOCUMENT FOR PROCUREMENT OF CONSTRUCTION WORKS FOR THE SECOND BARICHO – KAKUYUNI WATER SUPPLY PROJECT- LOT 1: SECOND BARICHO – KAKUYUNI PIPELINE

VOLUME II of III

NCB No. KE-CWSB-232660-CW-RFB

Project Name: Water and Sanitation Development Project (WSDP)
Credit No: KE 6030

Employer: COAST WATER WORKS DEVELOPMENT AGENCY (CWWDA)

Country: KENYA

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These Bidding Documents Consists of Four (4) Volumes:

i)	**Volume I**	-	Instructions to Bidders, Bid Data Sheet, Evaluation and Qualification Criteria, Bidding Forms, Works Requirements, Conditions of Contract and Contract Forms
ii)	**Volume II**	-	General and Particular Specifications and Standard Reference Numbers
iii)	**Volume III**	-	Engineering Drawings
iv	**Volume IV**	-	Bill of Quantities

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1 GENERAL REQUIREMENTS

1.1 Introduction

This contract is for the Construction of the Second Baricho Kakuyuni Pipeline including the associated pumps at Baricho Water Works and a new storage tank at Kakuyuni Secondary School. The works will improve water supply and reliability in Malindi, Kilifi, Watamu and Marereni urban and peri-urban areas.

1.2 Location of the works

The Works to be constructed are located within in Kenya's Coastal region and are within Kilifi County which is one of the 47 counties of Kenya. The Works are spread between Baricho aquifer and Kakuyuni Secondary School near Malindi town. Baricho aquifer is located in Kilifi County and 60km West of Malindi town.

A layout on the location of the works is attached as shown in Volume 3 Book of Drawings

1.3 Climatic conditions

Kilifi county has a bimodal rainfall pattern with average annual precipitation ranging from 300mm in the hinterland to 1,300mm in the coastal belt. The coastal belt receives an average annual rainfall of about 900mm to 1,300mm while the hinterland receives average annual rainfall of about300mm to900mm. The short rain season is experienced in the months of October, November and December while the Long rains are experienced in the months of March–April and May. The most important season to the hinterland is the short rains for pasture regeneration and water recharge while the long rain season is the most important season for the coastal area for crop production.

Areas receiving highest average annual mean evaporation ranges from 1800mm along the coastal strip to 2200mm in the Nyika plateau in the hinterland. The highest evaporation rates are experienced during the months of January to March in the county. The annual temperatures range between 210C and 300C in the coastal belt and between 300C and 340C in the hinterland. The county experiences a very important wind field with relatively moderate wind speeds ranging from 4.8Km/h along the coastal strip to 12km/h in the hinterlands.

1.3.1 Physical and topographical feature

Kilifi County has four major topographic features. The first one is the narrow belt, which forms the coastal plain and in width from 3km to 20km. The coastal plain lies below 30m above sea level with a few prominent peaks on the western boundary such as Mwembetungu hills.

Across this plain are several creeks with excellent marine swamps that are richly endowed with mangrove forests and present great potential for marine culture. This zone is composed of marine sediments, including coral, limestone, marble, clay stones and alluvial deposits that support agriculture.

The second topographical feature is the foot plateau that lies to the east of the coastal plain. It is characterized by a slightly undulating terrain that falls between 60m and 150m altitude and slopes towards the sea. A number of dry river courses transverse the surface with underlying

Jurassic sediments consisting of shells, sandstones and clays. This zone is covered by grassland and stunted shrubs.

The third feature is the coastal range, which falls beyond the foot plateau between 150m to 450m altitude and has distinct low range sandstone hills. The fourth is the Nyika Plateau, which rises from 100m to 340m above sea level covering about two thirds of the county area on its western side. This plateau is characterized by a low population density, thin vegetative cover, shallow depressions and gently undulating terrain. It constitutes the arid and semi-arid areas of the county, which are suitable for ranching. The drainage pattern of the county is formed by one permanent river, a number of ephemeral rivers and streams which drain into Indian Ocean. The permanent river is Sabaki River.

1.4 Brief Description of the Works

The works to be executed under this Contract comprise of the following:

a) Pump Station

- Supply installation of 3 No pump sets within the existing pump house (Q=820m^3/hr, H=70m)
- Supply and installation of surge vessels;
- Supply and installation of pump control electrical panels;
- Associated electrical works for the pumps
- Testing and commissioning of the pumps

b) Baricho Kakuyuni Rising main

- Excavation, supply and laying of 29 km of DN 800mm steel pipeline;
- Supply and installation of associated valves and other appurtenances;
- Testing and commissioning of the pipeline

c) Kakuyuni 5,000 m^3 reservoir

- Supply all materials and construct a 5,000 m^3 reinforced concrete reservoir and all related ancillary works;
- Testing and commissioning of the reservoir

1.5 Plan of operations and temporary works

The Contractor shall in accordance with the Conditions of Contract, and before commencing work on site, submit to the Engineer a fully detailed programme of work showing the order of procedure and methods by which he proposes to carry out the construction and completion of the works, and particulars of the organisation and staff proposed to direct and administer the performance of the Contract.

The works shall be carried forward to completion with the greatest possible expedition, to the satisfaction of the Engineer, in accordance with the programme.
The information to be supplied to the Engineer shall include drawings showing the general arrangement of the temporary offices, camps, storage sheds, buildings and access roads, and details of Contractor's Equipment and Temporary Works proposed.

1.6 Standard specifications

For convenience, and in order to establish the necessary standards of quality, reference will be made to specifications issued by national or other widely recognised bodies. Such specifications shall be referred to as "Standard Specifications" and shall be the latest editions of such Standard Specifications issued prior to the issue of the Bid Documents, together with such additions and amendments as may have been issued prior to the same date.

Subject to the written approval of the Engineer, any other internationally accepted Standard, which requires an equal quality of work, may be used. If the Contractor proposes to use a Standard Specification other than that specified, three copies of the proposed Standard Specification, in the English language, shall be submitted to the Engineer not less than twenty-eight days before approval of the Standard Specification is required.

In referring to Standard Specifications, the following abbreviations are used:

BS	British Standard
BSCP	British Standard Code of Practice
DIN	Deutches Institut für Normung
ISO	International Organisation for Standardisation
AWWA	American Water Works Association
EC	European Code
EN	European Norm
KEBS	Kenya Bureau of Standards

1.7 Units

In this Specification, on the Drawings, and in the Bill of Quantities, the metric system of dimensioning has been adopted except where it is understood that suppliers and manufacturers are not yet able to provide materials in metric sizes.

Where dimensions are given in metric units for materials which are only available in Imperial system dimensions, and vice versa, the Contractor may, subject to his obtaining the prior approval of the Engineer, substitute the nearest equivalent available standard size in the other system.

1.8 Level datum

It shall be the responsibility of the Contractor before commencing work to obtain from the Engineer in writing the values and locations of the benchmarks to be used in these works. All temporary benchmarks shall be referred thereto. The Contractor shall construct such temporary benchmarks as the Engineer may direct and shall agree the levels thereof with the Engineer. The establishment of such temporary benchmarks shall be deemed part of the Contractor's responsibility in setting out the works.

1.9 Sites for Permanent Works

The Sites of the Permanent Works are shown on the construction Drawings. The Employer shall have obtained (or shall obtain) the permission, way leaves etc required for the construction of the Permanent Works.

1.10 Definition and use of the Site

1.10.1 Definition of the Site

The Site shall include all those areas of land which, being public or private:

i. Are being provided by the Employer for the construction of the permanent works.

ii. Are being provided by the Employer for temporary works, including camps, offices and stores.

iii. Are acquired, leased, or operated by the Contractor as borrow pits or spoil tips for the permanent works, including all access roads.

1.10.2 Use of the Site

Access to the Site is gained from public and private highways. The Contractor shall be responsible for minor improvements, cleaning and maintaining all existing roads affected by his work while he is on Site. He shall also be responsible for repairing and making good any damage to these roads. If the Contractor, his subcontractors or suppliers, causes the damage, then the repairs will be at his own cost.

The Contractor shall be responsible for the construction, maintenance and repair of any temporary Site roads.

The lands and other places outside the Site, which are the property of or under the control of the Employer, shall not be used except with the approval of the Engineer.

The Contractor shall promptly remove any vehicle, wagon, barge or vessel or any other obstruction under his control that the Engineer may require to be moved for any purpose. The Contractor shall remove such obstruction promptly upon receiving such instruction and at his own cost, unless the Engineer shall decide otherwise.

The Contractor shall maintain access for the inspection, operation and maintenance of any of the Employer’s assets within the Site or elsewhere.

The Contractor shall not use any portion of the Site for any purpose not connected with the works unless the written permission of the Engineer has been obtained.

Except with the written permission of the Engineer, to be given when necessary for the execution of the works, the Contractor's employees will not be permitted to enter any of the Employer’s buildings or lands or sites under the control of other contractors or the Engineer. The Contractor shall warn his employees that any person found within such buildings or sites without authority is liable to be removed from the works in accordance with the Conditions of Contract

The Contractor shall restrict his activities to those areas of the Site adjacent to the works being executed and shall avoid any encroachment upon lands outside the areas for which possession has been given. Any trespass or damage or any claim arising from such encroachment shall be the Contractor's sole responsibility and he shall hold the Employer indemnified against all claims arising from such trespass or damage.

1.11 Compliance with Statutes and Local Regulations

The Contractor shall be responsible for acquainting himself with all current valid statute ordinance or bye-laws or regulations which may affect the works and shall cover these in his rates. This applies to Contractor's licences, work permits and other similar requirements for which no claim on the part of the Contractor other than the one inserted in the Bills of Quantities will be allowed.

1.12 Setting out

The Contractor shall appoint and employ the necessary qualified and experienced staff to set out the works accurately.

The Contractor shall establish and locate all lines and levels and be responsible for the correct location of all works.

Where directed by the Engineer, the Contractor shall take such levels and dimensions as may be required for the purposes of measurement before disturbance of the ground. These shall be agreed between the Contractor and the Engineer in writing before any ground surface is disturbed or covered up. Any work commenced without taking the said levels and dimensions shall be measured on the Engineer's reckoning of their values before disturbance. The Engineer's decision on this matter shall be final.

1.13 Construction and checking of work

The Contractor shall be solely responsible for and shall provide all labour, tools, lifting tackle, and other equipment required for the construction and checking of the works.

No operative shall be allowed to execute any type of work which is normally carried out by a skilled tradesman, unless the operative is thoroughly experienced and proficient in the trade concerned. Supervisors and operatives may be required to demonstrate their proficiency or produce certificates of competence to the satisfaction of the Engineer.

As each part of the work is carried out, it shall be subject to the approval of the Engineer.

1.14 Supervision and labour

The Contractor will be required to maintain a competent Site Agent and staff on Site throughout the construction period until completion of the works, and thereafter as may be required during the Defects Liability Period. The Engineer shall give prior approval to the appointment of this Site Agent and shall have the authority to withdraw this approval at any time in accordance with the Conditions of Contract.

All staff and labour employed on the works shall be employed in accordance with the labour and employment laws and regulations of the Republic of Kenya.

1.15 Specialist subcontractors

Where subcontractors are not nominated, the Contractor shall appoint specialist subcontractors for any sections of the works described herein in which he is not himself an experienced, recognised and approved expert.

A subcontractor nominated by the Employer or the Engineer will be required to hold the Contractor indemnified against all claims, accidents, damage or loss occasioned by any act of the subcontractor in the performance of the sub-contract.

The Contractor shall allow for phasing the work to meet the requirements of subcontractors and for varying his programme, or otherwise, to comply with the programme of the subcontractors.

1.16 Works executed by the Employer or other contractors

The Employer reserves the right to execute, on the site, works not included under this Contract and to employ for this purpose either his own employees or other contractors whose contracts may be either a sub-contract under this Contract, or an entirely separate contract. The Contractor shall ensure that neither his own operations nor trespass by his employees shall interfere with the operations of the Employer, or his contractors employed on such works and the same obligations shall be imposed on the Employer or other contractors in respect of work being executed under this Contract.

1.17 Contractor's site offices, workshops, storage and working areas

The Contractor shall be responsible for obtaining the land and for the provision of all temporary yards, stores, workshops, offices, mess rooms, shelters and for all services in connection therewith. The location of all such facilities shall be agreed beforehand with the Engineer and shall be such as to avoid obstruction and nuisance to the public.

The Contractor shall establish secure storage compounds and storage building where he shall store at his own risk all equipment and Plant awaiting erection. The Contractor shall also provide secure covered storage for all samples submitted to the Engineer for approval. Storage building shall be weatherproof and shall be of sufficient size to accommodate all items requiring covered storage.

The Contractor shall provide and maintain suitable and sufficient shelters and mess rooms for his workmen and supervisory staff as are customary and necessary. The Contractor shall provide sufficient closets or latrines to the satisfaction of the relevant authority.

The Contractor shall be responsible for providing all buildings, fences, etc. that he may require and on completion of the works shall be required to remove the same and restore the land to its original condition to the satisfaction of the Engineer. The mess rooms, closets and latrines shall be located in positions to be approved by the Engineer. The Contractor shall be responsible for making all arrangements for the disposal of waste from mess rooms, closets and latrines.

1.18 Services for Engineer's Representative

1.18.1 Resident Engineer's Site Office

For Supervision of the Works, rented office will be established at close proximity to the Project Area. The Contractor to provide the rented offices from the date of Commencement of Work to the date an office will be constructed or for the entire duration of the works as approved by the project manager. The rented offices including their locations shall be to the Resident Engineer's approval. The Office shall be of a design and construction approved by the Engineer and shall be constructed of strong, durable and weatherproof materials with walls, ceilings and floors with tiles adequately insulated against heat and cold.

The office shall be provided with equipment and furniture as will be directed. The Offices shall have burglar proofing to all windows and external doors. In addition to the above, provision will be made for parking for at least two vehicles. The Contractor shall arrange for the provision of internet connection. Provision shall also be made by the Contractor for all provisions as required including cooking gas, electricity, fresh water, light, attendance and stationery required in connection with execution of the Contract.

Security Guards hired from a reputable Security Firm approved by the Engineer shall be provided for day and night security at these Offices. The Office, furniture and equipment shall be insured against fire, theft and natural calamity.

- ✓ **1.18.1 (a) Provision and Consumables for the Resident Engineer's Office**

The following basic stationery per month will be provided under the Bill Item 1A231.1 of the P & G Bill. The stationery shall be subject to monthly approval by the Resident Engineer before procuring.

Stationery	**Quantity for Office**
Photocopy paper A4	4 Reams
A3 paper	2 Ream
Biro pens blue/black	½ Doz.
Clutch Pencils	½ Doz.
Box files	6 Nr
Spring Files	6 Nr
Document Wallets	6 Nr
Spirals (various sizes of Reports)	2 Doz.
Embossed (hardback cover)	2 Doz.
Perspex covers	2 Doz.
Cellotape (medium)	1 Nr
Masking tape (medium)	1 Nr
Staples	2 Pac.
Paper clips (various sizes)	2 Pac.
Pencil leads (0.5/0.7)	2 Sets
C-DR (Pack of 12)	1 Pac.
CD-RW (Pack of 12)	1 Pac.
Highlighters (set of all colours)	2 Sets
A6 hardcover notebooks	2 Nr
Soft Pencil Erasers (Staedtler or equivalent)	3 Nr
Envelopes (all sizes)	3 Doz.
Batteries for flashlights	3 Sets
Black ink cartridge/ toner for the A4/A3 printer	1 Set
Colour cartridges/toner for the A4/A3 printer	1 Set

In addition, the Contractor to supply adequate toiletry, cleaning materials, tea/coffee, milk, sugar, drinking water etc. under the respective bill items of the P & G. The list of Provisions and consumables shall be subject to monthly approval by the Resident Engineer. The Contractor shall also be responsible for payment for all services including water, electricity and security under the Bill Item 1A228.

- ✓ **1.18.1 (b) Provision of furniture and equipment for the Resident Engineer's office**

The Contractor under the bill item 1A212 and subject to the approval by the Resident Engineer shall suitably furnish the RE's offices with the following as minimum requirements;

a) 3Nr. Writing desks / work stations with 3 lockable drawers;
b) 1Nr. Executive desk with drawers and side desk including a chair
c) 1Nr. Conference table with 12Nr. Chairs;
d) Lockable storage cupboard
e) Office stapling and binding machine
f) 2Nr. External hard disk (1TB)
g) Split high wall AC system;
h) Electric fan for the respective rooms of the RE's office
i) 3Nr.Latest Desktop model as approved by the Resident Engineer;
j) 2Nr. Latest Laptops with at least 1TB HDD and 16GB RAM with latest Microsoft office installed and subject to the approval by the Resident Engineer;
k) A Kyocera 8124 Cidn all in one printer or its equivalent – capable to print both A4 and A3 in colour and B/W. The printer shall be approved by the Resident Engineer before procuring.
l) Digital Camera as specified by the Resident Engineer
m) 2Nr Samsung galaxy smart phones or approved equivalent.
n) Wall clock
o) Petty Cash Box with security lock

- ✓ **1.18.1 (c) Staff for the Resident Engineer's Office**

The Contractor shall provide the following staff for the exclusive use of the Resident Engineer for the duration of the Contract;

a) **Office Secretary** - The secretary shall be English speaking, with a minimum 2 years' experience in secretarial / office administration work. The secretary shall be conversant with standard office computer hardware and software (MS-Word, Excel, PowerPoint, etc.). The Secretary shall be interviewed and tested by the Resident Engineer prior to deployment on the Works.

b) **Office Assistant** - (messenger / tea boy / office cleaner)

c) **Drivers** - The Contractor shall provide a licensed driver for the exclusive use of the Resident Engineer. The driver shall have a minimum 10 years of clean driving record and a Certificate of Good Conduct from the Kenya Police. The driver is to be employed and paid by the Contractor (including all overtime, NSSF, NHIF, etc.) but will report directly to the Resident Engineer for day to day instructions. The Resident Engineer will interview, test and approve the driver prior to their deployment on the Works.

1.18.2 Transport Vehicles

The Contractor shall provide and service and maintain the vehicles to be used for supervision of the Contract by the Resident Engineer and his staff. The Contractor shall ensure that all vehicles

are licensed, comprehensively insured at all times, serviced and maintained in good condition to the satisfaction of the Resident Engineer or his authorized representative, so that the Resident Engineer shall at all times have the vehicles available for use in good serviceable condition. In the event of the vehicles being unserviceable for whatsoever reason, the Contractor shall provide alternative vehicles as provided in under the contract.

Payments for maintenance shall include for provision of fuels, lubricants and tyres, all regular maintenance, minor and major repairs, including those occasioned by accidental damage from whatever cause arising, and everything else necessary to satisfy fully the requirements of this Clause.

While procuring the vehicles under the construction contract, the makes, models and colours of the vehicles shall be approved by the Engineer prior to ordering. The Contractor shall, at completion of the construction works have the vehicles inspected by the authorised dealers to determine what repairs in addition to the ordinary service are required to be carried out on the vehicle. Upon such recommendation, the Engineer will give the necessary instructions. The Contractor shall then ensure the necessary service/repairs are done. A certificate of road worthiness and satisfactory mechanical condition to be obtained from the Dealer before the vehicles are handed over to the Employer.

If required by the Client, the following will be carried out:

- Inspection by the Government Inspection Unit, if applicable
- Inspection and Valuation by the Automobile Association (AA) of Kenya

The Contractor shall hand over the respective Inspection / Valuation Reports to the Employer together with the vehicles. A Provisional Sum has been included in the Preliminary and General Items to cover running and maintenance costs of the Project Vehicles. The vehicles will revert back to the Employer at the end of the Contract.

1.18.3 Communication Equipment

If provided for in the Bills of Quantities, the Contractor shall arrange for the installation, commissioning and maintenance in use of internet services for the Resident Engineer's Office.

The Contractor who will also provide for airtime for the Engineer's Representative staff to ensure smooth communication and coordination of the work.

The use of radio communications may be permitted but the Contractor shall be responsible for obtaining all the necessary permits and licences.

1.18.4 Photographic Equipment

Photographs showing the progress of the works shall be taken to record the progress of the work frequently by use of a digital camera. Special photographs showing particular features of the works or matters of interest in connection with the works or their surroundings shall also be taken from time to time as and when required by the Engineer.

The Contractor shall provide for the duration of the Contract photographic equipment for the sole use of the Engineer: The equipment shall comprise of two automatic cameras with zoom lens, flash attachment, and date and time printout of approved manufacturer. The Contractor is responsible for maintaining and servicing the Cameras in good working condition at all times and will provide a replacement one in case of breakdown.

A provisional sum has been included in Bill No.1 for the provision of the cameras, photos

development and miscellaneous items like camera batteries etc. The Contractor is required to arrange for reproduction of the progress photographs with a reputable studio.

1.18.5 Materials Testing

Within 4 weeks of the commencement of work on Site, the Contractor shall provide, and maintain during the execution of the Works, a concrete, soil and other materials testing laboratory having a floor area of not less than 20 square metres in an approved location. Alternatively, the Contractor may apply for approval by the Engineer for reputable laboratories near the works for the periodic testing of materials. The Engineer shall have full discretion and right to approve the proposed laboratory or disapprove laboratory which has been approved.

The laboratory shall be water-tight, weatherproof, insect proof, properly ventilated, and shall be adequately wired for electric light and power, with sufficient light and power points for the efficient use of the equipment installed. The Contractor shall ensure a continuous supply of electric power and water to the laboratory at all hours including nights, and recognised days of rest.

The laboratory shall contain suitable benches, shelves and cupboards, and sinks, and shall be provided with a piped water supply and appropriate drainage. Details of the Contractor's proposed layout of the laboratory shall be submitted for the approval of the Engineer before its construction is started.

The existence of the laboratory shall in no way relieve the Contractor of the responsibility for carrying out his own tests in order to maintain the degree of control of quality hereinafter specified.

If the Contractor chooses to establish his own laboratory, he will be required to equip it appropriately at all times during the Contract period:

1.18.6 Survey Instruments and Equipment

The Contractor shall provide chainmen, tradesmen, additional laboratory assistants or labourers to assist the Engineer in carrying out his duties. The Contractor shall provide for the duration of the Contract the following new survey and inspection instruments and equipment for the sole use of the Engineer:

(a) One modern total station of an approved type with tripod or a full set of RTK machine as will be approved by the Engineer.
(b) Two modern split levels of an approved type with tripods.
(c) Two levelling staves and ranging rods (metric).
(d) Two Plump Bobs.
(e) Three 200 m metal measuring tapes.
(f) Three 30 m metallic line tapes.
(g) Five 10 m retractable pocket tapes.
(h) Two Survey Umbrellas.
(i) Other or additional equipment shall be provided by the Contractor if so requested for the occasional use of the Engineer without additional payment.

The Contractor upon the request of the Engineer shall replace items damaged during the normal course of the Works. The Contractor shall provide all such labour and assistance as may be required by the Engineer for checking the Contractor's setting out.

1.19 Interference with existing works

The Contractor shall not interfere in any way, with any existing works, be it the property of the Employer or of a third party, whether such works has been shown to the Contractor by the Engineer, except where such interference is specifically described as part of the works, either in the Contract or in instructions from the Engineer to take over such works.

1.20 Materials for the works

All materials shall comply with the appropriate and latest Standard Specifications unless otherwise required hereinafter.

The Contractor, shall, before placing any order of materials, manufactured articles or machinery for incorporation in the works, submit for the approval of the Engineer the names of the suppliers from whom he proposes to obtain such materials, manufactured articles or machinery, together with a list of the same, giving the origin, quality, weight, strength, description and other relevant details. No materials, manufactured articles or machinery shall be ordered or obtained from any suppliers not approved in writing by the Engineer.
All materials shall be delivered to the Site a sufficient period of time before they are required for use in the works, to enable the Engineer to take such samples as he may wish for testing and approval.

Notwithstanding the fact that approval has been given to the source of supply, the Engineer may forbid the use of any materials if, upon delivery, they are found to be defective, or he considers them unsuitable for incorporation in the works. Such rejected materials shall be removed from the site forthwith.

The Contractor may propose alternative materials of equivalent quality to those specified, and subject to the Engineer's approval, such materials may be used in the works.

The Contractor shall have no claim against the Employer in respect of any financial loss which he may suffer as a result of the rejection of any such materials, and he shall also bear the cost of removing them from the Site.

The Engineer shall have the right to inspect materials and plant for the permanent works during the course of manufacture. The Contractor shall arrange for the right of access to manufacturing premises for the Engineer and his staff during normal working hours. The Contractor shall give the Engineer sufficient notice to allow him to observe the testing of any materials for the works at the place of manufacture. The Engineer shall also be given the opportunity to inspect any material or plant in their completed state before packing for transport to the site.

If requested by the Engineer, the Contractor shall provide the Engineer with copies of orders for the supply of goods or materials required for the works.

1.21 Dust, insect and vermin proofing

All materials supplied under this Contract shall be dust and vermin proofed where no protection is afforded in its normal manufactured form to ensure that no mechanical breakdown or excessive wear shall occur due to interference or damage by dust, insects or vermin.

All materials used in the works shall be resistant to attack by insects, microbiological life or other local fauna.

1.22 Rejected materials and defective work

Materials or work which, in the opinion of the Engineer, do not comply with the Specification, shall be classified as rejected materials or defective work, and shall be cut out and removed from the works and replaced as directed by the Engineer.

1.23 Existing works and services

The Contractor shall acquaint himself with the positions of all existing works and services including water mains, sewers, storm water drains, cables for electricity and lighting poles before any excavation is commenced.

The Contractor will be held responsible for any interruptions or damage, however caused, in the course of the execution of the works, to such existing works and services. Any damage caused shall be made good at the Contractor's expense.

Such existing works and services, where exposed by the execution of the works, shall be properly shored, hung-up and supported to the satisfaction of the Engineer and of the authority concerned. The Contractor shall exercise special care when refilling trenches or other excavations around such existing services. Stop cock boxes, water meters and the like shall not be covered up.

Poles supporting cables and the like adjacent to the works shall be kept securely in place until the works are completed and shall then be made as safe and permanent as before.

Notwithstanding the foregoing requirements and without lessening the Contractor's responsibility, the Contractor shall inform the Engineer immediately any existing works have been exposed and shall comply with any requirements of the authority concerned. Only when and as directed by the Engineer shall the position of existing works or services be changed by the Contractor to meet the requirements of the proposed work.

The Contractor shall make adequate provision so that when carrying out his work, no interference, damage or pollution is caused to highways and footpaths, or to any mains, drains, sewers, and the like or other parts of the works.

Wherever loads have to be carried over ground in which pipes, valves, culverts, and the like are buried, the Contractor shall take all precautions including where necessary, the provision and use of sleepered roads, light gauge railways or other means to prevent damage occurring to such underground works.

The Contractor shall not store any plant or materials or spoil heaps over existing water mains, or in such positions that interference with access to the mains, control valves and the like. Approval by the Engineer to the means of protection employed shall not relieve the Contractor of any responsibility in respect of damage occasioned by his operations.

The laying of pipework, ducts, drains and the like shall be arranged so as to cause as little disruption, to traffic or public movement as possible with the smooth operation of existing works.

When breaking out and making good existing structures, the Contractor shall disturb the existing structures as little as possible. All structures shall be made good with materials similar to those

used in the existing works, or such materials which are considered by the Engineer to be of similar appearance and suitable in all other respects.

1.24 Overhead power lines

Where work is being carried out in the vicinity of overhead power lines, the Contractor shall be responsible for ensuring that all persons working in such areas are aware of the safe working distances in the vicinity of high voltage overhead power lines especially when cranes or other large masses of steel are in the vicinity of the power lines.

The Contractor's attention is drawn to BS 162, which gives safe clearance for various voltages.

The Contractor shall take all necessary precautions to ensure the safety of his employees and all other persons where work is being carried out near overhead power lines.

1.25 Existing access

Existing access to lands, property and all other places shall be maintained by the Contractor for the duration of the works to the Engineer's satisfaction.

1.26 Excavation across roads and tracks

Before excavating across any public or private road or track, the Contractor shall give the Engineer seven days notice of his attention to excavate and shall include, in writing, the precautions he proposes to take for the continuance of passage and safety of traffic, and details of the warning signs and lights to be provided and operated. The excavation shall not commence until the written approval of the Engineer has been given.

1.27 Liaison with police and other officials

The Contractor shall keep in close contact with the police and other officials in the areas concerned regarding their requirements for the control of workmen, movement of traffic, or other matters and shall provide all assistance and facilities which may be required by such officials in the execution of their duties.

1.28 Preservation of trees

No tree shall be removed without prior written permission of the Engineer who will limit the removal of trees to the minimum necessary to accommodate the permanent works.

If trees are removed or damaged by the Contractor or his employees, without approval, then the Contractor shall replace such trees.

Replacement trees shall be not less than two years of age, obtained from a reputable nursery and of a species approved by the Engineer.

The Contractor shall plant, water and ensure that the replacement trees are properly established.

1.29 Protection from water

The Contractor shall keep the whole of the works free from water and shall be deemed to have included for all pumping, shoring, temporary drains, sumps and other measures and provisions necessary for such purposes and for clearing away and making good to the satisfaction of the Engineer any damage caused thereby.

1.30 Protection against fires

The Contractor is advised that, at all times, it is necessary to guard against fires starting within the Site or in the environs thereof, particularly as the result of the works or from the actions of his employees. The Contractor shall have available, at all times, a trained fire-fighting team provided with adequate fire-fighting equipment and shall deal with all fires on the Site howsoever caused.

1.31 Watching, fencing and lighting

The Contractor shall employ competent watchmen and guard the works both by day and by night. Any excavations, material dumps, spoil dumps or other obstructions likely to cause injury to any person or thing shall be suitably fenced off and at night marked by red warning lights.

Fences shall consist of at least three 15 mm diameter hemp ropes or 4mm diameter wires, or more if required, stretched tightly between poles, and standards securely planted in solid ground, well clear of the excavation. The poles and standards shall not be more than 15 metres apart, and where circumstances require, they shall be placed closer. Ropes or wires shall be stretched tight approximately 0.4 m, 0.8 m and 1.2 m above the ground. The Engineer may accept banks of spoil instead of fencing, if of suitable height and form.

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

The Contractor shall detail a person to switch off the lamps during the day and light them at least one hour before sunset.

If a road is closed, or partly closed to traffic, temporary traffic signs and barricades shall be erected by the Contractor to the satisfaction of the Engineer and the police, or other relevant authority, to give proper warning to traffic and the public. Lettering on road signs shall be black on a yellow background and shall incorporate reflective material. The signs shall be adequately illuminated at night.

1.32 Water and power for use on the works

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

The Contractor shall be solely responsible for the location and continuity of the supply of water for use on the works. Supplies may be derived from boreholes, rivers and streams, but shall in all cases be to the Engineer's approval. The abstraction of water from any sources shall not interfere with any permanent water supply. The Contractor shall be solely responsible for the transporting of water from its source to the point at which it is required for construction purposes,

and in such quantities and quality as to enable the works to proceed without hindrance due to the shortage of adequate water supplies.

The Contractor shall take care to avoid unnecessary use of water and to prevent any water running to waste.

The Contractor shall make his own arrangements for power supplies and shall be solely responsible for the location, procurement and maintenance of a power supply, adequate to meet his obligations under the Contract.

1.33 Employer as a supplier of water and power

The position of the Employer or his Agent as a supplier of water or power shall be identical with that of other suppliers, and quite separate from his position as Employer under the Contract. As in the case of a supplier, failure on the part of the Employer or his Agent to supply water or power will not relieve the Contractor of any of his obligations under the Contract, nor, in respect of any such failure, shall the Contractor have any claim under the Contract against the Employer.

1.34 Fuel supplies

The Contractor shall arrange for obtaining, storing and distributing all fuel oils required for the completion of the works.

1.35 Sanitation

The Contractor shall provide adequate sanitation and refuse collection and disposal facilities complying with state laws and local by-laws for all houses offices workshops, and the like, erected on the site, all to the satisfaction of the Engineer.

The toilet facilities provided at the site by the Contractor shall be made available, free of charge, to the employees of the Contractor and any of his subcontractors.

The Contractor shall warn his employees and subcontractors that any employee found fouling the site shall be removed from the site immediately in accordance with the Conditions of Contract.

1.36 First aid and medical services

The Contractor's attention is drawn to Legal Notice No. 79 of 22nd September, 1978 by which it is mandatory that every Contractor employing more than twenty people should appoint (in writing) a safety supervisor. A safety supervisor advice the management on all matters regarding safety, hygiene and welfare of the people affected by the Contractor's undertaking on the site. The safety officer may in addition carry out other duties.

The Contractor shall provide and maintain all equipment necessary to render first aid in case of accidents, snakebites or other emergencies. This equipment shall be kept in readiness at the sites of the works, at camps and wherever the Contractor's staff may regularly live and work. The Contractor shall ensure that there are persons available at all such places with knowledge of simple first aid procedures and able to administer snakebite treatment.

1.37 Health checks

The Employer may require that persons who will be working in and around the works undergo certain medical tests from public hospitals to ensure that all such persons are free from contagious diseases.

The Contractor shall make his employees available during normal working hours for undergoing the above mentioned health checks. Reasonable notice will be given.

The Contractor shall keep records in respect of all his employees, showing the dates on which health checks have been and will be carried out. The medical certificate for each employee shall be submitted to the Engineer before the employee shall be allowed on Site.

1.38 Health and safety

1.38.1 General

The Contractor shall use his best endeavour to ensure, so far as is reasonably practicable and to the satisfaction of the Engineer, the health, safety and welfare at work of his employees, including those of his Subcontractors, and of all other persons on the Site. His responsibilities shall include:

i. Provision and maintenance of safe and properly illuminated Contractor's Equipment;

ii. Establishment of safe and well-illuminated systems of working;

iii. Provision of protective clothing and equipment;

iv. Establishment of first aid stations, staffed and equipped to provide information, instruction, training and supervision on all aspects of safety and health on site;

v. Appointing as Safety Officer one of his senior staff who shall have specific knowledge of safety regulations and have had experience of safety precautions on similar works and who shall advise the Contractor on all aspects of safety and health on Site;
Provision and maintenance of safe access to all work areas on the Site;

vi. Provision of adequate sanitary facilities and maintenance of these in a clean and hygienic state for use by all persons employed by the Employer, Engineer, Contractor or other contractors on the Site;

vii. Measures to control flies, mosquitoes and pests in both working and recreational areas including chemical spraying, if necessary, in compliance with the rules and regulations of the Employer;

viii. Reporting details of any accident to the Site Safety Officer as soon as possible after its occurrence;

ix. Reasonable prevention of non-site personnel from entering the work areas.

1.38.2 Safety equipment and training

The Contractor shall provide:

i. All necessary breathing apparatus, gas testing equipment, safety harnesses and any other equipment required to ensure safe working of all his personnel on Site;
ii. Test certificates for all safety equipment;
iii. Proof that all relevant personnel have received appropriate training.

1.38.3 Health and safety plan

The Contractor is required to prepare an Environmental Safety Management Plan covering the hazards that may apply during the Contract, the rules and standards to be used in assessing risk and in undertaking work and the methods that he will employ to ensure compliance with his plan.

The Health and Safety Plan shall include details of the following:

i. Details of all potential risks and the proposals for dealing with such hazards;
ii. Controls to regulate risks that occur during all construction, testing and commissioning activities;
iii. Measures to avoid health risk in connection with the use, handling, storage and transportation of hazardous and harmful substances;
iv. Safety equipment and training proposals in respect of equipment referred to above.

1.39 Work in confined spaces

1.39.1 General

The procedures for working in confined spaces before completion of the works and after completion differ and are defined below.

1.39.2 Before completion of the works

The danger shall be under the Contractor's control. The construction of the works may result in the creation of hazardous confined spaces.

The Contractor shall:

i. produce and conform with a set of rules for working in confined spaces when carrying out work associated with the Contract;
ii. ensure that any person requiring working access to confined spaces under the Contractor's control shall comply with the Contractor's safety rules;
iii. advise the Engineer in writing of his authorised person responsible for supervision of work in confined spaces who will be subject to the Engineer's approval;
iv. submit to the Engineer a copy of his Practise for Working in Confined Spaces;
v. maintain on site copies of all issued Permits to Work;
vi. issue Permits to Work to other contractors, the Employer's personnel and the Engineer's staff as necessary.

1.39.3 After taking over by the Employer

The danger shall be under the Employer's control. The Site shall be regarded as an operational site.

The Employer shall notify the Contractor of his representative responsible for the Site.

When the Contractor undertakes remedial work or modification work on the Site, he shall comply with the Employer's procedures for Working in Confined Spaces and the following procedures:

i. The Contractor shall sign to certify that the procedure for Working in Confined Spaces shall be brought to the attention of, read to and understood by all his employees, subcontracted employees and all other persons under his contractual control required to work on the Site;

ii. No work shall be undertaken on any plant under the control of the Employer unless the person responsible for the plant has issued a written instruction. The Contractor shall ensure that all such instructions give adequate information, particularly with regard to all known hazards relating to the work to be undertaken;

iii. The Contractor must give reasonable notice to the Engineer of intended visits to Site and to programme the works to allow for the preparation of appropriate written instructions and authorisations.

1.40 Sign boards

Before the erection of any signboards or posters by the Contractor, the Contractor shall obtain the approval of the Employer and the Engineer to the size, location and wording of such sign boards or posters.

1.41 Building regulations

All buildings erected by the Contractor upon the Site and campsite or sites and the layout of the buildings shall comply with the Laws of Kenya and all local by-laws as far as they are applicable.

1.42 Contractor's tracked equipment

The Contractor's tracked equipment may not be run on any public or private road without the written permission of the owner or authority concerned.

1.43 Site meetings

The Contractor shall be obliged to attend all site meetings at the appointed time.

1.44 Pollution

During the execution of the works, the Contractor shall ensure that no pollution of existing watercourses is allowed to take place because of his activities. The Contractor shall take all reasonable steps to protect the environment on and off the site and to avoid damage or nuisance to persons or to property of the republic or others resulting from pollution, noise or other causes arising as a consequence of his methods of operation.

1.45 Site clearance upon completion of works

On completion of the works, the Contractor shall clear the site and remove all temporary buildings, equipment and debris. The Contractor shall level off and grade all areas used for haul, roads and all building, store and workshop areas. The whole of the site shall be left in a clean and tidy condition.

1.46 Inspections by the Engineer during the Defects Liability Period

The Engineer will give the Contractor due notice of his intention to carry out any inspection during the defects liability period. The Contractor shall, upon receipt of such notice, arrange for a responsible representative to be present at the times and dates named by the Engineer.

This representative shall render all necessary assistance and shall take note of all matters and things to which his attention shall be directed by the Engineer.

1.47 Abbreviations

The following abbreviations have been used for units and for other words or phrases as indicated.

(i) Units of length

µm	micrometre, 10^{-6} m
mm	millimetre
m	metre
km	kilometre

(ii) Units of area

m^2, sq.m	square metre
ha	hectare, 10^4 m^2.

(iii) Units of volume

l	litre
m^3, cu m	cubic metre

(iv) Units of time

s	second
min	minute
hr	hour
wk	week

(v) Units of mass

gm	gramme
kg	kilogramme
t	tonne

(vi) Units of weight and force

N	Newton
kN	kiloNewton

(vii) Units of pressure and stress

N/m^2	Newtons per square metre
Pa	Pascals, equal to Newtons per square metre
kN/m^2	10^3 Newtons per square metre
kPa	kiloPascals
bar	10^5 Newtons per square metre
MN/m^2	10^6 Newtons per square metre
N/mm^2	10^6 Newtons per square metre
MPa	MegaPascals

(viii) General abbreviations

%	per cent
AV	air valve
ch	chainage (distance in metres)
CIF	cost, insurance and freight
DI	ductile iron
dia	diameter
DN	nominal bore
Do	ditto
EO	extra over
FoB	Free on Board
GBP	Great Britain Pound
GMS	galvanised mild steel
GRP	glass reinforced plastic
GV	Gate Valve
HDPE	high density polyethylene
HYS	high yield steel
m/km	m per km
max	maximum
MH	manhole
min	minimum
ne	not exceeding
No.	number
nr	number (in Bill of Quantities)
OD	outside diameter
PCC	precast concrete
PN	pressure rating in bar
PSum	Provisional Sum
SV	sluice valve
uPVC	unPlasticised Polyvinyl Chloride
USD	United States Dollar
WO	washout valve
wt	weight

2 MATERIALS

2.1 Approval of concrete constituents

The Contractor shall submit to the Engineer full details of all materials that he proposes to use for making structural or non-structural concrete as defined in Section 4 of this Specification. No concrete shall be placed in the permanent works until the Engineer or his delegated representative has approved the constituent materials. Approved materials shall not thereafter be altered or replaced by other materials without the consent of the Engineer or his representative.

2.2 Water for concrete and mortar

Water for mixing or curing of concrete or mortar shall not contain more than the following concentrations of impurities:

	Max ppm
The sum of sulphates, alkali carbonates and bicarbonate	1,000
Chlorides	500
Suspended solids	2,000
Other dissolved solids	2,000

Seawater or brackish water shall not be used.

At the commencement of the Works the Contractor shall send a sample of the water proposed for concrete and mortar to an accredited laboratory capable of carrying out the full analysis of potable water in accordance with the Kenya Standard KS EAS 12: 2014 or similar approved.

The results of the analysis shall be submitted to the Engineer or his authorised representative. The sample of water sent for analysis shall be taken in the presence of the Engineer's Representative.

If the water selected, comes from a reliable potable water source the Contractor shall obtain a copy of recent analysis from the Water Examination Laboratory that normally tests water from the source. If the Engineer considers the recent analysis satisfactory then further tests required above need not be carried out.

If the source of water is changed it shall be tested as above. If the water contains over eighty per cent of the maximum concentrations of impurities given above, it shall be re-tested at two monthly intervals.

2.3 Aggregates for concrete

2.3.1 Aggregates to conform

Aggregates for concrete shall conform to the requirements for fine and coarse aggregates BS 882. Fine and coarse aggregates shall separately conform to the requirements set out in the following sub-clauses.

2.3.2 General requirements

Aggregate shall be clean, hard, durable and frost resistant and shall not contain iron pyrites, iron oxides (other than magnetite), mica, shale, coal or other laminar, soft or porous materials.

2.3.3 Grading

Fine aggregate shall conform to BS 882 Table 5, Zones C or M. In order to achieve an acceptable grading, it may be necessary to blend materials from more than one source.

Coarse aggregate shall be supplied in the nominal sizes specified and shall be graded in accordance with BS 882 for single sized aggregates. A coarse aggregate shall be predominantly angular, rounded or irregular as defined in BS 812, Part 1.

2.3.4 Chlorides

The chloride content shall not exceed 0.03% by mass expressed as chloride ion when tested in accordance with BS 812 subject to the further restriction on total chloride content hereunder.

2.3.5 Sulphates

The sulphate content shall not exceed 0.4% by mass expressed as SO_3 when tested in accordance with Clause 7.11 of this Specification subject to the further restriction on total sulphate hereunder.

2.3.6 Total chloride and sulphate content

The total chloride content arising from all ingredients in a mix including cement, water and admixtures shall not exceed the following limits, expressed as chloride ion and as a percentage of the mass of cement in the mix:

i. For prestressed concrete, steam cured concrete or concrete containing sulphate resisting or supersulphated cement: 0.05%.

ii. For any other reinforced concrete 0.3% in 95% of all test results providing no result is more than 0.5%.

The total sulphate content expressed as SO_3 of all the ingredients in a mix including cement water and admixtures shall not exceed 4.0% of the mass of cement in the mix.

2.3.7 Soundness

After five cycles of the test described in Clause 7.4 of this Specification, aggregates shall not show a mass loss of more than 18% using magnesium sulphate.

2.3.8 Alkali reactive minerals

No part of the aggregates shall contain any mineral known to have a potential to cause alkali, silica, alkali silicate, alkali carbonate or any other damaging chemical reaction between alkalis and aggregates. The minerals present should be determined in accordance with Clause 7.10 of this Specification, on a range of samples selected to include every mineral type present in the aggregate as a whole irrespective of the proportion of the mineral.

If during the course of the test it is concluded that an unequivocal identification of potentially reactive mineral is not possible, alternative tests shall be carried out such as to provide the required identification.

2.3.9 Flakiness

Flakiness Index of coarse aggregates when tested in accordance with BS 812 shall be as set out hereunder and not as given in BS 882 Table 1.

i. For nominal 40 mm aggregate and above, not more than 40.

ii. For nominal 20 mm aggregate and below, not more than 35.

2.3.10 Shell content

In addition to the requirements of BS 882, the content of hollow and flat shells shall not be such as will reduce the 28 day strength below the minimum average strength required or reduce the average 28 day strength by more than 5% when tested in accordance BS 1881 when ten cubes made of concrete with shells are compared with ten cubes made of concrete with shells removed.

2.3.11 Organic impurities

Fine aggregate shall be tested as set out in BS 1377 Test 8 and rejected if the percentage of organic matter exceeds 1%.

2.3.12 Acceptance testing aggregates

The Contractor shall deliver to the Engineer samples containing not less than fifty kilogrammes of any aggregate which he proposes to use in the permanent works and shall supply such further samples as the Engineer may require. Each sample shall be clearly labelled to show its origin and shall be accompanied by all the information called for in BS 882.

Tests to determine compliance of the aggregates with all the requirements of this Specification shall be carried out by the Contractor in a laboratory acceptable to the Engineer. If the tested materials fail to comply with the Specification, further tests shall be made in the presence of the Contractor and the Engineer and acceptance of the material shall be based on such tests.

The acceptance tests carried out by the Contractor shall generally be on three representative samples of fine and coarse aggregates taken in the presence of the Engineer. Total numbers of tests required for acceptance are as follows:

Test	**Fine Aggregates**	**Coarse Aggregates**
Water Absorption	-	3*
Flakiness Index	-	3*
Shell Content Determination	-	3*
Test for Shell Content (where required)	-	1
10% Fines Test or Aggregate Impact Value	-	3*

Gradings	3*	3 on each nominal size
Chloride Content	3*	3*
Sulphate Content	3*	3*
Soundness	-	3*
Petrographic Examination	Minimum 3	Minimum 3
Clay, silt and dust determination	3	3
Organic impurities	3	3

* One test on each sample

If at any time a significant physical or chemical change in the nature of the coarse or fine aggregate occurs, or a new source aggregate is used, the Engineer may direct that some or all of the acceptance testing be repeated.

2.3.13 Routine testing aggregates

The Contractor shall carry out routine testing of aggregates for compliance with the Specification during the period in which concrete is being produced for the permanent works. The tests set out below shall be performed on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to Site provided that no set of tests shall represent more than twenty five tonnes of fine aggregate nor more than five hundred tonnes of coarse aggregate, and provided also that the aggregates are of uniform quality. If the aggregate from any source is variable, the frequency of testing shall be as instructed by the Engineer.

Grading	BS 812
Silt and clay content	BS 812
Moisture content	BS 812
Cheek on organic impurities	Test in Clause 7.3 of this Specification

In addition to the above routine tests, the Contractor shall carry out the following tests at the frequencies stated:

i. Moisture content: As frequently as may be required in order to control the water content of the concrete as required by the Specification.
ii. Chloride content: As frequently as may be required to ensure that the proportion of chlorides in the aggregates does not exceed the limit stated in the Specification.

The Contractor shall take account of the fact that when the chloride content is variable it may be necessary to test every load in order to prevent excessive amounts of chloride contaminating the concrete. For this purpose, the Contractor shall use the rapid field test described Section 7 (the Quantab test). In the event of disagreement regarding the results of the field test, the chloride content of the aggregate shall be determined in the laboratory as described in BS 812 (the Volhard test).

2.3.14 Delivery and storage of aggregates

Aggregates shall be delivered to Site in clean and suitable vehicles. Different types or sizes of aggregate shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that contamination of the aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes occurs.

The storage of aggregates shall be arranged so that as far as possible rapid drying out in hot weather is prevented in orders to avoid sudden fluctuations in water content. Storage of fine aggregates shall be arranged so that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

2.4 Pulverised fuel ash

Pulverised fuel ash shall comply with the requirements of BS 3892 and shall have a carbon content not exceeding seven per cent by mass.

The maximum sulphate content of PFA expressed as SO_3 shall be 2.5% by mass PFA but if the weight of PFA in the mix exceeds the mass of cement in the mix, maximum content of SO_3 shall be 1.5%.

The maximum SO_3 content of the mix shall not exceed the limit given elsewhere in the Specification.

The fineness as expressed by the specific surface shall be within the range of Zones B or C in BS 3892, and not more than one test in ten shall show a result falling outside this range.

Pulverised fuel ash shall only be used in conjunction with cement complying with BS 12 and the total sulphate content of the mix from all sources, expressed, as SO_3 shall not exceed that stated elsewhere in the Specification.

2.5 Cement

Cement for use in the permanent works shall be Ordinary Portland Cement from approved manufacture and shall comply with KS EAS 18-1:2017 or equivalent.

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk.

Bagged cement shall be transported in vehicles provided with effective means of ensuring that it is protected from the weather.

Bulk cement shall be transported in vehicles or in containers built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place separate from other deliveries. The bags shall be closely stacked but shall not be stacked against an outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. No stack of cement bags shall exceed 3 m in height. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stacks.

Cement from broken bags shall not be used in the permanent works. Cement in bags shall be used in the order in which it is delivered.

Bulk cement shall be stored in weatherproof silos, which shall bear a clear indication of the type of cement contained in them. Different types of cement shall not be mixed in the same silo.

The Contractor shall provide sufficient storage capacity on Site to ensure that his anticipated programme of work is not interrupted due to lack of cement having due regard to factors outside the Contractor's control.

Cement that has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site.

The manufacturer or the Contractor shall test all cement used in the permanent works in a laboratory acceptable to the Engineer. The tests shall be in accordance with Clause 7.1 of this Specification, and the Contractor shall supply two copies of each test certificate to the Engineer.

Each set of tests carried out by the manufacturer or Contractor shall relate to not more than one day's output of each cement works, and shall be made on samples taken from cement which is subsequently delivered to the Site. Alternatively, subject to the agreement of the Engineer, the frequency of testing of cement delivered to Site from each cement works shall be one set of tests for every two hundred tonnes or for each delivery, whichever is the lesser amount.

Cement which is stored on Site for longer than one month shall be retested in a laboratory acceptable to the Engineer at the rate of one set of tests for every two hundred tonnes, or remaining part of any single delivery, whichever is the lesser amount. Testing shall be repeated at monthly intervals thereafter. Testing shall be in accordance with Clause 7.1 of this Specification.

Cement that does not comply with the Specification shall not be used in the permanent works.

The Contractor shall keep full records of all data relevant to the manufacture, delivery, testing and use of all cement used in the permanent works and shall provide the Engineer with two copies thereof.

2.6 Admixtures for concrete or grout

2.6.1 General

The use of admixtures in concrete may be required under the Contract to promote special properties to the concrete or may be proposed by the Contractor to assist compliance with Specification. In all cases, the Contractor shall submit to the Engineer full details of admixture he proposes to use and the manner in which he proposes to add it to the mix. The information provided shall include:

i. The typical dosage and the detrimental effects of an excess or deficiency in the dosage.
ii. The chemical names of the main active ingredients in the admixture.

iii. Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by mass of admixture.
iv. Whether the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage, and if so, the extent to which it does so.
v. Long and short term effects of the admixture on concrete including the effects on different types of cement and aggregates.
vi. Storage life.
vii. Safety precautions required in handling.
viii. Compatibility with other additives.
ix. Compliance with Standards.

The chloride ion content of any admixture shall not exceed 2% by mass of the admixture nor 0.03% by mass of the cement in the mix.

Admixtures shall not be mixed together without the consent of the Engineer.

2.6.2 Super plasticising admixtures

Super plasticising admixtures shall comply with BS 5075 Part, 3.

If the Specification or the Drawings specify, or the use of super plasticising admixtures is subsequently authorised by the Engineer, flow table tests carried out in accordance with BS 1881 Part 105 shall be used to control and record workability.

Test cubes shall be made in accordance with BS 1881 except that the concrete shall be placed in the cubes and compacted to the same degree as the concrete placed in the Works.
In addition to the normal trial mix cubes required, an additional set of cubes shall be made with 1.5 times the intended super plasticising admixture addition to assess the effect of over dosage on the concrete.

If super plasticising additives are not specified but the Contractor requests permission to use them, the Engineer shall not approve its use unless full particulars including chemical constituents of the admixture are submitted and the additional trial mixes mentioned above have be carried out and all are considered satisfactory.

The Engineer has the right to refuse the use of super plasticising admixture for concrete for particular structures.

2.6.3 Air entraining agents

In addition to the general requirements, air entraining agents shall be capable of producing an air content in concrete mixes within the limits stated in the Specification or on the Drawings without any tendency to produce excessive air content in the event of prolonged mixing times.
The effect of a proposed air-entraining agent shall be tested by the Contractor in trial mixes produced in the equipment that he proposes to use for the permanent works.

Air entraining agents shall comply with BS 5075.

2.6.4 Workability agents

Subject to the agreement of the Engineer, admixtures may be used by the Contractor to assist in meeting the requirements of the Specification or to aid the placing of concrete.

Workability agents shall comply with BS 5075 and shall not have any adverse effect on the properties of the concrete. If a reduction in strength of the concrete is caused, the Contractor shall counteract this by a reduction in water cement ratio or by an increase in cement content.

2.7 Mortar

Mortar shall be composed of fine aggregate as specified in Clause 2.3 and the type of cement as specified in Clause 2.5. The mix proportions shall be as stated on the Drawings or if not stated shall be one part of cement to three parts of fine aggregate by mass.

Small quantities of mortar may be hand mixed but for amounts over 0.5 m^3 a mechanical mixer shall be used.

The water content of the mortar shall be as low as possible consistent with the use for which it is required but in any case the water/cement ratio shall not be more than 0.5.

Mortar which is specified, as "dry pack" shall be mixed with sufficient water for the mix to become cohesive but not plastic when squeezed in the hand. Dry pack mortar shall be rammed into the cavity it is required to fill, using a hand rammer with sufficient force to ensure full compaction.

2.8 Reinforcement

Unless otherwise directed or shown on the Drawings, hot rolled high yield deformed reinforcement complying with BS 4449 shall be used throughout the works.

Where required, mild steel reinforcement and deformed high yield steel reinforcement shall comply with BS 4449. Steel mesh fabric shall comply with BS 4483 and hard drawn mild steel wire shall comply with BS 4482.

All reinforcement shall be from an approved manufacturer and, if required by the Engineer, the Contractor shall submit a test certificate of the rollings. The Contractor shall, when requested by the Engineer, provide sample pieces one metre long for testing.

Tying wire shall be 1.6 mm diameter soft annealed iron wire.

All reinforcement shall be free from scale, rust, grease, paint or other substances likely to reduce the bond between the steel and the concrete.

2.9 Formwork

The formwork may be of seasoned, planed, tongued and grooved timber, plywood, blockboard, tempered hardboard, steel or as specified on the Drawings.

All timber used for formwork shall be sound wood, well-seasoned and free from loose knots, shakes, large checks, warping and other defects. Before use on the work, it shall be properly

stacked and protected from injury from any source. Any timber that becomes badly warped or cracked, prior to the placing of concrete shall be rejected. All formwork for outside surfaces above final ground level shall be either tongued and grooved or provided with a suitable lining to produce a smooth surface finish.

2.10 Waterstops

All references to waterstops include groutstops. The standards for waterstops shall be BS. 2571, DIN 18541, Part 2 and US. corps of Engineers: CRD-C 572 , ASTM D-412 & ASTM D-638

Waterstops shall be of the material and form shown on the Drawings and as detailed in the Specification. No waterstop material shall be brought onto site until the Contractor has submitted full details of the materials he proposes to use, including samples, and the Engineer has approved these. All samples shall be of adequate length for testing. Test results from an independent laboratory approved by the Engineer will be accepted as an alternative to tests arranged by the Engineer.

Waterstops shall be made of materials that are resistant to chlorides, sulphates, or other deleterious substances that may be present in the environment of the permanent works.

Rubber waterstops may be of natural or synthetic rubber and shall have an elongation at breaking stress of at least 500% at 25^{o}C and shall be capable of accommodating a transverse movement of at least 50 mm.
Polyvinyl chloride (PVC) waterstops shall be extruded from an unfilled plasticised PVC polymer or copolymer that does not contain any reclaimed or scrap PVC. PVC waterstops shall have an elongation at breaking stress of at least 225% at 25^{o}C and shall be capable of accommodating a transverse movement of at least 10 mm.

Low modulus waterstops shall be of rubber or PVC as described above but shall have an elongation of at least 200% at 25^{o}C under a tensile stress of 6 N/mm^2 and shall be capable of accommodating a transverse movement of at least 50 mm.

Waterstops shall be supplied in lengths as long as possible consistent with ease of handling and construction requirements.

In rubber or plastic materials, joints other than butt joints shall be supplied ready-made by the manufacturer. Butt joints shall be made on site in accordance with the manufacturer's instructions and with equipment supplied for the purpose by the manufacturer.

Waterstop material shall be stored carefully on site to avoid damage and contamination with oil, grease, or other pollutants. Rubber and plastic waterstops shall be stored in cool well-ventilated places away from direct sunlight.

Rubber and plastic waterstops which are embedded in one side of a joint more than one month before the scheduled date of placing concrete on the other side, shall be protected from the sun.

Waterstops shall be firmly fixed in the formwork so that they cannot be displaced during concrete placing and shall be completely free of all dirt, grease oil, etc., before placing concrete.

Concrete shall be placed carefully round waterstops so as to avoid distortion or displacement and shall be fully compacted. Where waterstops lie in a horizontal or nearly horizontal plane the Contractor shall ensure that no voids are left on the underside of the waterstops.

Formwork round waterstops shall be carefully removed to avoid damage. If waterstops suffer any damage which cannot be properly repaired in-situ, the Engineer may require a section of concrete to be removed and the waterstop replaced.

2.11 Steel pipes and fittings

Steel pipes and fittings shall comply with BS EN 10244/bs3601 Non-alloy steel tubes and fittings for the conveyance of water for human consumption. DN 600mm and larger pipes shall be joined by bolted sleeve couplings in accordance with AWWA C219, BS EN 10224, and UNI 6363. They shall be coated with fusion bonded epoxy to AWWA C213 and smaller pipes shall be joined by push fit, spigot socket joints according to BS CP2010 Part 2, DIN 2640 and AWWA C200.

However, for this project and in cognizance of the prevailing weather conditions for the project area, the DN 800mm steel pipes shall be joined by push fit, spigot socket joints according to the abovementioned standards.

The inside of Steel pipes shall be lined throughout their entire length with solvent free epoxy linings suitable for drinking water to AWWA C210/NFA 49/API RP5L2/SABS1217/EN 10289. The materials and application process shall be subject to the Engineer’s approval.

The external protection for steel pipes shall be Fusion Bonded Epoxy to AWWA C213, DIN 30671, NFA 49-706, BG/PS/CW6, SABS 1271. Followed by HDPE coating as follows:

- 1 st primer base layer of Fusion Bonded Epoxy (FBE) of between 100 microns
- 2nd layer of extruded grafted adhesive of 200 microns,
- then followed by, 3rd top coat of extruded high-density polyethylene (HDPE)/polypropylene of 0.5 mm,

Screw jointed pipes shall comply with BS 1387. Flange jointed pipes shall have flanges complying with BS 4504. All steel flanged pipes and fittings shall be supplied complete with galvanized bolts, nuts and appropriate gaskets.

The Contractor shall, when called upon to do so, make available to the Engineer the manufacturer's certificates covering the chemical analysis and physical properties of the steel used in the manufacture of pipes. The pipes shall be hydraulically tested before leaving the factory to the test pressure specified in the relevant standard and the test certificates shall be submitted to the Engineer by the Contractor.

Flexible couplings shall be of the slip-on type as specified in BS 534 without central register unless otherwise specified. Rubber rings shall generally comply with BS 2494 Class D. The couplings shall be supplied complete with all necessary bolts, nuts, and rubber jointing rings and shall be protected, where buried, with denso-paste, denso-tape and polythene sheeting, or similar approved wrapping, which shall be installed in accordance with the manufacturers written instructions and to the approval of the Engineer.

2.12 Ductile iron pipes and fittings

Unless shown otherwise on the Drawings, ductile iron pipes and fittings shall be in accordance with the following:

ISO 2531:1974	"Ductile iron pipes, fittings and accessories for pressure main lines"
BS EN 545:1995	"Ductile iron pipes, fittings, accessories and their joints for water pipelines – requirements and test methods"

For pipes and fittings of 600 mm diameter and less, flexible joints shall be of the "Tyton" spigot and socket type unless indicated otherwise in the Bill of Quantities or on the drawings.

For pipes and fittings of 700 mm diameter and above, the type of spigot and socket flexible joint shall be subject to the approval of the Engineer.

Flanged joints shall be drilled in accordance with BS 4504, and shall be supplied complete with galvanised steel nuts and bolts, and appropriate gaskets.

Self-anchored flexible joints shall also be of the spigot and socket type, but the joint shall be tied together to prevent longitudinal movement. The joint shall permit an angular deviation of 2^{o} relative to the pipe axis after assembly, and shall be subject to the approval of the Engineer.
All spun ductile iron pipes shall be Class K9.

All puddle flanges shall be of the thrust resisting type.

All ductile iron pipes and fittings shall receive a cement mortar lining in accordance with ISO 4179. The external coating shall be in accordance with ISO 8179 comprising sprayed zinc coating to give a coverage of 130 g/m^2, followed by a bituminous varnish of 70 µm minimum dry film thickness.

Flange joints shall be supplied complete with all necessary bolts, nuts, and gaskets and shall be protected, where buried, with denso-paste, denso-tape and polythene sheeting, or similar approved wrapping, which shall be installed in accordance with the manufacturers written instructions and to the approval of the Engineer.

2.13 uPVC pipes and fittings

Unplasticised polyvinyl chloride (uPVC) pipes and fittings shall comply with BS EN 1452-2:2000 "Plastics piping systems for water supply, Unplasticized polyvinyl chloride (PVC-U).

Joints shall be of the spigot and integral socket type. Solvent weld joints are not permitted for buried uPVC pipelines.

Fittings for use with uPVC pipe shall be manufactured from either uPVC or cast iron shall have socketed joints. Cast iron fittings shall be bitumen coated. Aluminium alloy fittings are not permitted.

uPVC pipes and fittings conveying waste water shall comply with BS 5481:1977

2.14 Glass reinforced plastic pipes and fittings

Glass reinforced plastic pipes shall comply with BS 5480 and shall have the stiffness and pressure rating shown on the drawings. In addition to the information required by BS 5480, the manufacturer shall declare, and guarantee, the following:

i. The long term-ring stiffness of the pipe
ii. The modulus of elasticity of the pipe

Fittings for GRP pipe shall be of glass reinforced plastic or fabricated steel. The coating and lining of steel fittings shall comply with Section 2.11 of this Specification.

Service connections to GRP mains shall not be permitted.

2.15 HDPE pipes and fittings

Polyethylene pressure pipes and fittings for drinking water application shall be manufactured in accordance with EN 12201:2011 standard. All pipes shall be manufactured using a pre-compounded pigmented PE100 resin, having a Minimum Required Strength (MRS) value of ≥ 10.0 MPa, at a service temperature of 20°C for a minimum design service life of 50 years. The pipe manufacture shall be required to submit a list of polymer suppliers and data sheets of the proposed grades to be used for approval as a part of their submission of technical details for their products.

Pipe: Material: Polyethylene PE100 (MRS100), density ≥0.95 kg/dm³
Pressure Rating: SDR 17 – PN10
SDR 11 – PN16
Supply Lengths: All pipe sizes up to and including OD 75 mm shall be supplied in coils of 50 or 100 meters. All pipes OD 90mm and above shall be supplied in straight lengths of 12 meters.
Type of Joint: Butt Fusion

Fittings: Material: Polyethylene PE100 (MRS100), density ≥0.95 kg/dm³
Type of Joint: Electrofusion / Spigot type for Butt Fusion / Compression (for sizes 90mm and below)
Pressure Rating: SDR 17 – PN10
SDR 11 – PN16

The method of jointing shall be by butt fusion welding or where accepted by the Engineer, HDPE mechanical couplings shall be used. Steel couplings shall be allowed where steel appurtenances will be fitted.

The pipes shall be approved by independent accreditation bodies which certify piping materials for use in water supply networks. The pipe systems shall have the following basic minimum performance characteristics:

Parameter	Unit	Value
Average Density as per ISO 1183	Gm/cm^3	≥ 0.95
Melt Flow Index MFI 190°C / 50N as per ISO 1133	Gm/10 min.	0.4-0.55

Parameter	Unit	Value
Minimum Tensile Strength	N/mm^2	25
Elongation at Break	%	$\geq$ 600%
E-Modulus (Modulus of Elasticity)	N/mm^2	1200
Minimum Radius of Curvature at 20°C		25 x OD
Linear Coefficient of Thermal Expansion (VDE 0304)	$°K^{-1}$	1.3×10^{-4}

The following minimum basic information must be indelibly marked on the pipes at a minimum of 1 meter intervals.

(i) Name of Manufacturer/ Brand

(ii) Nominal Diameter x Minimum Wall Thickness

(iii) Material Classification (i.e. PE100)

(iv) Standard Dimension Ratio and Pressure Rating (SDR17 PN10 or SDR11 PN16)

(v) Reference Standard of Manufacture (i.e. EN 12201)

(vi) Production Year, and production batch details

The manufacturer/ supplier shall submit the following minimum basic documentation to the client and consultant for approval:

- Copy of at least 2 international independent accreditations/ approvals for conformity to manufacture as per EN 12201 and for use in potable water pipeline networks;
- All pipe materials shall be supplied with a material test certificate as per EN 10204;
- Manufacturer shall have the basic minimum management systems in place for ISO 9001 / ISO 14001. Copies of all such valid accreditation certificates must be provided as a part of the manufacturer qualification;
- Copies of other independent domestic and international approvals;
- Copies of certificates/ proof of successful supplies and/or completion certificates shall be submitted as a part of supplier qualification;
- Complete technical design and installation manual for PE pipe systems;
- Product catalogue and samples, if requested.

2.16 Concrete drain pipes

Reinforced concrete pipes and special fittings for drainage purposes shall comply with BS 5911 "Concrete cylindrical pipes and fittings including manhole inspection chambers and street gullies".

Unreinforced concrete pipes with ogee joints shall comply with BS 5911 Part 3.

2.17 Pipe Saddles

Pipe saddles for under pressure drilling shall be of the Universal Type with flexible strap for DI and Steel pipes PN 16, for PE and PVC pipes the pipe saddles shall be of the HAKU Type or similar, and shall be suitable and approved for the use with potable water at a nominal working pressure of 16 bar.

The outlet of the saddle shall be female thread and specially protected to avoid corrosion and incrustation.

The body of the pipe saddle shall be of ductile iron EN*-GJS-400-18 acc. to EN 1563 (GGG 400 DIN 1693), inside and outside epoxy powder coated complying in general with DIN 30677 part 2, coating thickness shall be minimum 250 µm, freedom from imperfections shall be tested by high-voltage method.

Saddle strap and bolts/nuts/washers shall be made of stainless steel 304 (minimum 1.4021) or 316 (minimum 1.4462). Strap shall be rubber lined to avoid direct contact between the stainless steel strap and the pipe.

Gaskets shall be of EPDM or NBR suitable and approved for potable water.

2.18 Valves

2.18.1 Gate valves

All wedge gate valves for working pressures up to and including PN25 shall conform to BS 5163:1986 (1991) "Specification for predominantly key-operated cast iron gate valves for water works purposes"

Wedge gate valves for higher working pressures and resilient seal valves shall also be of a waterworks pattern and flanged valves shall have face to face dimensions in accordance with the above standard.

All gate valves shall close in a clockwise direction and the direction of opening and closing shall be cast on the handwheels or valve casing with the words “OPEN” and “CLOSE” respectively. All gate valves shall be capable of being operated manually with a maximum applied torque of 150 Nm for valves with a nominal diameter more than 450 mm and of 100 Nm for valves with a nominal diameter less than 450 mm. The Contractor shall ensure that the gate valves supplied are fitted with appropriate thrust bearing guides and gearing to fulfil these requirements, ensuring that when reduction gearing is employed, the gear ratio shall no exceed 4:1.

Bypasses shall be fitted to gate valves where pipeline pressures deem it necessary and universally to valves of 500 mm diameter and larger.

Gate valves from DN40-DN800 that are resilient seated shall be designed and tested to the following standards

- EN 1074-1 and -2 (water supply, isolating valves)
- EN 1171 (industrial cast iron gate valves)
- EN 558 (face-to-face)
- EN 1092 (flange design)
- ISO 5210 (actuator flange)

Valve body and bonnet shall be corrosion protected with 250 µm fusion bonded epoxy, blue, complying with GSK.

Bonnet-body gasket shall be with a circular cross shape, positioned in a groove in the bonnet and encircling the bonnet bolts completely.

Full circle thrust collar provides fixation of the stem and low free running torques

Triple safety stem sealing with an NBR wiper ring, a polyamide bearing with four NBR O-rings, and an EPDM rubber manchette

Wedge nut shall be firmly fixated in the wedge core and not be able to move within the wedge. Joint between nut and wedge shall be tightly sealed in rubber. Material shall be brass.

A by-pass valve shall be available for DN 500mm and above.

Rubber in contact with the fluid shall be drinking water approved EPDM.

Maximum operating temperature shall be at least 70°C.

Valve body Markings shall include – Material, Manufacturer, DN, and Pressure class (cast on body) while Rubber wedge marking shall include – Material, Manufacturer, DN, Date of manufacture (moulded on the rubber)

Materials shall be according to following standards:
- EN 1563 (cast iron)
- EN 10088 (stainless steel)
- EN 12165 (brass)
- EN 12164 (brass)
- DIN 30677-2 (coating)
- GSK (coating)
- EN 681 (rubber seals water)

2.18.2 Butterfly valves

Butterfly valves shall conform to BS EN 593: 1998 "Industrial Valves: Metallic Butterfly Valves". The use of butterfly valves as main line valves shall not be permitted.

2.18.3 Check valves

Check valves shall comply with BS EN 12334: 2001 "Industrial Valves: Cast Iron Check Valves ".

2.18.4 Flap valves

Flap valves shall be of a light duty pattern, with flanged back, cast body and double hung gate with wrought iron or brass hinge pins.

2.18.5 Pressure reducing valves

(a) **General requirements**

The upstream pressure of this type of valve can vary from a full static head in a pipeline to the minimum residual static head during the maximum anticipated flow rate. The pilot valve system, where applicable, shall be capable of efficient functioning under the full range of inlet pressures.

(b) **Valve construction**

If hydraulic control activators prove impractical, an alternative control system incorporating electric solenoid activators may be considered.

All control and pilot valves shall be clearly and permanently labelled.

Diaphragm-actuated control valves with single or double diaphragm control chambers will be acceptable, providing that the main shaft is double guided in suitable renewable bearings, preventing excessive wear, during flow velocities exceeding 3m/s.

Preference will be given to control valves with an open assembly feature, which permits the Inspection of the control valve's internal operating mechanism, the seat, plunger, main shaft, etc. without the removal of the valve from the pipeline.

The control valve shall be provided with a dirt trap or strainer system containing a removable 100 - 200μm strainer cartridge and a suitable scour plug to flush accumulated debris. This shall be situated in the spool pipe on the upstream side of the valve preventing interference of the normal functioning of pilot valves and the obstruction of the main valve seat. The free flow area of this unit shall be larger than the actual control valve seat area.

Stainless steel trimmed control valves including the main valve seat, plunger assembly and shaft with epoxy powder coated steel or cast iron accessories are preferred to bronze trim. Pinned stainless steel valve seats are preferred to epoxy glued seats.

Pressure gauges shall be permanently mounted up and down stream of the valve on the control system to indicate all required pressures.

All pilot valves shall be supplied sealed, using sealing wire and lead seals, to prevent unauthorised tampering.

Pilot valve components subject to wear e.g. valve seats, pressure sensing membranes, shafts, hydraulic seals, resilient seats, etc. shall be readily available as replacement spare parts.

2.18.6 Specification for Combination air valve / Triple function air valve DN 50mm

The air valve shall be in accordance with BS EN1074.4 for drinking water.

The Air Valve shall be Combination type OR triple function type for drinking water systems. The chamber body shall be made of Ductile Iron with threaded inlet or flanged DN50. The coating on the Ductile Iron body shall be Fusion Bonded Epoxy at least 250 microns. On the discharge outlet there will be a screen to avoid bugs and dirt to enter the air valve.

Float shall be made of injected composite material. Automatic and Kinetic functions shall be supported by one float. Min. area of the automatic orifice will be 10mm^2. The automatic function shall be operated by rolling seal mechanism to assure self-cleaning.

The working pressure range of the air valve will be 0.2 – 16 bars. The air valve shall seal at min. pressure 0.2 Bar. The main chamber shall have a plug or a choc to drain and release the trapped pressure.

The float shall be closed only by water, to assure that the air valve shall not premature close,
The manufacture shall provide the air flow charts [in & out] for the air valve and will have to recommend for working zone on those charts with each air valve type and size, upon filling and draining the network.

The location and sizing of the air valves shall be backed by an optimization air valves software.

The manufacture of the air valve shall be approved by ISO9001, ISO14001, ISO18001 and shall provide Certificate of Conformity, Certificates of Test and 3.1 certificates (for materials used) for each air valve.

2.18.7 Specification for Combination air valve / Triple function air valve DN 80mm-DN 200mm

The air valve shall be in accordance with BS EN1074.4 for drinking water.

The Air Valve shall be Combination type OR triple function type for drinking water systems. The chamber body shall be made of Ductile Iron and flanged (DN80 to DN 200mm). The coating on the Ductile Iron body shall be Fusion Bonded Epoxy at least 250 microns. On the discharge outlet there will be a screen to avoid bugs and dirt to enter the air valve.

Float shall be made of injected composite material. Automatic and Kinetic functions shall be supported by one float. Min. area of the automatic orifice will be 11mm^2. The automatic function shall be operated by rolling seal mechanism to assure self-cleaning.

The working pressure range of the air valve will be 0.1 – 16 bars. The air valve shall seal at min. pressure 0.1 Bar. The main chamber shall have a plug or a choc to drain and release the trapped pressure.

The float shall be closed only by water, to assure that the air valve shall not premature close,
The manufacture shall provide the air flow charts [in & out] for the air valve and will have to recommend for working zone on those charts with each air valve type and size, upon filling and draining the network.

The location and sizing of the air valves shall be backed by an optimization air valves software.

The manufacture of the air valve shall be approved by ISO9001, ISO14001, ISO18001 and shall provide Certificate of Conformity, Certificates of Test and 3.1 certificates (for materials used) for each air valve.

2.18.8 Fire hydrants

Fire hydrants shall conform to the following specifications

	FIRE HYDRANT TYPE 2
Specifications	
Design standard	BS750 :2012 TYPE 2
	Designed according to EN 14339:2005

	FIRE HYDRANT TYPE 2
Specifications	
	EN 1074-2:2004
	Universal flange drilling to EN1092-2 (ISO 7005-2), PN 10/16
PN	**16**
valve operation	Clockwise to close. Closing direction engraved on valve cap
Outlet	Gun metal Bronze
body	Ductile Iron GJS -500-7 (GGG-50)
Body End	Ductile Iron GJS -500-7 (GGG-50)
Stopper Assembly	Ductile Iron GJS -500-7 (GGG-50)
Fastening	Stainless Steel A2
Body outlet seal	NBR rubber
Bonnet	Ductile Iron GJS -500-7 (GGG-50)
Bonnet Body Seal	NBR rubber
Thrust collar	Brass, DZR CW602N
Gland flange Assembly	Ductile Iron GJS -500-7 (GGG-50)
Dust Cap	Polyethelyne attached to Hydrant by Chain
Stem Cap	GJS-500-7
Stem /Spindle	Stainless steel 1.4021. Non rising
Coating	Fusion bonded epoxy coating 250um to DIN 3476
Seat	1.1 x PN(in bar)
Body	1.5 x PN(in bar)
	Hydraulic test according to BS750.
Approvals	WRAS Approved

2.18.9 Painting of valves

All valves shall be painted internally and externally to give the same standard of protection as for steel pipes and fittings. Surface protection shall be all to the approval of the Engineer.

2.19 Penstocks

Penstocks shall be rigid ribbed cast iron construction with frame. The frame back shall be cast with spigot for entering the concrete for stiff frame installation or flat as specified on the drawings.

The faces shall gunmetal of heavy section, securely pinned to machined surfaces on frame and gate, and ground in together to an accurate bearing. Gunmetal bearing strips shall also be fitted in the guide extensions. Each side of the frame shall have vertically down running cast iron cover bars furnished with adjustable wedges for limiting the downward movement of the gate when the seats are in register, and for applying a tightening force.

Spindles shall be of the non-rising type and screwed so as to close the valves when rotated in the clockwise direction. The direction of closing shall be clearly cast on the valve cap or hand wheel as appropriate.

Penstocks which satisfy the specified conditions of service and duty, but which are manufactured to standards not less than those specified, may be offered. Full descriptive details including detail drawings, which must be annotated in English, shall be supplied on all items whether as specified or as offered alternatives.

All penstocks shall have standard painting finish comprising of blast cleaning, two coats of red oxide primer and two coats of black bitumen paint for gate assembly and grey enamel paint for the headstock.

2.20 Meters and meter boxes

2.20.1 Bulk water meters

Unless otherwise directed, bulk water meters shall be Electromagnetic meters with AMR capability, Lithium battery with a life of 5 yrs.as specified and approved by the Engineer. The meters shall comply with Class B measuring requirements of BS 5728. The meters shall comply dimensionally with ISO 4064, and shall have flanges drilled to BS 4504.or Compatible with the supplied flange fittings

Meter chambers will be purpose constructed to standard details contained elsewhere herein.

2.21 Ferrules

Ferrules for connection to distribution mains shall be supplied with integral key-operated plug cocks and shall be suitable for under pressure tapping. The maximum size of ferrule to be fitted to an 80 mm diameter main and less shall be 20 mm diameter.

Ferrules shall be connected to distributing mains via cast iron saddles designed for use with the ferrule being installed and the particular pipe material.

2.22 Marker posts

Precast concrete marker posts shall be set in concrete and fixed near valves, fire hydrants, washouts, etc., changes in direction of the mains and where directed by the Engineer. The posts shall be as detailed in the Drawings.

2.23 Building materials

2.23.1 Precast concrete blocks

Precast concrete blocks shall conform to BS 2028 Type A Dense Aggregate Blocks. Blocks shall be solid or hollow, of the sizes required and shall be made in approved moulds of metal construction of sufficient strength to ensure the manufacture of blocks of even size and shape.

Concrete blocks for general walling shall be of an approved size. Cutting where necessary shall be such that clean sharp arises are produced without fracture or cracking of the portion to be used. Voids in cut blocks shall be filled solid with concrete.

Where concrete blocks are described as "hollow", cavities are not to exceed one third of the bearing surface and the material is in no case to be less than 50 mm thick.

The face of concrete blocks to be plastered shall have a reasonably dense fair finish from moulds.

2.23.2 Stone Masonry walling

The masonry stone strength characteristics shall be specified under the following classifications:
(i) Class B – Minimum compressive strength of 3.5N/mm2;
(ii) Class A1 - Minimum compressive strength of 7.0N/mm2;
(iii)Class A3 - Minimum compressive strength of 10.5.5N/mm2;
Sound and hard stones free from defects and with each surface at right angles to all adjoining surfaces shall be bedded and jointed in cement mortar 1:3 by volume. Joints shall be flushed up and grouted solid as the works proceed or pointed as required.

2.23.3 Polythene sheeting

Polythene sheeting shall comply with BS 4646.

2.23.4 Damp proof course

Damp proof courses shall conform to the requirements of BS 743. The sheeting for horizontal damp proof courses shall be fibrous asphalt felt cut to cover the entire width of the foundation walls.

2.23.5 Metal louvres

Metal louvres shall be pressed from steel sheet of minimum thickness 1.22mm (18 gauge). They shall be rustproofed at works by the hot dip galvanising process and supplied complete with steel frames and coupling transoms and mullions as required. All metal louvres shall be supplied complete with fine copper mesh woven flyproof screening fixed to the interior face.

2.23.6 Metal doors and windows

Metal frames shall be black mild steel while surface panels for doors shall be manufactured from A568 black mild steel 1.5 mm thick sheet steel or as indicated on the Drawings.

Surfaces of the doors shall be seamless and surface sheets shall be continuously welded along vertical edges. All welds shall be primed with zinc rich primer.

Doors shall be strong, rigid, neat in appearance, and free from warpage or buckle. Corner bends shall be true, straight and the minimum radius for the gauge of metal used.

Two samples of each type of door, door frame, window frame and door and window furniture shall be submitted to the Engineer for approval at least four weeks before construction.

Shop drawings of doors, door frames and window frames shall be submitted to the Engineer for approval before fabrication. Shop drawings shall show size, material, thickness, mortises, reinforcement and anchor details.

2.23.7 Door and window furniture

Door and window furniture shall be manganese brass sanded, toned and bronze lacquered finish to the approval of the Engineer.

2.23.8 Glass

All glass is to be of approved manufacture complying with BS 952 and to be of the quality specified, free from bubbles, smoke wanes, air holes and other defects. Window glass shall not be less than 4mm thick.

2.23.9 Metal roofing sheets

The fixing of all proprietary roof sheeting, etc. shall be in accordance with the manufacturer's details and as shown on the Drawings. Only the manufacturer shall carry out cranking of sheets, and all flashings etc. shall be standard units supplied by the manufacturer. All sheets and flashings shall be hot-dip galvanised and coated with an approved coating system.

2.23.10 Bituminous roofing felt

Bituminous roofing felt shall be in accordance with BS 747 Part 2.

2.23.11 Rainwater gutters

These shall be of galvanised steel complying with BS 1091. Gutters shall be of the box type, 150 mm square in cross section as shown on the Drawings. Downpipes shall be 100 mm square as shown on the Drawings.

2.24 Plumbing materials

2.24.1 Galvanised mild steel pipes

Galvanised mild steel pipes and fittings shall comply with BS 1387 or EN 10255 and shall be Class C. Threading for screwed and socketed joints shall be in accordance with the requirements of BS 21. Joints shall be made with an approved pipe-jointing compound in accordance with the manufacturer's instructions. Red lead compounds shall not be used. Joints in underground piping shall be coated with bitumen or other approved composition.

2.24.2 Fittings for galvanised pipes

All fittings for galvanised steel water pipework shall be galvanised heavy weight fittings in accordance with BS 1740. Fittings for waste pipework shall be galvanised malleable iron complying with the requirements of BS 143. Brass or gunmetal fittings shall be subject to the approval of the Engineer.

2.24.3 PPR pipes and fittings

PPR pipes will be in accordance with DIN 8077 and DIN 8078 and shall be jointed by fusion welding in accordance with DVS guideline 2207, Part 11. Where threaded fittings are used, they will be approved by the Engineer before use in the works.

2.24.4 Sanitary ware

Sanitary ware in white glazed fireclay shall be to the Engineer's approval.

Stainless steel sinks and drainers shall comprise 20 SWG pressed stainless steel single bowl single drainer sink overall size 1350 mm x 525 mm fixed in kitchen cabinet framing complete with 38 mm chromium plated grid waste with plug, chain and combination overflow, 38 mm copper P-trap with brass cleaning eye and combined taps and mixer with swivel inlets with adjustable centres. Double units shall be provided where these are indicated on the Drawings.

Bathtub units shall comprise white porcelain enamelled cast iron bath 1,675 mm or 1,525 mm long as required complete with 38 mm chromium plated grid waste, 38 mm bath trap assembly and 19 mm chromium plated pillar taps or combined taps and mixers as required.

2.24.5 Taps and stopcocks

Taps and stopcocks shall be to BS 1010. Stopcocks shall be fitted on the main service as it enters any building.

3 EXCAVATION, BACKFILLING AND RESTORATION

3.1 Clearance of ground

The Contractor shall clear the ground on or below which the works are to be erected removing vegetation and all superficial obstructions. The combustible material cleared shall be disposed of by strictly controlled burning which shall be approved in each instance by the Engineer or his authorised representative.

All trees, bushes and hedges are to be removed within a distance of two metres from the centre line of pipelines and for a distance of three metres in plan from any foundations. Roots are to be killed or removed within this width.

Trees, bushes and hedges at the Site shall not be cut down, damaged or destroyed without approval of the Engineer. Trees shall be defined as having a girth exceeding 500 mm measured 600 mm above ground level except where a tree has buttresses when measurement shall be taken immediately above the buttresses.

3.2 Agreement of existing ground levels

Before the start of any earthworks or excavation, but after site clearance, if any, the level of the existing ground shall be surveyed by the Contractor and agreed between the Contract and the Engineer. If the Contractor fails to take the requisite levels, the ground levels shown on the drawings or determined by the Engineer shall be taken as correct.

No allowance will be made for normal bulking or shrinking of the soil and the Contractor shall make allowance for this in his rates.

3.3 Classification of excavation

For purposes of measurement, excavation is classified as follows:

(a) Excavation in rock

"Rock" is defined as a material that requires the use of drifts, wedges or explosives for its removal and shall not include loose, rotten, shattered or fractured forms of rocks, or boulders less than $0.10m^3$ by volume. The fact that compressed air picks are required for the excavation of certain materials shall not qualify the materials to be classed as rock.

All loose, shattered or fractured rock shall be removed from excavations in rock. Where excavations in rock are carried out by blasting, the manner and extent of the blasting shall be such as will prevent damage to the surrounding strata or ground or to the works.

No excavations in rock shall be carried out by blasting where damage to surrounding strata or ground or properties or to the works would result thereby. The rates for excavation in rock shall be held to include for excavation by a means, as the circumstances require.

(b) Excavation in normal material

"Normal" material is any material not classified as rock.

For the purpose of payment, items are included in the Bill of Quantities for excavation in normal material and in rock.

The Engineer and the Contractor shall agree the classification of excavation as the work proceeds. In case of a dispute over the classification of rock, the ruling of the Engineer shall be final and binding.

3.4 Blasting

The Contractor shall keep in his office at the Site copies of State Laws applying to the transport, storage and use of explosives and shall supply one copy of each State Law to the Engineer. The Contractor shall also submit to the Engineer a copy of any instructions or notices that the Contractor may issue to his staff or workmen or post about the Site in compliance with such State Laws.

The Contractor shall submit to the Engineer details of the explosives that he proposes to use and of his proposals for the storage and transport of explosives to the Sites.

Explosives shall be used in accordance with the recommendations of the BS 5607.

The Contractor shall use explosives for blasting in connection with the work only at such times and places and in such a manner as the Engineer may approve but such approval shall not relieve the Contractor from his responsibility for injury, loss, inconvenience and annoyance to persons, damage to the work and adjoining structures, consequent to the use of such explosives. The Contractor shall be entirely liable for any accident which may occur and shall hold the Employer harmless and indemnified from all claims arising from such. Where loss, inconvenience, injury or accident is likely to be caused to persons, animals, works, property, places or objects the Engineer shall have power to regulate or prohibit the blasting and in the event of such regulation or prohibition the Contractor shall have no claim against the Employer.

The Contractor shall give warning each time of his intention to blast and shall station men on the roads and elsewhere with flags, horns and whistles and prevent persons, animals and traffic going into or remaining within the danger zone. He shall arrange for control of traffic on the main roads by the police during all blasting operations within 400 m of such main roads.

The Contractor's supervisor in charge of blasting operations shall have a valid licence for all types of blasting required including restricted blasting, a copy of which shall be made available to the Engineer.

The Contractor shall provide proper buildings in suitable positions for the storage of explosives to the satisfaction of the Engineer and the relevant Authority. The Contractor shall take all possible precautions and comply with all State Laws or other regulations governing the handling and use of explosives including the display on the site of warning notices explaining the procedure to be used in blasting operations, such notices to be displayed in all languages normally spoken by the personnel working on the Site.

In carrying out blasting the Contractor shall drill holes to the extent approved and in such number, position and direction and to such lengths and with loading of explosives of such quantity and power and means of detonating as will ensure that the excavation is taken out as

neatly as possible to the required profile without shattering the rock remaining or causing injury to concrete or fill already deposited in the vicinity.

In certain areas it is necessary to restrict blasting in order to protect installations of major significance as follows:

The Contractor shall, whenever he wishes to blast within 400 m of any public road, railway line, overhead power line or telephone line, draw this to the attention of the relevant authority concerned and ensure that all conditions imposed by them including attendance by the representatives of such authority are met. In all such cases, he will be required to provide cover to the area to be blasted, to the approval of the Engineer, to prevent damage to these services by flying debris.

The Contractor shall ensure, by limiting the amount of charge/delay or by the use of controlled detonations used at any blasting site, that the peak particle velocity at any existing building, structure or service, does not exceed 50 mm/s. The Contractor shall provide a suitable vibrometer and whenever called upon to do so by the Engineer, demonstrate by the use of the vibrometer that the charges he proposes to use comply with this Specification.

Compliance with the restrictions will not, however, limit the Contractor's liability in the event of any damage to any existing building, structure or services.

Notwithstanding any of the above, the Contractor shall cease blasting and continue to excavate in rock by barring, wedging or other approved methods, whenever called upon to do so by the Engineer.

If firing is done electrically, all precautions shall be taken to prevent premature explosions. All men other than the responsible foreman and one skilled man shall be withdrawn to a safe distance before firing wires are connected to the firing cable. The connection of the firing cable to die firing battery shall be the last operation. No charging or firing will be permitted when there are electrical storms or thundery conditions at or near the Site, when the time delay between the flash of lightning and the thunder clap is less than ten seconds.

After blasting, no man shall approach the area until it has been examined by the foreman or other responsible person and in the case of misfires the proper precautions shall be taken.

The Contractor shall be deemed to have included in his rates for items covering excavation for the supply of all explosives, transport, storage, supervision and compliance with the conditions and restrictions set out above.

3.5 Excavated material

Excavated material approved by the Engineer for use as backfill shall be deposited in spoil heaps confined to areas approved by the Engineer.

Topsoil shall be stored separately from the main excavated material and on no account disposed of without the approval of the Engineer.

The Contractor shall include in his excavation rates for removing to tip all surplus excavated material, rubbish and waste matter and for providing tips and leaving them with an acceptable appearance, all to the approval of the Engineer.

3.6 Timbering and dewatering of excavations

The Contractor shall carry out timbering in accordance with the recommendations in BS 6031.

All open excavation shall be securely timbered with suitable timber (or alternative form of sheeting other than timber) as may be required and whenever necessary to the satisfaction of the Engineer at the Contractor's expense. Timber shall not be left in the excavations as they are being filled up unless authorised by the Engineer.

Every precaution shall be taken by the Contractor against slips and falls, and the like in the excavations, but if any slips or falls should occur the Contractor shall at once make good the same including all surface restoration and reinstatement, all at his own cost. If any such fall or slip disturbs or weakens any foundation or support to the works or adjacent buildings, pipes, etc., or causes a space to exist outside the new work itself the Contractor shall execute such additional works as the Engineer may require in consequence thereof and fill up the space so caused, with concrete if necessary, as the Engineer may direct, all at the Contractor's own expense.

All excavation shall be kept free from water until construction work is complete and for such time as the Engineer considers necessary to safeguard the permanent work all at the Contractor's own expense. Trenches for pipework are to be kept dry and free of debris until final backfilling.

The Contractor shall be deemed to have included in his rates for excavation for the supply and operation of all pumps and the construction of any sumps or temporary drains necessary. Should any damage be caused by prolonged or excessive pumping, making good shall be carried out by the Contractor at his own cost and to the Engineer's approval.

The Contractor shall comply with all instructions of the Engineer regarding the supporting of the sides and dewatering of trenches or pits but shall not be relieved of his responsibilities under the Contract because no objection has been raised to the condition of the work.

3.7 Trench excavation

The minimum width of pipe trench shall be as indicated on the Drawings. This dimension will be used for measurement of the work and no separate measurement will be taken or allowed for over break. The Contractor shall ensure that at any point the width of the pipe trench is sufficient to permit the pipe to be laid and bedding to be placed and compacted around the pipe to the Engineer's satisfaction.

Each section of trench shall, where possible, have a bed of uniform gradient. Trench formation shall normally be in undisturbed ground, but where, in the opinion of the Engineer, the formation is unsuitable for bearing, extra excavation shall be carried out under the direction of the Engineer and the level made up again with selected fill material carefully compacted, or with Class 15 concrete. Such additional excavation and filling shall be paid for separately provided that the unsuitability is not due to the Contractor's method of working in which case the Contractor shall carry out the work at his own expense.

Unless explicitly directed otherwise by the Engineer, the trench formation shall be at a level such as will give a minimum cover to the top of the pipe barrel as indicated on the Drawings.

Where for any reason the required minimum cover cannot be achieved then the pipe shall be surrounded with Class 20 concrete in accordance with the details shown on the Drawings.

No greater length of trench shall be opened at one time than is approved by the Engineer. If there is a danger of erosion of trenches, the period between excavations of the trench, the pipe laying operation and subsequent backfilling shall be kept to a minimum.

If at any time any trench or excavation becomes dangerous, the Engineer shall be at liberty to call upon the Contractor to restore it to a proper condition at three hours' notice and, should the Contractor fail to carry out the work, have it done at the Contractor's expense.

Excavated material approved by the Engineer for use as backfill shall be stockpiled alongside or near the trenches. All surplus material shall be removed to tip.

The Contractor shall give due notice to the Engineer whenever the trench invert is about to be ready for examination and further work shall proceed thereon until the Engineer's approval is given.

3.8 Preparation, inspection and blinding of foundations

Where stated on the Drawings or elsewhere in the Specification, the excavation shall be carried out as described and the Final Surface treated as specified.

The faces of excavations shall be clean and trimmed to the required lines and levels. Any parts of the formation inconsistent with the nature and texture of the main formation shall be removed if authorised by the Engineer, and the voids so formed filled with a material and a manner approved by the Engineer. Such extra excavation including filling will be paid by the Employer provided it is not caused by any action or negligence by the Contractor.

Where the Final Surface is damaged or allowed to deteriorate through instructions not being complied with, the cost of the re-excavation to a firm base and making up with Grade C15 lean mix concrete shall be borne by the Contractor.

If any slips or fails occur, the Contractor shall immediately make good the same including surface restoration, all at his own expense.

The Contractor shall stop excavation at a minimum depth of 150 mm above any Final Surface to be blinded. The final 150 mm of excavation shall not be carried out until the Contractor is ready to protect the Final Surface with blinding.

The Contractor shall not excavate below the formation level or beyond any exposed faces shown on the Drawings. Any over-excavation shall be backfilled with Grade C15 lean mix concrete at the Contractor's expense.

The Contractor shall give due notice to the Engineer whenever any such work or foundation is about to be ready for examination and no further work shall proceed thereon until the Engineer's approval is given.

The Contractor shall at all times afford protection to any exposed formation to obviate deterioration and, where applicable, blinding concrete shall be laid immediately following the Engineer's approval of the formation.

3.9 Foundations and thrust blocks cast against existing ground

Where shown on the Drawings or directed by the Engineer that concrete shall be cast against the existing ground, the excavation shall be neatly excavated to the shape required. Where the foundation is inadvertently over-excavated, the space between the foundation and the soil face shall be backfilled with Class C15 concrete or as directed by the Engineer.

3.10 Fill

All filling directed by the Engineer shall consist of selected granular material uplifted, placed and compacted in layers not exceeding 250 mm thick, watered if necessary to ensure adequate compaction, all to the approval of the Engineer. No filling shall proceed without the approval of the Engineer.

Where in the opinion of the Engineer insufficient excavated material suitable for backfilling exists within 1 km of the place where the fill is required the Contractor shall if directed by the Engineer import suitable material either from borrow pits or from stockpiles. Items are included in the Bill of Quantities for the import of such material. Payment will only be made under these items for imported fill from borrow pits and from stockpiles more than 1 km from the place of filling. The volume to be measured shall be the volume of compacted fill in place.

3.11 Backfilling of trenches

Following laying, jointing, testing of pipelines and placement of pipeline bedding and surround, (see Section 5 of this Specification), backfilling of trenches shall be completed in 300 mm layers to a level of 75 mm above the surrounding ground with approved backfill material which shall be free from cobbles having any one dimension greater than 150 mm and containing not less than 50% of well graded material up to 25 mm nominal size.

Materials with high swelling characteristics or any other deleterious properties shall not be used unless specifically directed by the Engineer. Each layer shall be separately compacted using suitable rammers. All backfilling shall be completed as soon as possible after pipes have been tested and approved.

Under road crossings, the backfilling to pipes shall be brought up in 150 mm layers, and compacted to a density not less than 95% Maximum Proctor Density.

Pipes crossing under roads under construction should be excavated, the pipes laid, and backfilled after completion of the road earth works if the road at that location is in cut. In all cases, pipes should be laid and backfilled in advance of road subgrade processing operations.

Where, in the opinion of the Engineer, insufficient excavated material suitable for use as fill or bedding exists within one kilometre of the place where it is required, the Contractor shall, if directed by the Engineer, import suitable material either from stock piles or from borrow pits.

Items are included in the Bill of Quantities for the import of suitable material. Payment will only be made under these items for fill or bedding material imported from borrow pits and stock piles situated more than I km from the place of filling. Payment will be measured by the volume of compacted fill or bedding material in place, multiplied by the distance (to the nearest 0.5 km) in excess of 1 km that it has been transported.

Rates for excavation and backfilling of pipe trenches shall include for removal of surplus material to disposal areas within a radius of 2 km. spreading and levelling of the spoil, and reinstatement of access tracks, verges, storm drains and fences, all to the satisfaction of the Engineer.

3.12 Reinstatement

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

Immediately backfilling of trenches has been completed, temporary reinstatement of the ground shall take place.

When in the opinion of the Engineer a suitable period has elapsed after temporary reinstatement has been completed for there to be no further settlement, he shall allow the Contractor to carry out the permanent reinstatement. This shall not in any way relieve the Contractor of his responsibility for reinstatement and, should any further unforeseen settlement take place, the Contractor will be required to make good the reinstatement at his own expense.

Permanent reinstatement means that the ground surface shall be restored to its original form and condition.

Any diverted watercourses shall be reinstated in their former positions and topsoil shall be spread where the ground has been stripped. The Contractor shall be deemed to have included in the rates entered in the Bill of Quantities for the full cost of such reinstatement.

3.13 Top soiling and grassing

Topsoil for planting grass shall be selected topsoil from approved stockpiles of excavated materials or from stripping from borrow areas or from other approved sources. The materials shall contain the most fertile loam available and shall be free from excessive quantities of roots, weeds, sticks, stones or other objectionable material.

Areas to receive the topsoil shall be brought to within 150 mm of the prescribed final cross sections and finished ground levels at all points and finished smoothly and uniformly before topsoil is applied.

Topsoil shall be evenly placed and spread over the graded areas in one layer.

The Contractor shall allow for a temporary sprinkler irrigation system to the Engineer's approval and shall irrigate the newly planted grass to ensure germination and establishment of plants.

The Contractor shall repair at his own expense any damage to the slopes or any part of the works caused by excessive or irregular application of irrigation water.

When the topsoil has been placed on the areas to be planted with grass, levelled and compacted to finished grade it shall be brought to a friable condition by harrowing or other means to a maximum depth of 100 mm. All lumps and clods shall be thoroughly broken up.

All grass shall be of the creeping type. Approved grass sprigs shall be planted at 100 mm centres both ways on all areas designated by the Engineer. The grass areas shall be watered and maintained until a full grass cover has been established.

3.14 Hardcore

Hardcore shall consist of broken rock, concrete or other approved hard material, clean and free from extraneous matter, having a minimum particle size of 100 mm. It shall be spread and levelled, watered and compacted, and then blinded with a layer of fine material of grading 3 mm to dust, watered and compacted all to the Engineer's approval.

3.15 Pitching

Stone for pitching shall consist of sound undecomposed rock.

The stone as dressed shall be roughly cubical in shape with minimum dimensions of 150 x 150 mm x 150 mm for a nominal thickness of 150 mm pitching or 150 mm x 150 mm x 200 mm for a nominal thickness of 200 mm pitching.

Hard stone boulders may be used for grouted pitching only but in this case the size shall be 300 mm minimum diameter for a nominal thickness of 200 mm pitching.

For dry pitching the surface to receive the pitching shall be compacted and trimmed to slop covered with a 100 mm thick layer of compacted gravel well graded from 19 mm to 5 mm and the stone hand laid, interlocked and rammed into the gravel to give an even finished surface. Fill material shall then be rammed into the interstices.

Grouted pitching shall be constructed as for dry pitching except that the interstices of the pitching shall not be filled with fill material, but shall be choked with large rock spalls. Th pitching shall be thoroughly soaked with water, and cement mortar shall be worked into the interstices and smoothed off flush with the pitched face.

When dry pitching is specified, the Engineer may accept a grouted boulder pitched surface in lieu.

The rates for pitching shall include for compaction and trimming of the undersurface, providing and laying stone and gravel, providing and filling interstices with fill material or spalls and mortar, water, and any additional compaction of the filling behind the pitching.

3.16 Trial pits

The Contractor shall excavate, maintain and afterwards refill at the rates in the Bill of Quantities any trial pits ordered by the Engineer. The cost of trial pits required by the Contractor shall be at the Contractor's expense.

The sides of the pits shall, where deemed necessary by the Engineer for safety purposes, be supported by sheeting or boarding with adequate framing and a ladder shall be provided for inspection purposes, the costs of which shall be deemed to be included in the Contractor's excavation rates for trial pits.

4 CONCRETE FINISHES AND FORMWORK

4.1 Definitions

Structural concrete is any class of concrete which is used in reinforced, prestressed or unreinforced concrete construction, which is subject to stress and which is required to comply with other Clauses of the Specification.

Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling voids and similar purposes where it is subjected to significant stress.

A formed surface is a face that has been cast against formwork. A free surface is a horizontal or nearly horizontal surface produced by screeding or trowelling to the level and finish required. A pour refers to the operation of placing concrete into any mould, bay or formwork, etc., and also to the volume that has to be filled. Pours in vertical succession are also referred to as lifts.

Water/cement ratio is the ratio by mass of the free water in the mix divided by the mass of cement in the mix. Free water is the water in the mix including water absorbed by the aggregate.

Forms, formwork or shuttering shall mean all temporary moulds forming the concrete to the required shape together with any special lining that may be required to produce the concrete finish specified.

Falsework or centering shall mean the furnishing, placing and removal of all temporary construction such as framing, props and struts required for the support of forms.

4.2 Standard specifications

All workmanship materials, tests and performance concerning reinforced concrete shall, unless otherwise stated in this Specification, be in conformity with the following standard specifications:

BS 8110	Structural use of Concrete
	Part 1: Code of practice for design and construction
	Part 2: Code of practice for special circumstances
BS 8007	Code of Practice for design of concrete structures for retaining aqueous liquids.
BS 5328	Concrete.
BS 6073	Precast concrete masonry units.
	Part 1: Specification for precast concrete masonry units.

4.3 Concrete

4.3.1 Quality control of concrete production (150 mm cubes)

For each class of concrete in production at each mixer for use in the permanent works, samples of concrete shall be taken at the point of mixing or of deposition as instructed by the Engineer

and in the presence of a representative of the Engineer, all in accordance with the sampling procedures described in BS 1881.

The slump of each sample measured in accordance with Clause 4.6 shall be determined at the time of sampling.
Samples shall be taken on the basis of one for each 20 m^3 of concrete placed but in any case not less than one sample per day or one sample for each pour of concrete placed, whichever is the more frequent.

Test cubes shall be tested in accordance with Clause 4.5. The density of all cubes shall be determined before the cubes are crushed.

4.3.2 Failure to comply with requirements

The Contractor shall take any action instructed by the Engineer to remedy concrete that fails to comply with the Specification. Such action may include but is not necessarily confined to the following:

i. Adjusting the mix proportions until the concrete again complies with the Specification.

ii. Cutting test cores from the failed concrete and testing in accordance with BS 1881.

iii. Carrying out additional works to overcome the effect of the failed concrete.

iv. Removing the failed concrete.

v. Increasing the frequency of sampling until control is again established.

4.4 Concrete mixes

4.4.1 General

The classes of structural concrete to be used in the permanent works shall be those shown on the Drawings. The classes are designated in Table 4.4.1.

Concrete for water retaining structures shall have maximum water/cement ratios as shown in Table 4.4.1 and shall be in accordance with the recommendations laid down in Section 6 of BS 8007.

Concrete for other structures shall have maximum water/cement ratios as shown in Table 4.4.1 or on the Drawings.

The coarse aggregate maximum size shall be as shown in Table 4.4.1 or on the Drawings.

Frequency of sampling shall be in accordance with Table 7 of BS 5328.

Concrete mixes shall be designed mixes and shall generally be in accordance with Section 3 of BS 5328, and as specified in the sub-clauses below.

The Contractor shall be responsible for sampling, curing and testing of concrete.

4.4.2 Design of proposed mixes

The Contractor shall submit full details of all the mixes he proposes to use to the Engineer for his approval before proceeding with their use for the permanent works.

The Contractor shall design the mixes that he proposes to use in the permanent works to achieve acceptable workability and resistance to segregation during handling and placing. Mixes shall also comply with the following requirements:

The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150 µm size.

The cement contents shall be within the limits shown in Table 4.4.1 unless a higher cement content is required to meet the strength requirement.

Table 4.4.1 Specified requirements for concrete mixes

Mix designation	**C10**	**C15**	**C20**	**C25**	**C30**	**C35**
Cement to BS	12	12	12	12	12	12
Aggregates to BS	882	882	882	882	882	882
Aggregate size (mm)	40	40	40	20	20	20
Minimum cement content (kg/m^3)	200	200	240	300	325	325
Maximum free water/cement ratio	0.6	0.6	0.55	0.55	0.55	0.55
Maximum cement content (kg/m^3)	N/A	N/A	N/A	N/A	360	360
Slump (mm)	75	75	75	75	75	75
Air content (%)	0	0	0	0	0	0
Maximum temperature (^oC)	30	30	30	30	30	30
Minimum temperature (^oC)	5	5	5	5	5	5
Minimum density (kg/m^3)	2,350	2,350	2,350	2,350	2,350	2,350
Sampling frequency (m^3/sample)	50	50	50	15	15	15

The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than that shown in Table 4.4.1 taking due account of any water contained in the aggregates. The Contractor shall take into account that this requirement may need the inclusion of a workability agent in the mix

The workability shall be consistent with case of placing and proper compaction having regard to the presence of reinforcement and embedded items.

The crushing strength at twenty-eight days shall be determined in accordance with Clause 4.5.

The drying shrinkage determined in accordance with BS 1881 shall not be greater than 0.05%.

Blinding concrete shall be Class C15 for water retaining structures and C10 for other structures unless otherwise indicated on the Drawings or in the Specification.

Based on the results of the tests on the trial mixes, the Contractor shall submit full details of his proposals for mix design to the Engineer, including the type and source of each ingredient, the proposed proportions of each mix and the results on the tests on the trial mixes.

If the Engineer does not agree to a proposed concrete mix for any reason, the Contractor shall amend his proposals and carry out further trial mixes. No mix shall be used in the permanent works without the written consent of the Engineer.

4.5 Trial mixes

For each mix of concrete, the Contractor shall in the presence of a representative of the Engineer prepare three separate batches of concrete using the materials which have been approved for use in the permanent works and the mixing equipment that he proposes to use for the permanent works.

Six 150 mm test cubes shall be cast from each batch.

The making, curing and testing of all test cubes shall comply with the requirements of BS 1881. The slump of the concrete measured in accordance with BS 1881 shall be recorded.

Three cubes from each batch shall be tested for compressive strength at seven days and the remaining three at twenty-eight days. The density of all the cubes shall be determined before the cubes are crushed.

If the twenty-eight-day strength as determined by this Clause is less than the minimum average strength specified, then the mix shall be adjusted in order to comply. If adjustment of aggregate proportions does not increase the strength, the Contractor shall seek approval from the Engineer to reduce the water cement ratio.

If it is necessary to increase the workability, the use of a plasticity additive may be considered by the Engineer but shall not necessarily be accepted. An increase in cement content will not normally be acceptable.

The average strength of the three cubes crushed at twenty-eight days shall be referred to as one test result.

The average strength of the final nine trial mix twenty-eight day cubes accepted by the Engineer shall be referred to thereafter as the "final trial mix strength".

The Contractor shall carry out tests to determine the drying shrinkage of the concrete.

4.6 Workability

The slump for conventionally placed concrete, measured in accordance with BS 1881, shall be 50 mm ± 25 mm.

4.7 Transporting, placing and compacting concrete

Concrete shall not be placed in any part of the permanent works until the Engineer's consent has been given in writing, and the Contractor shall give the Engineer at least 18 hours' notice of his intention to place concrete.

The time elapsing between mixing and placing a batch of concrete shall be as short as practicable and in any case no longer than will permit completion of placing and compaction before the onset of initial set. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the permanent works.

If concrete placing is not commenced within twenty-four hours of the Engineer's consent, the Contractor shall again request written consent as specified above.

The concrete shall be discharged from the mixer such that the loss of slump between discharge from the mixer and placing shall not exceed 25 mm.
Excavated surfaces on which concrete is to be deposited shall be prepared as set out in Section 3 of the Specification.

Existing concrete surfaces shall be prepared as set out in Clause 4.11. Before deposition of further concrete they shall be clean, hard and sound and if required by the Engineer shall be wet but without any free-standing water.

Any flow of water into an excavation shall be diverted through proper side drains to a sump, or be removed by other suitable methods that will avoid washing away the freshly deposited concrete or any of its constituents. When they are no longer required, any underdrains constructed for this purpose shall be completely grouted up or dealt with by a method agreed by the Engineer.

If so instructed by the Engineer, rock surfaces against which concrete is to be placed shall receive a prior coating of mortar mixed in the proportions similar to those of the fines portion in the concrete to be placed. The mortar shall be kept ahead of the concrete. The mortar shall be well worked into all parts of the excavated surfaces and shall be not less than 5 mm thick.
If any fissures have been cleaned out as described in the Specification or as instructed by the Engineer, they shall be filled with the mortar or with concrete as instructed by the Engineer.

The amount of mortar placed at any one time shall be limited so that it does not dry out or set before being covered with concrete.

The concrete shall be deposited as nearly as possible in its final position. It shall be placed to avoid segregation of the concrete and displacement of the reinforcement, other embedded items, or formwork. It shall be brought up in layers approximately parallel to the construction joint planes and not exceeding 500 mm in compacted thickness unless otherwise permitted or directed by the Engineer, but the layers shall not be less than four times the maximum nominal size of aggregate in thickness.

Layers shall not be placed so that they form feather edges nor shall they be placed on a previous layer that has taken its initial set. In order to comply with this requirement, a layer may be started before completion of the preceding layer.

All the concrete in a single bay or pour shall be placed as continuous operation. It shall be carefully worked round all obstructions, irregularities in the foundations and the like so that all parts are completely full of compacted concrete with no segregation or honeycombing. It shall also be carefully worked round and between waterstops, reinforcement, embedded steelwork and similar items that protrude above the surface of the complete pour.

All work shall be completed on each batch of concrete before its initial set commences and thereafter the concrete shall not be disturbed before it has set hard. No concrete that has partially hardened during transit shall be used in the permanent works and the transport of concrete from the mixer to the point of placing shall be such that this requirement can be met.

Concrete shall not be placed during rain that is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete. Means shall be provided to remove any water accumulating on the surface of the placed concrete. Concrete shall not be deposited into such accumulations of water.

In drying weather, covers shall be provided for all fresh concrete surfaces that are not being worked on. Water shall not be added to concrete for any reason.

When concrete is discharged above its place of final deposition, segregation shall be prevented by the use of chutes, downpipes, trunking, baffles or other appropriate devices.

Forms for walls, columns and other thin sections of significant height shall be provided with openings or other devices that will permit the concrete to be placed in a manner that will prevent segregation and accumulations of hardened concrete on the formwork or reinforcement above the level of the placed concrete.

When it is necessary to place concrete under water the Contractor shall submit to the Engineer his proposals for the method and equipment to be employed. The concrete shall be deposited either by bottom-discharging watertight containers or through funnel-shaped tremmies which are kept continuously full with concrete up to a level above the water and which shall have the discharging bottom fitted with a trapdoor and immersed in the concrete in order to reduce to a minimum the contact of the concrete with the water. Special care shall be taken to avoid segregation.

If the concrete in a tremmie pipe is allowed to fall to such an extent that water enters the pipe, the latter shall be removed from the pour and filled with concrete before being again lowered into the placing position. During and after concreting under water, pumping or de-watering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

If concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Contractor shall immediately take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and shall thoroughly compact the concrete already placed in accordance with the Specification. All work on the concrete shall be completed while it is still plastic and it shall not thereafter be disturbed until it is hard enough to resist damage.

Equipment and materials to comply with this requirement shall be readily available at all times during concrete placing.

Before concreting is resumed after such an interruption the Contractor shall cut out and remove all damaged or uncompacted concrete, feather edges or any other undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.

If it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to a resumption, the new concrete shall be thoroughly worked in and compacted against the existing concrete to eliminate any cold joints.

Unless otherwise agreed by the Engineer, pours shall not be more than two metres high and shall as far as possible have a uniform thickness over the plan area of the pour. Concrete shall be placed to the full planned height of all pours except in the event of an interruption to placing in which case action shall be taken as specified.

The Contractor shall plan the dimensions of pours in such a way that thermal or shrinkage stresses are minimised.

The Contractor shall arrange that as far as possible the intervals between placing successive lifts of concrete in one section of the permanent works are of equal duration. This duration shall normally be not less than three nor more than seven days under temperate weather conditions unless otherwise agreed or instructed by the Engineer.

Where required by the Engineer to limit the opening of construction joints due to shrinkage, concrete shall not be placed against adjacent concrete that is less than twenty-one days old.

If concrete has to be placed against recently cast concrete within a period of less than twenty-one days, the pour shall be carried out as early as possible after the adjacent pour but precautions shall be taken to minimise shrinkage. The methods described in Clause 4.8 can be used to that effect. However, the Contractor shall submit for approval a proposed method and programme for placing of concrete.

When the Drawings call for contraction gaps in concrete these shall be of the widths and in the locations shown on the Drawings.

The concrete shall be fully compacted throughout the full extent of the placed layer. It shall be thoroughly worked against the formwork and around any reinforcement and other embedded items, without displacing them. Particular care shall be taken at arises and other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

Concrete shall be compacted with the assistance of mechanical immersion vibrators, unless the Engineer agrees to another method.

Immersion vibrators shall operate at a frequency of between 7,000 and 10,000 cycles per minute. The Contractor shall ensure that vibrators are operated at pressures and voltages not less than those recommended by the manufacturer in order that the compactive effort is not reduced.

A sufficient number of vibrators shall be operated to enable the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition, stand-by vibrators shall be available for instant use at each place where concrete is being placed.

Vibration shall be continued at each point until the concrete ceases to contract, a thin layer of mortar has appeared on the surface and air bubbles have ceased to appear. Vibrators shall not be used to move concrete laterally and shall be withdrawn slowly to prevent the formation of voids.

Vibration shall not be applied by way of reinforcement nor shall vibrators be allowed to touch reinforcement or other embedded items. The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing that shall not exceed the distance from the vibrator over which vibration is visibly effective.

4.8 Curing

Concrete shall be protected during the first stage of hardening from loss of moisture and from the development of temperature differentials within the concrete sufficient to cause cracking. The methods used for curing shall not cause damage of any kind to the concrete.

Curing shall be continued for as long as may be necessary to achieve the above objectives but in any case for at least ten days or until the concrete is covered by later construction whichever is the shorter period.

The above two objectives are dealt with in the following sub-clauses, but nothing shall prevent both objectives being achieved by a single method where circumstances permit.

The curing process shall commence as soon as the concrete is hard enough to resist damage from the process, and in the case of large areas or continuous pours shall commence on the completed section of the pour before the rest of the pour is finished.

Details of the Contractor's proposals for curing concrete shall be submitted to the Engineer before the placing of concrete commences in the permanent Works.

Exposed concrete surfaces shall be closely covered with impermeable sheeting, properly secured to prevent its removal by wind and the development of air spaces beneath it. Joints in the sheeting shall be lapped by at least 300 mm.

If for some reason it is not possible to use impermeable sheeting, the Contractor shall keep the exposed surfaces continuously wet by means of a water spray or by covering with a water adsorbent material which is kept wet, unless this method conflicts with the other sub-clauses of this Clause.

Water used for curing shall be of the same quality as that used for mixing as stated in Clause 2.2.

Formed surfaces may be cured by retaining the formwork in place for the required curing period.

If the use of the foregoing methods is inappropriate, surfaces which will not have further concrete bonded to them and which are not to receive an application of a finish may be cured by the application of an approved curing compound. Curing compounds shall contain a fugitive dye to enable the extent of the spread to be seen easily.

Curing compound used on surfaces exposed to the sky shall if instructed by the Engineer, contain sufficient finely divided flake aluminium in suspension to produce a complete coverage of the surface with a metallic finish when applied at the rate recommended by the manufacturer.

Curing compounds shall become stable and impervious to the evaporation of water from the concrete surface within sixty minutes of application. The material shall not react chemically with the concrete and shall not crack, peel or disintegrate within twenty-one days after application.

If instructed by the Engineer, the Contractor shall in addition to the curing provisions set out above provide a suitable form of shading to prevent the direct rays of the sun reaching the concrete surfaces for at least the first four days of the curing period.

The Contractor shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances as accepted by the Engineer which shall include the following:

i. limiting concrete temperatures at placing as set out in Clause 4.16.
ii. using low heat cement, subject to the agreement of the Engineer.
iii. insulating exposed concrete surfaces by using insulating blankets. Such blankets shall have a thermal conductance C value less than 1.0 $W/m^2/^oC$.
iv. leaving formwork in place during the curing period. Steel forms shall be suitably insulated on the outside.
v. preventing rapid dissipation of heat from surfaces by shielding from wind.
vi. avoiding the use of water sprays when such use would cause rapid cooling of the surface.

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from this cause.

No traffic shall be allowed on any concrete surface until it is hard enough to resist damage by such traffic.

Concrete placed in the permanent works shall not be subjected to any structural loading until it has attained at least its minimum average strength as defined in Clause 4.4.

If the Contractor desires to impose structural loads in newly placed concrete, he shall make at least ten test cubes and cure them in the same conditions as the concrete they represent. These cubes shall be tested singly at suitable intervals in order to estimate the time at which the minimum average strength is reached.

4.9 Records of concreting

Records, in a form agreed by the Engineer, shall be kept by the Contractor of the details of every pour of concrete placed in the permanent works. These records shall include class of concrete, location of pour, date of pour, ambient temperature and concrete temperature at time of placing, moisture contents of aggregates, details of mixes, batch numbers, cement batch number, results of all tests undertaken, location of test cube sample points and details of any cores taken.

The Contractor shall supply to the Engineer four copies of these records each week covering work carried out the preceding week. In addition, he shall supply to the Engineer monthly histograms of all twenty-eight day cube strengths together with accumulative and monthly standard deviations and any other information which the Engineer may require concerning the concrete placed in the permanent works.

4.10 Cutting, bending and tying of reinforcement

The Contractor shall be responsible for preparing all bending schedules in compliance with BS 4466 (Bending dimensions and scheduling of reinforcement for concrete) and the checking of those provided from the following information that will be given on the construction drawings:

i. Required bar diameter
ii. Required steel specification
iii. Bar locations and plan area covered
iv. Bar spacing
v. Bar cover
vi. Required lap length

The Contractor shall be responsible for determining:

i. Required number of bars
ii. Required shape code
iii. Required bending dimensions
iv. Overall length of each bar

Reinforcement shown on the drawings will be that required for structural purposes only. The Contractor shall be responsible for designing all reinforcement necessary for positioning and supporting structural reinforcement (chairs, spacing bars and the like).

The Contractor shall provide test certificates for all reinforcement giving details of compliance with the required specification.

All bars shall be hot rolled deformed, unless otherwise permitted by the Engineer. Bar reinforcement shall be bundled and each bundle of steel shall be tagged with identifying tags, showing the size and mark of the bar. The bundles shall be stacked clear of the ground in easily accessible positions that do not in any way hinder the progress of work and shall be kept clean.

When placed in the work reinforcement shall be free from coatings or dirt, detrimental scale, paint, oil or other foreign substances. When steel has on its surface rust, loose scale and dust which is easily removable, it may be cleaned by a method approved by the Engineer.

All reinforcing bars, ties, links and fabric shall be fixed in the positions shown on the Drawings within the tolerances specified in BS 4466. In no case shall the cover specified on the Drawings be increased by more than 5 mm.

Displacement of reinforcement beyond the specified tolerance shall be prevented by supporting the bars sufficiently and securely fixing them together at intersections where necessary.

The ends of all tying wires shall be turned into the body of the concrete and not allowed to project towards the surfaces of the concrete.

Spacers shall be used to maintain the cover to all steel and shall be made of dense cement mortar of one part cement and two parts sand.

Spacers shall be triangular in section and only one acute edge shall bear against the formwork, the flat side shall bear against the steel. Wire cast into the blocks to fix them to the reinforcement shall be 1.6 mm diameter soft annealed iron. The Engineer may approve the use of spacers made of other materials. Spacers shall not be used on the wet face of water retaining or water excluding structures. Chairs, stools, etc. shall be used to maintain clearance between two or more layers of reinforcement.

Nothing shall be allowed to interfere with the specified position of reinforcement. The fixing of reinforcement shall be checked before and during concreting, and particular attention shall be given to the position of top steel in cantilever sections. During concrete placing, a competent steel fixer shall attend to adjust and correct the position of any reinforcement that may be displaced.

All reinforcement shall be provided in full lengths as indicated on the Drawings. Splicing of bars, except where shown on the Drawings, shall not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible. Bar reinforcement shall not be welded without the Engineer's written permission.

In lapped splices, the bars shall be placed in contact and wired together in such manner as to maintain a clearance between bars of not less than 50 millimetres.

Mesh or mat reinforcement shall overlap sufficiently to maintain a uniform strength and shall be securely fastened at ends and edges. The edge lap shall not be less than forty diameters of the mesh reinforcement bar or two mesh widths whichever is greater.

4.11 Construction joints

Where lockers are used a rebate of not less than 5 mm and not greater that 10 mm shall be allowed on the inside face of the wall.

Whenever concrete is to be bonded to other concrete which has hardened, the surface of contact between the sections shall be deemed a construction joint.

Where construction joints are shown on the Drawings, the Contractor shall form such joints in those positions. The location of joints that the Contractor requires to make for the purpose of construction shall be subject to the agreement of the Engineer and details shall be submitted with the programme of Works required by the Conditions of Contract. The exact location of all construction joints shall be submitted to the Engineer at least twenty-eight days before the start of construction of the relevant part of the works. Construction joints shall be in vertical or horizontal plans except in sloping slabs where they shall be normal to the exposed surface or elsewhere the Drawings require a different arrangement.

Construction joints shall be so arranged as to reduce to a minimum the effects of shrinking in the concrete after placing, and shall be placed in the most advantageous positions with regard to stresses in the structures and the desirability of staggering joints.

Feather edges of concrete at joints shall be avoided and any feather edges that may have formed where reinforcing bars project through a joint shall be cut back until sound concrete has been reached.

The intersections of horizontal or near horizontal joints and exposed faces of concrete shall appear as straight lines produced by use of a guide strip fixed to the formwork at the top of the concrete lift, or by other means acceptable to the Engineer.

Construction joints formed as free surfaces shall not exceed a slope of 20% from the horizontal.

The surface of the fresh concrete in horizontal or near horizontal joints shall be thoroughly cleaned and roughened by means of high pressure water and air jets when the concrete is hard enough to withstand the treatment without the leaching of cement. The surface of vertical joints shall be similarly treated if circumstances permit the removal of formwork at a suitable time.

Where concrete has become too hard for the above treatment to be successful, the surface whether formed or free is to be thoroughly scabbled by mechanical means or wet sand blasted and then washed with clean water. The indentations produced by scabbling shall be not less than 10 mm deep and shall not extend closer than 40 mm to a finished face.

If instructed by the Engineer the surface of the concrete shall be thoroughly brushed with a thin layer of mortar complying with Clause 2.7, all as set out in Clause 4.7 immediately prior to the deposition of fresh concrete. The mortar shall be kept just ahead of the fresh concrete being placed and the fresh layer of concrete shall be thoroughly and systematically vibrated to full depth to ensure complete bond with the adjacent layer.

No mortar or concrete may be placed in position on or against a construction joint until the joint has been inspected and passed by the Engineer.

Expansion and contraction joints are discontinuities in concrete designed to allow for thermal or other movements in the concrete.

Expansion joints are formed with a gap between the concrete faces to permit subsequent expansion of the concrete. Construction joints are formed to permit initial contraction of the concrete and may include provision for subsequent filling.

Expansion and contraction joints shall be formed in the positions and in accordance with the details shown on the Drawings or elsewhere in the Specification.

4.12 Surface finishes produced without formwork

Horizontal or nearly horizontal surfaces which are not cast formwork shall be finished to the class shown on the Drawings and defined hereunder:

(a) U1 finish

All surfaces on which no higher class is called for on the Drawings or instructed by the Engineer shall be given a U1 finish. The concrete shall be levelled and screened to produce a uniform plain or ridge surface, surplus concrete being struck off by a straightedge immediately after compaction.

(b) U2 finish

The surface shall first be treated as a Class U1 finish and after the concrete has hardened sufficiently, it shall be floated by hand or machine sufficient only to produce a uniform surface free from screed marks.

(c) U3 finish

This is hard trowelled surface for use where resistance or appearance is important, or which is subject to high velocity water flow. The surface shall be floated as for a U2 finish but to the tolerance stated below. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, it shall be steel-trowelled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

4.13 Surface finishes produced with formwork

4.13.1 Classes of finish

The surface finish to be achieved on formed concrete surfaces shall be as shown on the Drawings and defined hereunder:

(a) Class F1 finish

This finish is for surfaces against which backfill or further concrete will be placed. Formwork may be sawn boards, sheet metal or any other suitable material that will prevent the loss of fine material from the concrete being placed.

(b) Class F2 finish

This finish is for surfaces that are permanently exposed to view but where the highest standard of finish is not required. Forms to provide a Class F2 finish shall be faced with wrought thickness tongued and grooved boards with square edges arranged in a uniform pattern and close jointed or with suitable sheet material. The thickness of boards or sheets shall be such that there shall be no visible deflection under the pressure exerted by the concrete placed against them. Joints between boards or panels shall be horizontal and vertical unless otherwise directed. This finish shall be such as to require no general filling of surface pitting, but fins, surface discoloration and other minor defects shall be remedied by methods agreed by the Engineer.

(c) Class F3 finish

This finish is for surfaces that will be in contact with water and for surfaces prominently exposed to view where good appearance is of special importance. To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood complying with B. S. 1088 or equivalent material in large sheets. The sheets shall be arranged in an approved uniform pattern. Wherever possible, joints between sheets shall be arranged to coincide with architectural features or changes in direction of the surface. All joints between panels shall be vertical and horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment in the plane of the sheets. Unfaced wrought boarding or standard steel panels will not be permitted for Class F3 finish. The Contractor shall ensure that the surface is protected from rust marks, spillages and stains of all kinds.

4.13.2 Curved surfaces

For curved surfaces where F2, or F3 finishes are called for, the formwork face shall be built up of splines cut to make a tight surface which shall then be dressed to produce the required finish.

Alternatively single curvature surfaces may be faced with plastic or plywood linings attached to the backing with adhesive or with escutcheon pins driven flush. Linings shall not bulge, wrinkle or otherwise deform when subjected to temperature and moisture changes.

4.14 Tolerances for concrete surfaces

Concrete surfaces in the permanent works shall not vary by more than the permissible amounts shown in Table 4.14.1.

Table 4.14.1 Tolerances for concrete surfaces.

Type of Structure	Dimension measured	Tolerance (mm)			
		Finish produced with formwork		Finish produced without formwork	
		F1	F2 & F3	U1	U2 & U3
Buried Concrete	Position	± 25	-	± 25	-
	Alignment	± 15	-	± 15	-
	Height up to 5m	± 25	-	± 15	-
	Thickness	± 10	-	± 10	-
	Straightness in 5m	± 15	-	± 10	-
	Step Displacement	10	-	10	-
Ordinary Exposed Concrete	Position	± 20	± 20	± 10	± 10
	Alignment	± 10	± 10	± 10	± 3
	Height up to 5m	± 10	± 10	-	-
	Thickness	± 10	± 5	± 5	± 5
	Straightness in 5m	± 15	± 10	± 10	± 10
	Step Displacement	5	3	5	0
Exposed** Concrete (Where plant is to be installed), Precast Concrete and Screeds	Position	± 5	± 5	± 3	± 3
	Alignment	± 5	± 3	± 3	± 2
	Height up to 5m	± 10	± 5	-	-
	Thickness	± 10	± 5	± 5	± 5
	Straightness in 5m	± 5	± 3	± 5	± 3
	Step Displacement	3	2	3	0
Measuring Devices (Flumes, Weirs etc.)	Position	-	± 3	-	± 3
	Alignment	-	± 3	-	± 3
	Straightness in 5m	-	± 2	-	± 3
	Step Displacement	-	0	-	0

Notes:

** This group is intended to be used where mechanical plant bears directly on the concrete. Where plant is mounted on grouted bed shims and the like, work shall be constructed within the tolerances specified for Ordinary Exposed Concrete.

4.15 Mixing concrete

Before any equipment for batching, mixing, transporting, placing, compacting and finishing concrete is ordered or delivered to Site, the Contractor shall submit to the Engineer full details including drawings of all the equipment which he proposes to use and the arrangements he proposes to make.

Concrete for the permanent works shall be batched and mixed in one or more central units unless the Engineer agrees to some other arrangement.

Batching and mixing equipment shall be modem efficient equipment complying with the requirements of BS 1305 and capable of producing a uniform distribution of he ingredients throughout the mass. Truck mixers shall not be used unless the Engineer agrees otherwise, in which case they shall comply with the requirements of BS 4251. If the equipment proposed by the Contractor does not fall within the scope of BS 1305, it shall have been tested in accordance with BS 3963 and shall have a mixing performance within the limits of Table 6 of BS 1305.

Unless the Engineer agrees otherwise, each mixing unit shall be tested for mix variability before it is used to mix concrete for the permanent works.

All mixing operations shall be under the control of an experienced supervisor.

The aggregate storage bins shall be provided with drainage facilities arranged so that drainage water is not discharged to the weigh hoppers. Each bin shall be drawn down at least once per week and any accumulations of mud or silt removed.

Cement and aggregates shall be batched by weight. Water may be measured by weight or volume.

The weighing and water dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerances described in BS 1305 and checked against accurate weights and volumes when required by the Engineer.

The weights of cement and of each size of aggregate indicated by the mechanisms employed shall be within a tolerance of plus or minus two per cent of the respective weights per batch agreed by the Engineer.

The Contractor shall provide standard test weights at least equivalent to the maximum working load used on the most heavily loaded, scale and other auxiliary equipment required for checking the satisfactory operation of each scale or other measuring device.

Tests shall be made by the Contractor at the intervals to be determined by the Engineer and shall be carried out in his presence. For carrying out these tests, there shall be easy access for personnel to the weigh hoppers. The Contractor shall provide the Engineer with copies of the complete results of all check tests and shall make any adjustments, repairs or replacements necessary to ensure satisfactory performance.

The nominal drum or pan capacity of the mixer shall not be exceeded. The turning speed and the mixing time shall be as recommended by the manufacturer, but in addition, when water is the last ingredient to be added, mixing shall continue for at east one minute after all the water has been added to the drum or pan.

If the Engineer has reason to doubt the adequacy of the mixing, he may order a variability test as set out in Test C8 in Appendix C and the Contractor shall forthwith carrying out such test, the results of which shall comply with the requirements shown in Appendix C.

The blades of pan mixers shall be maintained within the tolerances specified by the manufacturer of the mixer and the blades shall be replaced when it is no longer possible to maintain the tolerances by adjustment.

Mixers shall be fitted with an automatic recorder registering the number of batches discharged.

The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by the Engineer immediately before mixing begins each day and thereafter as the Engineer directs. When the correct quantity of water, determined as set out in the Specification, has been added to the mix, no further water shall be added, either during mixing or subsequently.

After mixing for the required time, each batch shall be discharged completely from the mixer before any materials for the succeeding batch are introduced.

Mixers that have been out of use for more than thirty minutes shall be thoroughly cleaned before any fresh concrete is mixed.

Mixers shall be cleaned out before changing to another type of cement.

4.16 Concreting in hot weather

The Contractor shall prevent damage to concrete arising from exposure to extreme temperatures, and shall maintain in good working order all equipment required for this purpose.

In the event that conditions become such that even with the use of the equipment requirements cannot be met, concrete placing shall immediately cease until the requirements can again be met.

During hot weather the Contractor shall take all measures necessary to ensure that the temperature of concrete at the time of placing in the permanent works does not exceed 30^{o}C and that the concrete does not lose any moisture during transporting and placing. Such measures may include but are not necessary limited to the following:

i. Shielding aggregates from direct sunshine.
ii. Sun shields on mixing and transporting equipment.
iii. Cooling the mixing water. If ice is used for this purpose, it shall be in flake form. Lump ice shall not be allowed to enter the tank supplying the mixer drum.
iv. Covering skips closely with polythene sheet so that the latter is in contact with the concrete.
v. Painting all equipment and sunshields white.
vi. Night work, provided that the Engineer has no other reason for refusing permission for night work.

Areas in which concrete is to be placed shall be shielded from direct sunshine and rock or concrete surfaces shall be thoroughly wetted if instructed by the Engineer to reduce absorption of water from the concrete placed on or against them.

After concrete in any part of an area has been placed, the specified curing process shall be commenced as soon as possible. If any interval occurs between completion of placing and start of curing, the concrete shall be closely covered during the interval with polythene sheet to prevent loss of moisture.

The Engineer shall have power to order the suspension of concrete production and/or laying when the shade temperature exceeds 30^{o}C if he is not satisfied that the precautions being taken or intended by the Contractor are adequate to prevent the temperature of the concrete rising above 30^{o}C

Under no circumstances will the Contractor be entitled to receive any additional payment for complying with the requirements of this Clause of the Specification.

4.17 Formwork

All forms shall be of wood, metal or other acceptable material and shall be built grout-tight and of sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations. Forms shall be constructed and maintained to prevent warping and the openings of joints due to shrinkage of the timber.

The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours. The design of the forms shall take into account the effect of vibration of concrete as it is placed.

All formwork shall, unless otherwise directed, be provided with 25 mm by 25 mm angle fillets to form splays on internal and external angles.

A grout check formed from 25 mm square hardwood timber shall be incorporated in the formwork to provide a clean, level, horizontal joint on exposed concrete surfaces at the top of each lift.

All joints in the formwork shall be either horizontal or vertical. End formwork shall be square across the mass of concrete.

Where concrete is to be deposited to a slope steeper than 20 degrees to the horizontal, top formwork shall be used to enable the concrete to be properly compacted unless the Engineer agrees otherwise.

Openings for the inspection and cleaning of the inside of formwork for walls, piers and columns shall be formed in such a way that they can be closed conveniently before commencing to place concrete.

Form clamps, tie bolts and anchors shall be used to fasten forms. The use of wire ties to hold forms in position during placing of concrete will not be permitted. Tie bolts and clamps shall be positive in action and of sufficient strength and number to prevent spreading or springing of the forms. They shall be of such type that no metal part shall be left within the specified concrete cover. For water retaining sections, methods of fixing the forms that result in holes through the concrete section when the formwork is removed shall not be used and built-in wall ties shall be fitted with water baffles.

All forms for outside surfaces shall be constructed with stiff wales at right angles to the studs and all form clamps shall extend through and fasten such wales.

The shape, strength, rigidity, grout tightness and surface smoothness of forms that are reused shall be maintained at all times. Any warped, bulged or otherwise damaged timber shall be replaced. Unsatisfactory forms shall not be re-used. If the surface finish on the formed concrete deteriorates as a result of deterioration of the faces of the forms, the Engineer shall instruct that forms be resurfaced, or discarded.

All forms shall be treated with approved mould or similar oil or be soaked with water immediately before placing concrete to prevent adherence of concrete. Any materials that adhere to or discolour concrete shall not be used.

All forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. Forms shall remain in place for the periods specified in Clause 4.21. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer shall order the work stopped until the defects have been corrected.

The Engineer shall approve all formwork before concrete is placed within it. The Contractor shall, if required by the Engineer, provide copies of calculations of the strength and stability of the formwork and falsework. Notwithstanding the Engineer's approval of these calculations, the Contractor shall be held responsible for the safety and adequacy of formwork.

4.18 Falsework and centering

The Contractor shall supply detailed plans for falsework or centering to the Engineer at least fourteen days in advance of the time the Contractor begins construction of the falsework. Notwithstanding the approval of the Engineer of any designs for falsework submitted by the Contractor, the Contractor shall be solely responsible for the strength, safety and adequacy of the falsework or centring.

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads from the weight of green concrete and shuttering and incidental construction loads.

Falsework or centering shall be founded upon a solid footing safe against undermining and protected from softening. Falsework that cannot be founded on satisfactory footings shall be supported on piling that shall be spaced, driven and removed in a manner approved by the Engineer. The Engineer may require the Contractor to employ screw jacks, or hard wood wedges to take up any settlement in the formwork either before or during the placing of concrete.

Falsework shall be set to give the finished structure the required grade and camber shown on the Drawings.

4.19 Forms for joints

Where permanent or temporary joints are to be made in horizontal or inclined members, stout stopping off boards shall be securely fixed across the mould to form a watertight joint. The form of the permanent joint shall be as shown on the Drawings.

Where reinforcement or waterstops pass through the face of a joint the stopping off board shall be drilled so that the bars or waterstop can pass through, or the board shall be made in sections with a half round indentation in the joint faces for each bar so that when placed the board is neat and accurate fit and no grout leaks from the concrete through the bar holes, joints or around the waterstop.

4.20 Release agents

Only approved chemical release agents, mould creams (emulsions of water in oil) or oils containing a proportion of surfactant not exceeding 2% will be permitted. Water-soluble emulsions and oils without surfactant shall not be used. Oil-based release agents shall be applied at a rate of seven square metres per litre one day in advance of concreting, preferably by spray or roller. Chemical release agents shall be applied in accordance with the manufacturer’s recommendations.

New timber face work shall be given three coats of release agent before use on the work to ensure uniformity of porosity on the surface.

On no account shall the release agent come into contact with the reinforcement.

4.21 Removal of formwork

Formwork shall be carefully removed without shock or disturbance to the concrete. No formwork shall be removed until the concrete has gained sufficient strength to withstand safely any stresses to which it may thereby be subjected.

The minimum periods that shall elapse between completion of placing concrete and removal of forms are as follows and apply to ambient temperatures higher than 10^{o}C:

Beam sides, walls and columns	-	I to 2 days
Slab soffits - props remain undisturbed	-	7 days
Beam soffits - props remain undisturbed	-	7 days
Removal of slab props	-	14 days
Removal of beam props	-	21 days

At lower temperatures or if cements other than Ordinary Portland are involved, the Engineer may instruct longer periods.

Compliance with these requirements shall not relieve the Contractor of his obligation to delay removal of formwork until such removal can be completed without damage to the concrete.

4.22 Grouting of pockets and holes and underpinning of base plates

Pockets and holding-down bolt holes shall be thoroughly cleaned out using a compressed air or water jet. Holes drilled by a diamond bit shall be roughened. The pockets and holes shall be filled with grout consisting of cement and clean fresh water mixed in proportion of two parts by weight of cement to one part by weight of water. The pouring of liquid grout shall cease as soon as each hole is filled and any excess grout on the surface of the concrete foundation shall be completely removed and the surface dried off before the following operations detailed in the other sub-clauses proceed.

The space between the top surface of foundation concrete and the underside of base plates shall be filled with a special mortar made up in the following proportions:

i. Portland cement: 1 unit
ii. Fine aggregate: 1 unit
iii. An additive acceptable to the Engineer to counteract shrinkage in proportions recommended by the manufacturer.

The special mortar shall then be mixed with the lowest water-cement ratio that will result in a consistency of mix of sufficient workability to enable maximum compaction to be achieved.

The special mortar shall then be well rammed in horizontally below the base plate and from one edge only until it is extruded from the other three sides. The mortar that has extruded shall then be rammed back to ensure complete support without voids.

4.23 Remedial work to defective surfaces

If on stripping any formwork the concrete surface is found to be defective in any way, the Contractor shall make no attempt to remedy such defects prior to the Engineer's inspection and the receipt of any instructions that the Engineer may give.

Defective surfaces shall not be made good by plastering or by sealing with any sealing compound.

Areas of honeycombing which the Engineer agrees may be repaired shall be cut back to sound concrete or to 75 mm whichever is the greater distance In the case of reinforced concrete the area shall be cut back to at least 25 mm clear distance behind the reinforcement or to 75 mm, whichever is the greater distance. The cavity shall have sides at right angles to the face of the concrete. After cleaning out with water and compressed air, a thin layer of cement grout shall be brushed on to the concrete surfaces in the cavity and it shall then be filled immediately with concrete of the same class as the main body and well vibrated/compacted with the provision of a lip to enable concrete to be placed. The form shall be filled to a point above the top edge of the cavity. After seven days, the lip of concrete shall be broken off and the surface ground smooth.

Surface irregularities that are outside the limits of tolerance set out in Clause 4.13 shall be ground down in the manner and to the extent instructed by the Engineer.

Defects other than those mentioned above shall be dealt with as instructed by the Engineer.

4.24 Hand mixed concrete

Concrete for structural purposes shall not be mixed by hand. Where non-structural concrete is required, hand mixing may be carried out subject to the agreement of the Engineer.

The mixing shall be done on a hard impermeable surface. The materials shall be turned over not less than three times dry, water shall then be sprayed on and the materials again turned over not less than three times in a wet condition and worked together until a mixture of uniform consistency is obtained.

For hand mixed concrete the specified quantities of cement shall be increased by 10% and not more than 0.5 m^3 shall be mixed at one time. During windy weather efficient precautions shall be taken to prevent cement from being blown away during the process of gauging and mixing.

4.25 Non-structural concrete

Non-structural concrete (NS concrete) shall be used for non-structural purposes where shown on the Drawings.

NS concrete shall be composed of aggregates complying with all-in aggregate within the grading limits of Table 3 of BS 882, Clause 2.3 and the type of cements specified in Clause 2.5 or on the Drawings.

The mass of cement mixed with 0.3 m^3 of combined or all-in aggregate shall not be less than 50 kg. The mix shall be proportioned by weight or by volume. The maximum aggregate size shall be 40 mm nominal.

The concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water shall not exceed that required to produce concrete with sufficient workability to be placed and compacted where required.

The concrete shall be compacted by hand or by mechanical vibration.

4.26 Protection of buried concrete

4.26.1 Materials

Plastic sheeting where shown shall be polythene sheeting 250 µm minimum thickness (except where otherwise specified) to BS 743 to the approval of the Engineer. The Contractor shall provide suitable samples for approval before any concreting works shall begin.

All joints in the plastic meeting shall be made with an approved polythene based adhesive tape. This tape shall also be used where tailoring of the sheeting to complicated shapers is necessary, e.g. gullies, pipe ducts, etc.

Bitumen coating shall consist of one priming coat and one finishing coat of approved bitumen-based, high-build, asbestos-filled liquid coating.

4.26.2 Concrete in contact with ground

Where directed by the Engineer or shown on the Drawings concrete work which will be placed directly against rock or soil or which will subsequently have backfill placed against it will be protected in the following way from the aggressive action of salts contained in rock, soil or groundwater:

Concrete placed directly against cut-face shall be protected by a layer of plastic sheeting laid over the area to be concreted. All laps shall be at least 300 mm wide and sufficient surplus sheeting shall be left to enable a margin of at least 300 mm width to protect above the ground/concrete interface to be sealed onto the adjacent finished concrete surface with the bitumen coating. Special care shall be taken to avoid damage to the plastic sheeting during concreting.

Formed or free concrete surfaces against which backfill will subsequently be placed will be protected by the application of bitumen coating.

No protection will be applied to surfaces against which concrete will subsequently be placed, except as described in the following sub-clause.

4.26.3 Ground floor slabs

A layer of plastic sheeting will be laid over the blinding concrete and below the ground floor slab. Laps in the plastic sheeting shall not be less than 300 mm and adjacent sheets shall be securely taped down to prevent movement during concreting operations. Care shall be taken to avoid damage to the plastic sheeting during concreting.

In the case of ground floor slabs, no protection shall be applied to the underside of the blinding layer.

4.27 Concrete chamfers

25 mm x 25 mm chamfers shall be formed on all exposed concrete arrises unless noted otherwise on the Drawings.

4.28 Precast concrete

4.28.1 Durability

Precast units required for use in exposed places, including items such as kerbstones and copings liable to be affected by de-icing salts shall be made with concrete of a class not weaker than 30 MPa and having a water/cement ratio as low as possible consistent with proper compaction.

The concrete shall include an air-entraining admixture to provide the following air contents by volume of compacted concrete:

i. Concrete containing 40mm max. nominal size aggregate 3-5%
ii. Concrete containing 20mm max. nominal size aggregate 4-6 %
iii. Concrete containing l0mm max. nominal size aggregate 6-8%

4.28.2 Dimensional tolerances

Units shall be accurately formed to the dimensions shown on the Drawings and within the tolerances set out in BS 8110 unless closer tolerances are called for elsewhere in the Contract.

4.28.3 Surface finish

The formed faces of precast units shall be finished to Class F3 as set out elsewhere in the Specification unless another class of finish is specified on the Drawings.

Free faces shall be finished to Class U2 unless another class of finish is specified elsewhere.

In cases where a special finish is required a trial panel shall be constructed by the Contractor which after approval by the Engineer shall be kept available for inspection at the place of casting and production units shall thereafter match the approved pattern.

Those parts of a unit which are to be joined to other units or to in situ concrete shall be brushed with a stiff brush before the concrete has fully hardened. Alternatively, if the concrete has been allowed to harden, the surfaces shall be roughened by sand blasting or the use of a needle gun.

4.28.4 Handling and storage of units

Precast units shall be handled in a manner that will not cause damage of any kind and shall be stored on a hard, impermeable base. Pre stressed units and large precast normally reinforced units shall be handled and stored so that no stresses shall be induced in excess of those which they will incur in their final positions in the permanent works unless they have been designed to resist such stresses.

Units shall be provided with adequate lifting holes or loops, placed in the locations shown on the Drawings or agreed by the Engineer and they shall be lifted only by such holes or loops. Where it is not possible to provide holes or loops, suitable sling positions shall be indicated in paint on the units.

Units shall be marked indelibly with the reference number and date of casting and shall be stacked on suitable packers that will not damage the concrete or stain the surfaces. Not more than two packers shall be placed under each unit and these shall be located either at the positions of the permanent support points or in positions such that the induced stresses in the unit will be a minimum.

4.28.5 Purchased units

If the Contractor proposes to purchase precast units from a supplier, he shall ensure that such units comply with the requirements of the Specification and shall carry out any tests that the Engineer may require to check compliance.

Units shall not be obtained from any supplier who refuses free access by the Engineer to the factory to inspect and test materials and workmanship.

4.28.6 Testing units

Precast units shall be capable of safely sustaining the loads that they have been designed to carry. If instructed by the Engineer, the Contractor shall subject units selected by the Engineer to load tests simulating the working conditions. Details of such tests shall be agreed between the Engineer and the Contractor.

In the case of units subject to bending loads the test piece shall be supported at full span and a loading equivalent to 1.25 times the sum of the live and dead loads which were assumed in the design shall be maintained for one hour without the appearance of any signs of distress. The recovery one hour after the removal of load shall be not less than 75% of the full load deflection.

If the unit fails to meet the above, deflection tests shall also be carried out which, on units subject to bending, shall be as follows. The unit shall be supported at full span and a load applied in increments instructed by the Engineer up to 95% of the designed ultimate load. This load shall be held for fifteen minutes without failure of the unit. The deflection at the end of this period shall be not more than 2.5% of the span. The load shall then be further increased until failure occurs.

5 PIPELINES AND ANCILLARY WORKS

5.1 Pipelaying generally

The Contractor shall be responsible for setting out from information provided by the Engineer, and shall include for such work in his excavation rate.

The Contractor shall place temporary chainage markers beside the pipe route at intervals of one hundred metres and at all changes of direction. The Contractor shall maintain all the markers until the end of the Defects Liability Period and shall replace any which become displaced or are destroyed.

Before laying a section of pipeline, sight rails shall be erected at each end and at each change in grade and direction with a maximum distance apart of one hundred metres. Sight rails and boning rods shall be of substantial construction and shall be painted black and white in such a manner as to indicate clearly the lines and levels to be worked to. The Contractor shall include the cost of this work in his excavation rates.

5.2 Pipe bedding and surround

Pipes are to be laid, where directed, on a bed formed with approved selected material carefully and thoroughly compacted over the trench formation. The Compaction Fraction value shall be determined in accordance with the test described in Clause 7.9 of this Specification.

The trench shall be backfilled to the levels indicated on the Drawings with approved selected bedding material thoroughly compacted in 150 mm layers. Should suitable material not be available from the particular excavation material, the Contractor will utilise material from other sections of trench or works, or find a source of suitable material.

Compaction shall be by hand using hand rammers of at least 7 kg mass or with approved mechanical equipment.

Approved selected bedding material shall be well graded granular material free from organic matter and with 100% passing through a 16 mm sieve and 90% passing through an 8 mm sieve.

5.3 Pipeline setting out and alignment

The locations of pipe bends are indicated on the Drawings. Where a pipeline changes direction but no bend is shown, the pipeline shall be laid to a curve by deflecting the pipe at each joint. The maximum deflection shall not exceed that permitted by the manufacturer.

5.4 Concrete protection

Where required by the Drawings or instructed by the Engineer or where the required minimum cover to the pipeline cannot be achieved, the Contractor shall provide a concrete surround in accordance with the details shown on the drawings. The bottom of the trench shall be free of any loose material or debris and graded so that the minimum dimension stated on the Drawings is maintained between the trench bottom and the barrel of the pipe.

5.5 Pipe jointing generally

After the excavation of a section of pipe trench has been completed by the Contractor, it shall be inspected and approved by the Engineer. The Contractor shall then place and thoroughly compact an approved bedding material over the trench formation, after which it shall be inspected and approved by the Engineer. Just before pipelaying, the trench shall be cleaned of all stone, soil and other debris that might have fallen therein. The pipes shall then be laid upon the bed with the bed being shaped to ensure uniform bearing of the whole length of the pipe, which shall include a depression being made in the bed to accommodate each pipe joint. In laying a non-pressure pipe, the work shall commence at the lower end and proceed uphill.

All pipes and fittings shall be examined for flaws, cracks, or any other damage immediately prior to laying, and any defective pipe or fitting shall be rejected and marked with a yellow cross in gloss paint to avoid, by accident, its incorporation into the Works at a later date.

If the Engineer deems the defective pipe as being suitable for use, the defective pipe shall be cut back at least 150 mm beyond any visible flaw and prepared for jointing. In the event of the Contractor opting to salvage pipes in this manner, he shall do so at his own expense and carry out individual testing of the pipes so salvaged outside the trench prior to laying. The foregoing shall all be in accordance with the Manufacturer's instructions and subject to the written approval of the Engineer.

All pipelaying and jointing shall be carried out by experienced pipelayers, well skilled in their work, to the grades, levels and lines shown on the Drawings.

For potable water gravity mains, pumping mains and distribution mains no pipe shall deviate from line by more than ±200 mm, nor by more than ±5 mm from level.

For gravity sewer pipelines, no invert level shall deviate by more than ± 5 mm between manholes, and no horizontal alignment shall deviate by more than ±10 mm between manholes.

Immediately before being laid, each pipe and fitting shall be carefully examined, and all dust, dirt and foreign matter must be removed from the inside. Care shall be taken to ensure that each pipe and fitting remains clean during laying. The use of a badger will be ordered by the Engineer, if, in his opinion, dirt is not being satisfactorily excluded. The badger, on a sound rope, is to remain within the bore of the pipe previously laid and jointed and it is to be drawn forward as the work proceeds throughout the whole length of the pipelines all at the Contractor's expense. The badger used is to be soft material that will not damage the internal surface of the pipes.

Pipes shall mate concentrically with the next to preserve a true and uniform invert. Pipes shall be uniformly bedded and shall not be allowed to rest on the joints or on hard objects in the bottom of the trench.

After bedding to the correct line and level, pipes shall be jointed. The joints shall be those recommended and supplied by the various manufacturers for each class and type of pipe and the method of jointing including expansion gaps between pipes shall be strictly in accordance with the manufacturer's instructions.

Jointing rings and the ends of pipes must be completely free of dirt and grit when the joints are being assembled.

Where recommended by the manufacturer, approved non-toxic lubricant shall be applied evenly over the entire surface of the pipe end and for a distance of 75 mm back to a thickness similar to a brush coat of enamel. The lubricant supplied shall be used directly from the container and shall not be thinned.

Due regard must be given to the thermal expansion of pipelines and where recommended by the manufacturer, or directed by the Engineer, a gap shall be left between adjacent pipe ends when each joint is made. The method of obtaining the required gap shall be determined according to the type of proprietary joint supplied, as indicated by the manufacturer.

HDPE small diameter pipes may be laid to curves, as recommended by the manufacturers.

For the insertion of valves and other fittings and where required, pipes shall be cut and prepared for use as necessary using approved tools and machines suitable for this purpose. Such tools and machines shall be provided by the Contractor and kept available at all times during pipelaying.

The Contractor shall pay particular attention to avoid damaging any protective coatings during laying and jointing operations. Any damage thereto shall be rectified immediately in accordance with the manufacturer's recommendations and to the Engineer's entire satisfaction.

Screwed joints on galvanised steel pipes and fittings shall be properly cut and fully screwed home, using approved jointing compound.

Flanged joints in cast iron or steel pipes and fittings shall have a rubber insertion ring, fitted without twist or distortion. The flanges shall be drawn uniformly together with the bolts fully tightened. No bolts shall be omitted. After jointing, the assembly shall be protected against corrosion with 'Denso' paste, "Denso”-tape and polythene sheeting, or similar approved wrapping, which shall be installed in accordance with the manufacturer's written instructions and to the approval of the Engineer.

Particular care must be taken to avoid contamination from petrochemical products in addition to any toxic substances.

Additional care should be taken to ensure that there is no ingress of soil, sand, stones, water, concrete, cement nor other extraneous material during the laying of pipes and suitable caps or plugs should be used, to cover open ends in the event of a prolonged interruption and on completion of each day's laying. The plugs shall be of the screw-up expanding type or of close fitting tapered wood.

Pipes having integral sockets shall be laid with the sockets facing up-stream unless otherwise agreed or instructed by the Engineer.

No more than two kilometres of untested pipe shall be laid at any one time.

5.6 Supply, transportation and handling of pipes

On delivery to the Site, pipes shall be carefully inspected for damaged ends, defects and any found to be faulty shall be marked and set aside for a decision from the Engineer as to their

acceptability. Any pipes delivered with cracks or other equivalent defects will be rejected and the Contractor shall remove from the Site.

Pipes with damaged ends shall be either completely replaced or have the ends cut off and trimmed at the discretion of the Engineer. They shall be cut to approved standard lengths.

The Contractor shall ensure that all pipes are properly handled both by his staff and by any cartage contractor employed by him. During transport, pipes shall not be allowed to rest on narrow cross-members on vehicles or anything else that might give concentrated loads due to the weight of the pipe or bumping of the vehicle, but shall be properly supported on soft material. Sufficient labour and equipment shall be on hand before loading and unloading is commenced and under no circumstances shall any material be dropped from a vehicle. Any materials that have been dropped from a vehicle shall immediately be rejected for use on the Works. The same shall apply for any pipes found defective before laying.

The handling of any pipes exceeding 200 kg mass other than by means of a crane is specifically forbidden. The Contractor shall maintain a suitable mobile crane on the Site and shall use it for all loading, unloading, transferring between vehicles and lowering into the trench of such pipes. The crane shall be fitted with a sling of ample width. Wire rope slings or hooks in the ends of pipes shall not be used for pipes or fittings of any diameter or mass.

The Engineer shall have the right to reject consignments or stocks of piping from which failed pipes have been drawn, or order them to be pressure-tested outside the pipelines, even though no defects are apparent, if there is reason to believe that mishandling has taken place.

The Contractor shall be wholly responsible for the acceptance from the supplier of all pipes and fittings ordered by the Employer, or Contractor.

After acceptance, full responsibility for the storage, handling, transporting, etc of the pipes and fittings shall rest with the Contractor, and any pipes and fittings subsequently found to be defective in any way shall be replaced by the Contractor at his own expense.

All materials ordered by the Employer shall remain the property of the Employer at all times, and whilst these materials are in the possession of the Contractor the Contractor shall insure the materials as though they were of his own supply.
The cutting of whole pipe lengths for use in closing sections of pipework will not be permitted except with the express approval of the Engineer. Previously cut lengths, which shall be stored separately shall be used, whenever possible, for closing sections. All cuts and the preparation of the ends shall be made strictly in accordance with the manufacturer's recommendations.

All materials ordered by the Employer shall be used under the direction of the Engineer.

Any surplus materials ordered by the Employer shall be transported to the Employer's store at the end of the Contract, or when directed by the Engineer.

5.7 Deviations at joints

Where a pipeline is laid to a curve by changing direction at joints the maximum deflection at each joint shall not exceed the following:

i. for any type of flexible joint, three quarters of the maximum permissible deflection stated by the manufacturer;
ii. for run lead joints in spigot and socket pipes, a deviation which will reduce the clearance between the barrel and the socket to 6 mm or the permissible deflection stated by the manufacturer whichever is the less;
iii. for welded joints in steel pipelines, the deflection shown on the Drawings. The ends of the pipes shall be cut to suit.

No deviations shall be made at flanged or solvent welded joints.

5.8 Painting of pipework in chambers

All metal surfaces within chambers shall be mechanically wire brushed to remove all loose scale, grease etc. Within two hours of cleaning, a primer shall be applied, followed after two hours by a first coat of heavy-consistency bitumen paint all to the approval of the Engineer. A second coat of the heavy consistency paint shall be applied after twenty-four hours. The final coating thickness shall not be less than 250 µm.

Preparation and application of the coating system shall be strictly in accordance with the Manufacturer's instructions.

This clause shall not be applied to chemically or thermally bonded coatings on steel pipes.

5.9 Storage of pipes

Before undertaking any work, the Contractor shall submit to the Engineer, for his written approval, his proposals for the storage of pipes and all fittings thereto.

Such proposals shall ensure that all pipes are properly stored on Site in accordance with the manufacturer's recommendations. During storage, pipes shall not be allowed to rest on narrow cross-members or uneven ground or anything else that might give concentrated loads due to the weight of the stacked pipes, but shall be properly supported on soft material.

All uPVC pipes and fittings shall be continuously protected during storage by covering them at all times with light gauge pale blue polythene sheeting or similar approved material to prevent UV degradation. The height and method of pipe stacking shall be in accordance with the Manufacturer's recommendations and such that excessive deformation of the lower pipes is avoided.

All couplings rings shall be stored lying flat and particular care shall be taken to prevent damage to the internal face of the ring or the spigot ends of the pipes which may affect the sealing of the coupling.

All rubber jointing rings and gaskets shall be stored in a cool dry place away from grease, oil and direct sunlight until required.

All pipework shall be kept well away from possible contamination sources e.g. on site diesel storage.

5.10 Pipes through structures

Where a pipeline passes into or out of a structure, including a manhole or similar chamber, two flexible joints with a short cut length between them shall be provided to the dimensions indicated on the Drawings.

The Contractor shall use cut lengths from his on going stock wherever possible and will not be paid extra for the cutting or preparation of the cut ends, or for the necessary couplings and jointing materials.

The centre of the first pipe joint from the external face of the structure shall be not more than 300 mm for pipes up to and including 500 mm diameter. Provisions for pipes larger than 500 mm diameter shall be as shown on the Drawings.

Where significant settlement may occur, the Engineer may require more than two flexible joints at each location.

5.11 Pipe anchor and thrust blocks

Pipe anchor and thrust blocks, as shown on the Drawings or directed by the Engineer, shall be constructed on pipelines at all bends, tapers, stop ends and slopes greater than 1 in 6.

The Contractor shall ensure that each one is built firmly into the undisturbed bottom and sides of the trench and that the ground is solid and has not been weakened by blasting or softened by water from leakage or other causes. The blocks shall be of concrete Class C20 and shall have been completed and hardened and cured for at least seven days before testing of the pipelines.

Anchor blocks will be measured per cubic metre of concrete required in accordance with the Drawings and the rate shall include for all excavation, rough shuttering and screeding of surfaces.

5.12 Connections to existing pipelines

The Contractor shall give the Engineer at least ten days' notice of the date after which he will be ready to make a connection to an existing pipeline. The Engineer shall notify the Contractor, in writing of the date that the connection shall be made. The date notified shall normally be within seven days of the date when the Contractor will be ready to make the connection.

All branches, valves, connectors, materials and tools for cutting and preparing the pipe and making the connections shall be ready before any work is done on the pipe. The nearest sectional valves shall then be shut off, the pipe drained and the connections made, all as expeditiously as possible to minimise disruption of use of the pipeline. The pipeline shall then be refilled slowly while the connections are checked carefully for satisfactory operation and any remedial works shall be undertaken immediately.

5.13 Fixing of valves

Valves shall be securely fixed with a spindle in a vertical position, unless otherwise stated. They shall be checked for ease of operation and water-tightness. Spindles shall be supported at intervals recommended by the valve manufacturers, but in any case at not less than 1,500 mm intervals.

Before each valve is put into service, all gears, bearings and spindles shall be oiled with an approved oil, as recommended by the manufacturer. No deleterious matter shall be allowed to come into contact with the working faces, and all sumps shall be maintained clean.

Every stuffing box shall be examined when the main is charged with water, and leaking boxes shall be adjusted or repacked with square plaited lubricated hemp packing of approved manufacture. The stuffing box shall not be packed so tightly that the friction of the packing on the spindle is excessive.

No air valve shall be stored in the sunlight, or upside down to expose the balls and air cavities. Air valves shall be checked before the main is charged to ensure that the balls and faces are not scored or split, and that there is no dirt or deleterious material in the cavities of the body. All air nozzles should be checked to see they are clear.

All valves shall be installed with a suitable dismantling joint or isolating valve in case of air valves to enable the valve to be removed from the pipeline. The clear gap provided by the joint shall be not less than 15 mm.

5.14 Valve chambers

Chambers for gate valves, air valves, hydrants and washouts shall be constructed to the details shown on the Drawings and in the positions shown on the Drawings or as directed by the Engineer.

Step irons conforming to BS 1247 shall be of malleable cast iron covered in polyethylene coating and shall be built into the walls of chambers to which permanent access is provided, as the work proceeds. Ladders to BS 4211 may be used in place of step irons if agreed with the Engineer.

Covers and frames shall be provided as shown on the Drawings. The tops of the covers shall be flush at all points with the surrounding surface of paved areas or as directed in unpaved areas. Any slight adjustment of the slab level that may be necessary to accomplish this shall be effected by topping the side walls with concrete.

Where any pipes are built into concrete or blockwork the pipe shall be surrounded in two layers of polythene sheeting unless a puddle flange has been shown on the Drawings.

5.15 Manhole covers, valve boxes, step irons and ladders

Manhole covers Shall be as indicated in the BoQs or as shown in the drawings.

Valve (stopcock) boxes shall be square with hinged lid, nominal size 150 mm x 150 mm. Where lockable covers are required, the locks shall be flush-mounted, integral with the lids.

Fire hydrant covers shall be manufactured in accordance with BS 750 and be suitable for medium heavy duty. They shall be 610 mm by 305 mm clear opening, marked with the letters FH and incorporate a lift-out cover chained to the frame.

Manhole covers and frames, valve surface boxes and fire hydrant covers shall be painted after installation with bitumen paint in accordance with Clause 5.8 of this section of the Specification.

Step rails shall be constructed of 16 mm diameter bars as indicated on the Drawings. Step rails shall be spaced at 300 mm centres.

Permanent ladders shall be of galvanised mild steel and shall be in accordance with BS 4211. Rungs shall be 20 mm diameter solid round bar and shall be at 300 mm centres. Stringers shall be 65 mm x 10 mm strip set 300 mm apart, shall extend I.0 m above the top rung and shall be turned out at the bottom and drilled for 12 mm stainless steel holding down bolts. Intermediate and top support stays shall be l00 mm x 100 mm strip, bolted to the stringers with 12 mm galvanised bolts and shall be of a length that will give a minimum clearance of 200 mm behind the rungs. Support stays shall have a maximum spacing of 2.5 m.

Ladders exceeding 4.0 m height shall be equipped with a safety cage consisting of hoops of 50 mm x 8 mm strip bent to a diameter of 0.76 m, fixed to the stringers at 0.55 m centres and joined by one additional stringer of 50 mm x 8 mm strip at the maximum distance from the rungs.

5.16 Manholes

5.16.1 General requirements

Manholes shall be constructed to the sizes and levels and of the materials indicated on the Drawings, taking into account also the requirements of this Clause. Ladders, step irons and other fixtures shall be in accordance with Clause 5.15 or as detailed on the Drawings.

Unless otherwise agreed by the Engineer, manholes shall be constructed after pipes have been laid, except that bases may be constructed earlier to avoid deterioration of the formation.

Backfilling around completed manholes shall be with suitable material deposited equally all round and compacted in layers not exceeding 300 mm.

5.16.2 Manhole bases

Precast bases shall be carefully set and levelled on a sub-base of 150 mm of compacted granular bedding.

In situ concrete bases shall be cast on a firm formation from which soft areas have been removed. If the base includes reinforcement, a preliminary blinding layer of concrete 50 mm thick shall be placed.

5.16.3 Brick manholes

Bricks for manholes shall be either an engineering class brick or a sound, hard, low permeability brick complying with BS 3921 and approved by the Engineer.

Bricks shall be laid on a full bed of 1:3 cement/sand mortar and all cross joints shall be filled. Bricks shall be laid with frogs up. Joints on the inside faces shall be flush pointed as the work proceeds unless the faces are to be rendered in which case the joints shall be raked out to a depth

of five millimetres. Rendering shall consist of 1:2 cement/sand mortar applied to the thickness shown on the Drawings.

5.16.4 In Situ concrete manholes

Formwork for interior faces shall be Class F2. Exterior faces may be cast against formwork or against natural ground. In-situ concrete manholes shall be constructed generally in accordance with Section 5 of this Specification.

5.16.5 Precast concrete manholes

Precast manhole rings shall comply with BS 5911.

Rings shall be set on a generous layer of 1:2 cement/sand mortar applied to the top of the previous ring. After setting the ring into place, surplus mortar shall be removed and both sides of the joint flush pointed.

All precast concrete manholes that fall within a road reserve are to receive a 150 mm concrete surround as shown on the Drawings.

Where a concrete surround is called for on the Drawings it shall not be placed until the mortar in the joints of the manhole rings is at least three days old at temperatures above $10^{o}C$, and proportionately older for lower temperatures.

5.16.6 Manhole covers and frames

Covers and frames shall be the type, size and weight shown on the Drawings. Frames shall be set in 1:3 cement/sand mortar to the levels indicated on the Drawings. Level differences shall be made up by not more than three courses of brickwork between the frame and the roof of the manhole or shaft.

Care shall be taken to see that frames do not suffer any distortion and that the cover will seat without any rocking.

For each type of cover installed, the Contractor shall supply five sets of lifting keys.

5.16.7 Benching in manholes

Where required by the Drawings, benching shall be formed with concrete placed semi-dry and formed to the required shape.

The benching shall then be finished by rendering in 1:2 cement/sand mortar. All surfaces shall be perfectly smooth with easy sweeps to minimise the risk of solid matter lodging on them.

5.17 Sealing of cable ducts

As shown on the Drawings or directed by the Engineer, cable ducts and similar openings into buildings or structures are to be sealed with a combination of expandable foam and outer sealant to prevent the ingress of water or vermin into such buildings and structures.

Surfaces for treatment shall be clean and grease free and porous surfaces shall be sprayed with water to ensure full curing of the expendable foam.

Expandable foam shall be applied and allowed to be cured in accordance with the manufacturer's recommendations.

Any accidental spraying of existing or new Plant with expendable foam shall be cleaned using acetone or other approved cleaner, in accordance with the manufacturer's recommendations and all at the Contractor's expense.

Health precautions shall be taken during the application of the expendable foam in accordance with the manufacturer's recommendations.

After the expendable foam has cured, an outer sealant is to be applied to the exposed surfaces of the plug formed by such foam. The sealant shall be a silicone-based building sealant.

6 BUILDING AND MISCELLANEOUS WORKS

6.1 Stonework

6.1.1 Stones

Stone for all purposes shall be the best of its kind, sound and durable, free from flaws and from soft, weathered or decomposed parts. The stone and the quarry from which it is obtained shall be subject to the approval of the Engineer, samples shall be submitted by the Contractor of the stone he proposes to use in the Works and the Engineer's approval shall be obtained before such stone is used or any order is placed. The stone used shall be clean and must be washed if deemed necessary in the opinion of the Engineer.

Stones for face work shall be as far as possible be quarry split. A moderate amount of dressing to trim off large projections will however be permitted. Exposed faces of stones for masonry shall be free from tool marks except such as are inherent in the nature of any dressing that may be specified. In rock-faced work the roughness on the surface shall not project more than 40 mm for stone less than 0.3 m^2 face area and not more than 60 mm for large stones.

6.1.2 Stone Masonry

Masonry shall be built to the lines and levels shown on the Drawings.

For face work the stones shall show a face of not less than 0.025 m^2 and not more than 0.1 m^2 in area and none shall be less than 100 mm in depth; they shall be laid to give a uniformly random appearance and shall be selected in laying so as to present an even distribution of large and small stones on the face.

For the arises, stones shall be roughly squared, quarry split and of a size to give out bands varying from 300 mm to 500 mm in length and in bands from 150 mm to 250 mm. The alignment of arises shall be set true to the required lines.

The stones shall be set in mortar with their natural bedding plane (if any) as near normal as possible to the face or normal to the line of thrust in the case of load bearing structures. Particular care must be given to obtaining a sound bond both longitudinally and transversely and there shall be at least one bonder, or length not less than two-thirds of the wall thickness, in each square yard of wall face.

The mortar, unless otherwise specified, shall be machine mixed cement and sand in the proportion of one part to three (1:3) parts generally as described in the specification. Mortar shall completely fill all interstices between the stones.

The face joints in rubble masonry may vary in thickness from 10 mm to 20 mm. They shall be finished as a neat weathered joint with mortar while the work proceeds where the masonry is specified to be "un-pointed". Where pointing is specified, the joints in each day's work shall be raked out to a depth of not less than 25 mm before the mortar has set. Subsequently the joint shall be filled with mortar and finished in accordance with Clause 4.6. The face of the masonry is to be kept wet while the pointing is proceeding. Provision shall be made to clean all exposed

faces both as work proceeds and on completion so that they are left in a neat, tidy and clean condition.

Building of masonry will not be allowed in heavy rain without the written consent of the Engineer. Building shall only proceed when suitable precautions to the satisfaction of the Engineer shall be taken against the action of rain on newly placed mortar. If for any reason of urgency the consent of the Engineer should be desired to a departure from these provisions, the Contractor shall submit to the Engineer for approval their proposals for protecting the materials and work from the weather.

6.1.3 Types of Masonry

The arrangement of the stones on the exposed face or faces of the masonry shall be as described below according to which type is called for on the Drawings.

(a) Random rubble un-coursed masonry shall be built with stones of irregular shapes taken generally as they come from the quarry, preparation being limited to the removal of inconvenient corners and excrescences. They shall be selected as the work proceeds to give a uniformly random appearance and no attempt shall be made to form courses.

(b) Random rubble masonry brought to courses shall be generally as the preceding type except that it shall be levelled up to courses between 300 mm to 400 mm in depth and coinciding with the quoin stones.

(c) Squared rubble coursed masonry shall be built in courses between 100 mm to 250 mm in depth of stones squared to rectangular shapes and selected so that all stones in one course are of approximately the same height.

6.1.4 Bedding of Stone Masonry

Unless otherwise directed by the Engineer, all masonry stones, when incorporated in the Works shall be laid on its natural bed, except in the case of arches where the natural bed shall be radial.

6.1.5 Special Stonework

Special stonework shall consist of approved stones dressed to the shapes and dimensions and with the faces tooled, all as shown on the Drawings. All stones shall be laid true to line and centre with mortar joints as shown on the Drawings.

6.1.6 Pointing of Joints in Masonry

Unless otherwise shown on the Drawings, pointing to masonry joints shall be flush and shall be formed by raking the joint clean and then filling it with pointing consistency mortar which shall be given a flush face with a steel trowel.

6.1.7 Hand Placed Rubble Filling

Hand placed rubble filling shall consist of stones individually selected and placed by hand firmly in place in bearing contact with each other or with the sides of the space to be filled; the voids shall be carefully filled with small rocks and spalls wedged together to form a compact mass.

The sides of stones shall be roughly trimmed if necessary with a spalling hammer to obtain a reasonably close fit. On the exposed face the stones shall be placed with their flattened sides uppermost and in the plane of the face.

6.1.8 Tipped Rock / Pitching

Rock protection on embankment slopes and around structures shall be to the lines and levels shown on the contract Drawings. The terms "tipped rock" and "pitching" refer to the manner in which the rock is placed.

The different classes of rock are specified on the Drawings according to nominal size and the maximum and minimum size of the individual particles. Within the size limits of each class, the rock fragments shall be well graded with not more than forty per cent (40%) of the rocks being smaller than the stated nominal size. The shape of the rock shall be roughly uniform with no dimension less than sixty percent (60%) of the largest dimension. The individual rock pieces shall be dense, durable and abrasion resistant.

The Contractor shall submit bulk samples of not less than 2 m^3 of each class of rock for approval by the Engineer prior to placing. These samples shall be retained for comparison with material being placed in order to ensure a reasonable degree of uniformity within each class.

The base on which rock protection is to be placed shall be compacted and trimmed to the lines and levels shown on the drawings. Where two or more classes of rock are specified, the lower layers shall be completed to the Engineer's approval before the placing of subsequent layers.

Tipped Rock shall be tipped directly into place and roughly trimmed to the required profile. The thickness, lines and levels of each class of tipped rock is shown on the Drawings.

Pitching will be used where a finished horizontal or inclined surface is required. It shall consist of hand placed stones, with spalls wedged into the interstices to produce an even surface, without projection above the neat lines shown on the Drawings. Care shall be taken to ensure that the stones are well bedded and the percentage of spalls shall not exceed forty percent (40%) of the total rock volume. Pitching on slopes shall be built upwards from the toe, unless otherwise directed by the Engineer. A coping consisting of large flat stones shall be laid along the top of stone pitching on slopes to produce a firm edge.

Tipped Rock and Stone Pitching shall consist of selected hard durable rock free from weathered or decomposed parts to the approval of the Engineer, containing no flaky stone and being well graded within the limits shown below. The thickness of the layer shall be as shown on the drawings.

Tipped rock / stone pitching shall be placed in an approved manner in order to produce a uniform well knit un-segregated layer in which all sized are held in position.

6.1.9 Gabions

Gabions shall be of the types and sizes shown on the Drawings. The cages shall be constructed from mild steel wire complying with BS 1052, "Specification for mild steel wire for general engineering purposes", galvanised in accordance with BS 443, "Specification for testing zinc

coatings on steel wire and for quality requirements". The wire shall be 3mm diameter formed into a fabric having a mesh of 75 mm x 100 mm for baskets and 60 mm x 80 mm for mattresses.

Stone filling for gabions shall consist of hard durable rock, free from weathered or decomposed parts. The minimum dimensions of each stone shall not be less than half its maximum dimension. For mattresses the stone shall be 200 mm to 150 mm for baskets the stone shall be 300 mm to 200 mm. The stone shall be obtained from a source approved by the Engineer. No stone shall be smaller than the size of the gabion mesh. In carrying out the filling, selected pieces of stone of elongated shape shall be placed with their flatter and elongated faces in contact with the mesh wherever possible.

The empty gabions shall be placed to line and level as shown on the Drawings or as directed by the Engineer and then stretched so that the gabions regain their shape on being filled. Diaphragms shall be provided at not more than 1m intervals for baskets and not more than 0.6 m intervals for mattresses. A gabion shall not be completely filled until the adjacent basket or mattress has been half filled, unless otherwise directed, in order not to cause displacements from bulging during filling.

For baskets at least two horizontal connection wires shall be tied between front and back of the gabion in each 1m compartment, at a height of 300 mm and 600 mm from the bottom as the stone fill reaches these levels. Additional tie wires shall be provided if necessary and in no case shall the gabion basket bulge by more than 40 mm. Where a continuous line of gabions is required, adjacent gabions shall be securely tied together at the top and bottom of the gabions with tying wire.

The gabions shall be filled to a level just sufficient to require the lid to be forced into place with a bar. The lid and all joints between baskets and between diaphragms and baskets shall each be tied down with a continuous running wire.

Where gabions are to be shaped, the shape shall be formed by folding the mesh internally and tying it with a continuous running wire.

All tying wire shall be galvanised and of same gauge as specified for the cages above.

The surface upon which gabions are to be laid shall be compacted to a minimum dry density of 95% of the maximum dry density (AASHTO T99).

6.1.10 Hardcore

Hardcore shall consist of broken rock, concrete or other approved hard material, clean and free from extraneous matter, having a maximum particle size of 100 mm. It shall be spread and levelled, watered and compacted, and then blinded with a layer of fine material of grading 3 mm to dust, watered and compacted all to the Engineer’s approval.

6.2 Damp proofing

Damp proof courses shall protrude beyond the outer face of the wall for a minimum of 25 mm, the last 10 mm of which shall be turned down on an approved profile to form an anti-ant lip. The material shall be laid on a cement screed trowelled smooth. At all angles, intersections etc. the material must be lapped not less than 75 mm.

A damp proof membrane of 500 gauge polythene shall be laid under floor slabs where indicated on the Drawings or directed by the Engineer and shall have laps of not less than 200 mm at all joints.

6.3 Bonding to concrete

All doorframes shall be fixed with holdfasts screwed to the frames one end and built into blockwork or concrete at the other end. Alternatively, holdfasts may be formed as an integral part of metal doorframes. Doorframes shall have three holdfasts at each side.

The holdfasts shall be of 6 mm x 25 mm galvanised wrought iron 200 mm long, one end turned up, twice drilled and countersunk for screwing to frames with stout screws and the other end formed swallowtail for building into brickwork etc.

Bonding ties shall be of 6 mm x 15 mm galvanised wrought iron 150 mm long with both ends formed swallowtail for building into blockwork, etc.

6.4 Blockwork walling

Blocks for walling shall be properly bonded together and in such manner that no vertical joint in any one course shall be within 100 mm of a similar vertical joint in the courses immediately above or below.

Alternate courses of walling at all angles and intersections shall be carried through the full thickness of the adjoining wall. All perpends, reveals and other angles of walling shall be built strictly true and square.

The blocks shall be bedded and jointed in 1:3 cement/sand mortar with beds and joints not more than 20 mm or less than 12mm thick, all flushed up and grouted solid as the work proceeds. All walling shall be properly protected as the mortar is setting.

Ends of lintels, sills, joints, roof trusses, etc. shall be built in and bedded solid in mortar. They shall bear 300 mm on supports and shall be cast with a recessed throating under the front edge. Block walls shall be pinned up to the underside of concrete beams and slabs with cement.

Timber frames shall be built in with holdfasts and bedded solid and pointed both sides in cement mortar. Lugs of window frames shall be built in or cut and pinned to blockwork. Frames shall be bedded solid in mortar and pointed in approved mastic applied with a caulking gun externally. All holes for pipes, electrical conduits, etc. mortises for bolts, dowels, etc. shall be cut or formed grouted up in cement and made good.
Horizontal reinforcement consisting of approved fabric shall be provided in every third course to span between the vertical block reinforcement. A proprietary wall reinforcement system may be used with the Engineer's approval.

At corners and junctions of walls, all horizontal reinforcement shall be lapped 300mm. The cavities of the blocks shall be filled with 1:3 cement/sand mortar around a mild steel reinforcing bar.

External faces of blockwork shall be rendered with 12 mm thick 1:5 cement/sand mortar to BS 5262 with a woodfloat finish.

Internal faces of blockwork shall be plastered to BS 5492 with an undercoat to suit the blockwork surface. The total thickness shall be 20 mm.

Openings through walls shall be formed to the net size required and rendered smooth in cement mortar. Where openings occur in cavity walls the wall shall be built solid all round the opening.

6.5 Painting

6.5.1 Delivery and storage

All materials are to be delivered to the site in the manufacturers' original containers with seals unbroken and are to be clearly marked with the manufacturer's name or trade mark and a description of the contents, colour or pattern, and, if applicable, the conditions for storage and the date by which they shall be used.

All materials are to be stored at Site in accordance with the manufacturer's directions and to the satisfaction of the Engineer.

6.5.2 Materials samples and tests

During the course of the work, the Engineer may take samples of any of the paints, varnishes, stains or sealers, either from the sealed or open containers, before or during use.

When requested by the Engineer to do so, the Contractor shall submit samples for testing in accordance with BS 3900. The costs of such test, including transport and incidental costs, shall be borne by the Contractor if the results show non-compliance with the Specification.

Any work executed with materials tested and found not to comply with the requirements of the Specification shall be burnt off or otherwise removed and re-executed as directed by the Engineer.

6.5.3 Workmanship

Before painting, varnishing, staining or sealing is commenced; every possible precaution shall be taken to keep down dust.

During the execution of painting and decorating work, the Contractor shall take all necessary precautions to protect the health and safety of the workmen, including provision of washing facilities. The Contractor shall comply with all statutory rules and regulations affecting the trades engaged on the work.

Only skilled workmen shall be employed. A properly qualified foreman shall be constantly in attendance on the work while it is proceeding.

All brushes tools and containers used in carrying out the work shall be clean and free from foreign matter and shall be thoroughly cleaned before being used for a different type of material.

An ample supply of dustsheets shall be provided to protect the work as it proceeds.

Unless the manufacturers instruct otherwise, all liquid materials shall be thoroughly stirred before use. Where necessary the liquids shall be strained to remove any skin before application.

All containers shall be kept securely covered with tight fitting lids when not in use.

No dilution of liquid materials will be allowed, except as recommended by the manufacturer or as otherwise permitted by the Engineer.

The Contractor shall arrange his work so that any treated surfaces to be subsequently covered up shall be treated before they become inaccessible.

The painting work shall be carried out in accordance with BS 6150 and all painting varnishing, staining or sealing shall be executed in dry conditions when relative humidity is less that 80%. No such finishes shall be applied to surfaces structurally or superficially damp and all surfaces must be ascertained to be free from condensation, dust, oil or any other foreign matter before application of each coat.

The tints of undercoats are to approximate to those of the finishing colour but in order to indicate the number of coats applied, a difference is to be made in the shade of each succeeding coat.

Primed or undercoated work shall not be left in an exposed or otherwise unsuitable situation for too long a period before completing process.

Rubbing down before application of the final coats shall be by means of the wet process with waterproof glass paper. Preliminary coats of paint shall be lightly rubbed down with fine sandpaper before the next coat is applied.

Finishing coats shall be applied evenly over the whole surface to give a solid film free from brush marks, sags, runs, orange peeling or other defects.

The Contractor shall clean down all paintwork on completion, remove all marks due to spill and leave all painted surfaces to the complete satisfaction of the Engineer.

6.5.4 Samples of workmanship and colour

The Contractor shall prepare samples of the different finishes on the appropriate backing material, with the correct priming and undercoats where applicable, for acceptance by the Engineer, including alternatives as directed. These samples shall be prepared at least twenty-eight days before commencement of the actual work.

6.5.5 Preparation of surfaces

(a) General

All surfaces shall be thoroughly prepared and shall be clean, free from loose dirt or other impurity. No paint shall be applied until all surfaces are thoroughly dry.

Preparation of the different materials to receive decorative and protective finishes shall be as specified below.

(b) Concrete and concrete blockwork

Surfaces shall be brushed down thoroughly to remove all dust and loose material. Mortar droppings and nibs shall be removed and defects made good.

Efflorescence shall be brushed off as it appears and all decoration deferred until it ceases.

(c) Plaster and rendering

Surfaces shall be brushed down to remove loose material and dust. The surface shall be washed, where directed, with a minimum of warm water and detergent, and allowed to dry.

Minor defects, cracks and holes, after cutting out as necessary, shall be made good and rubbed down flush with the surrounding surface.

Efflorescence shall be brushed off as it appears and all decoration deferred until it ceases.

(d) Hardwood

All surfaces shall be rubbed down smooth with fine abrasive, and dusted off. No further preparation is required for wood to be stained or clear sealed.

(e) Iron and steelwork

Bare iron and steelwork to be painted shall be thoroughly prepared by removing all grease, dirt, rust and loose millscale.

All tools shall be operated in such a manner that no sharp ridges or burrs are left and no cuts made in the steel.

Dust and other loose material shall be removed after cleaning. Oil and grease shall be removed with white spirit.

The priming coats shall be applied before any contamination or rusting occurs.

If the surfaces have been exposed to salt spray laden winds or to atmosphere polluted with chemicals, they shall be thoroughly washed with fresh water and allowed to dry before priming.

Steelwork delivered primed is to be thoroughly washed down to remove all dirt and grease. All defective paint, damaged, blistered, crazed or not firmly adhering, etc. shall be removed by scrapping back to a firm edge or, if necessary, the surface shall be completely stripped. All such areas shall be patch-primed immediately upon delivery. Areas damaged during erection shall be similarly dealt with.

(f) Galvanised iron and steel

Galvanised iron and steel surfaces shall be thoroughly cleaned to remove all grease, dirt, dust etc.

6.5.6 Priming

(a) General

Before priming, painting, varnishing, staining or sealing is started; all possible precautions shall be taken to keep down dust.

All metal fittings and fastenings shall be removed before the preparatory processes are started. They shall be cleaned and refixed in position on final completion of the work.

(b) Special priming

Unless the paint manufacturer recommends otherwise the following materials shall receive special priming:

i. Cement based surfaces, such as concrete, fair face blockwork and brickwork, render and plaster, and asbestos free boards containing cement which are to receive oil based paints, shall be treated with an alkali-resistant primer.
ii. Galvanised iron and steelwork shall be treated with calcium plumbate or a two-pack etching primer.
iii. Copper shall be treated with a suitable etching primer.
iv. Hardwood shall be treated with aluminium primer.
v. The smooth face of hardboard shall be treated with specially formulated hardboard primer.

All uncoated iron and steelwork cleaned of rust, millscale, etc., in preparation for painting shall be primed within twenty-four hours of preparation whether at the works or on Site.

6.5.7 Painting

Concrete surfaces are to receive one coat of undercoat and two coats of approved plastic emulsion.

Iron and steelwork are to receive one coat of red lead primer, two coats of undercoat and one coat of high gloss finish.

All wooden surfaces are to be primed with aluminium wood primer and are to receive two coats of exterior grade undercoat and one coat of exterior or interior, as appropriate, high gloss finish.

6.6 Plumbing

Galvanised malleable iron brackets shall be used for fixing galvanised steel pipes up to 50 mm diameter. Pipes larger than 50 mm diameter shall be fixed with galvanised iron or brass hinged holderbats. For fixing to timber, stout galvanised pipe clips screwed to the timber shall be used.

Drainage pipes shall be encased with 150 mm surround of Class C20 concrete beneath floor slabs.

6.7 Workmanship in timber

All joiner's work shall be wrought and finished with a clean even and smooth surface, arrises straight and cleanly cut, and all to be properly framed together, single or double mortised, and tenoned, housed, dovetailed or fitted with all proper and suitable joints whether these are shown on the Drawings or not, and all joints shall be fitted without stopping, the whole being glued, feathered, tongued and fixed with screws, nails etc. all detailed on the Drawings or as approved by the Engineer and in accordance with the best class of workmanship.

Adhesives used for timberwork shall be synthetic resins of the phenol and amenoplastic type BR in accordance with BS 1204 Parts 1 and 2.

Nails for joinery shall be oval lost head nails.

Screws shall be countersunk wood screws. Steel screws shall be used only in concealed positions, or where the work is to be painted, elsewhere brass shall be used. Steel screws in contact with aluminium shall be dipped in zinc chromate solution before fixing. Ironmongery is to be fixed with screws of the same metal, except for aluminium, which shall be fixed with chromium, plated brass screws.

All joinery shall be properly protected from injury or from weather by casing wherever required.

6.8 Wooden doors

6.8.1 General

The materials used in the construction of wooden doors shall be in accordance with BS 459. Doors shall be obtained from an approved manufacturer and the details and methods of construction shall be to the Engineer's approval.

6.8.2 Flush doors

Flush doors shall be 45 mm thick overall, faced both sides with 4mm plywood and lipped on all edges with 10 mm thick hardwood. External doors shall be faced both sides with exterior quality plywood and assembled with waterproof adhesive to type MR of BS 1203. Suitable blocking pieces for door furniture shall be built in. Glazed vision panels shall be inserted as shown on the Drawings and shall be to the approval of the Engineer.

Cupboard doors shall be as above but 40mm thick overall.

6.9 Door and window furniture

Each door shall be provided complete with all hinges, handles, locks, three keys per lock, bolts, doorstops etc. and all necessary screws, bolts and other fixings. Double leaf doors shall be provided with barrel bolts top and bottom of the first closing leaf, complete with flush mounted floor socket, and handle for the top bolt extended to 2.0 m above floor level.

Windows shall be provided with all necessary hinges, fasteners, locks, catches, stays, etc.

6.10 Glazing

Glazing shall be clear or obscured glass, set in metallic putty and shall be subject to the approval of the Engineer. Clear glass shall be used for all windows except in toilets or as otherwise directed by the Engineer. Glazing shall be carried out in accordance with BSCP 152 "Glazing and fixing of glass in buildings", and the window manufacturer's instructions.

6.11 Proprietary sheet metal roofing

The fixing of all proprietary roof sheeting, etc. shall be in accordance with the manufacturer's details and as shown on the Drawings.

6.12 Bituminous felt roofing

Bituminous roofing felt shall be laid in accordance with BSCP 144 Part 3. Before laying roofing felt the underlying concrete surface shall have any cracks and expansion joints sealed with a bituminous patching compound. A slip membrane comprising one layer of one ply roofing felt shall be laid and adhered to the concrete at all edges.

Two underlayers of two ply roofing felt shall be applied with 100 mm overlaps between strips, bonded with bitumastic compound at all edges. The overlap joints between successive layers shall be staggered to half the strip width.

A surface layer of grey mineralised surface felt of an approved colour shall be laid with 100 mm overlaps, fully bonded with hot applied bitumen compound.

6.13 Guttering

Gutters shall be laid to falls as directed. The general arrangement of the drainage system shall be to the Engineer's approval.

6.14 Fencing and gates

Wire and metal posts used in compound boundary fences and gates shall be of galvanised steel to the details shown on the Drawings.

Posts, stays and gates shall be primed with one coat of zinc chromate paint and finished with two coats of oil based aluminium paint.

The whole of the fencing shall be to a pattern approved by the Engineer.

6.15 Ladders

Unless otherwise indicated permanent ladders shall be of mild steel and shall be in accordance with BS 4211. Rungs shall be 20mm diameter solid round bar and shall be at 300 mm centres. Stringers shall be 65 mm x 10 mm strip set 300 mm apart shall extend 1.0 m above the top rung and shall be turned out at the bottom and drilled for 12 mm holding down bolts. Intermediate and top support stays shall be l00 mm x 100 mm strip, bolted to the stringers with 12 mm bolts and shall be of a length that will give a minimum clearance of 200 mm behind the rungs. Support stays shall have a maximum spacing of 2.5 m.

Ladders exceeding 4.0 m height shall be equipped with a safety cage consisting of hoops of 50 mm x 8 mm strip bent to a diameter of 0.76 m, fixed to the stringers at 0.55 m centres and joined by one additional stringer of 50 mm x 8 mm strip at the maximum distance from the rungs.

All components of ladders shall be galvanised after cutting, drilling and welding and all fixing bolts, nuts washers, etc, necessary to complete the installation shall be provided.

Ladders to insides of water retaining structures shall be galvanised mild steel.

6.16 Open mesh steel flooring

Open mesh flooring shall be to BS 4592 and shall be painted black in accordance with the Specification.

Kicker plates 100 mm high shall be provided round all openings.

6.17 Chequer plate flooring

Chequer plate flooring shall be of mild steel and manufactured with diamond chequering or other non-slip pattern. The plates shall be of sufficient thickness not to bend or spring in ordinary usage and shall be fitted evenly and truly into steel angle frames or curbing with suitable attachments for building into concrete flooring.

The plates and frames shall be painted an approved colour in accordance with the Specification.

6.18 Handrailing

Handrailing shall be designed and manufactured in accordance with Handbook No.7 (revised 1973) published by the Engineering Equipment Users Association. It shall consist of 38 mm diameter galvanised steel sections of tubing BS 1387, screwed at each end. The sections shall be joined by 38 mm diameter galvanised steel equal crosses, equal tees or short radius 90^{o} bends where appropriate, such that the top rail shall be 1 m and the lower rail 0.5 m above the concrete slab, and the spacing between standards shall be 2 m maximum. A 38 mm diameter galvanised steel flange shall be screwed to the base of each standard and drilled for four 20 mm diameter, 100 mm long mild steel rag bolts which shall be cast into the reinforced concrete slab.

All handrailing components shall be galvanised after cutting, screwing and drilling and shall be supplied complete with all bolts, nuts, washers and other fixings necessary to complete the installation.

6.19 Removal of anthills

Anthills that come within the area covered by the building and three metres clear all round shall be entirely removed and the queen eradicated. The cavity formed by the removal of the nest must be treated as described under Clause 6.26, filled in with approved materials in layers not exceeding 300 mm thick well rammed and consolidated.

6.20 Ant proofing

No ant treatment is to be carried out near potable water structures. Otherwise ant treatment is to mean the treatment of the whole of the surface under floors with a solution composed of 5 parts by weight of Pentachlorophenol to 95 parts by weight of furnace oil well mixed together.

The solution is to be applied by means of a watering can with a fishtail spout. It is to be accurately applied at the rate of five litres per square metre of surface.

Before and after the application the surface is to be cleaned free from foreign matter, particularly scrap timber and cellulose material.

7 TESTING

7.1 Testing requirements for cement

7.1.1 Acceptance testing

The testing requirements referred to in the Specification are detailed in BS 4550. The tests that are required for acceptance testing are:

i. Fineness: the specific surface shall not be less than 225 m^2/kg for ordinary Portland cement nor 325 m^2/kg for rapid-hardening Portland cement.

ii. Chemical composition: to be within the limits set out in KS EAS 12:2014 or equivalent.

iii. Setting time: the initial setting time shall not be less than forty-five minutes and the final setting time shall not be more than ten hours.

iv. Soundness: expansion shall not exceed 10 mm

v. Heat of hydration: the heat of hydration shall not exceed 250 kJ/kg at seven days, nor 2990 kJ/kg at twenty-eight days.

vi. Compressive strength: to be determined using either concrete cubes or mortar cubes. The strengths required are:

	Ordinary Portland Cement	**Rapid-hardening Portland Cement**
Concrete cubes – 3 days	13 MPa	18 MPa
Concrete cubes – 28 days	29 MPa	33 MPa
Mortar cubes – 3 days	23 MPa	29 MPa
Mortar cubes – 28 days	41 MPa	46 MPa

7.1.2 Compliance testing

When cement is re-tested, the tests to be carried out are iii and xi above.

7.2 Determination of shell content of aggregates

7.2.1 Shell content of coarse aggregates

From the material, previously dried overnight at 105 ^oC, a representative sample of about 1,000 g, obtained by coning and quartering, shall be weighed and spread out on a sheet of black paper. The pieces of shell shall be separated by careful hand picking and weighed.

The shell content is calculated as:

Shell content, per cent = 100 x weight of shell / weight of sample

7.2.2 Shell content of fine aggregates

About 1,000 g of aggregate, previously dried overnight at 105 ^oC, are ground to pass a 25 mesh BS sieve. By suitable division methods, e.g. riffling or quartering, a representative sample of 15 – 20 g is selected and further ground to pass a 100 mesh sieve. Of this material, 1 g is accurately

weighed into a 250 ml conical flask and 50 ml of distilled water and 20 ml of 0.5 N hydrochloric acid are added.

The mixture is boiled gently for three minutes and allowed to cool. Six drops of phenolphthalein indicator solution are added and the excess acid is titrated with standard 0.5 N caustic soda to a permanent pale pink colour.

The shell content is calculated as:

Shell content, per cent = 2.502 x (20 – B)

Where B is the amount of 0.5 N caustic soda, in millilitres, required to neutralise the excess hydrochloric acid.

7.3 Test for presence of organic impurities in aggregates

A 350 ml graduated bottle is filled to the 120 ml mark with a sample of the aggregate to be tested. A 3% solution of sodium hydroxide in water is added until the combined volume of aggregate and liquid is 200 ml. The bottle is stoppered, shaken thoroughly and allowed to stand for twenty-four hours. If after twenty-four hours the colour of the solution is no darker than pale brown, the aggregate under test may be deemed satisfactory.

7.4 Magnesium sulphate soundness test for aggregates

7.4.1 Purpose of test

This test is to determine the susceptibility of aggregates to deterioration by weathering.

7.4.2 Apparatus

i. A set of BS sieves: 75, 37.5, 20, 10, 5, 2.36, 1.18 mm, 600, 300 µm.

ii. A balance with capacity of 500 g accurate to 0 1 g for fine aggregates and a second balance with capacity of 10 kg accurate to 5.0 g for coarse aggregates.

iii. Drying oven capable of maintaining a temperature of 110ºC ± 5ºC and fitted with a fan for air circulation.

iv. Specific gravity bottle or other means of measuring specific gravity of solutions.

v. Saturated solution of hydrous magnesium sulphate (Epsom salts) obtained by adding about 1,400 gm of the salt to each litre of water at 30ºC. After solution has apparently ceased the liquid shall be cooled to 2OºC and allowed to stand for 48 hours. The specific gravity shall be between 1.295 and 1.308.

7.4.3 Preparation of samples

(a) Fine aggregate:

The aggregate shall be thoroughly washed on a 600 µm BS sieve and then dried to constant weight at 110ºC. The sample should then be sieved to refusal on BS sieves 5 mm, 2.36 mm, 1.18 mm, 600 µm and 300 µm to an extent that at least 100 g is available

at each size except on 5 mm. Weigh out 100 g ± 0.1 g from the fraction retained on 2.36 mm, 1.18 mm, 600 µm and 300 µm sieves and place each in a separate container.

(b) Coarse aggregate:

The aggregate shall be thoroughly washed and dried to constant weight at 110°C. It shall then be sieved to BS refusal on sieves listed below, the samples weighed out as shown. Each sample should be placed in a separate container.

Fraction	Weight required
75 mm – 37.5 mm	5 kg ±300 g
37.5 mm – 20.0 mm	1.5 kg ± 50 g
20 mm – 10 mm	1.0 kg ± 110 g
10 mm - 5 mm	0.3 kg ±5 g

7.4.4 Procedure

The samples shall be immersed in the prepared solution of magnesium sulphate for not less than sixteen hours but not more than eighteen hours so that the solution covers them by 10 mm. The containers shall be covered to reduce evaporation and maintained at 21°C ±10°C for the stated period.

At the end of the immersion period the aggregate sample shall be removed from the solution, allowed to drain for fifteen minutes and then dried to constant weight at 110°C.

The process of immersion, drying and weighing shall be repeated for the required number of cycles.

After completion of the last cycle, the sample shall be washed free of solution with clean water at 43°C. After drying again at 110°C, each fraction of the fine aggregate shall be sieved on the same sieve used to separate it and then weighed. Each fraction of the coarse aggregate shall be sieved on the next smallest sieve and then weighed. The initial and final sieving requirements are shown in the table.

Aggregate size	Sieve for producing fraction for test	BS sieve for final sieving
75 mm - 37.5 mm	Passing 75 mm Retained on 37.5 mm	20 mm
37.5 mm - 20.0 mm	20 mm	10 mm
20 mm - 10 mm	10 mm	5 mm
10 mm - 5 mm	5 mm	2.36 mm
5 mm – 2.36 mm	2.36 mm	1.18 mm
2.36 mm – 1.18 mm	1.18 mm	600 µm
1.18 mm – 600 µm	600 µm	300 µm
600 µm – 300 µm	300 µm	

7.4.5 Calculation of result

For each fraction, the difference between the initial weight and the final weight, divided by the initial weight and expressed as a percentage, is the loss in that fraction. The total loss of the sample is to be calculated as the sum of the weighted percentage losses of each fraction. The weighted percentage loss of a fraction is to be taken as:

Per cent loss of fraction times per cent of fraction in original sample / 100

In fine aggregates, any size finer than 300 µm shall be assumed to have 0% loss.

7.5 Potential reactivity of aggregate (chemical method)

This test procedure is described under Designation C289 of the American Society for Testing Materials and covers the chemical determination of the potential reactivity of an aggregate with the alkalis in Portland cement concrete, as indicated by the amount of reaction during 24 hours at 80^{o}C between a normal solution of sodium hydroxide and aggregate which has been crushed and sieved to pass a 300 µm sieve but retained on a 150 µm sieve.

The test requires special equipment not normally supplied to a site laboratory and skilled analytical techniques. Samples of the aggregates on which tests for potential reactivity are required should be sent to a laboratory acceptable to the Engineer.

7.6 Rapid field test for chlorides in aggregates (Quantab test)

The purpose of this test is to provide a quick method of testing for chlorides at the point of delivery so that immediate action can be taken to remove any contaminated load.

7.6.1 Apparatus required:

Plastic buckets.

Single balance capable of reading to 5 kg with an accuracy of $\pm$ 10 g.

Plastic drinking cups or similar containers,

Whatman No. 90 filter papers 125 mm diameter.

Quantab chloride titrators Type 1175 (supplied by Miles Laboratories Ltd., Stoke Court, Stoke Poges, Slough, Bucks. UK)

7.6.2 Method:

Weigh out 2 kg of the aggregate under test into a bucket. Add 2 kg of clean chloride-free water. Stir once every minute for fifteen minutes. Take a container of the solution from the bucket and place into it, point downwards, a filter paper folded into a cone. Insert into the clear liquid within the filter paper a Quantab titrator strip and leave until the yellow bar at the top of the strip has turned completely blue. Read off from the scale on the strip the level reached at which the strip has turned white (to first decimal point). Consult the calibration chart supplied with the test strips and read the percentage NaCl corresponding to the test strip reading.

Calculation:

If the percentage NaCl is X, the amount of chloride ion by weight of aggregate is given by:

$$\text{Cl ion} = 0.61 \text{ X } \%.$$

NOTE:It is important to ensure that the control number on the chart corresponds with the control number on the bottle of test strips in use.

7.7 Variability test for concrete mixers

This test is designed to check the ability of a mixer to mix concrete having acceptable uniformity by determining variations in the weight of air-free mortar and coarse aggregate in a unit volume of concrete.

7.7.1 Apparatus required:

i. An air content meter (approximately ten litre capacity or more).
ii. Scales with a capacity of 50 kg and an accuracy of 0.1%.
iii. BS standard sieves of 37.5 mm and 4 mm apertures.
iv. Four trays 600mm square.
v. Equipment to enable material to be weighed when suspended in water

7.7.2 Procedure:

Samples of about 40 kg each should be taken from the first and last parts of a batch of concrete being discharged from the mixer. Each sample should be large enough to ensure that after all aggregate larger than 37.5mm is removed, sufficient remains to measure the air content with the available meter.

Each sample should be dealt with as set out below.

i. Weigh the full sample (W kg).

ii. Remove all aggregate retained on the 37.5 mm sieve, wash it to remove mortar, weigh it under water, dry it to surface dry condition, and weigh it again in air. Record the weight in air, W, kg and the volume:

$$V_1 = (\text{weight in air - weight. in water}) / 100 \text{ m}^3$$

Fill the air meter with the material passing the 37.5mm sieve and record the weight and volume (w_1 kg, v_1 m^3) and measure the air content (a % by volume).

Place the material from the air meter into a 4 mm sieve and wash away all cement and material finer than 4 mm. Dry the residue to a saturated surface dry condition and record the weight W_2 kg.

7.7.3 Calculation of Results:

The unit weight of air-free mortar (M)

Weight of material in air meter = w_1

Volume of material in air meter when free of air = $v_1 \times 100 / (100 + a) = v_3$

Volume of air-free material below 37.5 mm in full sample = V_3 x (W-W_1) = V_1- / W_1

Volume of material retained on 37.5 mm sieve in full sample = V_1 (see 7.7.2 above)

Total air-free volume of full sample = $V_1 + V_2$

Weight of mortar in full sample = (W_I - W_2) x V_2 / V_3, kg

and M = (W_1 - W_2) x V_2 / V_3(V_1 + V_2) Kg/m^3

If M_1 is the unit weight of mortar in the sample taken from the first part of the batch and M_2 is the corresponding figure for the last part of the batch, then the variability in mortar content is:

100 x (M_1 – M_2 / (M_1 + M_2)

Coarse Aggregate Content A

Using the symbols above, the weight of aggregate retained on a 4 mm sieve in the air meter is w. and this is contained in a volume V_3.

Weight of aggregate retained on a 4 mm sieve but passing a 37.5 mm sieve in full sample is W_2 x V_2 / V_3

Total weight of aggregate retained on a 4mm sieve in full sample is W_1 + W_2 x V_2 / V_3 =W and A = W_2 / (V_I + V_2)

If A_1 is the coarse aggregate content in the first part of the batch and A_2 is the corresponding figure for the last part of the batch, then the variability is

100 x (A_1 - A_2) / (A_1 + A_2) %

7.7.4 Criteria for acceptable mixer performance:

The variability in air-free mortar content as defined above shall not be greater than the following limits for any one mixer:

For any one test	0.8%
Average variability over 3 tests	0.6%
Average variability over 6 tests	*0.5%*
Average variability over 20 tests	0.4%
Average variability over 90 tests	0.3%

the variability should be adjusted appropriately for numbers of tests intermediate between those stated. The variability in the content of coarse aggregate shall not be greater than 5 0% for any one mixer.

7.8 Test for efficiency of concrete curing membranes

The test determines the efficiency with which a curing membrane prevents the evaporation of water from the surface of concrete.

7.8.1 Equipment required

i. Rigid metal specimen moulds 150 mm x 300 mm at the top, 145 mm x 295 mm at the bottom and 54 mm deep, measured inside the tray.
ii. Rigid metal trays 150 mm x 300 mm and 3 mm deep.
iii. A curing cabinet with shelves to hold the specimens and capable of being maintained at a temperature of 37-39"C and a relative humidity of 30-40%. Conditioned air shall be introduced at the bottom of the cabinet and removed at the top, but the air circulation across each shelf shall be similar and capable of independent control.
iv. An accurate balance capable of weighing up to 10 kg and another capable of weighing up to 1 kg.
v. A flat metal screed 25 mm wide and 145 mm long fitted with a handle.

7.8.2 Preparation of test specimens

Test specimens shall be made from mortar having the following proportions by weight:

i. 1 part of cement complying with BS 12 or BS 146
ii. parts of Leighton Buzzard standard sand as described in BS 12 and BS 146.
iii. 0.4 parts of clean water.

The mortar components shall first be thoroughly mixed dry for at least one minute with a trowel on a non-porous plate. The water shall then be added and the mortar further mixed for between three and four minutes until a uniform consistency is obtained. If a uniform consistency is not obtained after four minutes, the mix shall be rejected and a fresh mix made.

During mixing, the temperature of the materials, the water, and the test room shall be between 14.5 ^{o}C and 18^{o}C.

The prepared mortar shall be filled into the test moulds in two layers, each not exceeding 25 mm and thoroughly tamped. The surface of the specimens shall be finished 10 mm below the top of the mould and screeded to a uniformly granular finish with the 25mm wide flat screed.

At least three test specimens shall be made for each membrane being tested together with a control specimen for each test specimen. If more than one membrane is being tested, one control specimen may he used for each shelf occupied in the cabinet.

7.8.3 Application of the membrane

Immediately after preparation of the test specimens, the weight of each shall be determined to the nearest gram and they shall then immediately be sprayed with the curing membrane under test. Coverage shall be uniform and the proper rate of coverage shall be checked by weighing the specimens again after spraying.

7.8.4 Test procedure

The specimens, together with the unsprayed control specimens, shall after determination of their weight to the nearest gram, be placed in the curing cabinet for a period of seventy-two hours, after which they shall be removed and reweighed.

In order to determine the loss of volatile matter from the curing membrane, the 3mm trays shall be sprayed at the same time as, and at the same coverage rate as the test specimens. These trays shall be weighed, placed in the curing cabinet with the test specimens and reweighed after seventy-two hours.

7.8.5 Calculation of efficiency index

From the weights of ingredients and the proportions of the mix, calculate the total moisture content of each specimen after placing in the mould.

Determine the loss of moisture of each specimen, from the weight before and after curing, making due allowance for the loss of volatile matter from the curing compound.

Calculate the percentage of moisture lost by each test specimen and each control specimen based on the amount of moisture that each originally contained.

if W is the average percentage loss in weight of the control specimens and W_1 is the average percentage loss in weight of the test specimens, then:

$$\text{Efficiency index} = 100 \times (W - W_1) / W$$

7.9 Compaction fraction value for pipe bedding mater1al

This test is a measure of the ability of pipe bedding material to provide adequate uniform support to pipes.

7.9.1 Equipment required

i. An open ended cylinder 250 mm long and with an internal diameter of 150 mm (e.g. 160 mm uPVC pipe).
ii. A metal rammer weighing 1.0 kg ± 0.1 kg and having a striking face 40 mm diameter.
iii. A steel rule.

7.9.2 Procedure

A representative sample of the material is required weighing not less than 1 kg and having moisture content approximately equal to that of the material when placed in the trench.

The cylinder is placed on a firm flat surface and the sample material is poured gently into it without tamping. The top of the material is struck off level with the cylinder and then all surplus material is removed from the surface.

The cylinder is then lifted to release the contained materials and replaced on the surface. About a quarter of the material is replaced in the cylinder and tamped vigorously until no further

compaction can be obtained. This process is repeated with the second, third and last quarters and the final surface is tamped as level as possible.

The distance from the top of the cylinder to the surface of the material is measured. The Compaction Fraction (CF) value is obtained by dividing the measured distance in millimetres by 250.

Materials with CF values over 0.3 are unsuitable for use as pipe bedding materials.

7.10 Constituent minerals in aggregates

The constituent minerals in aggregate shall be obtained by analysis in accordance with ASTM C294.

7.11 Sulphate content of aggregates

The sulphate content of aggregates shall be determined by carrying out BS 1377 Test 9 after crushing and grinding the stones in the aggregate so that the material will all pass through a BS 410 2 mm sieve.

If, after the initial testing, it can be shown that stones do not contain sulphate or gypsum then crushing and grinding of stones will not be required for subsequent routine testing unless the aggregate source has been changed.

The sulphate content of aggregate shall be reported as SO_3 to the nearest 0.01 per cent of the original oven-dry aggregate mass.

7.12 Cleansing of pipelines

All of the pipelines shall be cleaned by pigging and the cost of this shall be included in the rate for pipelaying, unless otherwise allowed for in the Bill of Quantities.

The Contractor shall put forward his proposals for the method of programming of the pigging and sterilising to the Engineer and obtain his written approval at least twenty-eight days before to commencement.

After testing, but before sterilisation, the lengths of pipeline of differing diameters shall be separately swabbed by passing a foam pig throughout each length or sections of each length as may be convenient at the discretion of the Engineer. The pig shall be inserted at one end of the length to be cleaned and its movement caused and controlled by feeding water into the pipeline from a convenient connection behind the pig and allowing the water to discharge to waste at the other end through a washout or other temporary valved arrangement.

Perforated discs shall be provided by the Contractor and temporarily inserted between conveniently situated flanged items in the pipeline to retain the pig where the configuration of the pipework and location of washout do not in themselves permit proper retention of the pig.

The time for any pigging operations to commence shall be decided by the Engineer and the operation of the Employer's existing apparatus to provide a supply of water and the rate of supply shall be strictly under the control of the Engineer.

Pigging shall be repeated as many times as necessary to ensure the complete removal of all extraneous material from the pipelines to the complete satisfaction of the Engineer.

The Contractor shall allow in his rates for all labour, equipment, materials, the supply of water and compliance with all other obligations specified herein.

Before handing over any pipeline to the Employer, the Contractor shall pass through it a rubber disc plunger or swab and in the case of jointed pipelines shall simultaneously flush the line with clean water. Both ends shall then be closed by temporary plugs or bulkheads to prevent entry of dirt or foreign matter.

7.13 Testing of pressure pipelines

7.13.1 General

The Contractor shall provide all water, fittings, blank flanges, test pumps, pressure gauges and all necessary labour, tools and materials for the testing of pipelines and pipework and shall include for this in his rates. Flange adapters suitable for each pipe diameter and material will be supplied with the pipe.

The Contractor shall put forward his proposals and programming for testing to the Engineer and obtain his written approval before commencement.

No section of pipework will be accepted by the Engineer or paid for until all requirements regarding tests have been fulfilled.

Any section of pipework that fails to pass the tests applied shall have the defects made good by the Contractor and a further test carried out. The cost of all remedial work and re-testing shall be borne by the Contractor.

The Contractor shall inform the Engineer at least twenty-four hours before a length is ready for an inspection or test.

7.13.2 Water tests on pressure pipelines

Pipelines in trenches shall be satisfactorily tested before backfilling over joints and fittings, but after all concrete anchor blocks and surrounds have set. Trenches shall be kept dry until the pipes have been satisfactorily tested.

The length of the section of pipelines to be tested may be determined by the Contractor but shall not exceed 600 m and shall be approved by the Engineer. Levels of the length of pipe section under test shall be such that the maximum test pressure, of 1.5 times the maximum allowable working pressure, is achieved at the lowest point whilst the minimum test pressure, of 1.3 times the maximum allowable working pressure, is achieved at all other points.

The ends of the section to be tested shall be blanked off by means of the end pieces, blank flanges or discs provided by the Contractor, together with any temporary anchorages that may be required to prevent any movement of the pipes during the test. Valves shall not be used to isolate test sections of the pipeline.

No filling of pipes with water for testing purposes shall be undertaken without the prior agreement of the Engineer. The pipeline or pipework shall be filled with water in such a manner as to prevent shock and the accumulation of air, and kept under observation for leakage at static head for twenty four hours or until the lining is saturated. The water for this purpose shall be reasonably clear and free of solids and suspended matter. If the Engineer is satisfied that the water content of the pipeline has been maintained a pressure test shall commence in the presence of the Engineer.

The pressure shall be raised slowly to 1.5 times the maximum working head specified for the class of pipe and maintained at that pressure for a period long enough for the Engineer to examine the whole section under test.

Thereafter, for a period of not less than 4 hours, the leakage of water as measured by the amount drawn into the pumps to maintain the pressure, shall not exceed 0.10 litre per twenty-four hours for each 1,000 m of pipeline for every millimetre of internal diameter of pipe for each 30 m head of pressure applied at the lowest point.

All pipes or joints which are proved to be in any way defective shall be replaced or remade and retested as often as may be necessary until a satisfactory test shall have been obtained and any work which fails or is proved by test to be unsatisfactory in any way shall be redone by the Contractor at his own expense.
On completion of a satisfactory test, any temporary anchor blocks shall be broken out, stop ends removed, and backfilling of the pipeline shall be completed.

No section of pipework shall be accepted by the Employer until all requirements of the test have been obtained.

On completion of successful tests on all sections, an overall test over the entire length of main shall also be carried out.

7.13.3 Air tests on pressure pipelines

When it is not possible to apply a final water test to a pipeline because no suitable water is available or because the pipeline is at a temperature below $0^{O}C$ for considerable periods or because the presence of water in the pipeline is unacceptable during commissioning or for another reason accepted by the Engineer the pipeline shall be tested with air pressure.

Before testing commences, all unnecessary personnel shall leave the area and the Contractor shall take all necessary precautions to avoid damage in the event of a burst.

The air pressure shall be increased in increments to a value to be instructed by the Engineer and this pressure shall be maintained for one hour.

The pipeline shall be carefully inspected for leaks by all the following methods:

i. the pressure should remain substantially constant after each increment.
ii. aural or electronic devices shall be used to detect the noise of any leaks.
iii. detergent solution shall be used to locate any audible leaks or to investigate suspect places.

7.14 Sterilisation of water mains

Potable water mains shall be sterilised after pigging and final pressure testing operations have been completed by filling them with chlorinated water containing at least 20 mg per litre of free chlorine.

Filling of the mains shall be effected through a metered connection from an approved source and chlorination shall be carried out at this filling point. The Contractor shall allow in his rates for a metered connection from the existing supply, should this be utilised, to the new main and also for the temporary provision of suitable chlorinating apparatus and its installation and such a chlorinator shall be capable of accurate dosage.

Before commencing chlorination, the Contractor shall submit for the Engineer's approval the chlorine sterilising agent he proposes to use. The Contractor may submit for the Engineer's approval an alternative method for sterilising the mains and should this be given, it shall in no way limit the Contractor's obligations in complying with the requirements below.

The chlorinated water shall remain in the main for twenty-four hours after which period samples shall be drawn off as directed by the Engineer to determine the chlorine residual of the water. The mains shall then be flushed out with water from the approved source and further tests of chlorine residual taken to ensure that the heavily chlorinated water has been completely evacuated from the main. Samples shall then be taken from a suitable connection and sent for bacteriological examination.

The samples shall be taken by the Contractor in the presence of the Engineer. If the results of the test on the samples show that the water contains any presumptive or typical coliform organisms in 100 ml of water the mains shall be either reflushed or the whole sterilisation process repeated as the Engineer may direct.

All operations affecting the Employer’s existing supply mains shall be carried out only after the Engineer's approval has been given and then under the direct control of the Engineer and all arrangements for sterilisation shall be as directed by the Engineer who may require lengths of mains to be sterilised in separate sections.

The Contractor shall allow in his rates for all labour, equipment, materials, the supply of water and compliance with all other obligations specified herein. Any repetition of sterilisation which may he required shall be at the Contractor's own expense and to the satisfaction of the Engineer.

7.15 Testing of water retaining structures

All concrete structures designed to retain water or other liquids shall be tested by the Contractor after completion for water-tightness. Such testing will not be allowed to begin until the structure has been fully completed and all concrete has reached its specified strength. The Contractor shall make preparations to begin testing as soon as possible after each main structure has been completed.

The tests shall be carried out by filling the structure with clean potable water obtained from an approved source. The Contractor shall be responsible for organising the supply of water and all costs involved including for water and transport if necessary.

After cleaning to the satisfaction of the Engineer, the structure shall be filled at an approximately uniform rate of increase of water level of not more than two metres in twenty-four hours to the intended top water level.

The water shall be left to stand for seven days, during which period visual examination and readings of water levels shall be taken. To allow for absorption where the structure is constructed of concrete, the level shall be maintained by topping up as necessary for four days. To allow for evaporation, an approved “evaporation tank” of minimum depth 1 m shall be provided by the Contractor and supported inside the structure with its open top above top water level.

The evaporation tank shall be partially filled with water, to approximately the same level as the structure, and the levels monitored during the test period.

After the four days absorption period, no topping up of the structure or the evaporation tank shall be carried out. For the following three days, the water levels in the structure and in the evaporation tank should be noted at intervals of twenty-four hours. During this period, the outer faces of the structure shall be carefully examined for signs of damp patches. If after allowance for evaporation, the level in the structure is found to have dropped by more than 3 mm in any twenty-four hour period, or by more than 9 mm overall, or there is excessive evidence of damp, i.e. "wet to the touch” during any time over a continuous twenty-four hour period on the outside faces, then the structure shall be deemed to have failed the test. If after allowance for evaporation, the level in the structure has not dropped by more than 3 mm in any twenty four hour period, nor by more than 9 mm overall, and no signs of excessive damp are visible on the outside faces, then the structure shall be deemed to have passed the test.

If the structure does not satisfy the conditions of the test, and the daily drop in water level is decreasing, the period of test may be extended for a further three days and if the specified limit is then not exceeded the structure may be considered as satisfactory.

Should the structure be deemed by the Engineer to have failed the test, the Contractor shall be responsible for, and bear the expense of, locating the source of leakage and carrying out all necessary remedial work as required by the Engineer to make the structure water-tight. A further test shall then be carried out as before and the procedure shall be repeated until the structure is deemed by the Engineer to have passed the water tightness test.

In reservoirs consisting of more than one compartment, each compartment should be separately tested to the level of the top of the division wall or walls before conducting the test to overflow level.

Roofs to potable water retaining structures shall be tested by the Contractor for water-tightness on completion. The Contractor shall flood the roof to a minimum depth of 25 mm of water for a period of twenty-four hours. The roof shall be considered satisfactory if no leaks or damp patches show on the soffit.

The structures will not be accepted by the Employer until they have been ascertained to be in a perfectly useable and watertight condition to the complete satisfaction of the Engineer.

No claim for extra payment to the Contractor shall be allowed if for any reason the Engineer is unable to allow filling or emptying to be carried out at the time requested by the Contractor.

The costs of all testing including the provision of water for water-retaining structures shall be deemed to be included in the Contractor's rates for concrete.

7.16 Sterilisation of structures for potable water

On completion of the test for water-tightness, to the satisfaction of the Engineer, the Contractor shall thoroughly clean the interior of the structure by hosing down the roof, walls, columns, baffle walls and floor with clean, potable water, from an approved source, and removing all debris, soil, silt or other material.

After the structure has been cleaned as described, to the satisfaction of the Engineer, the Contractor shall, when instructed by the Engineer and under the direction of the Engineer, sterilise the structure by chlorination as described below.

The Contractor shall provide a suitable chlorinator (including the provision of the chlorine), which shall be capable of injecting the required concentration of chlorine solution at a steady rate into the structure.

The Contractor shall introduce at least 30 mg/l of free chlorine whilst filling the structure to a minimum depth of 100 mm.

The Contractor shall then spray all surface areas to the underside of the roof, walls, columns and pipework with the heavily chlorinated water by means of a stirrup pump or similar appliance. A pump that requires petrol or fuel oil for its prime mover shall not be used inside the structure, but at the Engineer's discretion, an electrically driven pump may be used.

On completion of the spraying to the Engineer's satisfaction, the heavily chlorinated water shall be drained out of the structure and each compartment shall be filled with potable water from an approved source, to a minimum depth of 200 mm. This water shall then be drained out and the structure filled with potable water to overflow level.

Samples shall be taken as directed by the Engineer after the structure has been full for a period of at least two hours and shall be sent to an approved laboratory for analysis. If the results of the tests show that the water contains any presumptive or typical coliform organisms in a 100 ml water sample then sterilisation shall be repeated until the tests show that all pollution has been eliminated.

On completion of sterilisation, the Contractor shall close off access to the structure to all personnel, and no further work shall be permitted in areas allowing direct access to the interior of the structure. Should any unauthorised access occur, and if the Engineer rules that contamination may have resulted, the Contractor shall carry out at his own expense, such tests as the Engineer may require, to determine the extent of the contamination, and shall also carry out and bear the cost of any additional sterilisation measures required by the Engineer.

7.17 Alignment test on non-pressure pipelines

The alignment of all pipelines having a nominal diameter of less than 300 mm shall be tested by drawing through each completed length a mandrel 750 mm long and having a diameter 10 mm less than the nominal pipe diameter.

Pipelines having a nominal diameter of 300 mm and over shall be visually inspected in the following manner:

At one end of a run, a mirror large enough to cover the pipe area shall be set at 45^{o} to reflect the sky into the pipe. Alternatively, a floodlight having a white reflector may be used. The pipe run shall be inspected from the other end for straightness and obstructions. If no light can be seen through the pipe, the Contractor shall seek out the cause and correct it.

Large diameter pipelines shall be inspected by personnel entering them and the Contractor shall provide any equipment necessary for doing so.

7.18 Testing of manholes

All pipes leading into a manhole shall be effectively plugged and the manhole shall then be filled with water to the top or to 1.5 m above the highest pipe soffit whichever is the less.

If the water level drops by more than 25 mm in thirty minutes, the Contractor shall search for, repair the leak and then repeat the test.

8 MECHANICAL REQUIREMENTS

8.1 Introduction

This Section covers workmanship, materials of construction and other miscellaneous items applicable to all items of plant, together with general requirements for particular items of mechanical plant. All component parts of the Works shall, unless otherwise specified, comply with the provisions of this Section or be subject to the approval of the Engineer.

8.2 Materials and Workmanship

All submerged moving parts of the plant, or the pins and spindles, etc., of the submerged moving parts or the faces, etc., in contact with them shall be of corrosion resistant metals. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall also maintain their properties without ageing due to the passage of time, exposure to light or any other cause.

Where "stainless steel" is specified or used it shall have resistance to atmospheric corrosion not less than that provided by BS 970, Grade 410 S3. Particular attention shall be made to the prevention of seizure by fretting where two corrosion resistant metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants. Where bronze is specified or used it shall be zinc free.

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, they shall be selected so that the bimetallic corrosion is as low as possible.

Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice.

All similar items of plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of plant. Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.

All equipment shall operate without excessive vibration and with the minimum of noise. All revolving parts shall be dynamically balanced so that when running at all operating speeds and any load up to the maximum there shall be no vibration due to lack of balance.

All parts which can be worn or damaged by dust shall be totally enclosed in dustproof housings.

8.3 Design Life

Unless otherwise specified, all items of Plant shall be rated for continuous service at the specified duties under the prevailing atmospheric and operational conditions on site.

All materials and equipment shall be designed for long life with a minimum of maintenance and the Contractor may be called upon to demonstrate this for any

component either by the service record 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.

Except for consumable items such as gland packings, 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 continuous normal operation and where major dismantling is required to replace a part, such life shall be not less than ten years.

8.4 Welding

Welded parts consisting of steel to BS 7613:1994, BS EN 10029:1991, Parts 1 to 3 of BS EN 10113:1993, BS EN 10155:1993 and BS EN 10210-1:1994, BS 1501 - Grade 490A, RT, DIN 17100 or similar steel shall comply with requirements not less than BS 5135 or equivalent standard. BS 5135 gives the requirements for preheating the work before welding. Circumferential welds, etc. shall be fabricated and tested in accordance with BS 5500, BS 2633 or equivalent standards where applicable. All joints shall have the plate edges accurately prepared to the appropriate profile for welding. The parts shall then be assembled and accurately checked before welding proceeds. The welding and fabricating procedure shall be such that residual stresses are a minimum and distortion avoided. Special attention shall be given to ensure that distortion does not occur after machining to affect the alignment and operation of the part concerned.

Welding procedures shall be in accordance with BS 4870. Each unit shall be fabricated and welding completed before final machining or other fitting work is carried out. All fillet welds shall be continuous.

Electrodes used shall be low hydrogen type and shall comply with requirements not less than BS 639 or equivalent standard for carbon steels, and BS 2926 or equivalent standard for stainless steels. Only stainless steel electrodes shall be used for welding stainless steel. Stainless steel to be welded shall be suitably stabilised. Heated storage and ovens shall be provided for the electrodes.

Only skilled, qualified and tested welders shall be employed. The welders shall be tested in accordance with BS 4871 Part 1, or other equivalent standard. Detailed records of welding shall be kept, showing the name of each welder against each run in a weld and any welder found to be producing an unacceptable amount of defects shall be removed until he has passed the test again.

Where valve bodies, sleeves, etc., are of welded construction all longitudinal butt welds in the shell plates shall be completely radiographically tested. All circumferential butt welds in pipes shall, where possible, have at least 100mm in 1000mm of their lengths radiographically tested.

All production welds shall be subject to visual inspection by the Engineer. Visual inspections may be carried out at any stage of the welding of a joint.

Each weld shall be clearly marked adjacent to the weld indicating the identification of the welder. Steel die stamping will not be permitted.

All welds shall be 10 per cent ultrasonically tested. Ultrasonic testing shall be carried out in accordance with BS 3923 and the Contractor shall propose a standard of acceptance. All fillet welds shall be tested by ultrasonic crack detection, or other approved means.

Non-destructive testing shall be carried out on all welds in the factory and on the site (if permitted). All longitudinal butt welds shall be radiographically tested. All circumferential butt welds carried out in the shop shall have 10% of their length radiographically tested at positions indicated by the Engineer. Junctions between longitudinal and circumferential welds shall be included in this test. The remainder of the shop and site welds shall be ultrasonically tested throughout 100% of their length. Ultrasonic testing shall be carried out in accordance with BS 3923 and the standard of acceptance shall be approved by the Engineer.

Where ultrasonic tests indicate a flaw or defect in the weld this shall be examined using radiographic means. In the case of fillet welds the Engineer may require dye penetrant tests to be carried out on selected welds. The Contractor will pay for the testing and he should include these costs and expenses during pricing of the Bill of Quantities.

The Engineer retains the right to have cut out and removed one weld only for each welder at no cost to the Employer.

Welds rejected by the Engineer shall be cut out and replaced by the Contractor. If the cut out weld is found on test not to meet the Specification, the cost of the cutting out and rejoining shall be borne by the Contractor. If the weld is found satisfactory, the cost shall be borne by the Employer.

Welds rejected by the Engineer may, at his discretion, be repaired subject to the following:

Repairs to the filler weld which would penetrate the stringer bead will not be permitted. Arc burns shall not be repaired by welding, but shall be removed by grinding provided that no reduction in wall thickness is made in excess of 12-1/2 percent of the nominal wall thickness.

For all other items of plant the Contractor shall allow for the cost of radiograph examination of the welds. The positions to be examined will be indicated by the Engineer.

The "International Institute of Welding Collection of Reference Radiographs of Welds" shall be used as a guide for the interpretation of radiographs and as a basis for comparison regarding the nature and extent of weld defects. The minimum grade for acceptance shall be blue.

8.5 Fixings

Nuts, bolts, studs and washers for incorporation in the Plant shall conform to the requirements of the appropriate British or other approved standard. Nuts and bolts for pressure parts shall be of the best quality bright steel, machined on the shank and under the head and nut. Bolts shall be of sufficient length such 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 a diameter such 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 arrangements shall be provided where necessary and shall be subject to the approval of the Engineer.

Where bolts pass through structural members taper washers shall be fitted 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 and nut does not exceed half the yield stress of the material under all conditions.

All bolts, nuts and screws which are submerged in water shall be made of nickel-bearing stainless steel.

8.6 Lubrication

8.6.1 General

Provision shall be made for suitable lubrication to ensure smooth operation, heat removal and freedom from undue wear. Plant selected shall require minimum lubrication attendance and down time for lubricant change.

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 Engineer for approval before incorporation in the instruction manuals. In the case of grease lubricated roller type bearings for electric motors a lithium base grease is preferred.

The Contractor shall supply the first fill of oil and grease from approved lubricant suppliers.

All grease nipples, oil cups and dip sticks shall be readily accessible, being piped to a point as near as practicable to the lubrication point.

8.6.2 Grease Lubrication

Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose means more than once weekly and grease systems having shorter periods between greasings should be avoided. Where necessary for accessibility grease nipples shall be placed at the end of the 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 with spacing in accordance with the recommendations of BS 1486 Part 1. Button head type nipples shall be used for normal grease lubrication. (Anti friction bearings requiring infrequent charging shall be fitted with hydraulic type nipples). Where more than one special grease is required a grease gun for each special type shall be supplied and permanently labeled.

8.6.3 Oil Lubrication

Oil sumps shall be fitted 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 at 30° C shall be clearly visible in the sight glass type as viewed from the normal access floor to the particular item of plant, and they shall be easily dismantled for cleaning.

All sight glasses shall be firmly held and enclosed in metal protection in such manner that they cannot be accidentally damaged.

All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricants and to avoid leaking lubricants coming into contact with any electrical equipment, heated surfaces or any other potential source of fire.

Gear boxes and oil baths shall be provided with adequately sized filling and draining plugs and suitable means of oil level indication.

Roller chain drives shall have oil bath reservoir lubrication.

Drain points shall be located or piped to a position such that an adequately sized container can be placed beneath them. Where a large quantity of oil is involved or drainage to a container difficult, a drain valve and plug shall be provided at the point of discharge.

Bearings equipped with force fed oil lubrication shall be automatically charged prior to machinery starting up and pressure monitored during operation with automatic shutdown of machinery and alarm on low oil pressure.

Access, without the use of portable ladders, to lubrication systems shall be such as to permit maintenance, drainage and re-filling, without contamination of the charged lubricant.

The design of breathers shall take into account the humidity and atmospheric contamination at the vent point and measures be incorporated to prevent contamination of the lubricant.

The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running and a sufficient quantity of the approved lubricants for setting to work and for the commercial operation of the plant for two years after the Taking-Over Certificate has been issued.

8.7 Machinery, Lifting, Dismantling, Guards, Noise and Vibration

8.7.1 Alignment

Machinery bedplate design, packing and fixing shall be such as to minimise distortion and vibration. Aligned machinery shall be mounted on either bed or sole plates permitting removal and reinstatement without a requirement to regrout.

Bedplates shall incorporate fine adjustment of the vertical and horizontal alignment between driver and driven members.

Rotating shafts of connected items of equipment shall be aligned to within 0.1 degree of arc from true, and with not more than 0.05 percent of shaft diameter misalignment, measured in any plane along the axis of the two shafts.

8.7.2 Lifting

All machinery shall be fitted with lifting facilities. Large structures shall be provided with jacking points.

8.7.3 Machinery Dismantling

Tapped holes or other provisions must be made in all main castings, for the insertion of jacking screws or the fixing of drawing gear to facilitate dismantling. On items of machinery subject to frequent dismantling, bolts or studs shall be employed in preference to set screws.

8.7.4 Guarding

Guards shall be provided to prevent access to electrical apparatus and moving parts of machinery. They shall be designed to be secure but removable without disturbing other parts of the Plant. The Contractor shall ensure that stationery points, requiring access, are located safely, outside the guards. Large guards shall be equipped with small removable panels for the inspection and checking of enclosed components.

8.7.5 Noise and Vibration

The Contractor shall provide a quiet installation. All items of plant and equipment shown on the drawings shall be carefully chosen with a view to quiet operation.

All plant must be capable of being operated without excessive vibration and the minimum amount of noise. Should the overall sound level of any item of plant exceed 85dB(A) at 1 metre radius the Contractor shall include for suitable sound attenuation to achieve this level. This will apply in the audible frequency range 20 Hz - 20 kHz. Above 20 kHz, the Contractor must state whether any fundamental frequencies are generated in the ultrasonic region. Where plant is operating in the vicinity of residential buildings then the sound level at 1 metre radius from the outside of the pump or plant house enclosure or building shall not exceed 65dB(A).

The Contractor shall provide and fix all material for the prevention of transmission of noise and vibration through the structure. All fans, motors, A/C package units, compressors, diesel engines and other motive plant shall be mounted on resilient mountings in such a manner that the plant foundations are isolated from the floor or structure. In addition, all rotating plant shall be statically and dynamically balanced. Mechanical vibration shall be isolated by the use of anti-vibration mountings and flexible connections to ensure an isolation efficiency of 95% from the building structure.

8.8 Gear Boxes

Gear boxes shall have a life of 100,000 hours or above, be selected in accordance with A.G.M.A recommendation for horsepower calculation and service factor application and employ a standard reduction ratio. The service factor on installed motor power shall not be less than 1.8. Gear boxes which have to be angle mounted, shall have a rating, choice of bearings, seals and lubrication system which are suitable for such mounting. Dependence on splash lubrication alone is not acceptable but it may be used in conjunction with a forced feed method to reach all bearings and gears. Calibration of the oil dipstick and its position together with that of the sump drain plug will require special consideration.

8.9 Bearings

8.9.1 Below-Water Bearings

The Contractor shall select the most appropriate type of bearing for the Plant being supplied. Equipment with vertical shafts shall have thrust and guide bearings. All bearings shall be designed to exclude the ingress of water except where the bearings are water lubricated. Sealed for life units are acceptable subject to a minimum design life of 50,000 hours operation at maximum loading. Plant which may be subject to vibration whilst stationary shall be provided with bearings designed to withstand damage from such a cause. Below water bearings shall be of the journal type, of ferrobestos, rubber gunmetal or equal and journals of stainless steel.

8.9.2 Above Water Bearings

Single journal plain bearings shall have phosphor bronze or synthetic lubrication impregnated bushes and carbon or stainless steel journals respectively. Synthetic bearings shall only be used where bearing condition can readily be inspected. Plain type bearings shall be self-lubricating by either grease, forced oil or impregnation. Ball and Roller type bearings shall be adequately lubricated by oil or grease and sealed to prevent leakage of lubricant along the shaft. Attention shall be given to ensure that dismantling of bearings is simple and free from risk of damage.

Bearings fitted to gear boxes shall have a minimum design life of 100,000 hours at maximum loading.

8.10 Pumps

8.10.1 General

Each pump shall be designed and constructed to be suitable for the particular liquid to be pumped. Pumps shall be of the type specified and arranged as indicated in the Specification and Drawings. Pumps shall be designed to give the specified output against all losses including those relating to the pump station pipework and valves. The Contractor shall match his pump characteristics to the pipe system networks to achieve the highest pump efficiency and reliability. The pumps shall have a non-overloading characteristic over the complete range of head and quantity delivered and the drive shall be capable of operating the pumps against maximum run out conditions and still have a 10 per cent margin. Each set must be capable of running satisfactorily in parallel with

other sets in the system without throttling and by itself, without cavitations or overload under all operating conditions within the system characteristics given.

The pumps for the works shall be Vertical turbine pumps, vertical shaft submersible pump, long coupled design installed in a vertical orientation. The discharge nominal pressure shall be PN 16.

The whole pumping unit shall be capable of withstanding, without detriment, reverse rotation to a speed that would occur if the pump were to stop when the differential head was at a maximum and the delivery and/or non-return valve failed to close.

Pumps to be installed must have local reputable dealership and service support. Hydraulic performance test shall be in accordance with ISO 9906 class 2B

8.10.2 Pump Casings

The pump design shall ensure that alignment is maintained between the various assemblies by recesses, spigots and dowels and shall be such that all components liable to wear can be replaced. Components shall be permanently marked with the manufacturer's number and where dowels are not used, permanently marked for correct assembly. The pump casing shall have replaceable wear rings. The casings of the pumps shall be of a suitable grade of close grained cast iron to BS 1452 Grade 220 or nickel iron and have flanges to match the specified pipework. The waterways through the pumps shall be smooth in finish and free from recesses and obstructions.

Pumps shall be designed to facilitate maintenance, and manholes or handholes shall be provided to allow the interior of the casings and bearing seals to be examined without dismantling the pump. It shall be possible to remove pump impellers with the minimum disturbance to pipework and by suitable joints to allow the pump to be removed without dismantling the main pipework.

All joints shall be machined and faced and bolt holes shall be drilled and arbored. Locating pins shall be provided where necessary, also starting screw holes, the latter being provided with set screws.

8.10.3 Impellers

The impellers and guide vanes (if any) shall be of suitable material, accurately machined and smoothly finished to minimise hydraulic losses. The rotating elements shall be statically and dynamically balanced before final assembly. The impeller shall be readily withdrawable from the pump casing without the need to disconnect pipework.

8.10.4 Pump Shafts

The pump shaft shall be of high tensile or stainless steel adequately sized, with good fatigue, shock load and corrosion resistance. The duty speed range shall be well below the first critical speed of the shaft. Where a change in diameter of the shaft occurs the shoulder shall be radiussed or undercut to the appropriate BS to reduce stress concentration. The shaft shall be complete with easily renewable stainless steel protecting sleeves at glands and bearings.

8.10.5 Bearings

All bearings shall be liberally rated to ensure cool running and meet the load factors specified.

For vertically mounted pumps, the bearing shall be a combined thrust and journal type, designed to prevent any thrust loads being imposed upon the drive motor. The pump bottom bearing shall be lubricated by an enclosed water lubricated sleeve bearing suitable for potable water applications.

Where grease points are necessary they shall be fitted with removable screwed plugs which shall be accessible without removing guards. All bearings having automatic lubrication shall also have provision for hand lubrication.

8.10.6 Shaft Seals

The Contractor shall select a seal, compatible with his plant and best suited for the worst conditions likely to be met when the Plant is in operation. All seal materials shall be compatible with and/or resistant to the fluid or gas being handled. For potable water, seal materials shall be those specifically approved for use in the Water Industry.

Stuffing boxes shall be provided with renewable gland packing. Glands subject to abrasive liquors or negative pressures, shall embody suitably positioned lantern rings and a clean water continuous flushing system, operative whenever the Plant is in motion or a corrosive element is present. Gland adjustment nuts shall be readily accessible for routine maintenance. Gland drain pipework shall be installed, incorporating rodding facilities and adequate inclines discharging to the nearest sump or drainage channel.

Mechanical seals which are on pumps subject to abrasive liquor or gas, or subject to negative pressures or corrosive elements, shall be provided with a clean water continuous gland flushing system, operative when the item of plant is in motion or a corrosive element present. A back-to-back sealing arrangement with a flush/cooling system shall be accepted as satisfying the requirements of this Clause.

Special care in the selection of materials shall be taken in order to avoid binding and electrolytic action between the shaft sleeve and the seal components, particularly where long periods of idleness are inherent in the duty cycle as in the case of standby pumps.

The gland water connections supplying water seals of the pumps shall be provided with suitable filters to prevent abrasive matter in suspension from entering the gland stuffing box. These filters shall be designed to facilitate easy cleaning.

8.10.7 Pumps Miscellaneous

Cooling and lubrication water pipework shall be fitted with flow indicators where specified.

Horizontal pumps shall be mounted on a common fabricated steel bedplate manufactured from substantial rolled steel sections of welded construction with machined pads for mounting both pumps and motors. Folded plate type bedplates shall not be acceptable. Pumps and motors shall be dowelled in position to allow for easy relocation in the event of their being removed. The pump shall be connected to its driving motor by a flexible coupling of a type approved by the Engineer which shall be adequately guarded.

On horizontal pumpsets fitted with hydraulic balance devices the couplings shall permit free movements of pump shafts under load.

On vertical pumpsets where the shaft couplings are of the screwed type the couplings shall be positively locked.

The Contractor shall ensure that adequate NPSH is available to ensure that pumps operate without cavitation under the worst operating conditions.

Indicating pressure gauges each with an isolating cock and snubber shall be provided on the suction and delivery side of each pump except that a suction gauge is not required on submersible type pumps. All pressure gauges shall be provided with high and low level adjustable contacts which can be used to provide additional pump protection where specified.

8.10.8 Performance

The guarantees given in respect of output, overall efficiency and NPSH shall be verified with Class C tests in accordance with BS 5316 at the manufacturer's works in the presence of the Engineer. No negative tolerance shall be applicable to the guaranteed values for flow, head or efficiency. The tests shall be performed by pumps driven by their own motors.

The NPSH tests shall be carried out at the guaranteed duty point, at the maximum run out condition and at three points in between.

8.10.9 Surge vessels

Unless otherwise approved by the Engineer, surge vessels shall be Bladder Surge Tanks installed with a food quality butyl rubber bladder. The tanks can be installed either horizontally or vertically. The tanks shall be treated internally with food quality epoxy paint for corrosion protection and externally with fusion bonded epoxy colour blue. In order to verify the water level in the tank, the vessels shall be equipped with a level indicator as well as a manometer to verify the initial pre-charge pressure. If it is hydraulically required, the tank shall be equipped with a non return valve or an incorporated bypass in order to reduce the over pressure by consuming the energy of the flow reversal. This shall be as recommended by the manufacturer.

The Internal epoxy paint without solvents, colour white, shall be of thickness not less than 100 microns.

8.11 Flanges

8.11.1 General

All flanged connections of pumps, pipework, valves and other relevant equipment shall have flanges in accordance with BS 4504 Table 16, unless otherwise specified in the Particular Specification Sections.

8.11.2 Jointing

All flanged joints shall be made with 3 mm thick full face canvas reinforced rubber insertion gaskets to BS 4865 Part 1. During Installation all pipes shall be hung on their respective supports and lined up so that their joint faces are parallel before flanges are bolted together. In making joints, no springing of pipes into position shall be allowed.

Joints on flanges that exist or have been installed under other contracts shall be made with the same material and suitable for the flange faces.

8.12 Pipework

8.12.1 General

All pipe systems shall be arranged, installed, supported and provided with all necessary means of venting, draining and expansion, all to the approval of the Engineer.

The pipework layout shall be designed so that items of equipment and sections of pipework can be removed from the pipeline without major disturbance to the adjacent pipework. Particular care shall be taken to ensure that pipework thrusts are not transmitted to machinery or associated apparatus. The Contractor shall indicate on his detailed drawings the thrust blocks required to anchor his pipework.

The Contractor shall provide flexibility in the pipework at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipework where necessary to allow for some margin of error in the building work. Wherever possible flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust as a whole so that external anchorages may be kept to a minimum. Flexible joints shall also be provided for ease of erection and future dismantling.

All necessary supports, saddles, slings, fixings bolts and foundation bolts shall be supplied to support the pipework and its associated equipment in an approved manner. Dead legs shall be avoided but where this is not possible provision shall be made for flushing the pipework. Changes in pipe bore sizes shall be by the use of proprietary fittings or fabricated sections to avoid sudden changes.

Where relevant, formed bends and offsets shall be used and be cold formed in a standard pipe bending machine. They shall have an inside radius of not less than 4 times the outside diameter of the pipe.

Flushing and drain connections on pipework below 150 mm shall be made using proprietary welded fittings with G series internal parallel threads to BS 2779 which shall be immediately sealed with hexagon headed shouldered plugs and seals. Holes thus made in the pipe shall have burrs removed and be finally pulled through to remove loose particles.

Template or closure pipes shall be provided where necessary to facilitate erection. The design and construction of the template pipes shall be to the approval of the Engineer, and the Contractor will be responsible for establishing the dimensions of the template pipes such that there will be no strain placed on the connected items after installation.

All nuts, bolts, washers, flanges, gaskets, tied flanged adaptors, drain valves, special connection pieces, together with all terminal point connection materials shall be supplied under the Contract.

Viking-Johnson or approved equivalent flange adaptors shall be fitted where necessary to facilitate the removal of valves, etc.. Adequate provision shall be made for anchoring pipes at these joints.

Hydraulic Pipework shall be sized to maintain fluid velocities below those specified and provide a safety factor of 4:1 on the design pressure, which shall be taken as 120 per cent of the pump closed valve head.

Compressed Air Pipework shall be sized such that the air flow velocity does not exceed 8m/s. To provide adequate condensate drainage, the pipework system shall be run with a horizontal fall of not less than 1 in 50 in the direction of air flow and incorporate drainage points at distances of not less than 30 m. Drainage points shall be formed by use of equal tees with a down-pointing leg fitted preferably where changes of direction of flow occur.

Pipework materials, sizes, pressure ratings, fittings, coupling arrangements and medium carried shall be as detailed in the Particular Specification, pipework being in metric sizes throughout.

8.12.2 Steel Pipework

General purpose steel pipework with screwed fittings shall be of galvanised mild steel to BS 1387 heavy grade with fittings of galvanised malleable iron to BS 143/1256, having tapered internal and external threads to BS 21.

Steel pipe and fittings over 80 mm diameter, shall be carbon steel in accordance with BS 3601 with pipe sizes to BS 3600. Joints shall be flanged. Pipes shall be fabricated in accordance with BS 534 with welding in accordance with BS 2633 or BS 2971 and BS 4515.

After fabrication and machining of flanges all pipework and fittings shall be tested to a test pressure equal to 1□ times the flange pressure rating.

Where pipes are to be joined with sleeves or couplings, a sufficient length of pipe shall be left bare of coating to accommodate the sleeve or coupling.

Plain ended pipes shall be supplied rounded at both ends. An adequate number of pipes shall be supplied rounded throughout their length so that they may be cut and such pipes shall be clearly marked.

Couplings for use with steel pipes shall comply with BS 534 except where other types of couplings are shown on the Contract Drawings or specified in other sections of this Specification. Components of flexible joints from different manufacturers shall not be used together.

Tests on pipes shall be made in accordance with the relevant British Standard in the manufacturer's works when required by the Engineer and in the presence of the Engineer. Two copies of the results of all such tests shall be submitted to the Engineer.

Flanges on steel pipes shall be welded in accordance with BS 2633 or BS 2971 and shall have raised or flat faces. Gaskets for use in flanged joints shall consist of rubber complying with BS 2494 for type 1 rings or rubber reinforced with cotton and complying with BS 5292 or as instructed by the Engineer. On flat face flanges the gaskets shall extend over the full flange area and on raised face flanges they shall cover the raised face only. No asbestos shall be used on any flange of pipework or fitting carrying potable water.

Steel pipes which are to be welded shall have the ends prepared by the manufacturer to suit the type of welded joint shown on the Contract Drawings. The pipes shall be free of external and internal coating for a distance of 75 mm from each weld line.

After fabrication all welding scale and beads as well as hardened fluxes shall be removed and joints shall be free of pores and as smooth as possible. Where specified all pipes and specials shall then be degreased and grift blasted prior to coating with an approved fusion bonded epoxy coating. The coating shall be tested to ensure the correct thickness and the absence of pores using spark testing equipment.

Bends, branches and other fittings for use with steel pipe shall comply with the British Standard or other approved standard. Calculations for the design of all special fittings shall be submitted to the Engineer before manufacture commences.

Pipes shall be stacked on a firm base using two timber packers only under the barrel of pipes.

Fittings and specials of any type shall be stored in a single layer only. Pipes and fittings shall at all times be adequately protected from damage during transport, storage and handling. Pipes shall be fitted in the factory with end caps and reinforcement adequate to prevent distortion during transport, storage and handling. Rubber rings and other pipe jointing material shall be stored under cover away from direct sunshine.

8.12.3 Cutting Pipes

The cutting of pipes for making up lengths shall be carried out by a method which leaves a clean square end. Steel pipes used for cutting shall have been rounded throughout their length and shall be clearly marked as such. Cutting shall be carried out by cutting disc or by oxy-acetylene and the cut end shall subsequently be ground to the correct profile for the method of jointing in use.

8.12.4 Welded Joints

Line-up clamps shall be designed to prevent tears, scars, or indentations of the pipe walls and keep misalignment of pipes at a minimum. Interior line-up clamps are required for large diameter pipe.

All welding shall be carried out in accordance with specific procedures prepared by the Contractor and approved by the Engineer. Adequate precautions shall be taken to protect welding operations from wind, rain, blowing sand, etc..

All welders employed on the Works shall be fully qualified and shall have successfully passed all tests required by BS 4871 or the relevant API codes for the type of work each individual welder does. Welder qualification tests shall be carried out in the presence of

the Engineer or his authorised representative. The Contractor shall provide all necessary labour, pipe welding materials, and equipment for performing welder qualification tests on site. Arrangements for laboratory tests of coupons, if required, will be made and paid for by the Contractor. The Contractor shall maintain a list of approved welders agreed upon with the Engineer and no other employees shall perform welding operations on the Permanent Works.

Before welding, the pipe ends shall be swabbed with a leather or canvas belt disc to remove dirt, loose mill scale, rust, oil, grease, and other matter which may be injurious to the weld. Cleaning of pipe ends shall be done by power wire brushing and/or grinding. Pipe ends damaged such that they no longer meet joint specifications shall be rebevelled by a suitable machine. Pipe ends shall be aligned with line-up clamps such that the longitudinal weld seams of the adjacent pipes are staggered by at least 20 degrees. Stringer bead shall be applied by at least two welders welding in opposite quadrants. The number of filler and finish beads shall be in accordance with approved procedures. Completed weld shall have a substantially uniform cross-section around the entire circumference of the pipe. At no point shall the crown surface be below the outside surface of the pipe nor be raised above the parent metal by more than 1.5 mm. All joints on which welding has started shall be completed before the end of each day's work. At night or when work is not in progress, pipe ends of the pipeline shall be securely capped with a suitable cover to prevent the entrance of dirt, small animals, water, and foreign matter into the pipeline. Tie-ins shall be carefully aligned to limit residual and/or reaction stresses after completion of the weld. Tie-ins shall be made within the temperature range of 10^{o} to 30^{o} C. All production welds shall be subject to visual inspection by the Engineer. Visual inspections may be carried out at any stage of the welding of a joint. Each weld shall be clearly marked adjacent to the weld indicating the identification of the welder. Steel diestamping will not be permitted.

Non-destructive testing shall be carried out on all welds, both in the shop and on the site. All longitudinal butt welds shall be radiographically tested. All circumferential butt welds carried out in the shop shall have 10 per cent of their length radiographically tested at positions indicated by the Engineer. Junctions between longitudinal and circumferential welds shall be included in this test. The remainder of the shop and site welds shall be ultrasonically tested throughout 100 per cent of their length.

8.12.5 Flexible Joints

Any flexible joints in steel pipework shall be of the type specified or as shown on the Drawings. Flexible joints between pipes having integral sockets shall be formed by a shaped rubber gasket fitted within the socket or by a rubber ring of circular cross section (O-ring) placed on the pipe spigot. The type of flexible joint to be used shall be subject to the approval of the Engineer. Before any joint is made all parts of the joint shall be clean and free from mud, oil, grease or other deleterious matter. Fixed gaskets shall be lubricated strictly in accordance with the manufacturer's recommendations. O-ring gaskets shall not be lubricated. Components of flexible joints from different manufacturers shall not be used together. After jointing, the position of O-rings shall be tested with a feeler to ensure that they are correctly positioned. If any ring shows a significant departure from a line following a pipe circumference, the joint shall be broken and remade using a new ring. After completing the joint any damage to the protective coating shall be made good.

8.12.6 Flanged Joints

Flanged joints shall be made with rubber gaskets and shall be fitted without twist or distortion. Pipes and fittings shall be fully supported so that the flange faces are parallel and concentric. The flanges shall be drawn together uniformly by tightening opposite pairs of bolts in succession and no bolts shall be omitted. The size and number of bolts in flanged joints shall be in accordance with BS 4504 and BS 4772 for the pressure rating of the pipeline given on the Drawings. Bolt threads shall be coated with an approved paste such as Loctite before use unless otherwise instructed by the Engineer.

8.12.7 Bonding

All flexible, flanged and similar discontinuous joints shall be bonded across the joint to provide electrical continuity throughout each buried pipeline.

8.12.8 Deviations at Joints

The maximum deflection at each joint shall not exceed the following:

- For any type of flexible joint, three quarters of the maximum permissible deflection stated by the manufacturer;
- For welded joints in steel pipework, the deflection shown on the Contract Drawings. The ends of the pipes shall be cut to suit.
- No deviations shall be made at flanged or solvent welded joints.

8.12.9 Protection of Buried Pipes

External and internal protection to pipes shall be made good after completion of joints as directed by the Engineer. Protective tape of a type acceptable to the Engineer shall be applied in two separate layers. Each layer shall be wound with an overlap equal to half the tape width and shall extend at least 150 mm beyond the area requiring protection.

8.12.10 Gaps for Equipment

Where gaps have to be left in pipework for the later installation of equipment such as valves and other items, the ends of the pipes shall be accurately aligned one with the other across the gap paying strict attention to bolt positions if relevant. The length of the gap shall be accurately determined with the aid of dimensional sketches which shall be submitted to the Engineer before the work is carried out.

All gaps left for valves or other equipment shall include space for a dismantling joint.

8.12.11 Ductile Iron Pipework

Where specified Ductile Iron pipework shall be in accordance with ISO 2531, BS EN 545:1995, BS EN 598:1995 and BS EN 969:1996 with flanged joints and fittings unless otherwise specified. All pipes and fittings shall be protected against corrosion with an internal lining of cement mortar and an external coating of zinc and bitumen in accordance with BS 4772. The bitumen solution shall be in accordance with BS 3416 for use with potable water supplies.

8.12.12 uPVC Pipework and GRP Pipe and Fittings

- Unplasticised PVC (uPVC) pipes shall comply with:-

ISO 161/1 as stated on the drawings. Joints shall be either made with rubber sealing rings or shall be solvent welded as specified. Solvents shall comply with BS 4346 Part 3. Ferrules, straps and other metal fittings shall be gunmetalor

- Unplasticised PVC pipes shall comply with BS 4660:2000:2000:2000 or BS EN 1401-1:1998 as applicable for drain pipes.

- GRP pipes and fittings shall comply with BS EN 14364:2006+A1:2008.

8.12.13 Small Bore Pipework

Small bore pipework up to 15 mm OD shall be manufactured from stainless steel tubing with suitable compression type fittings. All small bore pipework and capillary tubes shall be adequately and securely clipped or clamped. Compression fitting bends shall be kept to a minimum as pulled bends of generous radii are preferred. Compression couplings shall be heavy series to BS 4368 Part 1.

Any gauges, transducers or switches, etc., fed via small bore pipework shall have an individual isolating cock adjacent to each component with adequate space being allowed for component removal for servicing.

8.12.14 Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the Contract Drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer's prior approval.

After the pipework is installed, the Contractor shall seal the ends of all ducts, pipes, or trenches leading into buildings. The seals shall be approved water, gas and fire sealing transit units with appropriate fillers. Insert blocks shall be fitted to duct and trench entries. All steelwork on such transit assemblies and frames shall be hot dip galvanized. Where detailed in the Specification or shown on the Contract Drawings, transit frames will be incorporated in the construction by the Civil works Contractor.

8.12.15 Reference Marking

Prior to despatch from the manufacturer's works each pipe section shall be marked with an appropriate reference number for future identification.

8.12.16 Protection of Pipework

Immediately after the completion of fabrication at the works or on site and during transport and storage, pipe ends shall be protected from external damage and sealed against ingress of dirt by suitable caps, plugs or other similar means. After cleaning and inspection, machined surfaces of all steel and ironwork shall be covered with preserving fluids of approved types or otherwise protected and all flanges shall be fitted with blank discs bolted to each face.

8.12.17 Branch Pipes and Bosses

Whenever any small bore pipework makes a connection into the pipeline system, a boss or branch pipe shall be provided which shall be at least twice the diameter in width and one diameter in thickness of the tapped hole which it contains.

Bosses shall be located at the main pipe horizontal centre line and those provided for water sample cocks shall be tapped 38 mm (1.5") BSP and have reasonable access for sampling. Bosses provided for instrumentation equipment shall be tapped 25 mm (1") BSP with a reducer fitted to suit the small bore pipework and isolating cock. Unused bosses shall be fitted with blank plugs having a central squared projection for tightening or removal.

Bosses shall be provided for pump performance monitoring. These shall be installed on all pump suction and delivery pipes at least 2 pipe diameters from the pump flange unless otherwise specified in the Particular Specification. Each tapping shall be provided with inch isolating cock.

8.12.18 Testing Pipework

Before testing commences the Contractor shall ensure that all anchor and thrust blocks are complete or that temporary supports have been installed. Thrust from temporary pipe ends or branch pipes shall be adequately strutted and the section under test closed off with stop ends, blank flanges or other closure fittings.

All pipes shall be cleaned before testing by flushing or as agreed by the Engineer.

All tests shall be carried out in the presence of the Engineer and for this purpose the Contractor shall give the Engineer 24 hours notice in writing of any pressure tests which he intends to carry out.

Within 24 hours of the completion of any test the Contractor shall submit two copies of a full record of the test to the Engineer. The record shall be in a form acceptable to the Engineer.

The pipe work to be tested shall be filled with clean water, making sure that all air is expelled. Mortar lined pipe shall then be kept under nominal working pressure for 24 hours. The pressure shall then be raised to the specified test pressure using a suitable pump which is fed from a calibrated tank. The test pressure will depend upon the particular circumstances and will be specified by the Engineer but for general guidance only, it will be 1.5 times the maximum sustained operating pressure.

The test pressure shall be held for the period instructed by the Engineer, pumping in water as required from the calibrated tank, and the amount of water used per hour shall be noted. The pressure shall be held for 24 hours and there shall be no loss of water.

8.12.19 Commissioning Pipe work

Commissioning shall not be commenced until the Engineer has approved the whole of the installation in writing.

8.13 Valves and Penstocks

8.13.1 General

Valves shall be provided as shown on the Drawings and in this Specification, and shall be specifically designed for use in drinking water. Valves shall, unless otherwise specified, be double flanged.

All valves and penstocks shall be of the sizes shown on the Drawings or stated in the Documents and shall be obtained from manufacturers approved by the Engineer.

Where specified valves shall be fitted with easing screws and a clean-out box in the base.

All valve bodies shall give the following information:-

- Manufacturer's name
- Hydraulic test pressure
- Size of valve
- Direction of flow `Arrow'

8.13.2 Valve Access

All valves, hand wheels, spindles and headstocks shall be positioned to give good access for operational personnel.

Extension spindles shall be supplied wherever necessary to achieve the specified operating requirements.

Valves buried or installed in underground chambers where access to a handwheel would be impractical shall be key operated.

It shall be possible either to remove and replace or to recondition seats and gates. Gland packings shall be accessible without removal of the valve from the pipework.

8.13.3 Operation

The operating gear of all valves and penstocks shall be such that they can be opened and closed by one man against an unbalanced head 15 per cent in excess of the maximum service value and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required operating torque of 150 Nm.

All handwheels shall be arranged to turn in a clockwise direction to close the valve or penstock and the direction of rotation for opening and closing shall be indicated on the handwheels.

Unless otherwise stated the handwheels shall be coated with black plastic and incorporate facilities for padlocking in either the open or closed position.

Headstocks and valves of 50 mm, or greater, nominal bore shall be fitted with mechanical position indicators to show the amount which the valve is open or closed in relation to its full travel, i.e. 0.25, 0.50, 0.75, 1.

8.13.4 Materials

Valve bodies, discs and wedges shall be of cast iron, with facing rings, seating rings, wedge nuts and other trim of corrosion resistant bronze, all as specified.

The valve stem, thrust washers, screws, nuts and other components exposed to the water shall be of a corrosion resistant grade of bronze or stainless steel.

Valve bodies and other components of plastic or other non-metallic materials shall be compatible with the medium and of robust industrial design.

8.13.5 Wedge Gate Valves

All wedge gate valves, unless otherwise specified shall be of the non-rising spindle type and be in accordance with the relevant clauses of BS 5163.

Valves shall have good quality cast grey iron bodies, high tensile brass spindles, gun-metal nuts, wedge gates with gun-metal faces and seats, bronze gland bushes and bonnets fitted with soft packing glands. Valves greater than 400 mm diameter shall have detachable bolted covers for inspection, cleaning and flushing purposes.

Valves shall be provided with renewable seats and it shall be possible to remove the gates without removing the valve body from the pipe work.

The gate face rings shall be screwed into the gate or alternatively securely pegged over the full circumference.

Unless otherwise detailed on the Contract Drawings, gate valves in chambers, and other similar locations shall be provided with hand wheels. Valves which are to be buried in the ground shall be provided with extension spindles, protection tubes, spindle caps, spindle supports and surface boxes.

Valves larger than 400 mm diameter and accessible for maintenance shall be fitted with a studded cast iron cover at the bottom of the valve body for inspection, cleaning and flushing purposes.

Where necessary to meet the requirements of Section 2.16.3, gate valves shall be provided with appropriate thrust bearing guides, and/or gearing and/or bypass valves. When reduction gearing is employed, the gear ratio shall not exceed 4:1. Valves of 450 mm diameter and above shall always be provided with reduction gearing for manual operation. Valves of 600 mm diameter and above shall always be provided with a bypass valve.

Each valve shall be tested in accordance with the requirements of BS 5153 open-ended in each direction.

Where specified, resilient seat type valves shall be provided. The wedge shall have a resilient Nitrile Rubber bonded to the cast iron wedge. The gates of all resilient seal valves of the same size and class shall be completely interchangeable, and be shaped so that the shoulders of the gate seal against the valve bonnet when the gate is fully open. Stem sealing shall be by O rings, which shall be replaceable under pressure with the gate fully raised.

8.13.6 Non-Return Valves

Non-return valves shall be installed as shown on the Drawings, suitable for the operating condition and where applicable conform to BS 5153. Long pattern valves shall generally be used.

Check valves shall possess high speed closing characteristics by use of heavy flaps with external weights where specified but designed for minimum slam condition when closing.

Flaps shall be fitted with renewable bronze or gun-metal sealing faces, which shall mate accurately with renewable bronze on gun-metal seating rings in the valve body. All seating/seals shall be positively located.

Covers shall be provided to allow ample access for inspection, cleaning and servicing and shall be supplied complete with tapped boss fitted with an air release cock.

Valves greater than 500 mm diameter shall be provided with lifting eyes, feet and jacking screws.

Hinge pins/shafts and internal fixing devices shall be stainless steel. Hinge pins/shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixings.

For valves with external levers and adjustable balance weight the hinge pins/shafts shall extend through a renewable sealing gland on the side of the body.

Valves installed on delivery lines at boreholes shall be of the single door swing type and fitted with heavy duty external lever suitable for back flushing.

Valve body design shall be such that there is adequate clearance around and at the back of the flap to minimize jamming by rags, solid matter, etc..

Check valves for potable water shall be free acting type single flap or multiflap with external by-pass and hand operated control valve as necessary. Flaps shall be of design and weight to suit the prevailing hydraulic conditions and shafts shall turn in close fitted low friction bearings.

Each valve shall be tested in accordance with BS 5153 or if outside the size of this standard to the form as set out in BS 5153 and to the nominal pressure designation/test pressure relationship set out therein or 700 kPa for 30 minutes whichever is the greater.

For potable water applications where space is at a premium wafer type double flap non-return valves with spring assisted closing may be specified. These valves shall have cast iron bodies and flaps with resilient seats and be fitted with stainless steel hinge pins and springs.

8.13.7 Air Release Valves

Air valves shall normally be installed at high points in pipework and as shown on the Drawings. The valves shall be capable of exhausting air from pipework automatically when being filled, the air being released at a sufficiently high rate to prevent the restriction of the inflow rate.

The valves shall also automatically release air accumulating in pipework during normal working conditions. Air valves shall be designed to prevent premature closure prior to all air having been discharged from the line.

Similarly the valves shall be capable of ventilating pipework automatically when being emptied, the air inflow rate being sufficiently high to prevent the development of a vacuum in the pipelines.

The material of the body and cover shall be cast grey iron.

Air valves shall be of the double orifice type with a large orifice for ventilation or exhaustion of the pipeline and a smaller orifice for automatic release of air under normal working pressure. The valves shall be suitable for the maximum working pressures in the systems and tested for pressure tightness in steps of 200 kPa up to the maximum working pressures and then for mechanical strength at 1.5 times maximum working pressures. All air valves shall be provided with isolating valves and flanged end connections.

The orifice shall be positively sealed in the closed position but the float (ball) shall only be raised by the water and not by a mixture of air and water spray.

The seating shall be designed to prevent the float sticking after long periods in the closed position.

8.13.8 Diaphragm Valves

Diaphragm valves shall be of the straight-through design with minimal flow resistance and glandless construction conforming with the requirements of BS 5156.

The valves shall be made up of two durable body parts and the diaphragm, all interchangeable with replacements parts for easy maintenance.

The diaphragm shall be moulded in a reinforced, flexible material of a grade to suit the specified duty and liquid content of the system. In the open state the diaphragm shall lift clear and not obstruct the flow of liquid. The internal surfaces of the valve body shall also be lined with material compatible with diaphragm duty.

Diaphragm valves shall be completely leak tight and suitable for pressures up to 10 bar.

The valves shall be operated by handwheel unless otherwise specified on the Contract Drawings. Handwheels shall have adequate leverage to give the closure effort required and a facility to lock in any position.

Where indicated on the Drawings diaphragm valves shall be supplied with extended spindles or extensions for pedestals.

8.13.9 Isolating Cocks

For isolation of small bore pipework tappings for instrumentation equipment, etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valves with the operating handle arranged to indicate the open and closed positions.

Where specified, means shall be provided for securing the valve body to a front panel or rear surface.

Where corporation cocks are specified, these shall be similar to the above isolating cocks but shall have a detachable key handle for fitting onto a squared operating shaft, the shaft end being marked to indicate the open and closed valve positions.

8.13.10 Penstocks

All penstocks shall be of the rising type unless otherwise specified, and the spindles shall be of adequate size to avoid buckling under load.

All spindle nuts shall be self aligning and their length shall be not less than twice the spindle diameter.

The top part of the penstock frames shall be sufficiently robust and substantial to prevent the frames bowing and if necessary, additional holding down bolts shall be fitted.

On rectangular penstocks the inverts shall be flush with renewable synthetic rubber seals on the bottom of the doors. The rubber shall be suitable for the application and of an approved type.

Penstocks shall be designed to ensure water tight closure at maximum head encountered in service.

Materials of construction shall be as follows:-

Stems and Spindles	-	Stainless steel
Stem Nuts	-	Gun metal BS 1400 - LG2
Sealing Faces	-	Appropriate to the conditions to be encountered in service
Fixing bolts, nuts & Washers	-	Stainless steel

Simple templates shall be supplied as soon as possible after approval of drawings to enable the civil Contractor to position the holes for holding down bolts for all penstocks over 1.0 m square.

8.13.11 Extension Spindles and Pedestals

Extension spindles shall be adequately sized to prevent buckling and shall be attached to the valve/penstock stem by a suitable adaptor incorporating two muff couplings, scarf lap jointed and pinned with at least two coupling joints included. Universal joints and waterproof sleeves shall be provided where specified. Extension spindles shall be manufactured from 080M40 (EN 8) steel.

Intermediate bearing support or guide brackets of cast iron, with slotted holes for site adjustment, shall be fitted to long shafts where necessary. Bearings shall be of PTFE or similar approved type.

Penstock and valve pedestals shall be of cast iron or heavy duty, welded, mild steel construction, with a substantial base and fixing provision. The base and top of the pedestals shall be machined normal to the axis of the drive shaft.

Where necessary, support guide bushes shall be fitted at the base of the pedestal.

The pedestal height shall be such that the handwheel is approximately 1 metre above the operator's floor level.

Covers of an approved type shall be provided for all rising spindles to totally enclose them when in the fully raised position.

8.14 Instruments and Ancillaries

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8.14.1 General

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

Panel mounted instruments shall have damp-protecting and dust-protecting cases. Instruments mounted outside instrument panels shall have weatherproof and dustproof cases. Instrument cases shall be of corrosion-resistant material or finish. Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust.

Unless otherwise specified instruments shall be finished in the manufacturer's standard colour. Instrument dials shall be of such material that no peeling or discoloration will take place with age.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 100 mm except where forming part of standard instruments and accessories such as air sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Equipment mounted in enclosure shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that changes of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without artificial cooling. Instruments shall be easily withdraw able from cases without interrupting their circuits.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously.

Measuring instruments shall have zero and span adjustment.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection

at all times including periods of servicing, adjustment, calibration and maintenance. Instruments mounted in open areas which could be vandalized shall be mounted in lockable vandal proof boxes.

8.14.2 In-Line Flow Meters

In-line flow meters shall be of the electromagnetic type complying with the requirements of BS 5792. They shall operate on electromagnetic induction principles and give an output signal directly proportional to the liquid rate of flow.

Each meter shall have a stainless steel metering tube (detector head) and a non-conductive liner suitable for potable water. End connections shall be steel flanged. The detector head shall be complete with corrosion resistant earthing rings and matching flange adaptors of the self-locking type (Flexlock or equal) suitable for use on the pipes described in the Particular Specifications. One flange of the detector head shall be connected to a flanged pipe, while the other shall be connected with the flange adaptor to faciltate removal.

The flow meter shall be carefully sited in the process pipework in accordance with BS 5792 and the flow meter supplier's instructions. Particular attention should be paid to the provision of the correct velocity range, earthing rings and the correct number of upstream and downstream clear diameters. A bypass and isolating valves shall be provided to allow the removal of the flow meter for maintenance.

Any taper pieces necessary to give the correct velocity range through the flowmeter shall be provided by the Contractor.

The primary flowhead shall be suitable for continuous submersion to BS 5490: IP68 or better. The maximum depth of submergence shall be 3 metres. The primary flowhead shall have electrodes which may be removed for cleaning or replacement without interrupting the flow.

Plant mounting enclosures for signal converters shall be to IEC 529, standard IP65 or better. Measuring ranges shall be continuously adjustable from 1 to 9.999 metres per second with facility to change to 0.5 to 5.5 m/s for high accuracy measurement of low flows.

For flows between 50-100% of the range, the accuracy shall be better than or equal to "0.5% of the actual flow rate; for flows between 10-50% of the range accuracy shall be better than or equal to "0.3% of the actual flow rate; and for flows between 1-10%, accuracy shall be better than or equal to "0.1% full scale value.

The effects of ambient temperature on the output signals shall not exceed 0.15% per 10^{o} C.

Relay units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall have conductivity discs.

8.14.3 Pressure Gauges and Switches

Pressure gauges shall comply with BS 1780. Pressure gauges, transmitters and switches shall have over range protection. No plastic material shall be used in their construction.

Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material. Pressure gauges shall have concentric scales.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

Recorder scales and charts shall be in accordance with BS 1794 and BS 3693 as applicable. Single-pen recorders used for more than one measurement shall have rotary switch selectors with plates engraved to show the identity of the selected measurement.

8.14.4 Electrical Indicators and Integrators

Indicators for use with analogue signal transmission systems shall comply with BS 89 and have an accuracy class index of 1.0. Indicator movements shall be critically damped (dead-beat). Indicators for use on more than one circuit shall have rotary switches to select the circuit, with engraved plates to show the circuit selected.

Indicators shall have circular scales or shall be of the vertical edgewise type and shall be designed to avoid parallax error. Scales shall be clearly marked in the specified units and shall comply with BS 3693. All instruments which are mounted on one panel or board, or are in adjacent groupings, shall have similar styles of figures and letters. Dials shall be white with black scales and lettering not subject to fading.

The material for scales shall be such that no peeling or discolouration will take place with age under all environmental conditions.

Major scale marks and numerals shall be of the same size and thickness and shall be separated by not more than twenty five minor marks. Pointers shall taper to the width of the scale marks.

Integrators shall be of the multi-digit cyclometer type. Each integrator shall have an integral or separate current-to-pulse converter with sufficient adjustment of the pulse rate to avoid the use of any multiplying factor except in integer power of 10. Each integrator shall incorporate an adjustable limiter whereby any input below a preset value is inoperative. Unless otherwise specified, integrators shall have a minimum of eight digits with a decimal point where applicable.

8.15 Corrosion Protection

8.15.1 Surface Preparation

(a) **General**

All surfaces to be coated with non-metallic coatings shall, where possible, be blast cleaned as specified below. Where blast cleaning is not possible because the material is thin gauge steel, the surfaces shall be cleaned by alternative means, but the Contractor shall obtain the approval of the Engineer before resorting to such alternative methods of surface preparation.

Surfaces to be coated with metal coatings shall be prepared in accordance with the standards governing the particular type of coating to be applied, e.g. BS 729 for surfaces to be hot dip galvanised. Surfaces to be coated with zinc metal spray shall be blast cleaned as specified below.

Any items not to be coated, which are in contact with or adjacent to surface due for coating, shall be removed or covered prior to surface preparation and coating operations.

Surface preparation and coating of metal surfaces shall not be performed: during rain, wind, fog or when dust is in suspension in the air. if the surface is likely to become damp after surface preparation and before coating. in areas where harmful particles are in suspension when surface temperature is less than 3ºC above the surrounding air's dew point. When air relative humidity is greater than 85% (or outside the range 50 to 85% when applying zinc silicate).

When air or surface temperature is below 5ºC for conventional solvent-based coatings or below 13ºC for chemically cured coatings, or when air or surface temperature is above that specified by the Coating Manufacturer. at any time when the above conditions are likely to occur before the coating is dry to handle.

(b) **Preparation and Priming of Blast-Cleaned Steel Surfaces**

(i) Degreasing

All surfaces shall be degreased before blast cleaning. If grease or similar contamination is introduced during the cleaning process, then the affected areas need to be degreased again, and the source of the contamination eliminated.

Grease and dirt shall be removed from the surface by emulsion cleaners followed by thorough rinsing with clean fresh non-saline water, by steam cleaning or by high pressure clean fresh non-saline water jetting. If white spirits or similar solvents are used then the use of a detergent or emulsion cleaner shall follow and the operation completed by thorough rinsing with clean fresh non-saline water. Detergent or emulsion cleaning with solvents without subsequent washing and rinsing with clean fresh non-saline water shall not be permitted. The surface shall then be allowed to dry thoroughly.

(ii) Blast Cleaning Equipment

Only dry blasting techniques shall be permitted.

All blast cleaning equipment shall be well maintained and the correct type of pot valves fitted for the specified grit. Blast nozzles shall be of the Venturi type and of suitable size and shall be replaced once the internal diameter is 33% greater than its original size.

Air for blast cleaning shall be of adequate capacity and capable of maintaining a steady optimum pressure. Efficient water and oil traps shall be installed and these cleaned regularly to ensure that the air used is both clean and dry. Condensation shall not be allowed to form in the delivery lines after the initial water and oil traps.

The blasting equipment shall be such that, at the end of the operation, the treated surfaces are completely dry and grease free.

(iii) Abrasives

Abrasives shall consist of angular chilled iron or steel grit, treated sand, or copper slag.

Chilled iron or steel grit shall have a hardness of 60-80 Rc. It shall have a good angularity of form with sharp cutting edges and shall be free of "half rounds", and shall be either grade G17 or Grade G24 to BS 2451.

Where sand is permitted as the blasting medium, then it shall be quartz sand washed, clean and dry and shall be gypsum and salt free. Sea sand shall not be used. The particle size shall be between 0.7 mm and 2.0 mm. Sand blasting shall not be used on surfaces to be subsequently metal sprayed.

All abrasives shall be maintained in a dry condition, adequately graded to remove overfine and detritus removed from the surface of the blast cleaned component. In the case of sand or copper slag, only virgin abrasives shall be used.

In the event of any grit being found under or embodied in the subsequent coating film, then the affected areas shall be re-blasted and the complete coating system re-applied.

(iv) Surface Cleanliness and Profile

Prior to the commencement of surface preparation surface irregularities including cracks, surface laminations, shelling, deep pitting, laps, fins, sawcuts and burrs shall be removed and all sharp edges radiused to at least 3mm. All bolt holes shall be drilled and the edges smoothed before blasting. All welds shall be continuous and they shall be made smooth and free from undercuts, slag inclusions and residues before blasting. Surfaces shall be made free from weld spatter and mineral scale before blasting. Irregularities which become apparent after blast cleaning shall be removed by grinding and dressed areas shall be reblasted to restore the required standards of cleanliness and roughness. Grinding must not reduce the metal thickness to below the required minimum metal thickness.

Blast-cleaned steel surfaces that shall be subsequently coated with a sprayed metal coating shall be cleaned to Sa 3 with a profile of 75 to 115 microns. Other surfaces to be coated shall be blast cleaned to Sa 22 or Sa 3 with a profile of 50 to 75 microns or 75 to 115 microns as by the Coating Manufacturer and approved by the Engineer. It is accepted that there will be isolated rogue peaks where the amplitude is abnormal but nowhere shall these exceed 150 microns for surfaces profiles of 75-115 microns and 100 microns for surfaces profiles of 50-75 microns.

The surfaces of steel shall, after completion of the blasting process, be cleaned using stiff bristle brushes or be air-blasted or vacuum cleaned to ensure that all traces of abrasive material and blast-cleaning products are removed.

If oil or grease gets on the surface of steel after blast-cleaning, then the oil or grease shall be removed by washing with an emulsion cleaner and the surface thoroughly rinsed with clean fresh non-saline water and dried. The surfaces shall then be blast-cleaned again to the specified standard.

Surface preparation operations for coating shall be terminated early enough during the day to permit application of the adopted primer on the prepared surface within daylight hours. The primer or first coat shall be applied as soon as possible, and not later than 4 hours after commencement of surface preparation and before any deterioration or contamination occurs of the cleaned surface. In the case of sprayed metal coatings, the

first coat shall be applied as soon as possible and not later than 2 hours after commencement of surface preparation.

8.15.2 Preparation and Priming of Non-Ferrous and Stainless Steel Metal Surfaces

Any oil, grease or lubricant shall be removed by washing with an emulsion detergent cleaner followed by thorough rinsing with clean, fresh, non-saline water followed by drying. Degreasing by solvent washing is not allowed unless it is followed by the above mentioned emulsion cleaning. Dirt, adherent matter and corrosion products (such as form on zinc and aluminium surfaces) shall be removed by light abrasion in conjunction with washing and rinsing with clean, fresh non-saline water followed by drying. Non-metallic inert abrasives shall be used such as fine abrasive paper, nylon pads or stiff brushes. Metal wire wool or wire brushes shall not be used.

Prior to priming, the surface shall be keyed either by light abrasion or light (sweep) blasting using non-metallic materials which are free from chlorides, copper and iron. This does not apply to matt or porous surfaces such as are produced by metal spraying or electrolytic deposition where the primer can be applied directly. In case of thin metallic coatings eg galvanised or metal spray, particular care shall be taken not to damage or deplete the coating. Surfaces which are too thin for blasting techniques shall be prepared as recommended by the coating manufacturer.

Before priming (or sealing as in the case of metal spray surfaces), the surface shall be perfectly clean, dry and in the correct environmental conditions as specified in section 2.1. The primer used shall meet the coating manufacturers recommendations for the particular non-ferrous metal surface to be coated. Oil/alkyd based primers are not to be used on zinc surfaces where the alkaline conditions at the zinc/coating interface can cause saponification and coating failure.

Noble metal trim that is to be coated with High Build Epoxy shall be prepared to the requirements stated in Section 3.22.1

8.15.3 Machined Surfaces

Machined parts, where immediate protective coating is not required, shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted machined interfaces, such as flanges, shall be coated with a thin coat of anti-rust compound before assembly.

8.15.4 Preparation of Other Precoated Surfaces

If, with the approval of the Engineer, an item has been supplied in its intermediate coating prior to installation, then the Coating Manufacturer's recommendations, with the approval of the Engineer, shall be followed with regard to surface preparation prior to the application of the top coat.

8.15.5 Preparation by Power Tools

Surfaces to be prepared by power tools shall be degreased as per Section 3.22.1.2(a) prior to any surface preparation. The surface preparation shall be such that, at the end of the operation, the surfaces are completely dry and free of grease and contamination.

Surface cleaning by power tools shall follow the recommendations of BS 7079 and shall be cleaned to ISO 8501-1 Grade St 3. Preparation by power tools shall not burnish the surface.

Any resulting loose material shall be removed by brushing, vacuum cleaning, or blasting with clean, dry, oil-free compressed air. Reference photographs shall then be taken prior to the application of any coating.

Surfaces prepared by power tools shall be primed by a surface tolerant epoxy primer

8.15.6 General Requirements for Coating Systems

The majority of coating systems are conventional liquid applied coating systems and the requirements set out in this specification relate strongly to the associated standard painting schemes. Attention is drawn to the following specialist coating systems:

Two pack solvent-free polyurethane
Vinyl ester with glass flake pigment
Extruded polyethylene
Vulcanised rubber
Fusion bonded epoxy

These systems are expected to have specific additional requirements and shall only be applied by specialist staff who have experience in applying these systems and who are approved by the coating manufacturer. Particular attention shall be paid to the Coating Manufacturers recommendations for application, inspection and testing, and repair method. Fully detailed vendor data as detailed below shall be submitted for Engineer review and approval prior to item manufacture.

In the case of coatings being applied by the Vendor or his Subcontractors, the Vendor shall maintain all documentation related to the purchase, storage and use of materials with reference made to the product type, material test certificates and storage life.

The Vendor shall submit fully detailed surface preparation and coating procedures to the Contractor for approval before commencing the coating operations which shall include the following information for each coating system as a minimum:

- Description of the items and substrates to be prepared and coated
- Description of the general application conditions at the coating site
- Method, equipment and abrasives for surface preparation
- Standard of surface cleanliness and surface profile
- Ranges of temperature, relative humidity and control methods
- Method and equipment for coating application
- Time between surface preparation and first coat
- Minimum and maximum dry film thickness of a single coat
- Number of coats and minimum total dry film thickness
- Relevant dry characteristics e.g. recoatability in relation to temperature and relative humidity
- Procedure for repair of damaged coatings
- Methods and frequency of inspection and testing
- Coating Manufacturers' technical data/application sheets

- Colour of each coat
- Potable water certification, where applicable the Coating Manufacturers' approval to apply specialist coating systems an Inspection and Test plan
- Cathodic disbondment test results (where applicable)

Zinc rich epoxy primers shall be based on 2-pack epoxy media, shall contain a minimum of 91% metallic zinc by weight in the dry film, and shall comply with the requirements of BS 4652 'Metallic Zinc-Rich Priming Paint (Organic Media)'.

Ethyl zinc silicate primer shall contain a minimum of 85% metallic zinc by weight in the dry film and shall comply with the requirements of Type 1 of SSPC Paint 20.

All coating used on any part of the plant in contact with water shall be non-toxic, non-carcinogenic, not impart taste, odour, or turbidity to the water or foster microbial growth.

To avoid the possibility of the presence of the carcinogenic polyaromatic hydrocarbons, all bituminous paints and coatings coming in contact with the water must be manufactured from petroleum or asphaltic bitumen, and not from Coal-Tar bitumen.

Lead based paint shall not be used.

All materials coming into contact with the conveyed water shall have current potable water certification from recognised certification authority.

Coatings used together with cathodic protection systems shall meet the cathodic disbondment criterion of the British Gas Corporation standard PS/CW6 when tested under conditions equivalent to Appendix F of that standard.

All coating materials shall be purchased from Coating Manufacturers well established in the manufacture of high performance coating materials for large projects for a period of at least ten years and all materials shall have a proven track record of at least five years. All coatings within a system shall be purchased from a single Coating Manufacturer to ensure compatibility.
All epoxy coatings shall be based on 2-pack formulations (apart from FBE) and all solvent based polyurethane top coats shall be 2-pack polyurethane acrylic formulations.

8.15.7 Coating Containers

All coatings shall be delivered in containers sealed by the Coating Manufacturer.

The name of the Coating Manufacturer, colour, type of coating, batch number shelf life and information regarding special storage requirements shall be clearly shown on each container. The markings on the containers shall clearly identify coating prepared with a special consistency for spray application.

The capacity of containers for single pack coating shall generally not exceed 5 litres. Single pack coating shall only be delivered in containers larger than 5 litres when the Coating Manufacturer has demonstrated that the method of preparing and applying coating delivered in larger containers is satisfactory. Zinc-rich coatings shall not be supplied in containers larger than 5 litres.

Two-pack coatings shall be supplied in kits by the Coating Manufacturer in sealed containers. Each kit shall have sufficient materials for a full batch of coating.

8.15.8 Storage of Coatings and other Materials

Coatings shall be stored under cover, in conditions as recommended by the Coating Manufacturer.

Coatings shall be stored in such a manner that each batch can be issued for use in the order of delivery.

A separate store shall be provided for cleaning solvents used for brush or other cleaning purposes. They shall not be stored where coatings or coating thinners are stored or where coatings are prepared for application.

Coatings with a limited safe shelf life shall not be used after the expiry date shown on the container.

Any coating which has "livered" or gelled or otherwise deteriorated in storage shall not be used. Thixotropic materials which may be stirred to obtain normal consistency are not subject to this restriction. Suspect materials shall either be rejected or referred to the Coating Manufacturer.

8.15.9 Preparation of Coatings for Use

Coatings shall only be prepared for use as recommended by the Coating Manufacturer.

All single pack coating, which is not to be applied by spray, shall be prepared before it leaves the store and no adjustment shall be permitted to coating in painter's kettles or other containers used in the application process.

Two-pack coatings and/or coatings for spray application may be prepared adjacent to the location where the coating work is to be carried out.

Mechanical mixing of coatings shall be by means of mechanical high-speed shakers or rotary mixers fitted with a flat blade and speed control.

All coatings shall be mixed to an even consistency before being used. Coatings shall not be used unless all the pigment, including that which requires to be loosened from the bottom of the containers, has been dispersed evenly throughout the coating.

Thinners shall not be added to a coating unless their use is in accordance with the Coating Manufacturer's recommendations.

Two-pack coatings shall be mixed in strict accordance with the Coating Manufacturer's instructions, immediately before application and batches shall be mixed using the full contents of the containers. The size of containers shall ensure a correctly proportioned mixture when the whole contents of the appropriate containers are used.

The pot life of the coatings shall be specifically noted and any mixed coating which has exceeded its pot life shall be discarded irrespective of its apparent condition. pots, containers and spay equipment shall be cleaned out and a fresh batch of coating prepared.

8.15.10 Certification

The Vendor shall furnish to the Contractor certificates of compliance showing that all batches of all coatings meet all the requirements defined in this Specification. All material certificates shall comply with DIN 50049, inspection certificate 3.1 B.

8.15.11 Colours and Tints

The colour of the undercoats shall contrast with the colour of the next coat so that each stage of work can be readily identified.

8.16 Particular Coating Requirements

8.16.1 Vinyl Ester Glass Flake

In addition to the requirements stated in this document, the glass flake shall have a maximum diameter of 0.365 mm.

8.16.2 Extruded Polyethylene

A UV stabilised grade, type S (special)-n (normal) to DIN 30670 of extruded polyethylene shall be used, with a softening point of between 120 and 130 EC. Softening point of extruded polyethylene to be Vicat test to BS 2782 Part 1 : 1990 method 120A.

8.16.3 Vulcanised Rubber

The rubber used for lining valves shall be a polyisoprene based ebonite, with WRC approval. The hardness shall be 60 to 75 Shore 'D'.

8.16.4 Fusion Bonded Epoxy

Materials shall conform to WIS 4-52-01:The use of polymeric anti-corrosion (barrier) coatings.

8.16.5 Cementitious Modified Polymer

Cements used shall comply with BS 12 Specification for Portland Cement.

Materials shall be based on a cementations modified styrene acrylic copolymer such as Liquid Plastics Flexcrete FCR 8951.

8.17 Coating Application

8.17.1 General

Environmental conditions during coating application shall be in accordance with the requirements of Section 3.22.1.1 of this Specification.

Adequate ventilation shall be provided during coating application. Respirators shall be worn by all persons engaged in spray coating. Adjacent areas shall be protected by the use of drop cloths or other approved precautionary measures.

At the time of application, coating shall show no signs of deterioration and the suspension of pigments shall remain uniform.

All coatings shall be applied by personnel approved by the Vendor in the application of that particular coating.

The method of application of coating shall be executed in accordance with the Coating Manufacturer's recommendations. In case of conflict between this Specification and the Coating Manufacturer's recommendations, the latter shall apply.

Special precautions to avoid over thickness shall be adopted when zinc silicate primers are being applied.

The pressure and volume of the compressed air used for spray application shall meet the work requirement and be free from oil and water contamination. Traps, separators and filters shall be emptied and cleaned regularly.

Brush application shall be used where spray application cannot be employed e.g. surfaces not accessible to the spray gun or for cutting in at edges and similar locations.

Each coat shall be applied in a continuous, even layer free of runs, sags, missed areas, holidays, pinholes or any other defect. Each area which has not been properly coated or missed shall be recoated. The exception is thickly applied, 100% solids coatings such as two-pack solvent-free polyurethane and vinyl ester with glass flake where minor runs and sags are not detrimental to coating performance and may remain unless unacceptable for cosmetic reasons.

Surfaces inaccessible after assembly shall be prepared and fully coated prior to assembly.

All ferrous metal surfaces to be insulated shall be prepared and fully coated prior to application of insulation. Metal surfaces of anodised aluminium, stainless steel, chromium plate, copper and bronze and similar finished materials shall not require finishing coating, unless otherwise indicated.

Parts of operating units (mechanical and electrical) such as valve and damper operating linkages, heat sinks, sensing devices, motor and fan shafts, shall not be coated unless otherwise specified.

Any code-required labels, such as Underwriter's Laboratories and Factory Mutual, or any equipment identification, performance rating name or nomenclature plates shall not be coated.

In situations where the build up of static electricity may affect the quality of the paint finish, the spraying equipment and component being sprayed shall be adequately earthed.

8.17.2 Joint and Tape Wrapping

The joints of pipes and fittings protected by wrapping shall be cleaned, coated with primer solution, profiled with mastic and wrapped with tape in accordance with the following requirements or other alternative Engineer approved joint protection system.

(a) Primer

A bitumen solution shall be applied to the cleaned surfaces of the joint to provide a continuous coat of well adhered primer.

(b) Mastic

The mastic shall be a non-setting material, impervious to moisture and resistant to mineral acids, alkalis, salts and temperatures up to 70 degrees centigrade. It shall be approved for use with potable water applications.

(c) Tape

Cold applied self adhesive tropicalised UV stabilised bituminous laminate PVC backed tape having a minimum thickness of 1.65 mm and spirally wound to give a 55% overlap.

Pipework to be tape wrapped shall be precoated.

Tape wrapping of pipework shall conform to AWWA C209. If there is disagreement between this Specification and the requirements of the Standard, then the requirements of the standard shall be followed after prior approval by the Engineer.

8.17.3 Brush Coating

Brushes shall comply with the requirements of BS 2992 where appropriate. Brushes shall be in good conditions and be of the correct type and size to suit the type of coating, and the surface being coated.

8.17.4 Spray Coating

The recommendations on spraying made by the Coating Manufacturers shall be followed.

Spray equipment, especially spray guns using compressed air, shall not be used in locations where over-spray, rebound, drift or spray mist causes a nuisance in the vicinity of the spraying operations.

For "Hi-build" coatings, where airless spray coating is specified by the Coating Manufacturer, alternative methods of application shall not be acceptable.

8.17.5 Galvanising

Hot dip galvanising shall conform to the requirements of BS 729 or ASTM A153. Continuous hot dip galvanising of sheet steel shall follow the recommendations of BS 2989.

The minimum weights of galvanised coating are:

Buried orifice plates	1000 g/m^2
Sheet steel for ducting	275 g/m^2
Orifice plates in chambers	610 g/m^2
Air and vent pipework	610 g/m^2
Compressed air pipework	610 g/m^2
Cable tray, trunking, and conduit	610 g/m^2
Firefighting pipework and fittings	610 g/m^2

Surface preparation of galvanised surfaces prior to coating shall be by the use of flash blasting using an abrasive free from iron, copper and chloride or prepared as per Coating Manufacturer's recommendations for overcoating galvanising.

Threaded fasteners including washers, excluding those in contact with fuel, oil, shall be hot dip galvanised in accordance with BS 729 or ASTM 153 to give a minimum zinc coating weight of 305 g/m^2 of galvanised surface.

Hot dip to BS 729 or ASTM 153 shall be carried out after completion of all welding, drilling, grinding and other fabrication activities associated with the items to be galvanised. In particular welding of galvanised items after galvanising is not permitted. All galvanising shall be applied by the hot-dip process with spelter, of which not less than 98.5% by weight of zinc shall be pure zinc. The zinc coating shall be uniform, clean, and smooth.

No parts likely to come in subsequent contact with fuel oil shall be galvanised.

All galvanised parts shall be protected from damage to the zinc coating due to poorly ventilated damp conditions and abrasion during the periods of transit, storage and erection.

Galvanised parts shall be overcoated.

8.17.6 Metal Spray

Sprayed zinc coatings shall comply with BS 2569 Part 1. The minimum thickness of the coating, unless otherwise specified, shall be 250 microns. The coating shall be sprayed in multiple passes with each one at right angles to the previous one (at least two passes on every part of the item).
Metal spraying and overcoating shall only be carried out by specialist Subcontractors equipped to apply the full protective treatment. The specialist Subcontractors shall be subject to approval by the Contractor.

Zinc sprayed surfaces shall be sealed within 4 hours with an epoxy seal coating system

8.17.7 Cement Mortar Lining

Cement Mortar lining of factory finished steel pipes and fittings shall comply with the requirements of Section 29 of BS 534.

Cement Mortar lining of ferrous items exposed to water shall have hand rendered coatings in compliance with the composition, curing, finishing and inspection and testing requirements of Section 29 of BS 534. The lining shall only be applied by specialist Sub-contractors who are fully equipped for this type of application.

The cement and coating shall be ordinary Portland Cement to BS 12 or ASTM C150 (type II). Single thickness coating shall be to BS 534 in pipes where the coating is applied by centrifugal spinning.

Surfaces of spigot and socket joint portions and flange faces shall be free from cement mortar to permit jointing of pipes and fittings.

8.17.8 Miscellaneous

Colour code marking for piping systems shall be provided as directed. Marking shall be by coloured, pressure-sensitive adhesive tape, and flexible pipe marker or coating.

Lettering shall be black enamel water-type decalcomania, finished with a protective coating of spar varnish. Samples shall be approved before application.

All erection markings shall be clearly legible afterwards. The integrity of the material to be coated must not be altered by the cleaning and coating process.

8.17.9 Manufacturer's Standard Finishes

Manufacturer's Standard Finishes shall comply with this Specification.

Special care shall be taken to ensure standard finishes are suitable for the particular conditions applicable to the individual items of plant.

8.18 Coating Application

8.18.1 General

Equipment which has been delivered for coating on-site shall be cleaned and coated according to this specification and with the required coating. Surfaces which are delivered to site coated with a transit primer (e.g. blast, holding, shop or prefabrication primer), shall have the transit primer removed prior to surface preparation and application of the permanent coating system.

8.18.2 Coating Repair

(a) General

Coating repairs shall be done in accordance with the recommendations of the Coating Manufacturer utilising materials from the same Coating Manufacturer. The Coating Manufacturer's recommendations shall be followed at all times.

Damage to each coat of coating, whether shop or field applied shall be repaired before succeeding coats of coating are applied. The repair to the coating shall reinstate completely the original coating system, including the surface preparation quality

The extent of repair to the damaged area shall extend 50mm into the sound coating. If the substrate is exposed the surface shall be prepared by spot blasting back to the substrate, feathering the sound coating and removing any signs of oxidation on any exposed bare metal.

If the substrate has not been exposed then the area of the damage shall be lightly abraded to remove evidence of the damage and the individual coats reapplied to give the correct final minimum dft.

Prior to the mechanical preparation and application of primer the metal surface and feathered area of undamaged coating shall be detergent cleaned and thoroughly washed with clean fresh non-saline water to remove all soluble salts and dried in a manner which shall not re-deposit contaminants on to the cleaned surfaces.

The coating used shall be as originally specified or shall be compatible with the original coating system and surface preparation technique.

(b) Hot Dipped Galvanised Surfaces

The repair of minor scratches or scuffed areas where the steel substrate has not been exposed shall be carried out in accordance with the requirements of BS 729 Appendix-D. The surface shall be detergent cleaned and washed with clean fresh non-saline water followed by light spot blasting to obtain a surface finish with a surface profile of 20 to 30 microns and using the two pack metallic zinc rich epoxy primer defined therein, which shall be applied in at least two coats to a minimum dry film thickness to equal that of the original coating.

Major damage as defined by BS 729 Appendix D shall require regalvanising or else repairing by a procedure approved by the Engineer.

(c) Metal Sprayed Surfaces

Minor scratches or scuffed areas where the steel surface is not exposed and the metal spray thickness is above the minimum specified thickness shall be degreased, cleaned and dried as per section 2.3 and recoated with the same overcoat as originally installed according to the Coating Manufacturers recommendations.

Major damage where the steel surface is exposed or the metal coating is below the specified minimum thickness shall have the damaged coating removed and the substrate prepared and the metal sprayed coating reinstated as originally specified. This repair shall be carried out by specialist Subcontractors.

(d) Cement Mortar Linings

Damaged coatings shall be removed to expose sound coating at least 25mm around the damaged area. The exposed area shall be thoroughly degreased and rinsed with clean fresh non-saline water and dried thoroughly.

The surface shall be lightly abraded and new mortar, mixed to the same cement sand ratio of the original coat, shall be applied by trowel to the cleaned exposed area to reinstate the required coating thickness.

8.18.3 Inspection and Testing

(a) General

All coating work, achieved in accordance with this Specification, is subject to inspection. Each phase of the work shall be inspected. Unacceptable conditions shall be corrected, reinspected and accepted before proceeding to the next phase. The level of inspection by the Vendor or his Subcontractors shall be 'full' as defined in BS 5493. All Vendors shall submit an inspection and test plan for the coating operations.
All tape wrapped pipe shall be inspected in accordance with AWWA-C209 Section 4.

Vulcanised rubber coatings shall be inspected and tested in accordance with Sections 5 and 6 of BS 6374 Part 5 and shall be subjected to 100% visual inspection.

Cement mortar/concrete linings of pipes and steel fittings shall be inspected and tested in accordance with Section 29 and of BS 534.

Extruded Polyethylene coatings shall be inspected and tested in accordance with DIN 30670.

(b) Environment

Accurate daily records shall be kept of air and surface temperatures, dew point and relative humidity conditions and the times of commencement and cessation of all phases of the cleaning, surface preparation and coating operation. These records shall be available for review.

Relative humidity shall be measured with a sling hygrometer. Air and surface temperatures, dew point and relative humidity shall be measured prior to commencement of surface preparation and/or coating and a minimum total of 4 times during a normal working shift and the results recorded. Work shall not be undertaken unless the results obtained are within the limits of this Specification.

(c) Surface Preparation

All surfaces shall be inspected visually to ensure compliance with the requirements of this Specification and the results recorded. The surface profile of abrasive blast cleaned steel shall be measured after preparation using replica tape and a portable micrometer. A minimum of one measurement or impression shall be made per square metre of prepared surface and the results recorded.

(d) Dry Film Thickness

The film thickness of each coat, and the total dry film thickness, shall be measured and all results recorded.

As a general rule the dry film thickness shall not exceed the specified minimum dry film thickness by more than 25%. Surfaces with coating film thicknesses below that specified, shall receive additional coat(s) of coating, as recommended by Coating Manufacturer, to obtain specified thickness. The dry film thickness shall not be below that specified.

Where the quality of film is impaired by excess film thickness, (e.g. wrinkling, mud cracking or general softness), the unsatisfactory coating shall be removed and re-coated in accordance with this Specification.

The thickness of dry coating films shall be measured by means of a suitable, properly calibrated electronic thickness gauges with an accuracy of at least +/- 10% of the measured thickness, as specified in BS 3900 part C5, method No. 6.

On substrates where electronic thickness gauges cannot be used or on coatings where the over coating times are too short to permit the use of electronic thickness gauges, the dry film thickness shall be estimated from wet film thickness measurements used by comb or wheel gauges as specified in BS 3900 part C5 method No. C7.

Measurements shall be recorded in the daily inspection reports. A minimum of two measurements per square metre for each coating is considered an appropriate reading frequency. Records shall be maintained of all thickness tests carried out along with the records of the coating system batch number, and dates of purchase, application, and shelf life.

8.18.4 Holiday Detection

All buried and wetted coatings shall be subjected to 100% holiday detection after final cure of the coating system. Tanks and pipework to be buried shall be subjected to 100% holiday detection immediately prior to burial. The method of holiday testing shall be as specified by the Coating Manufacturer.

The voltage applied shall be as specified by the Coating Manufacturer for that coating system. All defects found shall be marked, repaired and retested.

All results shall be recorded in the daily inspection reports.

8.18.5 Coating Adhesion

The adhesion of all buried and wetted coatings shall be measured using an Elcometer adhesion tester, or equivalent, to BS EN 24624, or equivalent test method, after final cure of the coating system. Since this test can be a destructive test, the coating adhesion shall be measured on test plates of the same material as the substrate being coated, which have been prepared and coated in an identical fashion to, and at the same time as, the surfaces being coated. A test plate shall be prepared for each item to be coated or at least for every 25 square metres of coated area.

At least three adhesion tests shall be carried out per test plate with the coating fully cut down to the substrate around the circumference of the dolly before testing. The minimum adhesion strengths shall meet the requirements of the Coating Manufacturer and shall not be less than 0.42 kg/mm^2.

If the adhesion test result on a test plate is below that specified for that particular coating system, the coating on the entire area to which the test plate relates shall be completely removed to bare metal and the surface be re-prepared and the complete coating system reinstated and reinspected in accordance with the requirements of this Specification. All results shall be recorded in the daily inspection reports.

8.18.6 Reports

All inspection results and records shall be written up into daily reports for the applied coating system.

8.18.7 Lighting Requirements

The lighting requirements shall follow the recommendations of the CIBSE Code for Interior Lighting 1984 (1989) lamps of colour rendering group 1A shall be used and the recommendations of BS 950 shall be followed as appropriate. An illuminance of at least 500 lux shall be provided on the task.

8.18.8 Cleaning

Cloths, cotton waste and other debris that might constitute a fire hazard shall be placed in closed metal containers and removed at the end of each day.

Upon completion of the work, staging, scaffolding, and containers shall be removed from the site or destroyed in an approved manner, coating and other deposits upon adjacent surfaces shall be removed and the entire job left clean and acceptable.

8.18.9 Health and Safety

In addition to complying with all relevant statutory regulations, all precautions that are necessary to avoid health and safety risks, either to operators or to personnel working in the areas concerned, shall also be undertaken.

Where air operated equipment is used, operators shall be provided with hoods supplied with a filtered clean cool air supply to prevent blasting and coating residues being inhaled. It shall be noted that coatings containing inflammable solvents, and applied in enclosed or confined spaces, present hazards and precautions must be taken to eliminate any danger. To avoid the explosion hazard, sufficient ventilation air must be provided to maintain the ratio of vapour/air at no more than 10% of the lower explosive limit. Data on minimum ventilation air quantity is given in the product data sheets. Similarly, to avoid the toxic hazards present in many coating solvents, sufficient ventilation air must be provided. Data shall be provided by the Coating Manufacturer, setting out the basic safety precautions.

8.19 Floor Trench Covers, Chequer Plate and Flooring

Unless otherwise specified, pipes and cables are to be laid in ducts below the finished floor level. The ducts shall be covered with steel plates with diamond chequering or other approved non-slip pattern, or with egg crate flooring. The plates or flooring sections shall be of sufficient thickness not to bend or spring in ordinary usage and shall fit evenly and truly into steel angle frames or kerbing with suitable attachments for building into the concrete floor.

The Contractor shall supply complete drawings showing the arrangement of trenches, chequer plates and egg crate flooring sections, fully dimensioned so that the trenches can be formed and the kerbs built into the floor by the civil works Contractor. The plates and flooring sections shall be divided into suitable sizes and lengths for lifting, with two holes in each section. One set of lifting keys shall also be supplied at each location.

8.20 Foundation Bolts and Fixing Arrangements

All foundation bolts and fixing bolts required to secure the items to be supplied and erected under this Contract shall be provided.

The Contractor shall provide, within the time(s) specified, dimensioned foundation drawings showing the type of foundation or fixing required for each item of plant. The Contractor shall state the mechanical strength of large fixing bolts, which shall be of an approved size and diameter, galvanized where not embedded in concrete, with galvanized nuts and washers.

8.21 Brackets, Fixings, Anchor Points and Pipe and Valve Supports

All brackets, hangers and fixings, anchor points and supports for the satisfactory installation of all pipework, valves and other equipment shall be supplied and erected. The supports shall prevent excessive movement of the pipework and eliminate extraneous stress on pump casings and other items of plant.

Where pipe and valve supports or anchors at attached to structures, the loadings imposed at the point of attachment shall be stated by the Contractor on submission of the relevant foundation drawings and approved by the Engineer.

All necessary nuts, bolts and washers for such fixings shall be included.

8.22 Guarding and Protection of Moving Parts

Moving parts of machinery including all shafts, couplings, collars, projecting key heads, gear wheels, belt drives, chain drives and all other moving machinery shall be guarded where necessary to give complete protection to operating personnel. All set screw on revolving shafts shall be countersunk or suitably protected. Guards shall be of an approved design, fitted where necessary with inspection doors. All guards shall be arranged so that they can be removed without disturbing the parts of the equipment they protect. Guards for shaft couplings shall at least be equal to BS 5304.

8.23 Schedule of Tests

8.23.1 General

As many tests as possible shall be arranged together. Five copies of the Contractor's records of all tests shall be furnished to the Engineer.

All material which is specified for tests at the manufacturer's works must satisfactorily pass such tests before being painted or otherwise coated.

All test instruments, fuels and consumables required for the tests, commissioning and setting to work the Plant shall be supplied by the Contractor. Test instruments and shall be to approval and shall be calibrated by a competent authority as may be approved by the Engineer.

8.23.2 Tests at Manufacturer's Works

The mechanical equipment supplied under this Contract will be tested to prove compliance with the requirements of this Specification and with the relevant British Standard specification where applicable.

8.23.3 Tests after Erection on Site

All Plant shall pass such tests on site as are required by the Engineer to prove compliance with the Contract independently of any tests which may already have been carried out at the Manufacturer's Works. In particular, all pump performance tests made at the Manufacturer's Works shall be repeated.

If, in the opinion of the Engineer, the Plant does not comply with this specification, the defect shall be rectified at no cost to the Employer.

9 ELECTRICAL REQUIREMENTS

9.1 Introduction

This Section covers the supply and installation of all electrical plant and equipment including all necessary calculations, technical details, catalogues, drawings, etc., for the plant, machinery, apparatus, equipment, systems, articles, and associated accessories as outlined on the Drawings and described in the Specification.

The final ratings of switchgear, electrical protection devices, cable ratings, etc., shall, in general, be dependent upon the ratings and characteristics of the pumping sets and mechanical plant being supplied and the adopted method of starting. In this respect it shall be deemed that the Contractor has taken this into consideration and has offered compatible electrical and mechanical plant and equipment.

The final arrangement of switchboards, switchgear and motor control panels is dependent upon the equipment offered and therefore subject to approval.

9.2 Voltage and Supply System

The supply to the Site is provided by SNEL and will be 15,000 V, or other 3 phase, 3 wire 50 Hz, stepped down through a suitably rated transformer to 415 V/240 V for distribution and service connections.

It shall be the responsibility of the Contractor to ascertain the SNEL voltage supply systems at the site. As shown on the Drawings, loads may be such that a 415 V supply can be extended directly to the compound without the need for a step down power transformer.

The Contractor shall also be responsible for liaising fully with SNEL with respect to:

- Providing a detailed assessment of the load demand at the site;
- Agreeing methods of starting for the proposed motors;
- Finalising details of metering requirements, terminations, glands, lugs and the like to suit the SNEL meters and cables;
- Advising SNEL of the approved Programme of Works so that SNEL can plan their installation.

9.3 Cables

9.3.1 General

This Section of the Specification deals with the materials and types of cables which may be used along with termination and identification requirements for the cables. Full details, catalogues, etc., shall be submitted with the Tender.

All cables supplied for use under the Contract shall be British Approvals Service for Electric Cables (BASEC) approved and shall be manufactured to the following British Standards, as appropriate, BS 5308-1:1986, BS 5467:1997+A3:2008, BS 6004:2000, BS 6007:2006, BS 6207-1:1995, BS 6346:1997, BS 6480:1988, BS 6500:2000 and BS 7430:1998.

9.3.2 Materials and Minimum Sizes

Cables shall have standard copper conductors, with minimum cross sectional areas as follows:

- Motor supply cables 4 mm^2
- Cabling to control devices external to switchboards 2.5 mm^2
- Telemetry control/digital signal cables 0.75 mm^2
- Domestic lighting 1.5 mm^2
- Domestic general power 2.5 mm^2

The neutral core of a cable or the neutral cable of a circuit shall be of the same cross sectional area as the associated phase.

9.3.3 XLPE Single Wire Armoured Cable

XLPE/SWA/PVC - cross linked low density polyethylene insulated, stranded copper conductors, extruded PVC bedding, galvanised steel wire armoured, flame retardant black PVC sheathed overall, suitable for use on an earthed system at a rated voltage of 0.6/1 kV as specified. Conductor temperature shall not exceed 90^oC for continuous operation and 250 ^oC for short circuit. Cables shall comply with BS 5467:1997+A3:2008.

Installation shall be direct in the ground, in underground service ducts or inside buildings clipped direct to a surface or cable tray.

Non-magnetic armour of hard drawn aluminium shall be used on single core cables.

9.3.4 PVC Insulated Single Wire Armoured Cable

PVC/SWA/PVC - PVC insulated, extruded PVC bedding, galvanised steel wire armoured, flame retardant black PVC sheathed overall, stranded copper conductors suitable for operation on a system at a rated voltage of 0.6/1 kV. Conductor temperature shall not exceed 70^o C for continuous operation. Cables shall comply with BS 6346:1997 and BS 6746:1993.

Installation shall be direct in the ground, in underground service ducts or inside buildings clipped direct to a surface or cable tray.

Non-magnetic armour of hard drawn aluminium shall be used on single core cables.

The cables shall be used on the low voltage (415 V) systems for cable ratings up to and including 10 mm^2, or control systems as appropriate shall be:

- multi-core, PVC insulated, extruded PVC bedded, single steel wire armoured, PVC oversheathed, or
- single core, PVC insulated and sheathed, unarmoured, or
- single core, PVC insulated, aluminium wire armoured with overall black PVC sheath.

9.3.5 Polyethylene Insulated Armoured Instrument Cable

Cables for use as instrument cables shall be to BS 6622 and shall be multi-pair, polyethylene insulated and bedded, single wire armoured PVC oversheath.

9.3.6 Sheathed and Insulated Flexible Cords

These cords shall be to BS 6500:2000 and shall be 85^{o} rubber insulated, H.O.F.R sheathed.

Flexible cords shall only be used for the following:

- Final connection between fused connection units, having flex outlets, junction boxes, and their associated appliance
- Lighting pendants

The minimum cross sectional area of conductors in flexible cords shall be 0.75 mm^2 (24/0.2 mm) and the length not exceeding 400 mm.

9.3.7 Flexible Cables - Power

Flexible cables where required and used to supply submersible motors shall be 600/1000 Volt grade EP rubber insulated with Niplas outer sheathing having flexible, annealed and tinned copper conductors. Alternative, special, standard manufacturers' cables may be considered. Details to be provided.

9.3.8 PVC Insulated Cable

This cable type shall be PVC insulated 600/1000 volt grade copper cable to BS 6004:2000 and shall only be used when enclosed within a conduit or trunking.

9.3.9 PVC Insulated and Sheathed Cable

This cable type shall be PVC insulated PVC oversheathed 600/1000 volt grade copper cable to BS 6004:2000 and BS 6346:1997 and shall be used as meter tails or transformer tails to switchgear provided that it is protected from mechanical damage. This type of cable shall also be used for direct, surface-run domestic wiring.

9.3.10 Screened Cable

These cables shall be PVC insulated, lapped with a non-hygroscopic tape, tinned copper wire braided. Signalling cables shall conform to BT Specification CW 1128 with armouring to CW 1198.

9.3.11 Mineral Insulated Cable

These cables shall be to BS 6207-3:2001,BSEN 60702-1:2002,BSEN 60702-2:2002 and shall have copper conductors with copper outersheath and PVC oversheath, 600/1000 volt grade.

This type of cable may only be used in specific environments or for specific services such as fire alarm systems, or similar type requirements.

9.3.12 Telephone Cables

Telephone cables shall be thermoplastic insulated multipair telephone type cables having twisted pairs of copper conductors.

9.3.13 Bare Copper Earth Wire (BCEW)

An earth wire shall be run with any selected cable, and be buried in the trench with it. The minimum size of earth wire shall be as shown on the Drawings or half the cross sectional area of the cable with which it is laid, whichever is the larger, and fixed to the power cable with nylon tie clips at regular intervals not exceeding 2,000 mm. The earth wire shall consist of annealed bare stranded copper conductor.

9.3.14 Earth Bonding Cables

Earth bonding cables shall be PVC/PVC type and have stranded copper conductors PVC insulated and sheathed.

9.4 Cable Installation

9.4.1 General

The Contractor shall plan and position all cable runs so that they do not foul other services, maximum accessibility is maintained and unsightly crossovers are avoided. The cable routes shall be planned along with other services so that agreed service reserves are followed. Details shown on the Drawings are indicative only.

All cables shall be neatly run, dressed and supported to the approval of the Engineer.

All cable supports and racks together with fixing bolts, clamps, nuts and screws for indoor situations and in cable trenches shall be included, and shall be made from galvanised steel or cast silicon aluminium. Cable supports and racks shall be made by a recognised manufacturer and to the approval of the Engineer. All supports and racks shall be arranged for the easy removal of any single cable in a multi-cable run without threading cables through supports and racks.

The Contractor shall produce a cable schedule so that all information relating to the cables is maintained. This information includes dates of manufacture, despatch, delivery to Site, installation, initial tests, connecting up and final testing and commissioning. In addition, the Contractor shall maintain a daily/weekly record of the cables as installation proceeds. These records shall be witnessed as necessary and shall form the basis of the Record Drawings.

Where cables are run together in the same tray, trench or conduit they shall be suitably derated or spaced to maintain current rating. Crossovers shall be avoided where possible. Power and signal cables shall be run separately to minimise interference.

Where a number of cables are terminated in equipment, they should finally approach the equipment from a common direction.

The Contractor shall supply all cable tray, cable trunking, saddles, cleats, hangers, brackets, trays, ladders, ties, nuts, bolts, screws, washers, packing and marker tape as may be necessary to complete the installation.

Marker tape shall be 150 mm wide, yellow with black printing "DANGER-ELECTRIC CABLES".

Where cables cross other services or other cables the required separation shall be maintained. In addition, concrete cable tiles shall be provided between the services to maintain the separation and protection, the tiles extending for a distance of 1000 mm either side of the existing services.

Power cables shall be installed without tees or joints unless approved by the Engineer. Cables shall not be installed in areas of direct sunlight. Where this is unavoidable, approved sunshields shall be supplied and installed.

All cables shall be suitably protected. Those running on the external surfaces of structures shall be protected against the effects of ultra-violet light. Where cables are sleeved through conduit or ducts, all ends shall be bushed to prevent damage to cable sheathing. The Contractor shall be deemed to have allowed for cable protection in his rates.

The as-installed drawings provided by the Contractor shall clearly show all services and cable details and dimensions.

9.4.2 Installation Direct in the Ground

The Contractor shall carry out all excavation, supply and install pipes or ducts where required, prepare the trench bottom, lay cables, provide and install markers and warning tape, backfill, consolidate, compact and make good, including the removal and disposal of all surplus material.

Power cables of rated voltage up to 1,000 Volts shall be buried at a minimum depth of 600 mm to the cable. Power cables of rated voltage above 1,000 V up to and including 15 kV shall be buried at a minimum depth of 1,000 mm to the cable centre. This may only be varied due to the presence of other cables or services.

The bottom of excavated trenches shall be free of sharp stones and other obstacles and shall be covered with sand or fine sifted soil compacted to a depth of 75 mm.

Cables shall be unrolled from the drums in such a manner as to avoid loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp obstacles or stones. A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered with a minimum depth of 100 mm of sand or fine sifted soil. The cables shall be overlaid with marker tape, before backfilling the trench with soil.
Where cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to separate the cables .

Controls and communication cables shall be laid not closer than 1,000 mm to high voltage cables.

When cables are in position in the trenches, an inspection will normally be required by the Engineer before backfilling commences. The first stage of backfilling is to be sifted soil or sand (as specified for the trench bottom) with cover being provided to a minimum

of 70 mm over the cable. Soft excavated material free of stones is then backfilled with the backfill rammed every 150 mm.

Small stones extracted from the excavated material may be mixed in with the backfill in the final stages, but large stones are to be removed from site. Surface material and any hard core removed prior to excavation is to be backfilled last and well rammed to restore the undersurface to original condition. Excess backfill is to be removed from the site.

The Contractor is responsible for reinstating any damage to gates, hedges, kerb stones, concrete paving, etc, and normally for the surface of any privately owned made up roads. For public roads the reinstatement of made up road surfaces will be carried out by the road authority and the trench backfill must be left in a suitable condition as required by the road authority.

Approved surface route markers shall be situated at all joints, bends and at minimum intervals of 30 metres on straight runs, as specified. Whenever the cables change direction markers shall be so placed that the change in direction is readily seen.

No cables shall be buried direct in the ground within buildings or concrete covered areas.

9.4.3 Installation in Underground Ducts

Where cables are laid under roads and paved areas more than 1,000 mm wide, they shall be installed in continuous runs of approved underground ducting, generally supplied and installed by others unless otherwise specified or shown on the Drawings. The Contractor shall be responsible for advising the civil works contractor of all required cable duct locations, these locations being agreed with the Engineer and shown on the Contractor's reticulation Working Drawings.

Underground ducts shall be constructed of impact resistant uPVC and laid at a minimum depth of 600 mm (to the duct centre), surrounded by at least 75 mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100 mm shall be laid at a minimum depth of 1,000 mm (to the duct centre). The duct shall be encased by 150 mm concrete on all sides.

When installing cables in ducts the following measures shall be observed:

- Cables shall be pulled in a straight line
- Rollers shall be positioned at the edges of draw pits both at the drawing in and drawing out points over which the cables shall be drawn
- uPVC pipes and cables sheaths shall be coated with an approved lubricant
- Sufficient draw-in points shall be provided and adequate room allowed for installation of cables
- The pulling rope shall be guided by rollers

In general, only one power cable shall be drawn into one duct. Where multiple cable systems are used, smaller cables (16 mm^2 and below) may occupy the same duct. However details must be agreed with the Engineer, and included on the Contractor□s Working Drawings.

When a duct is laid in the ground, a draw wire shall be pulled through with at least 1000 mm excess at each end and the draw wire left if the duct is not to be used immediately.

9.4.4 Sealing Cable Entries into Buildings

Where cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with "petroleum tap" and mastic or a silicon foam.

Where cables pass in or out of any duct entries into or within buildings, such entries together with any spare ducts, shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes.

9.4.5 Marking of Underground Cables

The location of all direct buried underground cables shall be identified by:

- brass plates fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass though the wall;
- marker posts on road verges, etc., at intervals of not more than 100 m and at all junctions and changes of direction along the route;
- marker posts at 10 m intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 150 mm high above ground level with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of a cable below, the depth and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer.

9.4.6 Installation in Cable Trunking

Cabling trunking shall be manufactured from heavy duty mild steel of thickness not less than 1.25 mm and hot dipped galvanised. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50 per cent spare capacity. Trunking shall have minimum dimensions of 50 mm x 50 mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.

The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self retaining `quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

Earth continuity straps shall be provided at all connections and jointing points along the route of the trunking to ensure complete earth continuity.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals as detailed in the IEE Wiring Regulations. Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking or a trunking fitted the bared ends shall immediately be given a coat of zinc rich cold galvanising paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Engineer before any work is started. The run shall be at least 150 mm clear of plumbing and mechanical services. Trunking systems erected outside a building shall be weatherproof.

9.4.7 Installation in Troughs and Trenches

Where the building structure incorporates purpose built covered trench systems, to accommodate the cables, power distribution cables may be laid on the floor of the trench providing all cables are readily accessible without the need to disturb other cables. Where the Engineer considers too many cables are present, or where the trenches are not suitable for laying cables on the floor of the trench, supports shall be provided. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.

The layout, fixing arrangement and the laying up of all cables shall be agreed prior to installation. All cables shall be accessible for easy removal without the need to disturb adjacent cables. The required cable separation shall be maintained at all times.

Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls, Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipework.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1 mm for trays up to 100 mm width, not less than 1.25 mm for trays from 100 mm to 150 mm width and not less than 1.5 mm width for trays from 150 mm to 300 mm width.

Cable tray and supports shall be to BS 6946:1988 and hot dipped galvanised to BS 7291-3:2006.

Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc rich cold galvanising paint. Similarly for PVC coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Engineer, together with proprietary cable cleats.

9.4.8 Installation in Buildings

Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or singly at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

No cables shall be buried directly in the ground within buildings or concrete covered areas.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Allowance shall be made for expansion and contraction of the cables.

Where cables cross a building expansion joint, due allowance shall be made for cable movement.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips, etc., shall be by means of non-corrodible screws inserted into approved wall fixings.

Cables hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to the recommendations in the IEE Wiring Regulations.

Ladder racking shall be constructed from heavy galvanised steel secured to walls or ceilings, or by preformed galvanised interlocking channel, cast into the structure.

Cables shall be located between 5 mm pegs spaced at 40 mm centres across a rung so that a 40 mm or 80 mm space is maintained between cable centres. Cleats shall be used where the ladder racking is vertical.

Wherever ladder sections are cut and shaped on site, cut edges shall be dressed and immediately painted with a coat of cold galvanising compound.

Cables shall be run at least 150 mm clear of plumbing and below heating and hot water pipework.

9.4.9 Cable Installation in Conduit

Conduits shall, in general, be galvanised heavy duty gauge steel screwed type for outdoor applications. Accessories shall either be malleable cast iron or pressed steel. PVC conduit will be considered for certain installations as specified. Conduits and fittings shall comply with BS 4568, BSEN 50086-1:1994, 4607 and 6099 as appropriate and shall not be less than 20 mm diameter.

A space factor of 40% shall not be exceeded, and conduit of less than 20 mm diameter will not be permitted. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed with all sharp edges removed before erection.

Where conduits converge, adaptor boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type.

Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All junction boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress or dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150 mm movement shall be allowed.

Surface conduits shall be secured and fixed by means of distance spacing saddles or clips which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. Runs shall be properly ventilated and allow for drainage of condensation. All surface conduit runs shall be marked out for approval by the Engineer before the installation is carried out. Where large multiple parallel conduit runs occur, galvanised trunking may be used instead.

Conduits installed on structural steelwork shall be secured by girder clips, drilled and tapped to the steelwork. Power driven fixings shall be used only with the approval of the Engineer. Any drilling or access which is required through any structural member of the building shall be clearly shown on the Contractor's Drawings submitted to the Engineer for approval. The Engineer may either restrict the size and locations of approved drilling or access, or may instruct the Contractor where such drilling or access shall not be allowed.

Exposed threads and plates where galvanising has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

Concealed conduits shall be securely fixed to prevent movement before laying of screed, floating of plaster, casting of columns or other building operations necessary after the conduit installation.

Crampers or similar fixings shall be used for attaching the conduit to blockwork, etc.. Building nails will not be accepted.

At least 15 mm shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted over the conduit. Conduit cast into reinforced concrete shall be fixed to shuttering to give a flush finish, and the conduit boxes shall be of a type approved by the Engineer for use in such locations.

Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for surface conduits. Draw-in wires shall not be pulled into the conduits during erection. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

The conduit installations shall be inspected by the Engineer before the building operation conceals the work.

Flexible conduits shall be of the waterproof galvanised type of PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough type box. The flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws, etc., will not be permitted.

Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

In locations where galvanised conduit would be liable to corrosion, PVC conduit shall be considered.

PVC conduit shall be of the oval or round high impact non-flame propagating type as specified and self-extinguishing, to BSEN 50086-1:1994 AND BSEN 50086-2:1996. Surface and concealed installations shall be generally as described for steel conduit.

PVC conduit fittings shall comply with BS 4607-1:1984, BS 6099 Section 2.2:1982. They shall all be white unless specified otherwise.

Jointing shall be carried out using a PVC solvent and socketed accessories. Expansion couplers shall be fitted in straight surface runs every 12 m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures of between 10^{o}C and 60^{o}C and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16 mm or less

shall be 1.5 mm. For deeper boxes the minimum wall thickness shall be 2 mm. All boxes which are intended to support luminaries or other heat sources shall have either external fixing lugs riveted to the metal fixing inserts or utilise steel insert clips.

9.5 Cable Terminations, Joints and Identification

9.5.1 General

Cable terminations shall be provided to suit the requirements specified and shall be either crimp type lugs, crimp type insulated wiring pins or soldered connections.

Where crimp type terminations are used lugs shall only be applied using a crimping tool having a ratchet which only releases after the correct pressure has been applied.

Excessive solder and "Dry" solder connectors will not be accepted. Care shall be taken to eliminate "dry" solder joints and in removal of excess solder.

Cable lugs shall be of such a size that only the minimum amount of solder is required in order to sweat the lugs solidly onto the tail ends.

The foregoing termination methods are not essential in "domestic" lighting and power installations beyond the final distribution board.

At terminations the cores of the cables shall be left of sufficient length beyond the termination to form cable tails for connecting to the equipment. Tails shall be adequately insulated and each cable core shall have its phase identification clearly marked.

Terminations shall be long enough to allow one additional termination.

The installation requirements associated with both the low voltage and control cables are such that, in general, no joints are necessary, the cable distances being such that one complete cable length is required between the various items of Plant. The Tender shall be submitted on this basis, joints only being permitted where authorised by the Engineer. Where joints are permitted they shall be made as set out below.

- Joints in cables shall be made in accordance with the cable manufacturer□s recommendations to suit the particular cable type;
- All cables shall be joined colour to colour and shall be tested for insulation resistance and continuity before jointing commences;
- The seals of the cables shall not be removed until preparations for jointing are complete;
- Joints shall be finished on the same day they are begun, and protection from weather shall be provided by the Contractor;
- Cast resin moulded type joints shall be used for PVC multicore cables;
- The jointing cores shall be insulated by means of several wrappings of PVC tape and then coated with PVC paste;
- The cable armouring shall be made continuous within the joint with copper bonding tape and clamps;

- A split mould, preferably of PVC, shall encase the joint and be filled with a proprietary brand of polyester resin.

9.5.2 Termination of Screened Signal Cables

Where the termination of a screened signal cable is required the cable shall be bonded to earth at one end only and the termination carried out as follows:

- Screen to Earth Connection - A suitable length of overall sheath shall be removed, the conductors separated from the screen and the screen insulated using a PVC sheath self-coloured green/yellow. A 30 mm long silicone rubber over sleeve shall be installed over the point of separation of the conductors, screen and overall sheath.
- Isolated Screen - A suitable length of the overall sheath and the screen shall be removed and a 30 mm long silicone rubber over sleeve installed over the point of separation of conductors and overall sheath.

9.5.3 Cable Glands - General

Glands shall comply with BS 6121-Part1:1989, BS EN 50262:1999. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide mechanical support. Where cable glands are exposed to the weather these shall be protected by heat shrink plastic tape or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.

Where the apparatus enclosure classification requires sealed cable gland entries, sealing shall be achieved by using threaded cable gland holes and polyfluorethylene (PTFE) tape.

Where terminations are to be effected for XLPE or PVC insulated cable, a compression type gland shall be used with means of securing armour wires within the body of the gland, and shall be of a size suitable for the cable used. The gland shall provide both armour moisture seal and outer sheath seal. PVC gland shrouds shall be provided for all terminations.

Cable glands shall be both electrically and mechanically sound and shall be complete with backnuts and bonded earth tags.

BW type indoor glands shall have a minimum of exposed armouring between sheath and gland. Self adhesive PVC tape shall be applied to exposed armouring and glands before the shrouds are fitted.

9.5.4 Identification of Cores and Wires

Terminals shall be identified by using purpose made indelible markers.

Each core shall be identified, at points of termination, using colour coded slip-on ring type markers.

The wire and associated terminal numbers shall be identical.

Where source and destination terminal blocks have different numbers, cores shall be double ferruled with both numbers.

Unless otherwise specified it shall not be necessary to identify terminations in domestic installations beyond the final distribution board.

9.5.5 Power Cable Terminations and Joints

Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors. Each cable entry into a terminal box shall be made through a suitable gland.

Boxes shall be of adequate proportions to accommodate all cable fittings including stress cones or other means of insulation grading. Boxes shall be openable for inspection without disturbing the gland plate, cable or termination.

Where air insulated terminations are used, the cable crutch shall be protected by a heat-shrink sleeve.

Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

Glands for armoured cables shall provide a positive armour clamp to the box or switchgear coating. This clamp shall completely support the cable weight so that no tension is applied to the termination. The clamp shall also provide earth continuity and be of adequate size to withstand the full fault current of the system for one second.
Where single core glands are required, these shall be non-magnetic. The gland plate shall also be of a non-magnetic material. Removable connections for bonding across the gland insulation shall be provided. The gland insulation shall withstand a test of 2 kV AC for one minute.

Aluminium cores of power cables shall be terminated using approved bimetallic connectors. All glands shall be provided with an earthing tag. For cables of 4 mm^2 or less, a serrated washer may be used instead for earth continuity.

9.5.6 Multicore and Control Cable Terminations

A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

Terminal blocks for terminating cables up to and including 35 mm^2 shall securely clamp the conductor, without damage, between two plates by means of a captive screw; pinch screw type terminal blocks shall not be used.

For cables above 35 mm^2, stud or bolted terminals shall be used, each cable being fitted with a suitable lug.

Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose made solid links shall be incorporated in the design of the terminal blocks.

Terminals which remain energised when the main equipment is isolated shall be suitably screened and labelled.

Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labelled.

Plant which has to be dismantled for maintenance shall have multicore cable terminations made off through glands onto an adaptable box. The box shall have terminal blocks, and connections shall be made to the equipment by single core wires and flexible waterproof plastic conduit. A separate earth core shall link the box to the equipment.

The Contractor shall supply and install complete approved marshalling boxes for both indoor and outdoor use, as required for terminating and marshalling all power and control cables at each item of Plant or en route as required. Spare pairs shall be included to facilitate cross patching in the event of a fault developing on the operational pairs. All marshalling boxes and terminals within panels and mimic panels shall accommodate all control cable requirements. Details of which shall be agreed and approved by the Engineer.

9.6 Switchgear and Control Equipment

9.6.1 Introduction

This Section of the Specification covers all switchgear and control equipment up to 1,000 V AC, including distribution switch and fuseboards, multi-motor control centres, control panels and desks, as well as individual units.

LV switchboards and panels shall comply fully with BS 5486-1:1990, BSEN 60439-1:1994, and be rated and ASTA certified for operation on a 415/240 V olt 3 phase 4 wire 50 Hz supply. They shall have and a minimum prospective short circuit fault rating of 5 kA or as may be shown on the Drawings. The fault ratings shall be commensurate with the fault levels of the network to which the components are connected. The Contractor shall be responsible for establishing the fault level at each site or compound and designing the panels accordingly.

The Contractor shall be responsible for checking the panel and switchgear manufacturers' drawings, together with all necessary interfacing requirements with SNEL and others. He shall signify his approval in writing to the Engineer, and submit copies of all manufacturers' drawings for the Engineer's approval. The Contractor shall be responsible for carrying out measurements of prospective short circuit current and earth fault loop impedance at each LV switchboard/distribution board upon completion of the works and shall incorporate the actual values onto the 'as-installed' drawings.

9.6.2 Construction – General

Switchboards and control panels shall be flush fronted and accessed, manufactured from 2.0 mm minimum thickness mild steel, multi-cubicle type. They shall be of folded and welded construction forming rigid units. Floor mounted panels shall be equipped with a mild steel channel bed frame at least 100 mm high to ensure rigidity and shall be impervious to corrosion by rust. Small units may be of the wardrobe type.

The switchboards and control panels shall generally be of the industrial/enclosed modular cubicle type. The switchboards and panels being of the cubicle pattern suitable for floor or wall mounting, comprising a sheet steel cubicle with front access as required

and specified complete with bus bars, circuit-breakers, fuse switches and MCCB's. They shall be of uniform height, rigid construction and neat appearance.

Where rear access is possible removable covers shall be provided for cabling etc. Separate cable compartments shall be provided.

All switches and breakers shall be individually labelled, showing the circuits controlled, by means of laminated plastic labels showing black letters on a white background.

Busbars shall be copper on insulated supports and capable of withstanding the fault level on the system at that point.

Switchgear shall be heavy duty, corrosion resistant, cast metal enclosed type, dustproof, and capable of operating on load at the rated current. Contacts shall be heavy duty silver surfaced type.

Cubicles shall be rigidly constructed. Those accommodating heavy duty switchgear shall be provided with an angle iron or heavy gauge folded steel framework, panelled in zincanneal or galvanneal.

All mounting brackets and additional items shall be supplied and installed to suitably support the switchboard in the position in which it is to be erected.

Ventilation shall be provided where required, with fine bronze mesh and suitable trim fitted to prevent entry of insects.

Dust tight enclosures shall have ample volume to dissipate heat which may be generated in service, and doors shall be provided with a neoprene seal fitted with a channel and closing against a suitable folded edge or ridge. Moulded sealing strips may be submitted for approval as alternatives.

Switchboards and control panels shall consist of incoming fused switches, circuit-breakers or isolators, and outgoing circuits controlled by fused switches, switch fuses, MCB's and MCCB's as required and as shown on the Drawings.

No live metal shall be exposed by the removal of normally closed or fixed doors or panels. Shrouds or insulated barrier pieces shall be provided.

The use of either circuit-breakers or fused units is subject to final approval by the Engineer. Alternatives to the use of the circuit breakers indicated will be considered, but only as an alternative.

Entry of cables, ducts, and conduits shall be neatly made and head boxes shall be provided as required. All entries and openings shall be vermin-proof.

The maximum height of panels shall be 2,200 mm above finished floor level.

Where switchboards are split for delivery each section shall have a maximum width of 2,000 mm and a maximum mass of 1,000 kg with removable eyebolts provided for lifting.

The switchgear, distribution boards and terminal cabinets shall fit in the spaces provided as indicated on the drawings. If there is any reason why a board will not fit into the space indicated on the drawings, the attention of the Engineer shall be drawn in good time to enable alternative arrangements to be made, either to the board or to its fixing position. It shall be the responsibility of the Contractor to verify the suitability of the space provided before trays of boards are fixed.

Unless otherwise specified, all contactors and relay control circuits shall be connected to an AC supply of a maximum of 240 volts.

Isolation of a control circuit supply to one or a group of starters shall not interrupt supplies to other starters.

All fuses shall be of the high rupturing capacity type to BS 88. Fuses rated 30 A and below shall be mounted in approved withdrawable fuse carriers. Carriers containing links shall be coloured white, whilst carriers containing fuses shall be coloured black.

Timer delay relays shall have a good repeat accuracy and the direction of adjustment for increasing and decreasing the timing period shall be clearly marked.

The circuit breaker associated with each starter shall be a triple pole unit rated for stalled motor duty and shall comply fully with the relevant British Standard. A padlocking facility shall be provided for locking in the OFF position.

The circuit breaker shall generally be housed within the same compartment as the starter with which it is associated and shall be mechanically interlocked with the compartment door.

The control supply shall be broken by auxiliary contacts on the circuit breaker in the open position.

The switchboards and panels shall be designed so that they can be extended in the future with the addition of further busbar/cubicle sections.

9.6.3 Mounting

Fixings for floor mounted switchboards and panels shall be by not less than four holding-down bolts at the front and rear of the equipment. They shall not be visible from outside the panel, but be readily accessible from within.

At least four lugs shall be provided for bolting wall mounted switchboards and panels to the wall. Fixings holes shall not be provided inside the panel, which shall stand at least 10 mm off the wall surface.

Fixings for post/column switchboards and panels shall be provided outside the enclosure. The back of the enclosure shall be drilled to accept fixings.

All mounting brackets, supports and additional items shall be supplied and installed to securely support the switchboards, panels and cubicles in position.

9.6.4 Cubicles

Separate cubicles shall be provided for each of the following:

- Incomer
- Bus-section
- Motor starter
- Common controls
- Telemetry
- Distribution board
- Feeder
- Outgoing terminations
- Other specified equipment

Each cubicle having its own door shall be totally separate from any other so that work can be safely carried out in one cubicle while others are still live.

9.6.5 Doors and Covers

Doors shall be adequately sized to readily and neatly accommodate all equipment to be mounted on them. They shall open at least 120 degrees, be rigidly constructed, suitably braced and provided with at least two substantial hinges which shall be captive when the door is closed.

Lockable catches shall be used each being provided with 3 keys on individual rings having a nameplate showing its identity details. Locking combinations requiring different keys shall be approved before manufacture.

Where padlocking facilities are specified, the padlocks will be supplied.

No equipment shall be mounted on covers. Large covers equivalent to half full height and above, shall be provided with handles to facilitate removal and replacement.

Each door and cover shall be provided with an internal welded earthing stud, and shall be bonded to the switchboard main earth bar.

Doors and covers giving access to potentially live conductors shall be provided with prominent warning labels.

Suitable shrouds or covers shall be provided for all live terminals and terminations, such that accidental contact cannot be made by the operators or the maintenance staff.

Where required, provision shall be made for inter-locking the incoming SNEL supply and standby diesel supply such that paralleling cannot take place under any circumstances. The inter-locking shall be by an approved means, castelle keys being provided. All other switches or breakers shall be provided with an approved means for locking off. Inter-locks shall be provided such that the front covers for any unit cannot be opened when the switch is in the □ON□ position and the switch cannot be operated when the cover is in the open condition. Flexible earth continuity bonds shall be provided for all hinged and swing panels.

9.6.6 Component Mounting

Each cubicle shall be provided with a removable rust-proofed steel backplate bolted to studs welded onto the rear of the cubicle. All components, other than door mounted,

shall be located on the back plate by bolting into tapped holes or using self-tapping screws. Nuts used to fix components shall be captive on the back plate. DIN rail type fixing may be used where appropriate.

Components shall be so mounted to prevent shock being transmitted from large components and thereby adversely affecting their proper function. The components shall be arranged to give adequate accessibility for maintenance and for removal of any one component with the minimum disturbance to the wiring. Plug-in connectors shall be used where possible.

9.6.7 Cabling Arrangement

Cabling shall enter panels through removable gland plates of not less than 3 mm thick steel or brass (for single core cables) fitted at least 350 mm above floor level, the final height being dependent on the cable sizes and bending radii. They shall be rust-proofed and provided with a welded and bonded earthing stud and adequately sized to accommodate present and known future cabling requirements. Access to both sides of each gland plate when it is in position shall be possible from within the equipment. Cabling shall enter at the top and/or bottom of panels as appropriate, and have a suitable means of fixing.

Gland plates are not necessary on small individual starters where access shall be by "knock outs". Gland plates shall be removable for drilling.

9.6.8 Bolts, Nuts, Washers and Screws

All bolts, nuts, screws and washers used for the construction of the switchboard shall be nickel or cadmium plated, except fixings on the face of the switchboard, which shall be stainless steel.

9.6.9 Protection and Finish

The internal colour shall be white and the protection of externally-mounted components shall be no less than that of the panel on which they are mounted. External colours shall be grey unless otherwise specified or approved. Full colour details to be submitted with the Tender.

Cases shall be rubbed down, undercoated with suitable primer and finished in not less than 2 coats of hard enamel, oven baked where practicable.

Externally mounted panels shall be protected to IP65 (weatherproof), with a rear sloping weather canopy projecting over the front by at least 150 mm. Door-mounted components shall be protected by a vandal resistant secondary glazed door so that all controls and indicators are clearly visible. Doors shall be locked and provided with stays.

Protection classification for all internal boards and panels shall be IP54 unless there is a specific requirement and the manufacturer considers that a particular compartment requires louvered ventilators. In such a case the classification shall be not less than IP31. Louvers shall be provided with fine mesh screens, as specified in Clause 3.6.2.

Externally mounted panels shall also be protected from the sun, a sun canopy being provided. The canopy shall overhang the panel by a minimum of 500 mm on all sides

and shall provide an air gap above the panel of at least 200 mm. Proposals shall be submitted with the Tender.

9.6.10 Auxiliary Supplies and Anti-condensation Heaters

Control supplies shall be 110 V or 240 V AC, derived from a transformer within the panel or a 4 wire 3 phase supply fused on its primary and secondary winding, each cubicle being separately sub fused so that a fault in one cubicle does not affect others.

Supplies to equipment mounted on the panel such as instruments shall be 110 V or 240 V AC derived from the control supply. Major items of equipment shall be separately fused. Other items within the same cubicle may be collectively fused, but separately from the control supplies.

Anti-condensation heaters shall be provided in all control panels, switchboards and motors to prevent internal condensation due to atmospheric or load variations.

Anti-condensation heaters within switchboards and panels shall be provided at the bottom of each cubicle to maintain an internal temperature of 5^{o}C above ambient. An adjustable thermostat with clear scale shall be installed at the top of each cubicle to limit the maximum temperature. Each heater shall be individually fused and provided with an isolation switch.

All heaters shall be rated for 110 V or 240 V AC and shall derive their supply from the control supply circuit.

Motor heaters shall be switched by normally closed contacts on the main contactor(s) such that the heater is energised when the motor is de-energised and vice versa. The heater circuit shall include an isolating switch and indicator lamp to show 'Heater Circuit On'. The heaters shall be energised from a 110 V or 240 V 50 Hz supply.

When maintaining plant fitted with heaters it will be necessary to switch off both the main isolating switch and the switch for the heater. A warning notice of this danger shall be fitted near the terminal box of every remote heater and at every panel or switchboard with heaters.

All such plant, whether fitted with a heater device or not, is to be provided with suitable drainage and to be free from pockets in which moisture can collect.

All indicating lamps shall be separately fused and protected.
All panels, switchboards and three phase motor starters shall be fitted with line indication lamps so that the operators and maintenance staff can readily identify the operation of all phases.

All protection components, under/over voltage relays, phase failure relays, etc., shall be provided with a visual identification to show when operation has occurred. Details shall be provided.

In addition to the individual lock-off emergency stops specified for each motor and rotating plant the composite motor control panels and/or switchboards supplying separately mounted starters shall be provided with an emergency "main" button such that all rotating plant can be immediately shut down. Auxiliary contacts shall be

provided to enable this shut down circuit to be extended to remotely sited main buttons should this be a future requirement.

All switchboards and motor control panels shall be fitted with a separately fused 13 ampere switched socket for maintenance.

In addition, larger panels shall be fitted with their own switched internal lighting system to facilitate maintenance. The fused circuit shall be extended from the live side of the incoming switch, suitable warning notices shall be provided to advise operators that the isolation of the main incoming switch/breaker does not render these circuit in operative.

9.6.11 Busbars and Main Connections

Each switchboard or control panel as may be required shall be equipped with a set of 3 phase and neutral air insulated busbars rated for a current of not less than the future connected load

Busbars, risers and droppers shall be ASTA certified and manufactured from solid copper fully complying with BS 5486, Part 2, enclosed in a separate chamber and shall be continuous over each section of panel as assembled prior to shipping, with the facility for future extensions at both ends of the panel. Busbars shall not be drilled for outgoing connections, which shall be made with clamps.

The riser and dropper bars shall be of an approved solid insulation phase segregated type, and fault rated to the same level as the main busbars. Riser and dropper bars shall be fully insulated.

Busbars systems shall be capable of withstanding a minimum prospective short circuit fault corresponding to the let through energy of a protective MCCB of equal rating to the busbar rating and connected to a prospective symmetrical fault level of 5 kA r.m.s.

The busbars shall be housed in their own compartment running the length of the switchboard or panel and shall not be exposed when any of the access doors or plates (other than those provided for busbars access) of the panel are moved for maintenance or other work.

Auxiliary bus wiring between units shall be protected and accommodated in areas other than the main busbar chamber.

All busbars shall be air-insulated, with tinned and bolted connections, clearly painted in correct colour of red, yellow, blue for the phases and black for the neutral.

It shall be possible, by removing covers, to readily gain access to all busbar, riser, and dropper joints in order to check tightness of nuts and bolts.

The framework and cable armouring clamps shall be efficiently bonded (with continuous copper strip) mechanically and electrically to the building and switchboard main earthing system. A high conductivity copper earth bar shall be bolted and efficiently bonded to the main frame to run the full length of each panel. This shall be colour coded yellow/green. Flexible earth continuity conductors/bonds shall be provided for all hinged doors and swing panels

9.6.12 Balance

The entire installation shall be balanced to the satisfaction of the Engineer and the Contractor shall carry out such alterations to switchboard connections as may be required to balance the electrical loads amongst the three phases.

9.6.13 Circuit Lists

The switchboards and distribution boards shall be fitted with a typed circuit list in the form of a card within a transparent envelope fixed to the inside door of each panel and distribution board. The form of the chart shall be to the approval of the Engineer and shall contain the following details:

- Incoming cable type and size including any circuit protective conductor;
- Size and type of incoming protective device;
- Measured values of earth fault loop impedance and prospective short circuit current at the board;
- Size and type of protective device on all outgoing circuits;
- Size and type of cables on all outgoing circuits including circuit protective conductors;
- Block layout of switchboard components to assist maintenance staff in the identification, operation and function of each component.

9.7 Motor Starters

9.7.1 General

All starters and controllers shall comply in all respects to BS 5424-2:1987, BS5424-31988 BSEN 60470:2001, BSEN ISO 14001:1996, BS EN 60947-4-1:1992, and BS 5424:Part 1, and shall form complete individual package units or complete units within the switchboards.

The control and protection arrangements shall be suitable for the type, size, voltage and duty capability of the relevant motor and the supplier shall state in detail the control and protection equipment which he proposes to use for each type and size of motor.

The starters shall be of the triple pole air breaker type. Unless otherwise stated, for motors up to and including 7.5 kW the starters shall be of the "Direct-on-Line" type capable of operating the relevant motor 15 times per hour, suitable for remote automatic and local push button manual operation.

Unless otherwise stated, for motors over 7.5 kW the starters shall be of a current limiting type suitable for remote, automatic and local manual operation. The type of starter shall be selected with due regard to the nature of the load being driven to ensure that the starting current does not exceed 2.5 times the full load current. Current limiting starters shall be of the Korndoffer autotransformer or star delta type. Electronic soft start devices shall not be permitted. The number of starts per hour for each motor rating shall be stated, this generally being a minimum of 5 (five).

In general each motor starter shall be equipped with the following basic equipment:

- Door interlocked, fault make/ load break, on load, incoming main circuit breaker.

- Contactors which shall be of the air break type fitted with arc chutes, magnetic blow outs and heavy hard drawn copper main contacts. Interlocks shall be provided to prevent simultaneous closure of the star and run contactors.
- Timing relay, where required, shall be electromagnetically-operated controlled timing of contactor sequence; a fully adjustable eddy current retarding mechanism shall be provided where necessary to suit the nature and conditions of the motor.
- Continuously rated operating coil (voltage to suit control conditions of 230 V).
- Auxiliary contacts for remote automatic control
- Adjustable over voltage relay unit
- Adjustable under voltage relay unit
- Overload relay device suitable for adjustment with calibration plates scaled in amperes. A door mounted reset facility shall be provided
- Control circuit fuses and links *
- Relay to protect against single phasing
- Ammeter of the moving iron type mounted on the starter and operated by a current transformer, where justified by rating, and complete with phase selector switch.*
- Provision for remote emergency stop button, float controls, etc..
- Hours run counter *
- Anti-condensation heater with thermostatic control
- Supply on, Running and Tripped indicator lights *
- Phase identification lights
- Test facility
- Hand/off/manual selector switches as required *
- Motor winding over-temperature release shall be provided in conjunction with the specified thermistor protection
- Duty selection switch as appropriate *
- Manual Stop/Start push-buttons *
- Relays to operate in conjunction with anti-vibration protection on larger motors shall be provided where specified.
- Relays to operate in conjunction with bearing temperature thermocouples on larger vertical spindle motors are to be provided where specified.

These facilities shall be door mounted.

Each starter shall be provided with a test facility enabling the control circuits to be energised only when the starter isolator and cubicle door are open. It shall not be possible to close the cubicle door with the test facility still switched on.

General layouts of the switchboards, control panels, etc. shall be submitted for approval before commencing manufacture. The final layout of all switchboards, panels, etc. shall be to suit the motor loads, standby diesel sets and mode of operation.

Suitable relays and timers shall be provided to prevent the simultaneous starting of the pumpsets unless the operating and protection systems are designed to accommodate the resulting starting surges.

9.7.2 Instruments, Indications and Alarms

The operating push buttons, switches or handles of all circuit-breakers, motor starters, isolators, etc. shall be located on the front of cubicles, or for cubicles of the desk type, on the face of the desk. There shall be visual indications of the "ON" and "OFF" positions. The stop push-buttons (and remote emergency stop buttons) shall be operable at all times and for all modes of operation.

All operations of fault and alarm circuits shall be clearly and individually indicated by lamps on the fascia of the switchboard. Fault and alarm lights shall remain on until the associated fault or alarm condition has been cleared and the system reset. An audible alarm shall also be provided to indicate operation of any major fault or alarm function. Acknowledgement of the major fault or alarm condition shall also cancel the audible alarm.

Indicating lamps shall incorporate a lamp test feature with either individual push to test or a common lamp test button.

Lamps on outdoor equipment shall be shaded from sunlight so that their operation can be clearly seen at all times of the day.

Push buttons fitted on the panel shall be of the shrouded type, unless otherwise specified, and shall have a label indicating their function.

Indicating lamps on panels shall be rated to withstand not less than 20% continuous overvoltage and shall be so designed that the heat from the bulb does not discolour the panel.
Indicating lamps fitted into the fascias of switch and instrument cubicles or panels shall be adequately ventilated.

Lamps shall be easily replaceable from the front of the panel by manual means preferably without the use of extractors.

The bezel of metal or other approved material holding the lamp glass shall be of an approved finish and easily removable from the body of the fitting so as to permit access to the lamp and lamp glass.

The lamps shall be clear and fit into a standard form of lamp holder. The rated lamp voltage should be 10 per cent in excess of the auxiliary supply voltage, whether AC or DC. For AC circuits lamp units shall be connected to the 110 V supply and shall have an integral transformer providing a 6 V supply to the lamp.

The lamp glasses shall comply with BS 1376:1974 and BS EN 60073:1993 and are to be in standard colours, red, green, blue, white and amber. The colour is to be in the glass and not an applied coating and the different coloured glasses are not to be interchangeable. Transparent synthetic materials may be used instead of glass, provided such materials have fast colours and are completely suitable for use in tropical climates and remain unaffected by the lamp temperature.

To comply with BS 4099, as a general principle, the following colours shall be adopted:

Green - Supply available but switch, starter, etc., in the open position

White - Switch or starter, etc., closed and plant running correctly

Red - Overload trips operated or major fault on plant

Amber - Warning signal, i.e. overloading of machine, high temperature, etc.

Blue - As necessary for other indication

Indicating lamps and push buttons shall be coloured in accordance with IEC 73 and in particular as follows:

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

Push Buttons	**Colour**
Start	Green
Stop	Red
Alarm Accept Acknowledgement	Black
Emergency Stop	Red

A separate indicator light or other means of indication shall be provided for each separate motor protection device to indicate activated.

Live line indication shall be provided at all panels so that the supply status in all compounds, pumps stations or facilities is readily available to operators and maintenance staff.

Indicating light bezels manufactured from plastic will not be acceptable.

All electrical indicating instruments shall comply with BS EN 60051-1:1999, BS 3693:1993 and IEC 51, be of the moving iron spring controlled type self contained instruments to Class 1.5 or better. Instrument size shall be 96 mm square with quadrant scale.

All instruments shall be back-connected mechanisms well protected by strong cases which shall be earthed and fully insulated. They shall be clearly readable with black markings on a white background. A red pointer shall be provided, adjustable (with a tool) from the front of the instrument, to indicate the normal or maximum reading.

Instruments shall be of the industrial grade and shall have a means of zero adjustment from the front without the need for dismantling. They shall be capable of sustaining the normal full load current, voltage, (via current transformer or other transducer as necessary) and shall not be damaged by the effects of faults in the system being monitored. Scales shall be of the 270^{o} type.

All wiring, space and connections and other items shall be provided for tariff meters, ammeters, voltmeters, selector switches and the like as applicable.

Instruments shall be flush mounted on the cubicles and effectively sealed against ingress of moisture, dust and insects. Instrument mounting height shall not exceed 1.80 metres

above floor level. Unless otherwise specified instrument full scale deflection shall be at least 120% of the normal operating point (i.e. nominal voltage or full load current).

All relay cases shall be black glass finish.

All voltage circuits of instruments shall be protected by a fuse in each unearthed phase, situated as close as practicable to the point of connection.

Voltage selector switches shall give phase to phase, phase to neutral readings. The class of accuracy of all meters, voltage transformers and current transformers shall be provided with the Tender.

Voltmeters shall be suitable for operating from the secondary side of the 110 V voltage transformers.

Ammeters in motor circuits shall be capable of withstanding the starting current of the motors and shall have a compressed overload scale for this purpose. The full load current shall be defined with a red line. Voltmeter scales shall have a red line indicating normal voltage.

Current transformers shall have short circuit ratings not less than those of the circuits with which they are concerned, and shall fully comply with BS EN 60617-10:1996/1997.

Separate current transformers shall be provided for protection and instrumentation duties. The rated burden of all current transformers shall be a minimum of 150% of the sum of the burdens to be imposed.

All current operated instruments and relays shall be suitable for operating on 5 A secondary windings of current transformers.

All protective relays, where provided, shall be fitted with indicating flags.

Instruments and relays shall be removed from the switchboards for transport and delivery and shall be packed in cases and transported and delivered with the associated switchboard.

Where specified, capacitors for correcting power factor shall be incorporated in the panel. Such capacitors shall comply fully with BS 7264-1:1990, BSEN 60831-1:1998, BS EN 60831-1:1998.

All motors shall be provided with emergency stop push buttons mounted on or adjacent to the motors which shall lock out the control circuit and shall require a key to reset the circuit.

9.7.3 Control Panel Cabling

Control wiring for motor control panels, switchgear, etc., shall be 600 volt grade PVC or XLPE insulated multi-stranded copper wire to BS 6004:2000 or BS 6007:2006. The minimum size shall be 1.5 mm^2 stranded conductor.

All terminals shall be referenced and detailed on the schematic diagrams to be submitted to the Engineer.

It shall be possible to gain access to any terminal of any component so as to be able to remove and replace the wire from that terminal without recourse to special tools, and without the need to disturb other components.

All wiring shall be neatly run bunched in neat forms. All wiring accessories of plastic material, such as cleats. conduits, strapping, etc., shall be non-corrodible and resistant to flame propagation.
Crimped pin extensions shall be fitted to all control circuit cables to prevent wandering strands before being inserted into Klippon type terminal blocks.

Cabling shall enter the panel from above or below as applicable and as specified elsewhere in the Specification. Cables shall be terminated using external boxes or internal gland plates.

Where necessary cable tray work shall be provided for supporting and fixing cables, and full glanding and terminating equipment and facilities shall be provided. Gland plates shall be mounted not less than 150 mm above the cubicle bottom. It shall be possible to terminate all cables without requiring access to live interiors.

Primary cabling shall be completely isolated from all control wiring, etc., and auxiliary terminals shall be likewise isolated from primary terminals.

All terminal boards and terminal blocks shall be of a type providing a positive mechanical clamp on connection. Terminals for the connection of all external cabling shall be situated near their respective gland plate and at a minimum distance of 200 mm from it.

Separate terminals shall be provided for incoming and outgoing connections and not more than two wires shall be connected to any one terminal.

Supplies for the motor heaters shall be controlled automatically by the main contactor such that the heater is on when the motor is de-energised. Motor heaters shall be separately fused and provided with termination facilities. Details shall be provided for approval.

9.8 Switchboard and Control Panel Components

9.8.1 General

Switchboard and motor control panels shall include all components specified together with the following. Fully detailed drawings and manufacturers specifications and component details and catalogues shall be provided for approval.

9.8.2 Air Circuit-breakers

Air circuit-breakers shall be 3-pole and neutral or 4-pole where used in conjunction with a standby generation scheme, spring-operated, withdrawable type having the following minimum features:

- Mechanical and electrical interlocking.
- Mechanical open, closed, spring-charged, and tripped indication.
- Trip-free mechanism
- Manually or motor wound spring closing mechanism

- Facilities for padlocking
- At least one unused volt-free changeover auxiliary contact, wired down to outgoing terminals
- Magnetic and thermal adjustable overload, short circuit and earth fault protection with facilities to prevent unauthorised adjustment
- Mechanical trip push-buttons

Additionally and where necessary:
- Closing solenoid
- Shut trip coil
- Undervoltage trip coil

These features shall be provided to suit the specific operational requirements at the various compounds, the details of which shall be agreed.

If circuit-breaker carriages cannot be comfortably handled by one man, a suitable trolley shall be provided.

9.8.3 Contactors

Contactors shall be block type, equipped with auxiliary contacts for all necessary indication, local and remote control requirements together with a means of mechanical indication to show when it is energised. They shall generally be of the triple pole air break type, electromagnetically operated with inherent no volt feature. Each contactor shall have a minimum of three spare auxiliary contacts.

Rating of contactors shall be strictly according to manufacturer's instructions.

Contactors shall be suitable for continuous heavy duty and normally fitted with 240 Volt coils. They shall be of the robust construction to BS EN 60470; 2001, BS EN 60947-4-1:1992 BS 5424-2:1987-3:1988 where applicable, and rated at not less than the current carrying capacity of the outgoing circuit.

Contactors shall comply with IEC 158, 99:1998 and those for motor circuits shall have make and break capacity of the motor starting current, mechanical duty of double the frequency of starts under the most extreme operating conditions with an absolute minimum of three consecutive starts from cold and five starts in any one hour when hot.

9.8.4 Current Transformers (CT)

Current Transformers shall be of an appropriate class and accuracy for the application, with outputs such that the combined relay, instrument and internal burden is not greater than 60% of the rated output of the CT. They shall be securely fixed but have provision for easy removal and replacement. Details shall be submitted for all CT types being supplied.

9.8.5 Fused Switches and Isolators

Fused switches and isolators shall comply fully with BS EN 60947-3:1992 and shall be air-break, door interlocked and padlockable in the off position, preventing the cubicle door from opening. They shall be mounted on cubicle back plates, with a spindle connecting each switch or isolator to a door-mounted actuator. Spindles shall be kept

short or be provided with an intermediate support, so that they readily engage the actuators when the door is closed.

Fused-switch units, where installed, shall be of the flush type, totally enclosed in sheet steel cases and doors. Units shall be dustproof and capable of operating on load at the rated current. Contacts shall be heavy duty silver surfaced type, and in open position the fuse elements shall be disconnected from both line and load terminals. HRC fuse elements shall be fitted to each unit, of correct rating for the outgoing conductors which they protect. Where operating handles of the units protrude in front of the board, they shall be of either the removable or telescopic type.

Fuse switches not forming part of composite panel shall be as specified above but suitable for wall mounting in an enclosed sheet steel case.

- Fused switches shall be a fitted with appropriately rated HRC fuse links in each phase and a solid link in the neutral.

- Sufficient auxiliary contacts shall be provided to isolate all incoming power supplies to the cubicle. The control supply auxiliary contacts shall close when the fuse switch is in the on and test positions. The fuse switch main contacts shall be open in the test position.

- Moving contacts of fused switches shall, for maintenance purposes, be safely and readily removable as a complete assembly when the remainder of the switchboard is energised.
- The fuse switch associated with each starter shall be a fully shrouded triple pole unit rated for installed motor duty and shall be housed within the same compartment as the starter with which it is associated and shall be mechanically interlocked with the compartment door.

- A padlocking facility shall be provided for locking in the OFF position and a minimum of four spare auxiliary contacts shall be provided in each unit.

- Switch fuse units shall be generally as specified for the fused-switch units and shall be of a similar pattern and from the same manufacturer.

9.8.6 Fuses and Links

Fuses shall be of the high rupturing capacity cartridge type complying with BS 88 and rated according to their function in accordance with the manufacturer's recommendations. They shall be fixed inside panels behind a 3 mm polished bakelite escutcheon panel which shall be readily removed, and to face the doors, at sufficient spacing to facilitate easy fuse/link withdrawal.

Fuse holders and carriers shall be coloured black, and link holders and carriers white.

Both fuse holder and fuse element where provided shall be correctly rated for the duty required. Fuses and links shall be grouped where appropriate according to their functions and shall be clearly marked both on the panel and the associated wiring diagrams.

Spare fuses shall be provided and fitted into clips within the switchboards, three fuses to be provided for each of the ratings installed. Details to be agreed to suit each switchboard/panel.

9.8.7 Hours Run Counters

Hours run counters shall be of the cyclometer type, suitable for flush mounting and non-resettle, having 6 digits (minimum) plus tenths, and with a readily visible indicator to show that they are operating.

9.8.8 Moulded Case Circuit-breakers

Moulded case circuit-breakers shall be manufactured in accordance with the requirements of BS EN 60898:1991, BS EN 60947-2:1992, or BS ISO /IEC 15773:1998.

Unless otherwise specified circuit-breakers shall be category P2 in accordance with IEC 157 requirements of the fixed pattern, triple pole and neutral, and four pole where used in conjunction with a standby generator unit.

Moulded case circuit-breakers shall employ a trip free mechanism capable of simultaneous operation of all poles and providing contact clearance and contact position indication sufficient to allow the circuit-breaker to be employed as an isolator. Contact clearance shall conform to the minimum figures specified in BS 6499:1998 and/or the equivalent IEC standard. Circuit-breaker closing mechanisms shall be manually operated unless otherwise specified.

Unless otherwise specified moulded case circuit-breakers shall be fitted with a thermal overload device to provide an inverse time characteristic and magnetic trip device adjustable for all ratings of MCCB in excess of 100 A. The following, minimum, features shall be included:

- Mechanical and electrical interlocking
- Mechanical open, closed and tripped indication
- Trip-free mechanism
- Facility for padlocking without the use of loose components
- At least one unused volt free changeover auxiliary contact, wired down to outgoing terminals, for remote indication
- Shunt trip coil and undervoltage trip where required.

Full details of the units being offered shall be submitted with the Tender.

9.8.9 Miniature Circuit-breakers

Miniature circuit-breakers shall be manufactured in accordance with the requirements of BS 3871, Part 1. Unless otherwise specified miniature circuit-breakers shall be category M5 and Type 1, 2, 3 or 4 as specified.

Miniature circuit-breakers shall be single pole or triple pole as specified and shall be suitable for the type of load that they feed. They shall be fault rated so that back-fuse protection is not required and shall include clearly marked ratings.

Miniature circuit-breakers shall be suitable for bolted or clip fastening to busbar assemblies and may be assembled together to form a distribution board.

Unless otherwise specified miniature circuit-breakers shall be provided with a manual trip free mechanism and thermal and magnetic trip elements to provide inverse time overload and instantaneous overcurrent operation to the characteristic required.

For special application, as required by the IEE Regulations or as specified herein or shown on the Drawings, miniature circuit-breakers employing residual current detection and tripping operation shall be employed.

Such units shall be rated to detect and operate at an earth leakage current of 30 mA, unless specified otherwise.

RCDs shall be used in conjunction with, and not in place of, miniature circuit breakers, the MCBs providing the overload and short circuit protection requirements of the circuit.

9.8.10 Overload Relays

Overload relays shall be of the thermal type, with inherent ambient temperature compensation and single phasing protection. They shall be of the manual reset type, having mechanical indication of the tripped conditions, respectable without opening the compartment door.

Calibration shall be adjustable between 80 and 150% of motor full load current.

On motor drives, of 100 kW and above, overcurrent relays shall be of the definite minimum and inverse time limit pattern.

9.8.11 Voltage Protection Relays

Regulation at certain towns has proven to be a source of plant failure and damage. Adjustable protection relays suitable for providing both under voltage and over voltage protection shall be included within the starter units. Full details shall be submitted with the Tender. The relay units shall be suitable for voltages of +10% and -15% of the nominal voltage.

9.8.12 Phase Failure Relays

Phase failure relays shall be connected to all phases and neutral and shall de-energise at or below 90% of rated voltage on any one or more phases. The relays shall be separately fused with contacts wired down to outgoing terminals.

9.8.13 Push Buttons

Push-buttons shall be at least 25 mm in diameter with chromium plated or similar Bezels. Plastic Bezels will not be acceptable.

They shall generally match indicating lamps in style, start push buttons being recessed to prevent accidental operation. Stop push buttons shall not be recessed.

Emergency stop push buttons, shall be of the "stayput" mushroom headed type. Composite motor control panels shall include a door mounted emergency stop button that will automatically shut down all pumping plant when activated.

9.8.14 Relay Units

Relays shall be either of the plug in or block type.
Plug-in relays shall be fitted with transparent plastic dustproof covers, retaining clips a base into which the relay plugs and external connections, made using easily accessible screw clamp terminals. Bases and relays shall be keyed to prevent relays being plugged into incorrect bases.

Block type relays shall be totally encapsulated.

Relays shall have changeover contacts and a means of visually indicating that they are energised.

The pin configuration of each relay shall be printed on the casing and on the schematic diagrams.

Time delay relays shall be of the multi-pin plug-in type and adjustment for increasing and decreasing the timing period shall be clearly marked.

9.8.15 Residual Current Devices (RCD's)

Residual current devices shall be back connected (behind the door), current operated, with a sensitivity of 30 mA., door mounting so that the test push-button and operating lever are readily accessible.

Operation of RCD's shall not be impaired by any DC component in the current.

9.8.16 Selector Switches

Selector switches shall be of the rotary type spring loaded to ensure clean controlled operation having bezels at least 50 mm square with all switch positions fully and clearly identified.

They shall be equipped with sufficient contacts of the correct rating and type, if necessary by means of auxiliary relays, to enable all control/indication/alarm requirements to be fulfilled.

Operating handles shall be interchangeable and securely fixed to the switch mechanism by a keyed shaft and recessed retaining screws.

Where lockable switches are provided it shall be possible to operate them without the key, but also possible to lock them in any position and withdraw the key.

9.8.17 Terminals

Removable DIN rail terminals shall be provided for all wiring, mounted at an angle to provide ease of access, with centre-disconnecting link type terminals for analogue signal circuits, isolation or test purposes, sufficient, suitably sized earth terminals, and end and earthing end stops.

All terminal boards and terminal blocks shall be of a type providing a positive mechanical clamp on connection. Terminals for the connection of all external cabling shall be situated near their respective gland plate and at a minimum distance of 150 mm from it.

All main phase terminals shall be suitably marked to ensure that the correct phase rotation is obtained when the plant is connected to the supply.

Separate terminals shall be provided for incoming and out-going connections and not more than two wires shall be connected to any one terminal.

Barriers shall be provided on all banks to group terminals into logical divisions and between power terminals of different phases.

Control terminals shall be separated from power terminals.

Outgoing terminals shall be grouped on a common rail in the termination section. Each group shall comprise terminals common to a motor starter reference or alternatively, for control circuit wiring, grouped or barriered with regard to the voltage levels.

In all cases care shall be taken to ensure that terminals are easily accessible after all wiring has been installed and terminated. All connections shall be made on the front of terminal blocks.

No more than two conductors shall be connected to one side of a terminal. Outgoing cables shall be wired so that all panel wiring is connected to one side only.

The terminal numbers, voltage grouping, and terminal block layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All terminals shall show the circuit wire number reference.

9.8.18 Thermostats

Thermostats shall be of the tamperproof adjustable type, with a range centred on the temperature at which they will normally be set and not close to one end. They shall not be mounted close to heat-generating equipment.

9.8.19 Timers

Timers shall be of the electronic, synchronous or cam type only depending upon the application. They shall have linearly calibrated scales, in units of time, each scale division being a maximum of 5% of full scale. Repeat accuracy shall be within 0.5% of full scale.

Electronic and synchronous timers shall be of the plug-in or block type, provided with "energised" and "timed out" indicators. They shall be surface mounted when within cubicles but, where front mounted to give operator access, they shall be flush mounting and provided with a lockable cover to prevent unauthorised interference.

Plug-in units with retaining clips shall plug into bases to which external connections are made using screw clamp type terminals that are easily accessible. Timers and bases shall be keyed to prevent mismatching.

The pin configuration of each timer shall be printed on the casing.

9.8.20 Transformers

Small transformers for auxiliary supplies shall be double wound, screened, and suitably rated, with all windings of copper and terminals fully shrouded. Each transformer shall be provided with an indelibly marked and permanently fixed label to indicate ratio, rating, voltage, currents, and connections.

Primary and secondary circuits shall be fused (or MCB protected) and neutral linked with one side of the secondary earthed.

Where 110 V socket outlet supplies are required transformers shall have a centre-tapped earthed secondary winding, both ends of the winding being fused.

9.8.21 Spare Ways

The drawings generally indicate the number of spare circuits that are to be provided and equipped under this Contract as part of the manufacture of the switchboards, motor control panels and distribution boards. Where spare ways have not been indicated, the following shall apply.

For switchboards, a minimum of two spare, equipped, ways shall be provided, the ratings of the protection devices being commensurate with those shown for active circuits.

For motor control panels, a minimum of two spare equipped ways shall be provided, the spares relating to the provision of the protection, MCCB or similar but not starters. However, space shall be provided for the inclusion of future starter units. The ratings of the protection devices shall be commensurate with those shown on the drawings.

A minimum of two TP/N spare, equipped ways shall be provided in distribution boards, the ratings being commensurate with those shown on the Drawings. In addition, a minimum of two blanking plates shall be provided for the future inclusion of additional circuit breakers.

Details shall be submitted for final agreement and approval.

9.9 Switchboard and Panel Wiring

Ample wiring space shall be provided within the switchboards and panels and all wiring shall be carried out in a neat and systematic manner with cable supported clear of the panels and other surfaces at all points to obtain free circulation of air.

In all cases, the sequence of the wiring terminals is to be such that the junction between multi-core cables and the terminals is effected without crossover. Insulated bushes are to be provided where necessary to prevent the chafing of wiring .

All panel wiring is to comply with the requirements of BS 6231:2006 Type A or B, as appropriate. Conductors are to be copper and have a minimum cross section equivalent to 7/0.67 mm (2.5 mm^2) or 1/1.78 mm (2.5 mm^2), but single stranded conductors should only be employed for rigid connections which are not subject to movement or vibration during shipment, operation or maintenance. Flexible conductors equivalent to 30/0.25 mm (1.5 mm^2) or smaller sizes generally shall only be employed with the written approval of the Engineer.

No wires may be teed or jointed between points.

Electrical wiring and instruments are to be located so that leakage of oil or water cannot affect them.

Bus wiring between control panels, etc., is to be fully insulated and to be completely segregated from the main panel wiring.

All metallic cases of instruments, control switches, relays, etc., mounted on control panels or in cubicles, steel or otherwise, are to be connected by means of copper conductors of not less than 2.5 mm^2 section to the nearest earth bar. These conductors may be bare or have insulation coloured green or green/yellow striped.

Colour coding of the separate phases, neutral and earth, shall be provided and maintained throughout the installation. Where necessary, further identification of wiring shall be provided to the extent necessary to permit any conductor to be located and traced. Also colour coding of remote control and local control wiring shall be provided. Voltages of control systems shall be clearly stated.

Colour coding shall be:

- Red - Red phase
- Yellow - Yellow phase
- Blue - Blue phase
- Black - Neutral
- Green/Yellow - Earth
- Grey - 110 V AC
- White - D.C.

Cable for specialist applications such as co-axial shall be of an approved type.

All wiring shall have crimped terminations, only one wire being held by any one crimp. Crimped lugs shall be of the insulated type without conductor exposure between the crimps and wire insulation.

The type of crimp used shall be appropriate for the type of terminals to which it connects.

Terminations shall be neatly arranged leaving adequate length for one additional termination.
Wiring shall be neatly laid in limit compression insulated cleats, insulated straps or, where more than ten wires follow the same route, in plastic slotted-sided trunking with clip-on cover. Where trunking is used, the ratio of effective overall cross-sectional area of cables shall not be greater than 40% of the trunking cross sectional area.

Holes in steelwork, etc., through which cables pass shall be protected using nylon grommets, or edging strip suitable for the size of hole.

Cables used for control, extra low voltage and instrument signal transmission likely to be affected by interference shall be screened and/or spaced from each other and from heavy current power cables, at a distance to ensure that resultant electrical "noise" is insufficient to cause any form of malfunction of associated equipment.

All wiring shall be identified at each end by means of glossy plastic ferrules showing the wire number as on the schematic diagrams. Ferrules shall be colour coded, 'Z' type and indelibly marked.

9.10 Electric Motors

9.10.1 General

All motors shall be of a make approved by the Engineer and shall be suitable for operating from the specified power supply. Motors shall comply in all respects with the relevant parts of BS 4999 and BS50347:2001, and shall be designed to run at high power factor and efficiency at the prescribed plant duty.

Motors shall be three phase, squirrel cage, induction type, continuously rated for the heaviest specified duty, totally enclosed and suitable for operation on the electricity supply and determined by the Contractor in relation to the power requirements, ambient temperature, altitude and normal working conditions of the mechanical plant offered.

The starting (locked rotor) current of any motor shall not exceed 6 times the full load operating current. Motor starting torque shall be at least 120% of the pump torque requirements throughout the starting sequence. Motors shall be capable of running backwards at rated speeds under backflow conditions without damage to the motor.

In addition to the requirements of BS 5000-11:1973 the motors shall be capable of satisfactory operation with a frequency variation of 5% above or below the normal frequency of 50 Hz.

The design of the motors shall be adequate in all respects for the number of starts per hour required when the pumping plant is in normal operation.

Where an insulation Class is specified the requirements of BS 4999 shall be met. The limit of temperature rise shall be for the appropriate Class of insulation quoted. Class F insulation shall be provided, but with Class B temperature rise limitations.

Motors shall be fitted with locating type bearings and/or heavy type thrust bearings at the non-drive end and roller type bearings at the drive and according to the type of motor offered, but all bearings shall be of adequate proportions and design suitable for the particular application, and shall have ample capacity to allow the pump to operate for short periods with the discharge valve closed.

Details of the bearing types being proposed, grease, oil, shall be submitted for all vertical motors together with details of the grease lubricated bearings for horizontal split case motors.

The motors shall be built of high grade components and materials in accordance with the best practice for the type of plant offered.

Motors 5 kW and above shall be fitted with temperature sensitive thermistors embedded in the motor to control a winding over-temperature relay mounted in the control cubicle. Each motor shall have at least 3 thermistors. The thermistors shall be suitable for connection to a monitoring unit in the motor control circuit to provide protection against

winding failing due to overheating. The motor starters shall trip in the event of high winding temperature being experienced.

The motors shall be capable of delivering 10% in excess of the maximum power absorbed by the equipment being driven. The motors, where practicable, are to be selected to provide an element of commonality, thus flexibility in use at each site, particularly dosing pump motors.

Only ISO standard roller and/or ball grease lubricated bearings shall be fitted.

The grease lubrication shall be applied using hydraulic type nipples which are freely accessible, without any dismantling, or otherwise piped out to a readily accessible location.

"Sealed for life" bearings shall not be used.

Continuously rated anti-condensation heaters shall be installed in all motors above 5 kW that are to be installed or in damp or cold environments. They shall be sized by the supplier to suit the motor frame size.

Heaters shall be located within the motor so that the heat dissipated does not damage the insulation of any of the windings or associated cables.

Terminals boxes shall be separated from the frame and shall be reversible to allow cable entry at the top, bottom or either side, suitable for cable glands required. Terminal mountings shall be arranged such that the motor supply wiring can be disconnected without disturbing its internal connections.

The end of each winding shall be brought out to a separate terminal, connecting links being provided to facilitate interconnection of individual terminals.

A diagram of connections shall be fixed inside the terminal box cover which shall be provided with watertight, oil resisting gaskets.

Where motor anti-condensation heaters are fitted additional terminals and a separate cable gland entry shall be provided. A warning label on the terminal box cover shall be provided stating □WARNING, LIVE HEATER TERMINALS, ISOLATE BEFORE REMOVING COVER□.

Plates shall be fixed on each motor, giving the following information:

- BS No _____ No. of Phases _____
- Manufacturer _____ Motor kW _____
- Serial No _____ Voltage _____
- Insulation Class _____ Current at FL _____
- Frequency _____ Speed _____

All motors rated in excess of 160 kW shall be fitted with suitable vibration control devices to automatically shut down the motor in the event of excessive vibration. The

Contractor shall stipulate the vibration tolerances associated with each motor rating above 160 kW and shall recommend appropriate control devices, details of which shall be submitted for approval.

For motors larger than 160 kW, kilowatt hour meters, with maximum demand indicators shall be provided.

Vertical spindle motor units rated in excess of 5 kW shall be fitted with a thermocouple at the upper thrust bearing to shut down the motor in the event of the bearing temperature exceeding a recommended value. Details shall be provided for approval

Motors that are water cooled shall include suitable protection to safeguards against the lack of water flow.

Where required by the specified operational system, motor circuits shall include suitably rated rotary off, manual or automatic switches.

The Contractor shall submit details of the painting specification and colour range being proposed. The Employer will finally decide on the colour, this being in accordance with the manufacturers standard colour charts.

All motors shall be provided with two earthing terminals.

The motors shall be commercially silent in operation and shall run free from vibration. They shall be of robust design with frames and covers constructed in cast iron. Fan covers and cowls shall be of a strong and durable material (plastic, PVC or GRP will not be acceptable). The rotors shall be fully keyed to the shafts and shall be balanced both statically and dynamically.

Motors shall be labelled to correspond to their respective starters. These shall be at least 40 mm x 75 mm x 2 mm in stainless steel on non-ferrous metal. Details shall be agreed.

Air vents and other openings where provided will be screen protected.

9.10.2 Submersible Motors

Submersible motors shall be capable of continuous operation under water at the conditions specified. Heater requirements do not apply to these units.

The motor shall be installed vertically and rigidly coupled to the submersible pump such that both the pump and motor are completely flooded. The windings of the motor shall be insulated with an approved waterproof plastic or other approved material as recommended by the manufacturer. The motor shall be squirrel cage rotor motor with the rotor suitably supported in lubricated plain bearings.

The cable from the motor shall be sealed at its exit by a water tight cable gland. Sufficient cable shall be provided to meet the installation requirements.

9.10.3 Surface Motors

Surface mounted motors shall be weather proofed fully tropicalised, and suitable in all respects for external operational duties in the climatic conditions prevailing. The connections of the motors shall be brought out to terminals at the side of the frame and

properly clamped and terminated within a cable box complete with correct glands to accept the size and type of cable specified. In general the glands shall be downward pointing at an angle to pass the cables clear of the base frame and plinth.

9.10.4 Cables for Submersible Motors

Cables for submersible motors shall be a 600/1000 volt grade multicore cable and consist of conductors of high conductivity tinned copper wire, EPR insulated and with super tough rubber sheath. The cable shall be suitable for suspension within a borehole approximately 60 metres deep and shall include all necessary internal supports (i.e. steel core or similar) to prevent undue strain being imposed on the cable conductors. Two clips shall be supplied for each length of riser.

9.10.5 Emergency Stop/Lock-Off Push Buttons

Emergency stop/lock-off push buttons shall be provided adjacent to the pumping units specified. Each shall be of the surface mounted weatherproof push to break and mushroom type with latching device to resist the push button return movement so that contacts remain normally open until the latch is released by a counter clockwise direction.

The buttons shall be robust and watertight suitable for the environment at the various locations, with IP enclosure. Certain stop buttons will be wall mounted, others will be mounted on frames 1,000 mm above the floor level, as stated in the Particular Specifications. The frames, boxes, terminations, screws and fixings shall be supplied.

9.10.6 Power Factor

The overall power factor of the plant under any load or operating condition shall not be lower than 0.9 lagging. Power factor correction capacitors shall be provided for each motor of above 5 kW rated output. In addition capacitors shall be fitted to smaller motors as necessary to maintain the minimum power factor specified above.

9.10.7 Safety Devices and Controls

The control requirements for the pumping plant have generally been specified elsewhere. The Contractor shall include for all requirements to meet both the manual and automatic control of the plant and pumpsets. In addition to the safety devices already specified, the Contractor shall provide for other protection devices and equipment that are necessary to protect against any operating conditions which would be liable to cause damage to the plant, for example, lack of water at the pump suction.

9.11 General Services

9.11.1 Labels and Notices

Labels shall be provided to describe the duty of or otherwise identify all items of equipment, mounted internally and externally, with clear, concise and unambiguous wording. Each label shall be permanently secured to the panel surface adjacent to the item to which it refers but not to trunking covers or other readily removable items, using plated screws.

All component labels shall have circuit designations which can be easily correlated with the drawings. Labels shall be provided on or adjacent to fuse carrier bases, where

provided, to indicate the rating of the fuse to be employed. Labels shall be manufactured from laminated plastic or similar white/red/white for danger and warning labels, otherwise white/black/white. Edges shall be bevelled and lettering at least 5 mm high. In addition to component labels, each cubicle door shall bear a large identification label (minimum lettering size 8 mm), whilst each panel shall bear a large overall identification label (minimum lettering size 12 mm). In addition to individual terminal numbers each group of terminals shall be provided with a "Function Description" label.

Warning notices, in red lettering on white background, shall be provided on all automatic start-up equipment.

Component "stick on" block diagram identification labels shall be fixed to the inside of each cubicle and starter panel.

The diagrams shall match the component layouts so that easy identification of all components is possible.

9.11.2 Shrouding

Shrouding shall be provided such that it is not possible to touch a live conductor, with or without a tool, unless a positive step has been taken (using a tool) to remove a cover, shroud, etc.. All such covers and shrouds shall bear adequate labels identifying the potential danger.

9.11.3 Control Circuits

All circuits shall be designed as far as possible to fail to safety. Generally, control relays shall de-energise for the safe condition.

Safety interlocks, designed to prevent injury to personnel or damage to equipment, shall be direct in operation.

Circuits shall be as simple as possible subject to necessary operational and safety constraints, involving a minimum number of components.

Where automatic control of several items of equipment is provided by a PLC, then a simple back-up automatic control system, independent of the PLC, shall be provided to give rudimentary unmanned control in the event of PLC failure. Such a system need not to be efficient or even provide 100% plant availability, but it shall come into operation automatically in the event of normal control system failure.

9.11.4 Steel Conduit and Fittings

Steel conduits and fittings shall comply with BS EN50086-1:1994, BS 4607-5:1992 and 6099-Part: 1981 as appropriate. Distance type saddles shall be use for all surface exposed steel conduit.

Conduits shall be installed in such a manner that all cables can be drawn in after erection by means of a draw-in tape. Conduit joints shall be painted with approve metallic paint. Elbows and tees shall be avoided where practicable, and normal bends or sets used. Exposed outlet boxes shall be cast metal and flush boxes shall be cast or sheet metal. No knock outs shall be removed unless used. Where conduits enter sheet metal boxes

they shall be locked-nutted back and front. Burrs and obstructions shall be removed before installation of boxes and conduits.

No conduit shall be smaller than 20 millimetres in diameter.

Boxes shall generally be galvanised steel, small, circular 60 mm type with steel covers.

Adaptable boxes shall be galvanised steel with overlapping lids but without "knockouts".

Box covers shall be fixed by brass round or cheese head screws.

9.11.5 Plastic Conduit and Fittings

Plastic conduit, where approved for use by the Engineer, shall be heavy gauge, high impact. Fittings, fixings and accessories shall be of the same manufacture and colour as the conduit.

All accessories shall be fitted with earthing terminals.

9.11.6 Trunking

Trunking shall be heavy duty, galvanised, minimum coating designation being grade G275, manufactured from grade Z2 steel.

9.11.7 Cable Tray and Accessories

Galvanised cable tray shall be perforated, heavy duty return flange type, hot dipped galvanised after manufacture.

Plastic coated cable tray shall be diamond pattern, heavy duty, black PVC covered.

Rigid PVC cable tray where approved for use by the Engineer, shall be manufactured from rigid unplasticised PVC having a thickness of not less than 3.0 mm. It shall be perforated and have provision for a cover. The material of manufacture shall be self-extinguishing or non flammable and suitable for use in ambient temperature of -20 to +80^{o}C.

Fixings shall be carried out using manufacturer's recommended brackets and supports.

9.11.8 Low Water Level Sensor

Low water level electrode sensor units shall be provided within wet wells, boreholes and within certain storage tanks and water inlet chambers. The sensors shall be supplied complete with all required cabling, fixings and terminations. The units required for installation within the boreholes shall be complete with two clips for each length of riser.

9.11.9 Sump Pump Controls

Submersible drainage pump units shall be supplied complete with suitable float operated on-off controls. The pump units shall be supplied with control panels/starter units as specified, cables, supports, fixings as required.

9.11.10 Coordination

The Contractor shall be fully responsible for the necessary liaison and coordination of all works on site.

Cross site cable runs shall be basically as indicated in the drawings. However, the final routes and layouts shall be to suit pipework, drainage, cables, foundations and the like. The Contractor shall produce drawings for approval indicating the proposed routes of his cable. These shall in general follow an agreed service reserve.

9.11.11 Locks

Sufficient padlocks with individual keys of a type approved by the Engineer shall be provided for locking the following items:

- Lockable, lock-off, isolating fuse switches and feeder pillars and the like, and
- Inter-locks, lock-off, ACB's (and/or Castelle interlocks)

Each shall be provided with four keys and be individually identified.

9.11.12 Continuity

All conduits, trunking, duct, trunking, cable tray etc shall be mechanically and electrically continuous thought. Where steel conduits cross expansion joints, flexible steel conduit sections, PVC served, shall be inserted, or other approved means used to provide the necessary continuity and flexibility.

9.11.13 Radiated Interference

The Contractor shall ensure that radiated interference from all items of Plant is suppressed to the limits specified in BS 800 and BS 833.

9.12 Earthing

9.12.1 General

The system of earthing on the LV reticulation will generally be TN-S as defined in the IEE Wiring Regulations (17th Edition). Earthing systems shall comply with BSCP 1013 and BS 7430:1998 and the current edition of the IEE Wiring Regulations. Separate earth protective conductors shall be employed throughout on mains, sub-mains and all final circuits.

As a minimum the metalwork of all items of electrical plant, electrical system neutral points, power and control cable armouring and screens, and extraneous metalwork including structural steelwork and pipework, shall be connected to the earthing installation.

Earthing continuity in non-electrical plant shall normally be achieved via metal to metal faces, metal hinges, and metal fixings. Earth straps shall only be supplied where earth resistance is high or there is risk of corrosion or similar which could in the future increase resistance and affect earth continuity.

All structural steelwork within the site shall be bonded to the earthing system.

All pumping plant shall include an earth continuity conductor or tape which shall extend from the pump/motor frame/bed plate to the main station/switchboard earthing system.

The final arrangement of the earth electrode system shall be to the requirements of the supply authority and to the satisfaction of the Engineer.

The earth resistivity at the sites may vary and the Contractor shall include for taking earth resistance readings both before and at least once during construction, and one final reading, at every earth point to ensure the specification values are obtained.

Each system shall be varied according to the immediate location. Each local earth system shall be installed progressively until the value of earth resistance is obtained to the satisfaction of the Engineer.

At the various compounds an earth busbar system shall be supplied, connected to earth electrodes, to which the following shall be connected:

- Star points of all transformers on the medium voltage side.
- Sheathing of cables.
- Metalwork at the compounds, other than carrying cables.
- Earth wires from equipment, external to main pump stations, that is fed only from that pump station.
- Main incoming water pipes.
- The building metallic structure.
- The lightning protection system where provided.
- Fencing as finally agreed.

The earthing continuity of each metal sheathed cable shall be maintained by efficient bonding between the cable sheath, the gland, and the metal case of the switchgear or other metal clad accessory or appliance at which the cable terminates. In addition, ICEW's or BCEW's shall be run with all cables as specified or as shown on the drawings.

3 core cables may be used to single phase items of equipment, the third conductor being used as the insulated copper earthwire.

The size of all earth wires bonding equipment to a main earthing system shall be such that a current of three times the fuse rating of the circuit or one and one half times the overload setting of the circuit breaker can flow without adverse effects.

All joints between wires and other earthing metalwork shall be mechanically sound and soldered.

The earth leads shall be insulated until the connection is made to the electrode system. A bolted test link shall be installed to facilitate regular testing of the earth electrode system resistance.

The insulation of the earth lead shall be insect and rodent resistant.

All materials used in any earthing installation shall be adequately protected against corrosion and earth leads shall be protected against any mechanical damage.

9.12.2 Installation

The earthing installation shall comprise an earth terminal, earth busbars, circuit, earthing conductors, equipotential bonding conductors, main earthing conductor and earth electrodes. The circuit earthing and equipotential bonding conductors shall be of the radial, grid or ring form as dictated by the plant layout.
The earthing installation shall be protected from mechanical damage and corrosion.

Joints in tape conductors shall be riveted and soldered, brazed, clamped, bolted or exothermically welded. Non-corrosive flux shall be used for soldered joints. Clamped and bolted type joints shall be tinned and shall only be used above ground.

The interconnection of conductors below ground shall be by means of exothermic welding or brazing. Compression type lugs shall be provided for the termination of cables.

Earthing conductors shall be buried directly in the ground or secured to building structures, cable racks and trays using proprietary fixings.

Where the soil is aggressive to copper, buried earthing conductors shall be protected by an approved sleeving.

An equipotential bond shall be provided to all buried metal pipework at the point of entry into a building or chamber where electrical apparatus is installed. Electrical continuity across all pipe joints within the structure shall be ensured. Where pipework incorporates a compression coupling (e.g. Viking-Johnson coupling), a bond shall be provided to any isolated section.

Cable armouring and screens shall be bonded to earth at both ends unless otherwise specified. Cable armour shall not be used as the sole earth protective conductor.

9.12.3 Conductors

Circuit and main earthing and equipotential bonding conductors shall be high conductivity copper tape or 1000 V grade PVC insulated multi-stranded cable. PVC cable insulation shall be striped green/yellow. Cable lengths shall be continuous and intermediate jointing is not permitted.

The main bonding conductor shall be not less than 16 mm^2 and supplementary bonding of non-electrical plant not less than 10 mm^2. All connections shall be made using compression type cable lugs, taped on completion to completely seal the lug and any bare copper from the atmosphere. The surface to which earthing bonds are fixed shall be cleaned free from paint and other non-conducting material and coated with petroleum jelly.

The Contractor shall provide the following supplementary bonding conductors which shall be made in 2.5 mm□ cable if mechanically protected, or 4 mm□ if not mechanically protected:

- All sink and shower units to pipework
- All small power outlets and sink units within a 2.5 metre radius of each other
- All metallic tanks

9.12.4 Earth Electrodes

Earth electrodes where used shall be copper or copper clad high tensile steel rods having minimum copper thickness of 0.25 mm and outer diameter not less than 16 mm. The rod shall penetrate a minimum of 2,400 mm below ground level. Where multi-rods are used they shall be separated by a distance of not less than the driven length.

Earth rods shall have hardened tips and caps and be extendable. Bare copper tape buried at a minimum depth of 600 mm shall be used for interconnection of rods.

Where soil conditions make the use of rods type electrodes impracticable a grid configuration may be used comprising horizontally buried bare high conductivity copper tape of dimensions 15 mm x 4 mm minimum. Tape shall be buried at a minimum depth of 600 mm.

All earth electrodes shall be buried in a mixture of well ground charcoal and common salt in a ratio of 2:1.

Earth rods shall be provided with a non-ferrous clamp for the connection of the earthing conductor. Each connection between conductor and earth electrode shall be suitably protected against corroding elements in the soil with bituminous tape.

The connection shall be made in a concrete inspection chamber set flush with the finished ground level. The inspection chamber shall be permanently marked `ELECTRICAL EARTH'.
Marker posts and plates shall be provided to mark the position of the electrodes and buried connections. The markers shall be similar to those provided for cable routes.

9.12.5 Main Earthing Terminal

Where specified, a main earth terminal shall be installed in a convenient location. This shall comprise a high conductivity copper bar of sectional area at least that of the main earthing conductor. The terminal shall be supported on porcelain barrel type insulators and wall-mounted.

The terminal shall be of sufficient length to accommodate, with 25% spare capacity, bolted copper tape connections to:

- the earthing conductor(s) between the earth terminal and earth electrodes
- circuit protective conductors between the earthing terminal and exposed conductive parts
- the main equipotential bonding conductors between exposed and extraneous conductive parts
- the system neutral earthing conductor (where specified)

Facilities (a) and (d) shall be removable with a tool to permit measurement and testing.

Earth studs shall have a minimum size of M8.

9.12.6 Tests on Site

On completion of the earthing installation the Contractor shall measure the resistance of each electrode installation and of each complete earthing system to the general body of the ground. All other tests stipulated in the Reference Standards shall also be carried out.

The contractor shall carry out tests to verify that exposed metalwork within the buildings is effectively bonded and install supplementary bonding connections as necessary to ensure proper continuity. In particular supplementary bonding shall be provided to individual suspended systems throughout the buildings.

The resistance to earth of each complete network shall not exceed five □.

9.12.7 Lightning Protection

Where buildings, structures or sections of the plant are to be protected against lightning or static charges, an earthing system shall be provided. The installation shall be carried out in accordance with BS 6651.

The down run conductor shall be of hard drawn high conductivity copper of 25 mm x 3 mm section. The tape shall be fixed to the outside of the structure by means of stand off saddles. Where indicated, connections shall be made to the concrete reinforcing. The route of the tapes and the fixings shall be discussed with the Engineer before installation.

Where specified the conductors shall be PVC insulated to prevent corrosion and to blend with the building fabric.

A test link shall be installed in each down conductor adjacent to the earth rod at a height of 1,200 mm above ground level. The overall resistance of the earth termination system to earth shall not exceed 10 □. If this requirement is not met the number of earth electrodes shall be increased or they shall be interconnected until a value of 10 □ is attained.

Earth rods shall be not less than 16 mm diameter copper or copper-clad steel, provided with hardened tips and driving caps. Each rod shall be provided with a non-ferrous clamp for connections of the copper strip. Each connection shall be housed in an inspection chamber set at ground level.

Where feasible, the lightning protection grounding system may be inter-connected with the system earth to ensure equipotential under all conditions.

A provisional sum has presently been included for supply and installation of the lightning protection system, the details of which will be agreed as may be required to suit the operation and protection of the compound.

9.13 Small Power and Lighting Distribution System

9.13.1 General

The installation shall include the distribution board, wiring, lighting fittings, socket outlets, earthing and lightning protection and external floodlighting as required together with all conduits, trays and accessories as necessary to complete the whole of the installations as specified and as shown on the drawings.

In general, Corrosion resistant fluorescent fittings shall be used for internal lighting with weatherproof fittings for exterior fittings mounted on building structures above and adjacent to the door openings.

External wall mounted corrosion resistant luminaires shall be installed using a back entry conduit system terminating behind the respective fitting with an end box mounted on the building fabric. Appropriate neoprene seals shall be used to prevent ingress of moisture. The final connections of each fitting shall be sleeved with silicon glass over sleeving.

The final circuit arrangements and phasing shall be agreed for all compounds and buildings to suit the requirements of the IEE Regulations and the Contractor's working drawings.

9.13.2 Wiring

The installation shall in general be surface within pump houses, etc. but concealed in offices, dwellings and similar structures. The circuit wiring being continuous on a loop-in, loop-out system. The final connections to the fittings shall be by lid and cord grip, the circuit wiring terminating within the conduit box at a suitably rated terminal block. The final connection from the block (via the cord grip) to the fitting shall be carried out in heat resisting 3 core PVC/PVC (or similar) cable, white in colour.

9.13.3 Internal Lighting

Luminaries shall be complete with all supports, suspensions, flexible cables, pendants and plugs. They shall be connected to the main circuit wiring with heat resisting flexible cables of a minimum core size of 24/0.20 mm^2.

Protective classification shall be IP42.

The earthing of all luminaries shall be by a separate core in the connecting flex cable or cable system, securely bonding the earth terminal on the fitting to that of the interconnecting cables.

Where adjacent luminaries are connected to different phases of the supply, a label shall be fitted internally warning of the presence of the phase to phase voltage.

Luminaries shall not transmit load to suspended ceilings unless the ceiling and lighting is of integrated design with the appropriate supports.

Lampholders for flexible pendants shall be of the all-insulated skirted pattern with cord grips.

The fixings, connection boxes and other parts of the luminaries shall be erected at times to suit the building programme. The glassware, diffusers, shades, lamps and tubes shall not be fitted until all building works are complete. Fittings shall be left clean inside and outside and ready for use.

9.13.4 Incandescent Fittings

Incandescent fittings shall be supplied complete with their lamps. Lampholders in totally enclosed fittings shall be of a heat resistant type and shall be connected with heat resistant cable. Generally, Bayonet Cap lampholders and lamps shall be used.

9.13.5 Fluorescent Fittings

Fluorescent fittings shall be of the corrosion-resistant type and supplied complete with their lamps. They shall be complete with tubes, auxiliaries and all other items required for their complete installation. The fittings shall have a completely enclosed wiring channel for accommodating wiring and auxiliaries, and supporting the lampholders, reflector and diffuser as applicable.

In general fluorescent fittings complete with reflectors shall be used for lighting within the buildings and weatherproof fluorescent fittings with IP65 enclosure shall be used for exterior fittings mounted on building structures above or adjacent to the door openings.

Diffusers where specified shall be of flame retardant extruded acrylic or GRP material. They shall be either opal or prismatic pattern as specified.

A gasket shall be fitted between the diffuser and the body to form an effective seal.

The luminaries shall comply with BS EN 60598-1:1993 and Part 2:2003 for Class 1 ordinary, indoor normal atmospheres and Class 11A for chemically corrosive atmospheres, where appropriate.

Fluorescent luminaries shall have two suspension or fixing points and shall be complete with lamps.

Fluorescent lamps shall comply with BS 1853-2:1995 BS EN 60081;1994.

Unless otherwise specified, lamps shall be coloured `white' for industrial use and `warm white' for commercial and domestic lighting. Lamp caps shall be of the bi-pin type.

The light fittings shall be manufactured by Thorn or similar in all respects.

9.13.6 Lighting Switches

All lighting switches shall generally be metalclad surface mounted in pump houses and similar areas and flush in domestic and office buildings. They shall be fitted into approved surface or flush conduit boxes. Lighting switches shall be minimum 6 Amp rating of the type specially designed for AC circuits. Exterior switches shall be of IP65 enclosure pattern. All switch boxes shall be provided with earthing terminals. Mounting height shall generally be centred at 1.375 m above FFL subject to site and building details. Metalclad switches shall be to BS 3676:1989 and BSEN 60669-1:1996.

Internal lighting switches shall have white moulded plates and shall comply with BS 3676:1989. They shall be supplied complete with box, cover plate and fixing screws. External lighting switches shall be of the metalclad, galvanised and weatherproof pattern with rotary action. They shall be surface mounted. Alternatively, the sealed splashproof pattern with enclosures IP54 to BS EN 60947-1:1992 will be considered.

At multi-switch positions, the switches shall be contained in multi-gang boxes.

Where operation of a lamp or group of lamps is required from two separate locations, two way switches shall be fitted with intermediate switching where shown.

9.13.7 Socket Outlets and Spur Outlets

The socket outlets in pump houses and similar shall be generally metalclad and positioned as indicated on the drawings. The socket outlets shall be surface mounted, fitted into approved surface conduit boxes. All boxes shall be supplied with adjustable steel grids and earthing terminals. They shall be 3 pin shuttered and switched where specified. Earthing pins and shutters shall be provided throughout, the outlets being manufactured by Legrand, MK, or similar.

Domestic pattern socket outlets shall be flush mounted, of ratings indicated on the Drawings, 3 pin (with earth) and shuttered complying with BS 1363. Industrial pattern socket outlets shall comply with BS 4343. Spur outlets shall comply with BS 5733 and shall include a switch and neon light.

Plugs tops shall be provided with all outlets complete with fuses and 100% spare fuses.

Industrial sockets shall be to IP44 protection for surface mounted switch socket outlets used internally and IP67 where used externally. A corresponding plug top shall be issued with each socket.
The light switches and socket outlets shall be of the same range and pattern where located in one room, structure or building. The units shall be as manufactured by Legrand , MK, or similar approved. Details shall be provided.

The mounting height to the bottom line of the outlet shall be:

- 250 mm above the worktop surface
- 450 mm above the finished floor level in office areas
- 1,200 mm above the finished floor level in workshop and storage areas (excepting over workbenches)
- 1,200 mm above the finished floor level in pump stations

The above requirements are intended as a general guide. Final details shall be agreed with the Engineer on site to suit the particular facility, plant layout etc.

9.13.8 Three Phase Power Outlets

Three phase power outlets shall be provided where indicated on the drawings. These shall be mounted the surface, switched, complete with plug top and as manufactured by Legrand, MK, or similar approved.

9.13.9 Distribution Boards and Consumer Units

The distribution boards shall be a moulded case and miniature circuit-breaker type and shall be of the totally enclosed metal clad, cubicle type of surface pattern as indicated. They shall be complete with hinged lid and so constructed that the circuit-breaker toggles are concealed when the lid is closed. The distribution board shall be controlled by an isolating switch integral with the board.

Distribution boards shall be equipped with RCD's, HRC fuses or miniature circuit-breakers, arranged for triple pole and neutral or single pole and neutral outgoing circuits from a three or single phase and neutral incoming supply.

The circuit breakers shall be provided with thermal overloaded and magnetic short circuit tripping and a quick trip-free mechanism. The Contractor shall ensure that the necessary discrimination between each main panel and final sub-circuit is provided. Circuit breaker distribution boards used throughout the installation shall be of the same pattern, range and manufacture. All MCBs shall have a short circuit capacity not less than 5 kA.
Doors shall be lockable, hinged and gasketted to give a damp and dustproof enclosure. The degree of protection shall be IP43 (indoors) and IP55 (outdoors). The boards shall conform to BS 5486 and shall be provided with conduit and cable gland entry plates.

The busbars shall be mounted on non-hygroscopic insulators, completely shrouded or PVC insulated, coloured to denote the appropriate phase. The current rating of the busbars shall not be less than the current rating of the incoming circuit. A neutral bar shall be provided with a separate terminal for each circuit.

Fuse carriers used in distributions boards shall be of the fully shrouded pattern and shall employ HRC fuses only. They shall be mounted on the back plates using spacers so that outgoing wiring can pass behind the carriers.

Distribution boards employing miniature circuit breakers shall be capable of accepting breakers of mixed ratings of standard or residual current detection type.

Distribution boards shall be provided with an earth bar to allow connection of circuit protective conductors. The number of connections shall be equal to the number of single ways. A main earth terminal shall be provided to allow bonding of the enclosure in accordance with the requirements of the IEE Regulations. All earth, neutral and phase connections within distribution boards shall be numbered correspondingly by tagging the wires.

Such an earth terminal shall also be provided on the local isolator enclosure where this forms a separate unit to the distribution board.

A fully detailed and comprehensive circuit list approved by the Engineer shall be fixed inside each distribution board, enclosed in a transparent incombustible envelope.

Consumer units shall be of the flush or surface mounted metal enclosure type complete with all MCBs and isolating switches, basically as specified for the distribution boards. Details shall be submitted for approval.

9.13.10 Fused Connection Units

The Contractor shall supply and install all fused connection units feeding electrical appliances mounted adjacent to the electrical appliance. For floor mounted appliances the mounting height to the bottom line of the outlet shall be 450 mm above finished floor level except where otherwise stated on the drawings.

Fused connection units shall be installed such that, where applicable, the connecting flexible cable is no longer than 300 mm.

Fused connection units shall be to BS 5733:1995 or similar and shall be mounted in enclosures with white moulded cover plates in offices and metal clad type in plant rooms, pump stations or similar locations, and shall be of the MK, Crabtree or Legrand type as shown on the drawings. Isolators shall be to BS 3676: 1996 and shall be mounted in enclosures with white plastic or metal cover plates as shown on the drawings.

9.13.11 Emergency Battery Lighting Unit

Emergency self-constrained light fittings will be positioned as indicated on the drawings to provide lighting in the event of a power failure. The lighting units will have between 1 to 3 hour autonomy.

The units shall be double spot light or multi-spot type complete with mounting bracket and charging facilities operated from a 240 V AC supply. The battery light shall be arranged to switch on in event of failure of the AC supply to the fittings and shall operate for minimum of three (3) hours from the battery without re-charging.

Recharging shall be automatic on the restoration of the main supply and the period of the recharging shall be approximately 12 hrs. The fitting shall generally be provided with an earthed metal case housing the battery and switching equipment.

The lamps shall be 12 W tungsten halogen operated by a sealed type lead acid battery. A solid state constant voltage charger shall be provided together with low voltage cut-out protection to protect the battery against over-discharge. The units shall be suitable for the environments in which they are to operate.

9.13.12 Portable Hand Held Fire Extinguishers

Portable hand held fire extinguishers shall be provided as specified below. They shall be in accordance with BS 5306- 3:2003, BS 5423 and local CFO requirements.

Each extinguisher shall be complete with a suitable wall fixing bracket. The final mounting/fixing shall be agreed on site.

The 5 kg portable carbon dioxide fire extinguishers shall comply with BS 7863:1996 and BS 5423. The bodies of the extinguishers shall be seamless steel cylinders manufactured to BS BS7867:1997, BS EN -1:1997.

The 12 kg portable dry powder fire extinguishers shall comply with BS 3465 : 1962 and BS 5423. The bodies shall be constructed of steel not less than the requirements of BS 1449 or aluminium to BS 1470 : 1972 and shall be suitably protected against corrosion.

9.14 Floodlights

Floodlighting units shall be of a type designed and constructed for the application. They shall be complete with 500 W tungsten halogen lamp, enclosure, reflectors, etc, and all items necessary for their installation.

They shall be of corrosion resistant light alloy with clear toughened glass front, the whole assembled to provide a weatherproof unit with IP65 enclosure.

Galvanised steel poles, complete with horizontal mounting brackets, shall be provided as shown on the drawings. The poles shall be complete with a service door which shall provide access to the back-board, fused cut-out, gland plate. Sufficient space shall be provided to permit a maximum of three cable terminations.

Wiring between the MCB, fitting and lamp, via the control gear, shall be 20 A rating butyl rubber insulated, PVC sheathed cables or equal approved.

A separate earth wire shall be run between each lighting fitting and the earth termination situated at the supply point.

Foundation details shall be provided for approval. All cable glands, fixings and terminations shall be provided.

The mounting of the floodlights and associated brackets shall be such that both horizontal and vertical alignment can be carried out at site after installation.

The floodlights shall be manufactured by Thorn or similar in all respects.

The holes for the planted root columns shall be excavated to a depth as recommended by the column manufacturer and the hole diameter shall not be more than twice the diameter of the column base, and shall be to the satisfaction of the Engineer.

The column with bracket affixed shall be placed centrally in the hole in a vertical position on a pad of concrete and the hole filled with concrete in 150 mm layers of 200 mm radial thickness around the column up to a depth of 150 mm below ground level. The excavation shall be backfilled and evenly rammed. A flexible PVC duct not less than 50 mm diameter shall be installed through the concrete surround into the column via the cable entry slot to provide a clear route for the electricity supply cable complete with draw cord.

9.15 Road Lighting

Road lighting shall be provided at the compounds as indicated on the drawings and as generally specified. The lighting shall utilise galvanised steel poles as specified for the area floodlighting, the top mounting spigot being modified to accommodate an outreach support bracket capable of supporting a 70 W high pressure sodium 50N-T corrosion resistant fitting with IP65 enclosure, strong durable canopy, integral control gear with hinged tray. Details of the poles, outreach bracket and fitting supporting arrangements shall be provided for approval.

The outreach brackets shall be fixed to the pole spigot by at least three Allen screws or similar type fixings. The poles and outreach brackets shall be galvanised steel, the service door, fuse cut-out, wiring and earthing shall be generally as specified for the floodlighting poles.

Road lighting and floodlighting requirements are, in general, photo-cell controlled from the switchgear. The Contractor shall locate the photo-electric cell units externally on structures at locations to be agreed on site. All conduit, wiring, cabling and connections required for the photo-cells shall be supplied and installed under this contract. Override test/control switches shall be provided on the face of the switchgear panels to permit the manual operation of all lighting circuits should this be required.

The Contractor shall label all columns with their respective designated numbers, the details of which shall be agreed. This shall be done by means of stencilling the number in black characters onto the column, bollard or mast. Size of characters and locations shall be advised on site and shall be to the approval of the Engineer.

All road lighting columns shall have their access doors orientated in a common manner with respect to the roadway throughout the site and shall have their lanterns orientated as shown on the drawings. Columns shall be positioned at least 1 000 mm back from the road edge, the final distance being agreed to suit overhangs, curbing etc.

9.16 Control and Monitoring Systems

9.16.1 General

The Contractor shall design, supply and install all equipment for the automatic control and monitoring of the Plant being supplied under this Contract and to achieve the operating sequences specified. The equipment shall be complete in all respects and shall be suitable for use with the plant offered.

In general the plant will be controlled from level sensing units and float switches. Manual means of controlling the plant shall also be provided at the motor control panels.

The pumping and protection systems shall include:

- Pressure switches to detect a change in pressure (high/low) to include alarm
- Cut-outs to protect against closed valve, broken pipe, etc., and
- Start and stop for pump sets

All protection and safety devices shall initiate an alarm siren on the monitoring/control panel section of the main motor control centre, and will also initiate a warning light, dedicated warning lamps being provided for each protection/safety device. The siren shall be muted, the warning light remaining energised until the fault or protection device has been cleared and reset. A complete monitoring/warning/control system shall be provided for all plant and equipment, details to be submitted with the Tender.

In addition to the control of the pump sets, means of identifying high water level and low water level in the wet wells, tanks, etc. shall also be provided. The activation of either the high or low water probes shall, in addition to stopping or starting the pump set, also initiate a visual alarm. This shall take the form of a suitably labelled red indicator light mounted integral with the relay/changeover switch cabinet positioned within the control room or similar type operators areas to suit each compound.

The operation of the pressure switches, high level and low level probes and other safety/warning devices shall automatically energise a warning lamp on the control panels and switchboard the operators are fully aware of the nature of the plant shut down/operation.

The final method of wiring to the above switches, probes and safety devices, the actual locations of the switches and their settings shall be agreed to suit the layout of the pipe work and the operating parameters of the system. It shall be deemed that the Contractor prices include for all requirements.

9.16.2 Marshalling Cabinets

Marshalling control cable cabinets shall be provided at the sites to suit the requirements of the control system. The cabinets shall be either independent units protected to suit the environment or may form an integral part of the motor control centre or switchboard. The final locations shall be to suit the overall control systems.

The cabinets shall be complete with access doors and all terminating blocks and units as manufactured by Klippon or similar approved. Sufficient spare units shall be provided to facilitate cross patching from a faulty section of the cable to a healthy section.

9.16.3 General Facilities

The Contractor shall ensure that all starters, cabinets and the like have sufficient auxiliary contacts, terminations and fixings to meet fully the requirements of the control systems, together with sufficient spares to meet future requirements.

The pressure switches and control probes shall be of approved manufacture and type, suitable for use with potable water. The Contractor shall include, in addition to the supply and installation of the switches and probes, etc., for all wiring, cables, trunking, connections and the like to complete the entire control system as specified, including all wiring to and from switches, floats, probes, switchboards and alarms, etc. Details of the pressure switches, floats and probes shall be submitted with the Tender.

Alarm circuits shall consist of indicator lights which shall re-set automatically only upon cessation of the alarm condition.

The system of level and alarm condition sensing and signal transmission shall be to the approval of the Engineer, with emphasis placed on simplicity of operation and durability of construction.

9.17 Schedule of Tests

9.17.1 General

As many tests as possible shall be arranged together. Five copies of the Contractor's records of all tests shall be furnished to the Engineer.

All material which is specified for tests at the manufacturer's works must satisfactorily pass such tests before being painted or otherwise coated.

All test instruments, fuels and consumables required for the tests, commissioning and putting the plant into full operation shall be supplied by the Contractor. Test instruments shall be to approval and shall be calibrated by a competent authority as may be approved by the Engineer.

9.17.2 Tests at Manufacturer's Works

Details of tests to be carried out on particular items of electrical plant shall be as follows. Other items of plant and equipment will be tested as required. Similarly, further tests as

necessary will be carried out on the plant as instructed by the Engineer or required by the relevant BS or Code of Practice.

The electrical equipment supplied under this Contract will be tested to prove compliance with the requirements of this Specification and with the relevant British Standard specification where applicable.

High voltage and insulation resistance tests shall be made when the apparatus is hot.

Tests shall include, but not be limited to, the following as may be applicable:

- H.V. pressure tests and insulation resistance check
- L.V. pressure tests and insulation resistance check
- Injection test
- Shunt trip test
- Closing test
- Operation of all inter-locks and protection devices.

9.17.3 Tests after Erection on Site

All Plant shall pass such tests on site as are required by the Engineer to prove compliance with the Contract independently of any tests which may already have been carried out at the Manufacturer's Works. In particular, all electrical pressure tests made at the Manufacturer's Works shall be repeated at voltages to be approved by the Engineer.

The entire installation shall be tested and commissioned in accordance with the Regulations for Electrical Installations published by the Institute / or Electrical Engineers (London) - 16th Edition, including the latest amendments and with the details contained within the General Specification. In addition, particular attention shall be paid to the specific testing requirements of specialist equipment described in this Specification. Prospective Fault Currents (Ipsc) and Earth Fault Loop Impedance (EELI) shall be measured and recorded at different locations on each installation including at each LV switchboard, distribution board and at the furthest socket outlet from the source on each socket outlet circuit, and at each item of fixed equipment.

Testing and commissioning procedures shall be such as to effectively prove the correct operation of all components and their integration into the systems. The testing shall also prove that the systems function in accordance with the appropriate design criteria.

All systems shall be fully tested and commissioned prior to the Engineer being invited to witness a full demonstration of the system and verification of its functioning and correct commissioning, except where specifically indicated otherwise within this Specification.

No equipment other than 415/240Volt lighting supplies shall be energised without the permission of the Engineer. The contractor shall be responsible for the safety of both plant and personnel from the initial energisation of all plant and until hand over.

The results of all tests shall be recorded and inserted into the Operating and Maintenance manuals.

If, in the opinion of the Engineer, the plant does not comply with this specification, the defect shall be rectified at no cost to the Employer.

9.18 Automatic Voltage Regulator

9.18.1 Safety

Under no circumstances should any work be carried out on the unit, connections or cabling unless the electricity supply is isolated. Only qualified electricians should work on the AVR and it's installation.

9.18.2 Positioning of AVR.

It is important to carefully consider the place chosen to site the AVR.
9.18.1 Positioning of Indoor Units - The unit should be sited on a firm, dry and level surface. A position allowing access on all four sides to permit preventative maintenance would be advantageous. As there are cooling fans mounted in the cabinets it is important that there should be adequate space around the unit. As a guide, a free space of at least 300mm should be left in all directions around the AVR. Keep the AVR away form sources of heat and excessive dust and dirt. It should not be positioned where it will be in direct sunlight.
9.18.2 Positioning of Outdoor units - The unit should be sited on a firm, level surface. A concrete base is recommended. A position allowing access on all four sides to permit preventative maintenance would be advantageous. As there are cooling fans mounted in the cabinets it is important that there should be adequate space around the unit. As a guide, a free space of at least 300mm should be left in all directions around the AVR. Ensure cable routing to/from the AVR will not subject the cable to damage. Protect the AVR from possible damage from road vehicles. Do not site it close to exhaust outlets, rain water outflows or areas frequented by animals.

9.18.3 Ventilation

The unit should be positioned such that a free flow of air is available. It is especially important to ensure that cooling fan inlets and outlets are free from obstruction. A free space of at least 300mm should be left in all directions around the AVR.
Open the front door of the AVR and identify the power PCBs, ST221 or ST165.
These have rows of triacs on heat sinks and resistors on sub-PCBs. A 'comb' shaped item is used to support these heat sinks during transit. Remove them before use so as to maximize air flow.

9.18.4 Cables and Terminations

Before any connections can be made, the incoming and outgoing cable sizes have to be selected and, on 200A units and above, the appropriate ring terminals fitted. Cable size may be selected using values of calculated current bearing in mind the usual limiting factors such as volt drop, heating, etc. The appropriate breaker sizes can also be designed. Note that the input and output currents can differ by 40%. This means that a larger cable size may have to be employed on the input than the output.

Table 2.4.1

Output	KVA(415)	Input A(max)	Input MCCB	Output MCCB	ring size MM
10	7.2	14	16	10	8
20	14	28	32	20	8
30	21	41	50	32	8

50	36	69	80	50	8
75	54	103	100	80	8
100	72	138	160	100	8
150	108	207	200	160	8

9.18.5 Circuit Breakers

The recommended input and output breaker ratings are given in table 2.4.1. Values not shown may be interpolated. Due to the fact that breaker ratings jump in large steps it is strongly recommended that adjustable trip level MCCBs are used. In this way a high degree of protection may be achieved. The input MCCB should be of a type suited for use with inductive loads (with a high initial surge current). The output breaker should be chosen to suit the nature of the load.

9.18.6 Incoming Connections

The three incoming lines should be connected to the terminals marked R1 S2 T3 on the terminal panel in the section marked INCOMING MAINS. The incoming neutral (if present) is connected to the N terminal and the system earth is connected to the E terminal. Care should be taken to ensure that all terminals are securely tightened. See photo 2.6.1. Note – cable access is from below to the rear on indoor units and via a gland plate at the bottom right on outdoor units.

9.18.7 Outgoing Connections

The three outgoing lines should be connected to the terminal panel in the section marked OUTGOING MAINS. The outgoing neutral should be connected to the N terminal and the load earth to the E terminal. N.B. The outgoing neutral cable should be fully rated. Care should be taken to ensure that all terminals are securely tightened.

9.18.8 Earth/Neutral Connections

The Incoming and outgoing earth terminals of the AVR are connected together and connected to the metal chassis work of the AVR. In the interests of safety, they must be connected to a good quality, low impedance site earth point. Customer should also note that, due to the isolating nature of these AVRs, the output phase and neutral connections are floating with respect to earth. Depending on the site electrical arrangement, it may therefore be required to connect the output neutral terminal to the earth terminal to reference the load supply to site earth.

9.18.9 System Power-Up.

Before the system is powered-up for the first time the following checks should be carried out **by qualified personnel only**.

Inspect the input and output terminations for tightness, correct wiring and phase rotation.

Check that the building electrical service is of sufficient capacity to supply the input current of the AVR, remembering that this can be 40% higher than the output current to the load.

Check building electrical service is of correct nominal voltage and wiring configuration and that main circuit breakers are suitable for the inductive/transformer nature of the load represented by the AVR.

Ensure that the load equipment is ready to be energized.

Set the Bypass switch to ‘Normal’ , position ‘1’.

Turn the AVR output circuit breaker to ‘Off’.

Check the ‘delay’ setting on the AVS is set appropriately for the load, e.g. 30 seconds for electronic loads, 3 minutes for air conditioners/compressors.

Once the above conditions have been verified, input power may be applied to theAVR.
Once input power is applied, the AVR regulator boards should power up as shown by the three green LEDs on the front door (indoor units) or on the power boards (outdoor units).
The AVS will go into a wait mode (see section 4.5) for up to 3 minutes,
depending on the AVS delay setting and on how long has elapsed since the AVR was last powered up. This will be indicated by a yellow LED on the AVS indicator LEDs.
At the end of the wait time the noise of the contactor engaging will be heard and power will be supplied to the output. Now turn on the AVR output circuit breaker to supply power to the load.
Check that power is reaching the load correctly.
Check that the AVR ventilation fans are all running, extracting air.

9.18.10 Functional Description

This three phase AVR is fitted with isolation transformers in a delta-star configuration. This provides and clean, isolated supply to the load with a 'new' neutral connection. The AVR is made up from three identical single phase regulator units. Each of these monitors its own output voltage and adjusts for variations in mains supply voltage so as to maintain an output voltage within close limits.
When the AVS function is fitted, the outputs from the regulator are connected through a contactor to the load. The contactor is controlled by a three phase Automatic
Voltage Switcher PCB which monitors the AVR outputs. This connects the load only when all the phase voltages are within acceptable limits. There is a delay function in the AVS to prevent frequent switching of the load.
A change-over switch is provided to by-pass the AVR in the event of needing to perform maintenance on the AVR. The switch is usually kept in the 'normal' (1) position but can be set to by-pass (2) if needed. There is also a centre off position,
See notes on the by-pass switch regarding neutral connection before using the by-pass mode.
An output circuit breaker is provided to protect the AVR from overload current and short circuit loads.
Fans and thermal switches provide temperature control and protection. Filters, suppressors and fuse provide electrical protection.

9.18.11 Transformer Configuration

These AVRs are fitted with isolating transformers, one per phase. These provide a high degree of isolation from input to output. They also greatly attenuate common mode noise from the supply and prevent it reaching the load.
The primaries are each nominally 415V rated and are connected in a delta configuration. In the indoor 30A AVR each primary is made up of two coils connected in series. See appendix 1 for the connection diagram. In the outdoor 30A, indoor 50A and outdoor 50A AVRs, the primaries are made up of two coils connected in parallel. The 12A and 20A transformers have single coils.
The secondaries are nominally 230V rated and are connected in a star configuration so as to generate a new neutral point. The secondires are in fact made of two coils each connected in parallel.
A further advantage of the delta input configuration is that an incoming neutral connection is not required from the supply. Often neutral supply connection is poor or missing and this can cause damage to loads and regulators due to high phase to neutral voltages that result.

9.18.12 AVR Function

This is based on an isolating transformer with tap changing on the output. There are seven taps to each transformer giving an accurate output voltage for a wide range of input voltage. Table 4.3.1 below shows the ratios of the seven taps for each phase.

The taps are switched by generously rated triac banks to cope with motor start and other high in-rush loads. Low value resistors are fitted with each triac to ensure that high currents are shared equally between the triacs within each bank.

Input voltage 415

Colour	O/P Ratio	L-N O/P Voltage
Violet	0.87	208
Blue	0.953	228
Green	1.035	248
Yellow	1.118	268
Orange	1.212	290
Red	1.318	316
Brown	1.423	341

Table : AVR Transformer Ratios.

This technique results in a voltage stabiliser which has no moving parts, responds quickly to voltage fluctuations and is not as large or heavy as other AVRs utilizing different regulation techniques.

A micro-controller forms the heart of the control system. It measures the AVR output voltage and turns on the appropriate triac bank to select the correct tap. A potentiometer is provided for fine adjustment of the output voltage. The microcontroller also measures the frequency of the mains supply and compensates accordingly. This also means that the AVR will work over a frequency range of 45 - 88Hz automatically and down to as low as 30Hz for short periods to help cope with diesel generator loading problems.

Frequency and voltage measurements are filtered by the circuit and software to remove noise and so prevent spurious tap changes.

A watchdog function is implemented in the micro controller. This independently monitors the operation of the micro-controller and its software. If it detects a malfunction, it will reset the micro and re-initialise the control system.

The low voltage DC supply to power the control circuit is generated from a small isolated winding in the main transformer for each phase. This is passed through temperature switches on the transformer coils so as to shunt the AVR down in the event of overheating. The low voltage supply is also protected by a fuse.

Additionally, a hardware reset circuit is included which monitors the supply rail for the control circuit. If the mains are so low that the control circuit will not function correctly, the monitor circuit will put the micro-controller into the reset state and turn off all triacs.

When the mains supply increases to a usable level, the monitor circuit will restart the micro and the system will re-initialise. This ensures an orderly and controlled restart from a brown-out or blackout condition. The circuit is designed with a large hysteresis so that the unit will not attempt to turn on again until the supply voltage is sufficient to withstand possible starting surges. This avoids the possibility of such a surge of current causing the supply to dip sufficiently to turn the unit off again.

Additional protection is provided by temperature sensors fitted to each transformer. If the AVR is used at full load and either the ambient temperature is excessively high or the ventilation grills have been obstructed, the temperature of the transformer may increase beyond reasonable limits. In such an event, the temperature sensor will disconnect the supply to the corresponding control board and thereby turn the output off. When the transformer has cooled sufficiently, the sensor will restart the AVR.

When restarting after the above condition the AVR may cause equipment to begin to operate suddenly. Steps should be taken to ensure that this does not expose persons to risk.

9.18.13 AVS Function

The Automatic Voltage Switcher (AVS) is a device for the protection of electrical equipment against fluctuations, interruptions and other abnormalities in the electricity mains supply.
There is an option with the AVRs to have an AVS connected at the output of the AVR to protect the load from high and low voltage should the supply voltage go outside the regulation range of the AVR.
The Three Phase AVS monitors various parameters of its input, and keeps it connected to the equipment so long as all the parameters are within defined acceptable limits. This is the **normal** condition and it is indicated by a **Green LED** (light emitting diode).
If the voltage goes outside these limits, the AVS disconnects the equipment from the mains and this is indicated by the **Red LED.**
When the mains supply returns within the acceptable limits, indicated by an **Amber LED**, the mains remain disconnect from the equipment during the **wait time**, user adjustable by adjustment of delay pot on AVS PCB. If during the wait time the mains again goes outside the limits, the wait time does not start from the beginning, however it will always give a minimum of 10 seconds from the last 'red' condition before turning on.
At the end of the wait time, when the mains supply is within the limits, 'normal' condition returns indicated by the Green LED, and the load is re-connected to the mains.

The parameters monitored by the Three Phase AVS are:

a) Value of the Mains Voltage

The normal condition is when the values of the mains voltage of all the phases are within certain preset limits referred to as the "window". The AVS detects when the voltage of any one or more phases goes outside the window, either over- or under-voltage.

b) Phase Relationship.

The AVS monitors the phase relationship between the three phases of the supply. The normal condition is when the phase difference between the three phases is 120 degrees, corresponding to T/3 where T is the period of one cycle.

c) Phase Rotation (Optional).

The AVS can detect a phase rotation error of the three phase mains supply. It will switch off if the phases are not in the correct order.
Detection of parameters c) above is not standard, but is obtained by an optional change of control chip.
The output of the AVS PCB is a single volt-free relay contact. This is used to control a contactor with rating to suit the output current rating of the AVR. It has three independent contacts sets, to switch the three phase lines of the AVR output.

9.18.14 Bypass Switch Function (Optional).

This is used to take the AVR out of circuit, bypassing the supply straight to the load.
A fully rated, in line, mechanical switch is used to achieve this. This ensures that the supply to the AVR cannot be re-connected unintentionally by component failure or supply disruptions. This is particularly important if the bypass is used to enable maintenance to be carried out.
The bypass switch is a changeover switch with three positions. See diagram 4.5.1 below.
The '1' position is 'normal' and connect the supply to the input of the AVR while the AVR output passes through the output circuit breaker to the load.
The centre '0' position is an off function and disconnects the incoming supply from both the AVR and the load.
The right hand '2' position bypasses the AVR by disconnecting the supply from the

AVR input and instead connecting the supply direct to the load.

9.18.15 Bypass Switch Connections.

The AVS contactor isolates the supply voltage from the AVR output circuits but it may be advisable to turn the output circuit breaker off as well. In the by-pass and off modes, the supply is disconnected from the AVR transformers and regulator boards as well as the AVS PCB. However, great care should be exercised as the other terminals and bypass switch connections are still connected to the supply and will be live.
Note: If the AVR is used in bypass mode, a good neutral supply is needed at the input, as this will now be connected to the load and form the load neutral point. (In normal mode, an incoming neutral is not required due to the isolating transformer and delta input configuration of the transformers.)

9.18.16 Surge Arrester.

4.6.1 Function - This PCBis mounted directly behind the incoming and outgoing terminals on the terminal board. It is designed to prevent high voltage spikes and surges from causing damage either to the AVR or to equipment down the line from the AVR. These spikes are commonly caused by lightning, sub-station load switching or heavy motor load switching.
4.6.2 Operation - The unit incorporates multi-stage MOV protection circuits. Which is designed to clamp high voltage, high energy spikes from the line or the load. It also incorporated X2 rated mains filter capacitors to filter high frequency noise and slow down fast transient edges that might otherwise cause malfunction of the AVR or the load equipment.

9.18.17 Suppressor Boards.

These small PCBs are fitted on the side of the transformers and mount two filter capacitors. The filter noise and fast transient edges on the output connections of the AVR so as to prevent noise from the load from disturbing the correct function of the AVR circuits.

9.18.18 Fuse Board.

There is a small fuse board (ST179) mounted on the terminal board of the AVR. It provides as fused supply to the ventilation fans from the regulated AVR output supply. It also provides a fuse supply for the lines to the three phase AVS PCB.

9.18.19 Ventilation Fans

In the indoor AVR there are four fans fitted near the top of the enclosure, two on each side. They run continuously and extract warm air from the top of the AVR enclosure.
Cool air is drawn in from the ventilation panels lower down the AVR casing.
In the outdoor AVR, there fans mounted under a cover on the door. These perform the same function as for the indoor unit. They draw cool air into the AVR enclosure via ventilation grills lower down at the rear of the enclosure.

9.18.20 Output Circuit Breaker

This is provided to protect the AVR from overload and short circuit on the output. It can also be used to isolate the load during testing.

9.18.21 Digital Meters.

Some models are fitted with digital meters to show input and output voltage and output current. When fitted to indoor units the meters are fitted on the door, externally visible. When fitted to outdoor units the meters are again fitted to the door but only visible when the door is open.

There are two meters; the upper shows input and out voltage and the lower shows output current. A button is provided to toggle the display from input to output voltage, with an LED indicating.

9.18.22 Maintenance

Front Access.

The front of the AVR enclosure has a hinged, lockable door. This can be opened to view the main power PCBs for the AVR. The indicators on these PCB can then be viewed but care must be taken when opening this door with the power connected.

Rear Access

On the indoor AVRs, there is a rear access panel which can be removed to again access to the AVR input and output terminals, in addition to other components.

On the outdoor units, there is no rear access and all parts are accessed via the front door. Great care should be exercised if power is turned on while the rear door is opened because the live power terminals will be exposed.

9.18.23 Cover Removal.

On the outdoor unit, the AVR cover is of a one piece construction and cannot be removed. All components are accessible via the large front access door.

On the indoor units, full access to all components can only be gained by removal of the whole cover of the AVR. To do this proceed as follows:

1. Turn off and isolate the power.
2. Remove the rear access panel.
3. Open the front access door and carefully remove the small plugs from the phase status LEDs. Also remove the ribbon cable from the AVS LED PCB. Remove this wiring from the inside of the door.
4. Remove the earth wire from inside the door, as well as the earth wires between the case sides and base.
5. Open the door fully and lift it off it's hinged. Place it to one side out of the way.
6. Remove the pull-off connection from the ventilation fans.
7. Loosen and remove the lifting eyes/bolts in the top cover of the AVR.
8. With the help of an assistant, lift the whole cover up and off the AVR to reveal the transformer and circuit boards.
9. Fitting the cover is the reverse process of removal.

9.18.24 Routine Checks.

This is a fully solid state AVR with no moving parts and therefore requires only the minimum of maintenance. You can expect many years of trouble-free service with the AVR completely unattended.

Isolate the incoming mains supply before carrying out any maintenance.

The only maintenance required is to clean any dust and dirt from the outside and inside of the casework which could be restricting the free ventilation of the equipment. There is a ventilation grill to the rear of the outdoor unit that should periodically be cleared of any dust, obstructions or other build-up. If there is a buildup of dust on the PCBs then this should also be carefully removed with a soft brush.

It is also wise on any equipment periodically to check the security of the electrical connections and the condition of the cabling. Again ensure the power is turned off before starting work. Check that all the ventilation fans are functioning correctly.

9.18.25 Specifications.

MODEL : Three Phase Automatic Voltage Regulator
Input voltage : 230/400V +19% -30% (Other voltages available)
Output voltage : 230/400V +/- 4% (Other voltages available)
Correction time : within 15 m sec
Frequency range : 45Hz to 88Hz
Voltage protection : Automatic under and over voltage protection with **(AVS Option)** with automatic re-start. Adjustable voltage limits and delay.
THD : < 0.25%
Max. amb. Temp. : 40 ºC
Acoustic Noise : < 45 dB
Expected Service Life : > 25 years
Technology : All solid state (static) switching
Bypass modes : Built in manual bypass – mains direct to output
Filtering : Input and output noise and spike filtered
Attenuation Ratio : 10:1
IP Rating : Indoor unit IP21 – Outdoor unit IP44
Standards : Manufactured to comply with :-
EN60065
EN60555
BSEN50081
BSEN50082

9.18.26 General Specifications

Input

Frequency range 45Hz to 75Hz (i.e 50Hz –10%, +50%. or 60Hz –25%, +25%).
Additional voltage THD* <0.2% at input (tested at 100% linear load), (No PWM methods used)
Maximum input THD* Can withstand >10% THD from the supply.

Output

Additional voltage THD* <0.25% at output (tested at 100% linear load), (No PWM methods used).
Crest factor > 1: 3 permissible on load current (tested at 100% load).
Synchronization Output synchronized to input.
Permissible overload 1000% for 100ms,
150% for 4 minutes,
110% for 10 minutes.
Load types Designed to run lighting, motors, battery chargers, communications equipment, office equipment, SMPS, air conditioners, Compressors, industrial machines, medical equipment and others.
Suitable for all domestic, commercial and industrial sites.

9.18.27 General

Technology All solid state (static) switching.
Efficiency >96% (at 100% linear load).
Control integrity Microcontroller based control system provides self checks, system monitoring and diagnostic indicators.
Control protection Internal surge arrestors and filters in control circuit protect against disturbances. Filtering algorithms and fault tolerant software protect against disturbances and false measurements.
Ambient temperature range 0 to +55ºC.
R elative humidity >95%, non condensing.

Acoustic noise < 45 dB (A).
Expected service life > 25 years.
Standards Manufactured to comply with :- ISO9001:2000, CE, EN 50081-1:1992, EN 50082-1:1998,EN 55022:1998, EN 61000-4-2:1995/1998, EN 61000-4-3:1996, EN 61000-4-4:1995,EN 61000-4-5:1995, EN 61000-4-6:1996, EN 61000-4-11:1994, DD ENV 50204, BS EN 61558-1, EN 60065, EN 60555.
Input range -30% to +22%
Output accuracy ± 4%
Correction speed 1250 Volts per sec.
Response within 15 millisecond .
kVA rating The AVR range is wide and covers units from as small as 250VA up to 100kVA in single phase and 10kVA to10000kVA in three phase. To choose the correct size from the Sollatek range, refer to the kVA calculator at the back.
Efficiency 88% at 25% load
94% at 50% load
96% at 75% load
97% at 100% load
Power factors Unaffected by load power factor.

9.19 Detailed technical specifications for distribution transformers

9.19.1 Scope

This specification is for oil-immersed, air-cooled, outdoor type mini substation mounted distribution transformers for 11kV distribution systems operated at 50 Hz.
The specification covers transformers of the following voltage ratios and ratings:

- 3.3KV/433V: 2MVA

The specification also covers inspection and test of the transformer as well as schedule of Guaranteed Technical Particulars to be filled, signed by the manufacturer and submitted for tender evaluation.
The specification stipulates the minimum requirements (including features to deter vandalism) for pole mounted three phase distribution transformers acceptable for use in the company and it shall be the responsibility of the Manufacturer to ensure adequacy of the design, good workmanship and good engineering practice in the manufacture of the transformers for Client. The specification does not purport to include all the necessary provisions of a contract.

9.19.2 References

The following standards contain provisions which, through reference in this text constitute provisions of this specification. Unless otherwise stated, the latest editions (including amendments) apply.

ISO 1461: Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods.
IEC 60076: Power transformers.
IEC 60296: Specification for unused mineral insulating oil for transformers and switchgear.
IEC 60354: Loading guide for oil – immersed power transformers.

IEC 60214: Tap-changers - Part 1: Performance requirements and test methods, Part 2: Application guide

IEC 60512: Connectors for electronic equipment

BS 381C: Specification for colours for identification coding and special purposes

10 ENVIRONMENTAL HEALTH & SAFETY

10.1 Environmental & social management plan

The Contractor must carry out all works in accordance with Kenyan Environmental Laws and Regulations, and the requirements of this document.

It is also a contractual obligation for the Contractor to take full cognizance of the environmental and social concerns and requirements as stipulated in the Employer's Environmental and Social Management Plan (ESMP) prepared for this Project constituted in the ESIA report for the project which will be issued to the Contractor on Award.

Accordingly, the Contractor shall be required to prepare a site-specific Environmental and Social Management Plan (ESMP) for the project. This site-specific ESMP shall be based on the Contractor's evaluation of the requirements of these Specifications and the Employer's ESMP. The site-specific ESMP shall be submitted to the Engineer for approval before commencement of works.

The site-specific ESMP shall generally comply with the guidelines set out below.
The site-specific ESMP is the Contractor's operative document on how to enforce, mitigate, inspect and monitor potential Project impacts during mobilization, construction and demobilization. In this sense, it is an eminently practical and concrete instrument.
Based on the above, the structure and content of the site-specific ESMP shall emphasize the following aspects:

(i) Executive Summary
(ii) Introduction
(iii) Project Description
- Focus on impact-generating activities (e.g. demand of water and permanent materials, earth movement, etc.);
- Environmental liabilities: identify and include a photographic registry of pre-existing environmental liabilities (e.g. gully erosion areas, abandoned borrow pits, unauthorized dumping sites, etc.) that are not attribute to the implementation of the Project.

(iv) Potential Impacts during Mobilization, Construction and Demobilization
- Apply simple rating of significance;
- Quantity/quality impacts (e.g. surface and type of vegetation to be removed, amount and type of wastes to be generated, noise levels, etc.);
- Identify places where specific impacts will manifest

(v) Mitigation Plan
- Specify the detailed measures to mitigate the identified impacts (also by location)
- Include designs for measures requiring structural solutions (e.g. gabions, etc.);
- Include the schedule of implementation of mitigation measures in relation to the general construction schedule;
- Health and Safety Plan (detailed);
- Waste Management Plan (detailed);
- Traffic Management Plan (detailed);

- Labour management plan(detailed)
- Training Program (detailed);
- Accident and Emergency Response and Preparedness Plan
- Covid 19 awareness and measures to curb and prevent spread
- Grievance redness Mechanism
- HIV/AIDS Awareness and Prevention Program (include only a reference to this Program to be prepared by an NGO);
- Community Relations Program;
- Location and technical specifications for installation and operation of campsites, including workshops, garages, laboratories, offices, communal kitchenette / dining facilities, sanitary installations, etc.;
- Location, and technical specifications for operation of quarries and borrow pits, and procedures for negotiation with and compensation of land owners where they are located;
- Location and technical specifications for installation and operation of concrete batching, stone crushing, cement mixing and asphalt plants;
- Location and technical specifications for installation and operation of temporary and permanent dump sites.

(vi) Inspection Plan

- Inspection function: specify frequency, locations and instruments (e.g. checklists, site reports, photo registry, etc.) to conduct site inspections;
- Permitting: required environmental permits and schedule to obtain them;
- Specific actions and responsibilities: what, who, where, when, how and why

(vii) Monitoring Plan

- Specify, for each variable: frequency of measurement, locations, methods/equipment, units/measures, quality standards, and reporting requirements and periodicity, including establishment of trends.
- Specific actions and responsibilities: what, who, where, when, how and why.

(viii) Organization and Management

- Specify organizational structure, personnel, resource and equipment requirements, reporting requirements and periodicity, and inter-institutional communication and coordination mechanisms.
- Specific actions and responsibilities: what, who, where, when, how and why

(ix) Annexes

- If the Contractor wishes to incorporate information beyond the indicated above, such as the policy, institutional and regulatory framework for environmental management in Kenya, biophysical and socio-economic characteristics of the area of influence of the Project, etc., that information should be included as an annex and not in the body of the site-specific ESMP. Preferably, such information should not be attached and, further, if necessary, the pertinent chapter of the ESIA should be referenced.
- Annexes should be used, if necessary, to include detailed information on the specific topics of the ESMP (e.g. inspection forms or checklists, design of structural mitigation measures, photographic registry of environmental liabilities, etc.).
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10.2 Health and safety management plan

The Contractor shall submit a project specific Health and Safety Management Plan (HSMP) for approval of the Engineer before commencement of works.

The Contractor must at all times comply with CWWDA / KIMAWASCO / Kilifi County Laws and Regulations during the Planning, Design, Construction and Commissioning Phases of the Project.

10.2.1 Site-Specific Health and Safety Management Plan

The Contractor shall appoint a full time qualified Health and Safety Manager who shall have responsibility for all safety issues on the Project. The Contractor must submit a site-specific Health and Safety Management Plan (HSMP), which shall, as a minimum, address the following:

1) Introduction (including objectives of the HSMP)
2) Hazard Prevention and Control
   (i) Risk assessment (including description of risk assessment method used);
   (ii) Prevention, protection and control measures (based on risk assessment performed):
      a) Personal protective equipment and clothing: safety goggles, ear plugs, work boots, dusk masks, protective clothing etc.;
      b) H&S and sanitary facilities, equipment, materials and personnel: first-aid kits and stations, health personnel, safe drinking water, sanitary facilities, accommodation, washing facilities, domestic waste disposal, etc.;
      c) On-site safety measures and procedures to protect workers against accidents and health risks in the performance of construction-related activities:
         - Site security: access, safety of visitors, separation of work and rest areas, signage, etc.
         - Handling of raw materials: earthwork, gravel, crushed rock, sand, etc.
         - Handling of other materials causing dust development, such as cement;
         - Handling of hydrated lime and other activators and additives;
         - Handling of asphalt;
         - Hazardous materials management
         - Handling of inflammable materials;
         - Maintenance of vehicles and machinery;
         - Deep Excavation and trenching;
         - Emergency prevention, preparedness and response.
   (iii) Contractor's participation in Health and Safety Training Program
   (iv) Contractors participation in awareness creation of COVID 19 and prevention measures
   (v) Contractor's participation in HIV/AIDS Awareness and Prevention Program
   (vi) Provide specifics of training and instruction: topics, frequency, modalities, target audiences, instructors, training materials, etc.
   (vii) Potential Topics:
      a) Occupational safety risks and prevention
      b) Health risks and prevention
      c) Use of personal protective equipment
      d) Safe work procedures: general and specific.
      e) Organization and Management
   (viii) Organizational structure, personnel, equipment, communication and reporting requirements, accident and incident reports, and procedures and tools to verify and ensure compliance with occupational health and safety requirements.

(ix) Annexes should be used, if necessary, to include detailed information on the specific topics of the HSMP, such as (illustrative list):

a) Accident Report forms.
b) Dangerous Occurrence forms (near misses).
c) Safety Audit Forms.
d) Safety Check List.
e) Safety Rules.
f) List of hospitals, emergency evacuation strategy and other arrangements to treat seriously injured staff.
g) List of personnel trained in first aid and their places of deployment.
h) List of first aid kits and locations where these will be held.

10.2.2 Site-Specific Traffic Management Plan

The Contractor shall deploy trained/ train traffic marshals who will be responsible of controlling traffic while executing works along or on road crossings and whenever road diversions may be necessary. The possible topics to included are:

1) Introduction (including objectives of the TMP)
2) Project management responsibilities
3) Road safety control measures and methodology

10.2.3 Site-Specific Labour management plan

These shall describe how recruitment will be done, and entitlement and right of the workers. The following shall form part of the report

1) Introduction (including objectives of the (LMP)
2) Determination of wages and salaries
3) Employment contracts to include detailed information on the specific topics of the HSMP, such as (illustrative list):
   Employment rights and benefits
   Employment deductions and wages
   Over time and compensation
4) Mode of termination
5) Legal obligations and safeguard interst
6) Company policy
7) Workers transport from site
8) Management of direct contractors and sub-Contractors

SCHEDULE OF STANDARDS

The materials covered by this Specification are to be of a quality equal in all respects to the latest editions at the time of Biding of the following British Standards and other references or to any other widely accepted standard specification, which in the opinion of the Engineer, maintains an equal or better standard of quality: -

The Contractor shall supply to Engineer one copy each of the latest edition of the following standards marked with an asterisk (*).

(a) British Standards

REFERENCE	TITLE
*B.S 12	Specification for portland cement
B.S 65: 1981	Specification for vitrified clay pipes, fittings and ducts, also flexible mechanical joints for use solely with surface water pipes and fittings.
B.S 88	Cartridge fuses for voltage up to and including 1000 V a c and 1500 V d c
B.S.89	Direct acting indicating electrical measuring instruments and their accessories.
B.S 148: 1984(1992)	Specification for unused mineral Insulating oils for transformers and switchgear
B.S 5486	Low voltage switchgear and controlgear assemblies
B.S EN 60298: 1996	A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
B.S. 7354: 1990	Code of practice for design of high-voltage open-terminal stations
B.S 171	Power transformers
B.S 7263	Precast concrete flags, kerbs, channels, edgings and quadrants
B.S 410: 1986(1995)	Specification for test sieves
B.S 459	Specification for matchboarded wooden door leaves for external use
B.S 460	Specification for cast iron rainwater goods
B.S EN 512: 1995	Fibre-cement products, pressure pipes and joints (A.C)
B.S EN 124: 1994	Gully tops and manhole tops for vehicular and pedestrian areas. Design requirements, type testing, marking, quality control.
*B.S 534: 1990	Specification for steel pipes, joints and specials for water and sewage.
*B.S 5911	Precast concrete pipes, fittings and ancillary products.
B.S 569	Specification for asbestos-cement rainwater goods
B.S 5629	Insulating varnishes containing solvent.
B.S 729: 1971 (1994)	Specification for hot dip galvanised coatings on iron and steel articles
B.S 743: 1970	Specification for materials for damp-proof courses
B.S 747: 1994	Specification for roofing felts
*B.S 812	Testing aggregates
*B.S 882: 1992	Specification for aggregates from natural sources for concrete
B.S 952	Glass for glazing
B.S 6925: 1988	Specification for mastic asphalt for building and civil engineering (limestone aggregate)
B.S 6510: 1984	Specification for steel windows, sills, window boards and doors

REFERENCE	TITLE
B.S 1125: 1987	Specification for WC flushing cisterns (including dual flush cisterns and flush pipes)
B.S 1142: 1989	Specification for fibre building boards
B.S 1186	Timber for and workmanship in joinery
B.S 1196: 1989	Specification for clayware field drainpipes and junctions
B.S 1203: 1979 (1991)	Specification for synthetic resin adhesives (phenolic and aminoplastic) for plywood
B.S 1204: 1993	Specification for type MR phenolic and aminoplastic synthetic resin adhesives for wood
B.S EN 545: 1995	Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods.
B.S EN 598: 1995	Ductile iron pipes, fittings, accessories and their joints for sewage applications. Requirements and test methods.
B.S 5642	Sills and copings
B.S 1243: 1978	Specification for metal ties for cavity wall construction
B.S 1244	Metal sinks for domestic purposes
B.S 1247	Manhole steps
B.S 1254: 1981	Specification for WC seats(plastics)
*B.S1377	Methods of test for soils for civil engineering purposes
B.S 1414: 1975 (1991)	Specification for steel wedge gate valves (flanged and butt-welding ends) for the petroleum, petrochemical and allied industries.
B.S EN 612: 1996	Eaves gutters and rainwater down-pipes of metal sheet. Definitions, classifications and requirements.
B.S 6566	Plywood
B.S 1521: 1972 (1994)	Specification for waterproof building papers
B.S 1560	Circular flanges for pipes, valves and fittings (class designated)
B.S 4987	Coated macadam for roads and other paved areas.
B.S 1722	Fences
B.S 1868: 1975 (1991)	Specification for steel check valves (flanged and butt-welding ends) for the petroleum, petrochemical and allied industries.
*B.S 1881	Testing concrete
*B.S 6073	Precast concrete masonry units
B.S EN 971	Paints and varnishes. Terms and definitions for coating materials
B.S 7664: 1993	Specification for undercoat and finishing paints
B.S 10137	Plates and wide flats made on high yield strength structural steels in the quenched and tempered or precipitation hardened conditions
B.S. 7668: 1994	Specification for weldable structural steels. Hot finished structural hollow sections in weather resistant steels.
B.S EN 10029: 1991	Specification for tolerances and dimensions, shape and mass for hot rolled steel plates 3 mm thick or above
B.S. EN 10113: 1993	Hot rolled products in weldable fine grain structural steels
B.S. EN 10155: 1993	Structural steels with improved atmospheric corrosion resistance. Technical delivery conditions

REFERENCE	TITLE
B.S. EN 10210	Hot finished structural hollow sections of non-alloy and fine grain structural steels
*B.S 4449: 1988	Specification for carbon steel bars for the reinforcement of concrete
*B.S 4466: 1989	Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete
*B.S 4482: 1985	Specification for cold reduced steel wire for the reinforcement of concrete
*B.S 4483: 1985	Specification for steel fabric for the reinforcement of concrete
*B.S 4504	Circular flanges for pipes, valves and fittings (PN designated)
B.S 4576	Unplasticized polyvinyl chloride (PVC-U) rainwater goods and accessories
B.S 4592	Industrial type flooring, walkways and stair treads
B.S 4622: 1970 (1983)	Specification for grey iron pipes and fittings
*B.S EN 969: 1996	Specification for ductile iron pipes, fittings, accessories and their joints for gas pipelines. Requirements and test methods.
*B.S 5075	Concrete admixtures
*B.S 5150: 1990	Specification for cast iron gate valves
*B.S 5153: 1974 (1991)	Specification for cast iron check valves for general purposes
B.S 5155: 1984 (1991)	Specification for butterfly valves
*B.S 5163: 1986 (1991)	Specification for predominantly key-operated cast iron gate valves for waterworks purposes
*B.S 5328	Concrete
*B.S 5493: 1977	Code of practice for protective coating for iron and steel structures against corrosion
B.S 5492: 1990	Code of practice for internal plastering
B.S 6004: 1995	Specification for PVC-insulated cables (non-armoured) for electric power and lighting
*B.S 8007	Code of practice for design of concrete structures for retaining aqueous liquids
*B.S 8110	Structural use of concrete
B.S. 8206	Lighting for buildings
B.S. 5247: Part 14:1975	Corrugated asbestos-cement
B.S. 8204	Screeds, bases and in-situ floorings
(b) <u>British Standard Codes of Practice</u>	
C.P 143: Part 10: 1973	Galvanised corrugated steel: Metric units