NAKURU RURAL WATER AND SANITATION COMPANY LIMITED

NAIROBI - NAKURU – MAU SUMMIT PPP ROAD PROJECT

VOLUME IX: WORK'S SPECIFICATIONS

Project Name

RELOCATION OF WATER SUPPLY AND SEWERAGE INFRASTRUCTURE ALONG THE PROJECT ROAD

SECTION IV: GILGIL WEIGH BRIDGE TO BARNABAS AND NJORO TURN OFF TO TOTAL MAU SUMMIT.

Issued on: 10TH MARCH 2021

Contract No: NRW/10/2021-2022

Technical Specifications

Contents

Specifications Background

The specifications outlined hereunder have been adopted from the following BS, Standards, Codes of Practice and Design Manuals:

- Ministry of Water and Irrigation – Practice Manual for Water Supply services in Kenya, October 2006.
- Water Supply – AC Twort et al – 5th Edition
- Basic Water Treatment for application Worldwide – George Smethrust, 1979
- Water and Wastewater Engineering, Volume 1 & 2 – Gordon M. Fair; John C. Geyer; Daniel A. Okun
- Water and Wastewater Technology - Mark J. Hammer and Mark J. Hammer Jr. – 4th Edition
- BS 3505 – Specifications for uPVC pressure pipes for Cold Portable Water.
- BS 3601/AWWA 200 – Specification of Steel Pipes and tubes for Pressure purposes
- KS 06-149 Part 2 – Specification for uPVC Water Pressure Pipes
- WHO Report No. 4 – Selection and Design Criteria for Community Water Supply Projects
- BS 3601 – Specification for Steel Pipes and Tubes for Pressure purposes

The references are used in a complementary manner. Where requirements of two or more codes or standards are found to conflict, the more stringent of them is adopted for the purpose of this project.

As a result, the specifications have been developed, refined, revised, and compiled over the years by Howard Humphreys' Design teams. Focus has been on usage of this specifications in similar projects over the last 20 years which has resulted in sound projects that meet the unique requirements of various Clients. The design life of the various project has been exceeded. The methods have been application of the codes, feedback form results achieved and improvement.

The Engineer's experience is that strict adherence of the outlined specifications will result in better workmanship and sound implemented systems.

Whenever reference is made to "The Engineer" (or "The Resident Engineer") or "The Engineer's Representative" in the specifications, it shall be construed to mean "The Project Manager" or "The Project Manager's Representative" respectively.

Scope of Works

The Works in this Contract will be executed along the **Nairobi-Nakuru-Mau Summit road (A8).** The Scope of Works include:

- Laying of approximately 28 km of assorted HDPE diameter pipeline
- Interconnection of the existing pipeline to a newly laid pipeline
- Joining of the newly laid pipeline by butt fusion and electrofusion where necessary
- Directional micro tunnelling to pass various diameters pipeline
- Installation of various pipeline appurtenances like, water meters, sluice valves, gate valves, air valves etc as directed by the Engineer.
- Construction of valve and control chambers, thrust blocks, wash out chambers etc
- Installation of marker posts as directed by the Engineer
- Any other ancillary works as may be directed by the Engineer

The construction period is **3 Months**

Technical Specifications

List of Clauses

Section 1. General Requirements

101 Project Background

Nakuru rural water and sanitation company (NARUWASCO) was incorporated under the companies' act, cap 486 of the laws of Kenya (certificate of incorporation number C.128339 dated September 2006). The company was established to provide clean portable water and sanitation services within the prescribed area of jurisdiction. The memorandum and articles of association of the company is aligned to the constitution of Kenya, 2010, which provides water and sanitation as devolved function.
Accordingly, the company is fully owned by County Government of Nakuru serving the entire Nakuru county apart from former municipalities which include Naivasha and Nakuru.
The company comprises of nine board of directors who are competitively recruited. Out of the nine directors, six directors represent the stakeholders from sub-counties served by NARUWASCO while one represents professionals. These sub-counties include Bahati, Gilgil, Molo, Kuresoi, Njoro and Rongai.
On the normal day to days operation, the company is managed by a team of qualified staffs headed by the managing director. Due to the vast region covered, NARUWASCO is divided into five administrative regions that are run semi-autonomously by the area managers. These regions include Eastern, Western, Southern, Northern and Central.

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Specific mandates of NARUWASCO are derived from the objects in the Memorandum and articles of Association and section 78 and 83 of water act 2016 which states that a water service provider shall be responsible for;

- The provision of water services within the area specified in the license
- The development of county assets for water service provision
- To hold the county or national public water services assets on behalf of the public

102 Quality and Approvals

The materials and workmanship shall be the best of their respective kinds and to the approval of the Project Manager. The words "to the approval of the Project Manager" shall be deemed to be included in the description of all items relating to design, construction, installation and materials and workmanship for the due execution of the Works.

The Contractor shall submit all data, details and samples as necessary and as reasonably requested by the Project Manager of all materials that the Contractor proposes to use in the Works. Method statements which adequately demonstrate the Contractor's proposed method of working, methods of maintaining safety and compliance with the programme shall be submitted for the Project Manager's approval prior to the commencement of work on any area of the Site.

Where the Contractor is responsible for the preparation of Construction Documents to describe the permanent works such Construction Documents shall be approved prior to the procurement of any materials or commencement of any work to which the documents relate.
No materials, Plant or equipment shall be procured for the Contract and no work, permanent or temporary, shall commence without first obtaining the Project Manager's approval.
All materials, Plant and equipment supplied shall be designed for operation under the above-described conditions.

103 Construction Documents

Drawings and Documents which are to be submitted by the Contractor to describe the Permanent Works shall become Construction Documents upon their approval.

All drawings, technical specifications, bill of quantities, schedules, cost estimates; programme and other information to be submitted by the contractor shall be in English and shall be submitted for approval in triplicate. Following approval, the contractor shall supply a further five copies to the Project Manager. Construction Documents shall not be departed from without the approval of the Project Manager.

All drawings and documents submitted by the Contractor shall have been checked, signed and be ready for issue and shall bear:

- Title of the drawing or document;
- Scale;
- Date;
- Work item reference number complying with an approved numbering system;
- Name and references of the Contractor;
- Names of the employer and the Project Manager;
- Date of approval by the Contractor and the signature of the person responsible for approval.

Drawings and documents submitted for approval shall be delivered to the Project Manager's office as designated by the Project Manager.

Unless otherwise specified the Contractor shall allow a minimum of 21 days, after the date of receipt by the Project Manager for approval of drawings and documents by the Project Manager.

104 Operation and Maintenance Manuals

The Contractor shall submit to the Project Manager for approval six copies of the Operation and Maintenance (O&M) Manuals as described in Clause 58 of the Contract Data.

The Contractor shall supply the final version of the O&M Manuals prior to the issue of the Taking-Over Certificate for either the whole of the Works or the respective Section or part of the Works. Each set shall be bound together in a stout plastic or other approved cover.

O&M Manuals shall be supplied written in English language, all parts and equipment listings shall be in English.

105 Level Datum

Before the commencement of constructional work the Contractor shall establish, in a position to the approval of the Project Manager, steel datum pegs which shall be securely concreted in. The level of these pegs shall be established and agreed with the Project Manager and all levels used in the construction of the Works shall be referred to these established datum points. The correctness of this datum shall be checked at regular intervals during the construction period as agreed with the Project Manager.

Where possible construction drawings and all levels used for construction shall be referred to the

national height datum as defined by the Survey of Kenya. The Contractor shall be responsible for obtaining the location and values of the permanent benchmarks. In cases where such benchmarks do not exist, the site datum shall be agreed with the Project Manager.

106 Setting Out of the Works

The site layout drawings show indicative site layouts. Prior to commencing construction, the Project Manager will agree with the Contractor the basic information supplementary to that shown on the Drawings such as the position of manholes, chambers, centre-lines and base-lines sufficient for the Contractor to locate the Works.

The Contactor shall prepare detailed setting out drawings and data sheets as necessary and submit them to the Project Manager in triplicate for approval. Any modifications to the setting out drawings or data sheets required by the Project Manager shall be made by the Contractor and resubmitted for final approval. Should it be necessary during setting out or during construction for the approved setting out details to be amended, the Contractor shall amend the drawings or data sheets or make new ones for approval as required by the Project Manager.

For pipelines, the Contractor shall in the presence of the Project Manager set-out the pipeline alignments in accordance with the indicative alignments shown on the drawings taking into account physical features on the ground, any existing services, any requirements of relevant Authorities and any changes deemed necessary by the Project Manager, confirming the locations of all valves, air valves, washouts, hydrants and bends.

The Contractor shall prepare and submit to the Project Manager, at an approved scale, plans of the pipeline route and profiles of ground levels after any initial clearing of the wayleave or easement showing the proposed pipe invert levels and precise chainages for all valves and fittings for approval. Following approval the Contractor shall submit to the Project Manager two copies of the agreed alignment and profiles.

107 Boundaries of Works

The Employer shall provide the Site upon which the Permanent Works are to be constructed. Where a drain or pipeline is to be within an existing road or track reservation or is otherwise located in land designated Public Domain the Site width will be restricted to the limit of the public land. The existing boundary fences and walls shall not be disturbed without prior approval of the Project Manager and, unless road diversions and closure notices are approved and posted, carriageways shall be left available for the safe passage of traffic.

The Contractor shall not enter upon or occupy with men, tools, equipment or materials any land other than the site without the written consent of the owner of such land.
On occupation of the Site or other land the Contractor shall provide such fencing, as required.

108 Work through Private Land

In order that the necessary parts of the Site which are on private land may be obtained the Contractor shall supply the Project Manager with full information of his programme sufficiently in advance of the dates upon which the Contractor proposes to enter upon each areas of the Site. The Contractor shall where required, in consultation with the Project Manager, programme the Works to designate the areas of the Site to which the Contractor is to be given possession and the sequence of taking possession.

The Contractor shall obtain written approval before entering upon any private land or cutting through ditch, bank, hedge, wall, fence or any other form of boundary marking and he shall carry out all reasonable requirements as approved by the Project Manager in the matter of reinstatement.

109 Public Utility Mains and Services

Where the Contract indicates the positions of existing services or apparatus the positions shown are believed to be correct but no warranty is given as to the accuracy or completeness of the information.

It shall be the responsibility of the Contractor to obtain all information available from the Public Utility Authorities regarding the position of existing mains and services and he shall copy this information to the Project Manager as soon as he obtains it.

The Contractor shall carry out excavation works in a manner which safeguards any existing services, including hand excavation as necessary and shall be responsible for the cost of any repair work necessitated by damage caused by him to any main or service and for any costs arising from the disruption.

The Contractor shall obtain all information and assistance from the Public Utility Authorities for the locating of the mains and services and shall agree with the Project Manager any trial excavation which may be necessary to confirm or establish these locations.

The Contractor shall be responsible for locating all existing services, whether known to the Public Utility Authorities or not, and shall conduct his own survey as necessary to accurately locate all services. All efforts to identify these existing services shall be carried out in advance of conducting excavation for the permanent works.

Any temporary or permanent diversion of mains and services shall be agreed with the appropriate Authority.

110 Safeguards to Existing Pipes, Cables, Structures

It shall be the Contractor's responsibility to safeguard by means of temporary or permanent supports or otherwise all existing sewers, pipes, cables, structures, or other things which would be liable to suffer damage if such precautionary measures were not taken.
Safeguards shall be to the approval of the Project Manager and of the undertaker or owner concerned.

111 Record Drawings

At all sites and any locations where the Contractor executes work under the Contract, including locations where the Contractor undertakes repair or rehabilitation work, the Contractor shall record the location and nature of all water supply and wastewater works including their ancillaries and any associated services.

Where instructed by the Project Manager for the purpose of producing Record Drawings, the Contractor shall undertake such surveys and investigations to determine the location of existing services. Such surveys and investigations shall be additional to those surveys and investigations undertaken by the Contractor for the purpose of determining the location of services prior to excavation.

The Contractor shall where necessarily utilize appropriate equipment and where instructed by the Project Manager excavate trial pits to confirm the location and determine the size and nature of the

buried services.

For sites where the Contractor undertakes permanent works Record Drawings shall be submitted to the Project Manager, for approval, in the form of As Built Drawings. In the case of repairs and rehabilitation the Record Drawings shall be submitted for approval within a period of 21 days following execution of the work.

Record Drawings shall be prepared to an approved format, and scale in line with the construction drawing.

112 Connections to Existing Pipes, Cables and Equipment

The Contractor shall be responsible for joining up and making connections between pipes and cables laid by him and existing pipes and cables. The Contractor shall submit to the Project Manager a drawing showing the details of the connection, and shall state the date on which the particular connection is required, and the work shall not proceed until the Project Manager's approval has been given.

The Contractor shall be responsible for ensuring the compatibility of new pipes and cables with existing pipework, cables, tubing and equipment.

113 Lighting, Watching and Traffic Control

Where necessary for safety of the public or where required by the Project Manager, the Works shall be properly fenced and signed. In addition, the Works shall be lighted from half an hour before sunset until half-an-hour after sunrise and at other times when visibility is poor. The position and number of the lamps shall be such that the extent and position of the Works are clearly defined. Each Site shall be provided with watchmen as required.

114 Contractor's Offices

The Contractor shall provide and maintain offices for the use of his representative and staff to which written instructions by the Project Manager can be delivered. Any instructions delivered to such offices shall be deemed to have been delivered to the Contractor.

Offices shall be located to give convenient access to the Works and shall be subject to the approval of the Project Manager. The Contractor shall be responsible for obtaining the land on which to establish any temporary site offices.

116 Vehicles for the Project Manager

The Contractor shall maintain for the duration of the Contract vehicles for the use of the Project Manager.

117 Contractor's Yards, Stores and Accommodation for Workmen

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 Project Manager and shall be such as to avoid obstruction and nuisance to the public.

The Contractor shall construct 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 Project Manager 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. They shall be properly screened and maintained in a clean and sanitary state at all times. The Contractor shall be responsible for making all arrangements for the proper disposal of waste.

118 Water and Electricity Supplies

The Contractor shall make all arrangements for and provide adequate supply of potable water to each site as necessary for the execution and testing of the Works and for use by his workmen.

The Contractor shall make arrangements for and provide any electricity supply required for the execution of the Works, including the Tests on Completion.

119 Contractor's Staff and Workmen

The Contractor shall agree to employ Kenyan workers to the maximum extent possible. The Contractor shall provide a competent Site Agent to the approval of the Project Manager to be in charge of the work who shall not be changed except with the consent of the Project Manager.

The Contractor agrees that his workmen and employees shall be considered for all purposes in his direct pay and employ and under his supervision and control. He shall be directly and personally responsible for discharging all obligations, financial or other, which may be or becoming owing to any such workman or employee or to his successors, assignees or personal representatives. There shall be no contractual or legal relations of any kind whatsoever between the Employer and any such workman, employee or any person employed in the performance of the Contractor's obligations under this Contract.

The Project Manager may request and the Contractor agrees to accept the request for the immediate removal from the site of any employee or worker of the Contractor adjudged by the Project Manager to be incompetent, disorderly, and unreliable or of bad character. Such employee shall not again be employed on the Works.

120 Training of Employers Workmen

The Contractor shall make provision for the on-site training of up to 3 of the Employer's staff.

121 Project Management

121.1 Project Control

The Contractor shall provide within his site organization a project management capability to advise and be directly responsible to the Site Agent. (Contractor's chief site representative). The duties of the section shall include the following:

a) Planning and programme preparation particularly in relation to the requirements of the Employer and the public authorities, and the requirements to maintain water supply and wastewater disposal services where careful detailed arrangements have to be made and adhered to.

b) Planning the execution of the Works in a manner which minimizes disruption to the water

supply system and will permit the efficient and effective commissioning of the water supply system and their respective components.

c) Ensuring adequate potable water supplies and wastewater disposal services are maintained to all consumers.

d) Continuous surveillance of progress and anticipation of factors likely to affect the timely performance of the Contract.

e) Making proposal for modification to forward planning and to the programme at an early stage in the light of factors resulting from (d) above.

f) Continuous appraisal of the Contractor's methods and routines particularly as to their effect on the community and property.

g) Forward planning for resource requirements taking due account of possible shortages and delays in the arrival on site of materials, equipment, plant and personnel and their mobilization for effective usage.

h) Acquisition and process of up-to-date information for progress meetings with the Project Manager. The preparation of monthly progress reports including an update of the detailed programme and cash flow forecast which shall include progress photographs as directed by the Project Manager.

The Contractor's project management staff shall be of adequate ability and experience. Programmes shall be based upon Critical Path Management (CPM) networks in precedence format and shall be prepared using a suitable PC-based project management software package approved by the Project Manager.

Reporting shall be in a manner compatible with the Employers project management procedures and shall use the Earned Value (EV) Technique and shall monitor the actual gross value of work completed against the predicted value.

121.2 Monthly Statements and Certificates

Monthly statements and certificates shall be submitted in an approved manner and format. In addition to the statements submitted in hard copy the Contractor shall submit a computer copy using data base software as prescribed by the Project Manager. The statements and certificates shall detail the measured value of the work completed on each item of the Works in such detail that the Project Manager can identify location and measurement of each item. A location shall constitute a single structure such as a reservoir, pump station or section of a pipeline or a component of a system such as a pipeline valve complex.

Each item shall be uniquely identified in accordance with the numbering system as instructed by the Project Manager.

121.3 Progress Meetings

The Contractor shall provide a suitable venue, near the vicinity of the Site, and arrange progress review meetings to be chaired by the Project Manager at monthly intervals to coincide with submission of

monthly progress submissions. The Contractor shall allow for attendance by the Project Manager and up to 4 representatives of the Project Manager's or Employer. The meetings shall be attended by the Contractor's senior representatives, Site Agent and other members of his senior staff as may be deemed necessary.

122 Equipment for the Employer

The Contractor shall hand over to the Employer on completion of the Works a complete set of tools and equipment together with spare parts and fittings to facilitate the maintenance and operation of the installed works.

123 Facilities for Survey and Inspection by the Project Manager

The Contractor shall make available technicians and such labour, materials and safety equipment as the Project Manager may require for inspections and survey work in connection with the Works. The Contractor shall provide all necessary tackle, test equipment, access, labour, staff and any other thing the Project Manager may reasonably require in order that he may safely, conveniently and quickly carry out such inspections as he deems necessary at any time during the execution of the Works and during the Defects Liability Period. The Project Manager, his representative and assistants, shall not inspect any area of the Works where they deem the safety provision to be inadequate and the Contractor shall undertake any work required by the Project Manager in order to make it safe.

124 Inspections by the Project Manager during Defects Liability Period

The Project Manager will give the Contractor due notice of his intention to carry out any inspections during the Defects Liability Period and the Contractor shall thereupon arrange for a responsible representative to be present at the times and dates named by the Project Manager. This representative shall render all necessary assistance and shall record all matters and things to which his attention is directed by the Project Manager.

125 Protective Clothing and Safety Equipment

The Contractor shall provide for the Project Manager, his Representative and assistants any additional protective clothing and safety equipment necessary for the proper discharge of their duties on the Site.

The Contractor shall provide any necessary protective clothing and safety equipment for the use of authorized visitors to the site including the Employer and his staff and representatives and those of any relevant authority who have reason to visit the Site.

126 Notice Boards

The Contractor shall provide and erect sign boards at the Sites where works are being executed, giving information to the public on the Project and the Employer and further details as will be prescribed by the Employer. The location of the sign boards at the sites will be indicated by the Project Manager. The Contractor shall maintain, alter, move or adapt the sign boards from time to time as may be instructed by the Project Manager. The display of any named Sub-contractors or any other information associated with the Works shall be to the approval of the Project Manager.

127 Language of Correspondence and Records

All communications from the Contractor to the Project Manager shall be in the English language. All books, timesheets, records, notes, drawings, documents, specifications and manufacturers' literature shall be in the English language. If any of the aforementioned is in another language a certified

translation in English shall be submitted to the Project Manager.

128 Standards and Regulations

Each and every part of the Works shall be designed, constructed, manufactured, tested and installed in accordance with an internationally recognized standard, Code of Practice, or Regulation applicable to that part of the Works.

Such standards and codes shall include:

a) British Standard Specification last published.

b) International Electromechanical Commission, where available (IEC).

c) International Organization for Standardization (ISO).

The Contractor shall provide and keep permanently on site copies of such standards as may be directed by the Project Manager and shall make them available to the Project Manager as required.

129 Equivalency of Standards and Codes

Wherever reference is made in the Contract, including Specifications, Drawings and Bill of Quantities, to specific standards and codes to be met by the goods and materials to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise stated in the Contract. Where such standards and codes are national, or relate to a particular country or region, other authoritative standards that ensure a substantially equal or higher quality than the standards and codes specified will be accepted subject to the Project Manager's prior review and written consent. In the event the Project Manager determines that such proposed deviations do not ensure substantially equal or higher quality, the Contractor shall comply with the standards specified in the Contract.

130 Quality Control

The Contractor shall be responsible for his own quality control and shall provide sufficient competent personnel for supervising the Works, taking and preparing samples and for carrying out all necessary tests.

131 Units

The International System of (metric) Units as set out in ASTM E380 shall be used throughout the Contract except where otherwise provided.

132 Inspection and Testing during Manufacture

The performance of each item of Plant or Pipe shall be tested in accordance with the Specification to the requirements of the Project Manager.

Test certificates in triplicate shall be submitted by the Contractor to the Project Manager within 2 weeks of the date of the tests. Type tests are not acceptable. Test certificates shall be supplied for tests carried out on the actual Plant being supplied.

Plant shall not be dispatched from the manufacturer's works until it has passed the specified tests and approval been given by the Project Manager.

The Project Manager shall at his discretion witness tests of individual items of Plant at the manufacturer's works. The Project Manager shall be given three weeks' notice in writing before such tests are to take place.

The acceptance by the Project Manager of any item of Plant or equipment after testing at the manufacturer's works shall in no way relieve the Contractor of his responsibility for the correct performance.

Section 2 Earthworks, Backfilling and Restoration

201 Conditions of Site

Before carrying out work on any Site, the Site shall be inspected by the Contractor in conjunction with the Project Manager to establish its general condition which shall be agreed and recorded in writing and by means of digital photography.

Details recorded shall include the location of all boundary and survey beacons, the condition of buildings, surface, terracing (if any), ditches, watercourses, roads, tracks, fences and other information relating to the Site and elsewhere which may be affected by the works.

In the case of way leaves for pipelines the boundaries of the way leave will be defined by the Employer and the contractor shall where directed provide erect and maintain in position, from commencement to the final completion of the Works, in every section substantial timber stakes or similar approved markers not less than 1.5 m high indicating the position of the boundary at 100m or other such intervals as the Project Manager may direct. In the event of any boundary or survey mark established for the purpose of land title being disturbed or displaced the Contractor shall forthwith replace the beacon. Where necessary the Contactor shall employ the services of an approved licensed surveyor for the purpose of setting out boundaries.

202 Site Clearance and Topsoil Removal

Site clearance shall be carried out over the areas to be occupied by the Permanent Works before beginning excavation or filling or other work, and shall include the clearance of all trees, stumps, bushes and other vegetation and the removal of all boulders between 0.01 and 0.2m3 volumes. Boulders located within 1m of any pipe centreline shall be removed where directed by the Project Manager.

Before beginning clearance in any area the Contractor shall give seven days written notice of his intention to the Project Manager who will determine the extent and limits of such clearance.

Topsoil shall mean the surface layer of soil which by its humus content supports vegetation and is unsuitable, as a formation to roads and concrete structures or as a backfill or bedding material. The extent and depth of topsoil that needs removal shall be agreed with the Project Manager. Topsoil shall be set aside for re-use or disposal as directed by the Project Manager.

Trees to be removed shall be uprooted or cut down as near to the ground level as possible. Bushes, undergrowth, small trees stumps and tree roots shall, where directed by the Project Manager, be grubbed out. All holes left by the stumps or roots shall be backfilled with suitable material in a manner approved by the Project Manager.

The Project Manager may require that individual trees, shrubs and hedges are preserved; the Contractor shall take all necessary precautions to prevent their damage.

In the case of wayleaves for pipelines and the like, the Contractor shall preserve as far as practicable all grass and other vegetation outside the limits of trenches and permanent works and shall not necessarily destroy crops or any vegetation whose removal would not be essential to his operations.

203 Erosion

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

204 Ground Levels

Before commencement of any earthworks or demolition the sites shall be surveyed, as necessary, in conjunction with the Project Manager to establish existing ground levels. These agreed ground levels shall form the basis for the calculation of any subsequent excavation and filling.

205 Trial Holes

The Contractor shall excavate refill and restore in advance of his programme such trial holes as he may require for determining the nature of the subsoil and the location of existing underground services and obstructions.

206 Excavation Generally

Excavations shall be made in open cutting unless tunnelling or heading is specified or approved by the Project Manager and shall be taken out as nearly as possible to exact dimensions and levels so that minimum of infilling will afterwards be necessary. The Contractor shall ensure the stability and safety of excavations and shall take all measures necessary to ensure that no collapse or subsidence occurs.

Except where described in the Contract or permitted under the Contract excavation shall not be battered. The sides of all excavations shall be kept true and shall where necessary be adequately supported by means of timber, steel or other type struts, walling, poling boards, sheeting, bracing and the like.

Excavations shall be kept free from water and it shall be the Contractor's responsibility to construct and maintain temporary diversion and drainage works and to carry out pumping and to take all measures necessary to comply with this requirement.

In the event of soft or otherwise unsuitable ground being encountered at formation level or if the formation is damaged or allowed to deteriorate the Contractor shall forthwith inform the Project Manager, shall excavate to such extra depth and refill with compacted granular or other approved fill or C15 concrete (minimum compressor strength 15N/mm2) as the Project Manager may require. With respect to the side face of any excavation against which concrete or other work will be in contact the Project Manager may require that the net dimensions of the work be increased.
The Contractor shall be responsible for the disposal of Surplus excavated material off site, which shall be to a location approved by the Project Manager. No excavated material suitable for re-use shall be removed without the approval of the Project Manager.
The Contractor shall not deposit excavated materials on public or private land except where directed by the Project Manager or with the consent in writing of the relevant authority or of the owner or responsible representative of the owner of such land and only then in those places and under such conditions as the relevant authority, owner or responsible representative may prescribe.

207 Excavation in Excess

If any part of any excavation is in error excavated deeper and/or wider than is required the extra

depth and/or width shall be filled with Grade C15P concrete or compacted granular or other approved fill to the original formation level and/or dimensions as the Project Manager directs.
In pipe trenches where the pipe is not bedded on or surrounded with concrete, excess excavation shall be filled with compacted granular material. Excess excavation in rock trenches shall be filled with concrete (15N/mm2 compressive strength) up to 150mm below the pipe invert.

208 Mechanical Excavation

Mechanical excavation shall be employed only if the subsoil is suitable and only in such manner which will allow adequate support of the excavations. The Contractor shall ensure that there are no pipes, cables, mains or other services or property which may be disturbed or damaged by its use.

209 Excavation for Pipelaying

The width of trench excavation shall be the minimum required for efficient working after allowance has been made for any timbering and strutting and shall not exceed the widths described in the Contract. At anyone spread the maximum length of open trench shall not, without the prior approval of the Project Manager, exceed 100 metres.

Trenches in rock for pipes up to 100mm bore shall be excavated to provide a minimum clearance of 100 mm around the outside of the pipe and joints. For pipes exceeding 100mm bore the minimum clearance shall be increased to 150mm.

Where the trench is in rock or rocky ground the Contractor shall excavate the pipe trench to a depth of 150mm below the invert of the pipe and refill with compacted granular fill.

The materials for re-use excavated from trenches shall be stockpiled at the sides of the trench except where this would obstruct any road or footpath and prevent the passage of traffic or pedestrians. In such cases the Contractor shall excavate the trench in such lengths and stockpile the excavated materials at such places as the Project Manager may require.

Where excavation for pipe laying is carried out behind thrust blocks on existing pipelines the Contractor shall provide adequate support arrangements to transfer thrusts to the surrounding ground.

210 Headings

Excavation for pipes in heading shall be carried out to the approval of the Project Manager and to dimensions which will permit a proper inspection to be made. The heading shall be properly and securely timbered. The pipe shall be laid on a minimum thickness of 150mm of concrete. After the pipe has been laid, jointed and tested the heading shall be filled in short lengths not exceeding 1 metre with Grade C15P concrete or as directed. The heading shall be completely filled with concrete and hard filling shall then be rammed into the concrete at the crown of the heading.

Special precautions shall be taken to prevent a slump in the concrete and to ensure that no slips or falls of the heading or in the ground above or in the shafts can take place.

211 Excavation for Foundations of Structures

The Contractor shall give sufficient notice to the Project Manager to enable him to inspect and approve foundations in advance of placement of the permanent works. The Project Manager may

withdraw his approval if work is not commenced within 48 hours or the formation is subsequently allowed to deteriorate.

If the Project Manager directs a bottom layer of excavation of not less than 75mm thickness shall be left undisturbed and subsequently taken out by hand immediately before concrete or other work is placed.

Formations which are to receive concrete blinding or a drainage layer shall be covered with such blinding or layer immediately the excavation has been completed, inspected and approved by the Project Manager.

Surfaces against which permanent works are to be placed shall be kept free of oil, water, mud or any material.

No concrete or other materials shall be placed until formations have been approved. Adequate notice shall be given to the Project Manager to enable him to examine the formation.

212 Rock Surfaces under Concrete Structures

212.1 Concrete Placed Directly on Rock

Rock under concrete structures shall be prepared by picking, barring and wedging or other methods which will leave the rock in as sound a condition as may reasonably be expected according to the rock quality.

Rock surfaces shall be thoroughly cleaned by compressed air and water jet or such means as the Project Manager my direct before concrete is placed.

212.2 Concrete Placed on Capping Layer

Where instructed the rock excavation shall be taken down to a depth of 1.0m below the underside of the structure and the excavation backfilled with capping materials to the required formation level. Capping material shall be granular material. The material shall be compacted in 150mm layers to achieve a density of not less than 95% maximum dry density at optimum moisture content + 5% to 2% as determined by the BS heavy compaction tests to BS 1377.

213 Explosives

The Contractor shall at all times take every possible precaution and comply with the Explosives Laws of Kenya and regulations relating to the handling, transportation, storage and use of explosives and shall at all times when engaged in blasting operations post sufficient warning flagmen to the full satisfaction of the Project Manager's Representative.

The Contractor shall also provide a special proper store for explosives in accordance with local regulations and shall provide experienced men with valid blasting licences, for handling explosives to the satisfaction of the Project Manager and the authorities concerned.

The Contractor shall at all times make full liaison with and inform well in advance and obtain such supervision and permission as is required from the Police and all Government Authorities, public bodies and private parties whosoever concerned or affected by blasting operations.

Blasting shall only be carried out on those sections of the Works for which permission in writing shall have been given by the Project Manager and the relevant authorities and shall be restricted to such hours and conditions as may be prescribed. Blasting within 10 metres of existing water mains will not be permitted.

Blasting shall be carried out so as not to weaken existing structures or the foundations or ground adjacent to the existing and proposed works. The Contractor shall take all necessary precautions to prevent loss, injury or accident to persons or property and shall be entirely liable for any accident or damage that may result from the use of explosives.

The Contractor shall submit to the Project Manager for his approval a method statement including details of the intended drilling patterns, depths of holes, the amounts of explosives at each location and the method or sequence of setting off that he proposes to use.

214 Excavated Materials Suitable for Re-use

In so far as they are suitable and comply with the Specification, materials arising from excavations shall be re-used in the Works.

During excavation, the Contractor shall ensure that all material suitable for re-use are kept separate and set aside and protected as necessary to prevent loss or deterioration.

The materials forming the surface and foundations of roads, road verges, tracks and footways shall when excavated, and if required for further use, be carefully separated. All hard materials shall be kept free from soil or other excavated materials.
During excavation of pipe trenches the Contractor shall ensure that all granular or other approved material suitable for filling around and over pipes shall be kept separate and re-used for this purpose.

Paving slabs, bricks and similar surfaces shall be carefully removed and stacked. Prior to the commencement of excavation the number of badly broken and unsuitable paving slabs, bricks etc. on the line of the excavations shall be agreed with the Project Manager.

In verges and other grass surfaces the grass and top soil shall be stripped and separately stacked.

215 Backfilling of Excavations

Backfilling shall be thoroughly compacted in layers not exceeding 150mm compacted thickness and by means which will not damage the Works.
Backfilling of reinforced concrete structures shall be with suitable material approved by the Project Manager.

“Granular material” as backfill is defined as unconsolidated quarry dust, gravel, sand or similar in which the clay or silt content is not predominant. The use of angular crushed stone shall not be permitted.

216 Pipe Beddings

Unless otherwise specified granular material for beddings shall consist of aggregate to BS EN 12620 and shall conform to the following grading.

Pipe Nominal Diameter (mm)	Max Size (mm)	Grading (mm)
<50	sand	N/A
50	10	10 single-size
80	10	10 single-size
100	10	10 single-size
150	15	10 or 14 single-size or 14 to 5 graded
200 to500	20	10, 14 or 20 single-sized or 14 to 5 graded or 20 to 5 graded
>500	40	10,14 20 or single-size crushed rock or 14 to 5 graded or 20 to 5 graded or 40 to 5 graded

Granular bedding material where specified shall have a Compaction Fraction not greater than 0.3 as ascertained by the test method described below.

Aggregates for flexible pipes shall consist of sub-rounded or rounded material which will not cause damage to or penetrate the pipe material.

Sand bedding material shall consist of approved local sand which material shall have a Compaction Fraction ascertained by the test method described below of not greater than 0.3.
Class A bedding shall consist of Grade C15P concrete bed and surround.

Class A1 bedding shall comprise a 120 degrees cradle of Grade C15P insitu un-reinforced concrete under the pipe with selected backfill material to a depth of 300mm above the crown of the pipe.

Class B bedding shall comprise a 180 degrees bed of single-size granular material in accordance with the above table, with selected backfill material to a depth of 300mm above the crown of the pipe.

Class S bedding shall comprise a complete surround of granular material in accordance with the above table to a depth of 150mm above the crown of the pipe.

Class D bedding shall comprise a hand-trimmed natural bottom to the trench with selected backfill

material placed around and over the pipe to a depth of 300mm above the crown of the pipe.

Granular bedding and selected backfill material, placed around and to a thickness of 300mm above the crown of the pipes shall be placed simultaneously on both sides of the pipe in layers not exceeding 150mm thickness and compacted by the use of hand rammers taking particular care to compact the material under barrel of the pipe and around joints.

In trenches where there is a continuous accumulation of groundwater, the trench shall after obtaining the approval of the Project Manager, be over-excavated by 150mm and shall be backfilled using compacted granular material in accordance with the above table.

If the quantity of suitable material which can be obtained from the excavations is insufficient, the Contractor shall either screen the excavated material or transport suitable material from other excavated or borrow pits on the Site. In cases where insufficient material exists on the Site, the Contractor shall import suitable material after obtaining the written approval of the Project Manager.

217 Compaction Fraction Test

217.1 Apparatus required:

1) Open-ended cylinder 250 mm long and 150mm ± 5mm internal diameter (150mm diameter pipe is suitable);
2) Metal hammer with striking face 38 mm diameter and weighing 1 kg.
3) Rule.

217.2 Method

Obtain a representative sample, more than sufficient to fill the cylinder (viz. about 10kg). It is important that the moisture content of the sample should not differ from that of the main body of material at the time of its use in the trench.

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

Measure down from the top of the cylinder to the surface of the compacted material. This distance in millimetres divided by the height of the cylinder (250mm) is the Compaction Fraction of the material under test.

To obtain a representative sample about 50kg of the proposed material should be heaped on a clear surface and divided with the spade down the middle into two halves. One of these should then be similarly divided, and so on until the required weight sample is left.

218 Selected Backfill Material

Backfill in contact with the pipes shall be selected material and shall not contain larges stones, rocks, tree roots or similar objects which through impact or by concentrating imposed loads might

damage the pipes. The material shall be capable of being compacted without the use of heavy rammers and should be free of clay lumps or other material larger than 745mm or stones larger than the maximum particle size specified for pipe bedding.

219 Backfilling of Pipe Trenches

The trench above pipe bedding level (300mm above the crown of the pipe) shall be filled with the approved back fill material obtained from the trench excavations, free from clay limps, boulders and rock fragments larger than 150mm.

If the quantity of material which can be obtained from the pipe trench excavation is insufficient, the Contractor shall either screen the excavated material or transport suitable material from other excavations or borrow pits on the Site. In cases where insufficient material exists on the Site, the Contractor shall import suitable material after obtaining the written approval of the Project Manager.

The material shall be placed in layers not exceeding 150mm thickness and compacted by the use of rammers to achieve a density of not less than 95% maximum density at optimum moisture content +5% to -2% as determined by the BS Heavy Compaction Test to BS 1377.
For trenches in fields and open areas where agreed by the Project Manager the trench backfill shall be compacted to obtain a density of not less than 85% maximum dry density at optimum moisture content +5% to -2% as determined by the BS Heavy Compaction Test to BS 1377.
The density of the compacted fill shall be determined by the Contractor using the "sand replacement" method as directed by the Project Manager.

Before backfilling trenches the Contractor shall obtain approval from the Project Manager of the methods he proposes to use and shall demonstrate by means of tests that the specified compaction can be achieved. The method of compaction shall at all times be to the approval of the Project Manager.
Where ground water conditions are such that the bedding material would be likely to act as a carrier for ground water from higher of lower ground, the Project Manager may instruct flow barriers of suitable selected earth or concrete to be inserted in lieu of bedding material. Such barriers to be erected at reasonable intervals close to flexible joints in the pipe.

220 Making Good Subsidence after Backfilling

Backfilling, whether in foundations or in pipe trenches, shall be thoroughly compacted by ramming and any subsidence due to consolidation shall be made up with extra compacted material.

Should subsidence occur after any surface reinstatement has been completed the surface reinstatement shall first be removed, the hollows made up, and then the surface reinstatement re-laid.

Any subsidence that occurs adjacent to the Site of the Works which is attributable to the Contractor's activities shall be reinstated to the full satisfaction of the Project Manager.

221 Removal of Timbering from Excavations

Timbering shall be removed from the excavations before or during the process of backfilling except in so far as this removal of timber would be likely to cause damage to adjacent property,

structures or structure foundations in which event the Contractor shall leave in the excavation such timbering as he considers necessary or as may be ordered by the Project Manager.

222 Reinstatement of Surfaces

All surfaces whether public or private that are affected by the Works shall be reinstated temporarily in the first instance and when the ground has consolidated fully the Contractor shall reinstate the surfaces permanently.

Temporary reinstatement and permanent reinstatement of all surfaces affected by the operations of the Contractor shall be carried out and maintained to the satisfaction of the Project Manager and the responsible authority or owner.

Temporary reinstatement shall be carried out immediately the trenches are backfilled. Permanent reinstatement shall not be carried out until the ground has consolidated completely. The Contractor shall inform the Project Manager before carrying out this work. In the event of further settlement occurring after completion of the permanent reinstatement the Contractor shall forthwith make good the reinstatement to the approval of the Project Manager or responsible authority.

For the purpose of temporary and permanent reinstatement in bitumen and surfaced roads the surface width of trenches shall be increased by 150mm on each side of the trench for a depth of 75mm to provide a solid abutment for the surfacing material.

Reinstatement of surfaced roads shall be carried out to the approval of the relevant authority.
The responsible authority shall have the right to carry out permanent reinstatement at the Contractor's expense.
Trenches in open ground shall be reinstated to the condition in which the ground was before excavation was commenced. The final surface of the trench shall be flush with the surrounding ground.

In verges and other grass surfaces and after the backfilling had been thoroughly consolidated the topsoil shall be re-laid rolled and planted with grass or other vegetation as directed by the Project Manager as may be necessary and watered until the grass has become well established. Should the planting fail it shall be replanted as required until satisfactory growth is obtained. If at any time any reinstatement deteriorates the Contractor shall restore it to a proper condition immediately.

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

All trees, shrubs and plants shall be carefully transplanted and shall be returned to their original location after the refilling of the excavations. Return of old or mature trees may be waived in cases where the age of the tree makes return impracticable, and approved tree seedlings shall be planted in their place. Topsoil shall be carefully set aside and replaced at the surface of the backfilling.

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

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

In the case of footpaths the trench shall be refilled and rammed as specified to within 125mm of the surface. A foundation layer of 100mm compacted thickness of approved crushed limestone shall then be laid and compacted. The surface shall be cleaned and primed and the footpath surfacing shall be temporarily reinstated with 25mm compacted thickness of 14 mm nominal size dense wearing course macadam laid and compacted so as to achieve a dense, smooth and even course surface using a roller of 750 to 3000kg mass. Any kerbs shall be reinstated to their original condition.

The trench surface shall be thus maintained until the end of the Period of Maintenance or permanent reinstatement is ordered by the Project Manager. Where permanent reinstatement is ordered by the Project Manager the temporary surface and part of the foundation shall be removed to 50mm depth to permit the construction of a tiled or paved surface to match the original surface. An approved tiled or paved surface shall then be laid and bedded on sand or mortar to an even finish.

223 Safety of Excavations in Roads

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

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

224 Temporary Reinstatement of Asphalted Roads

In all asphalted or bitumen sprayed roads the trenches shall be refilled and compacted to the underside of the original road surface. A sub-base layer shall then be laid consisting of approved free drainage granular material conforming to the following grading limits:

100% by weight passing 50mm sieve
75-95 by weight passing 25.4mm sieve
40-75 by weight passing 9.51mm sieve
30-60 by weight passing 4.75mm sieve
20-45 by weight passing 2.0mm sieve
15-30 by weight passing 425mm sieve
5-15 by weight passing 72mm sieve.

A base layer shall then be laid consisting of approved crushed limestone material conforming to the following grading limits.

100%	by weight	passing 50mm sieve

60% - 80%	by weight	passing 20mm sieve
25% - 40%	by weight	passing 5mm sieve

The materials shall have a plasticity index of not exceeding 6%. The materials forming the sub-base and foundation shall be laid in layers, brought to optimum moisture content and compacted to 95% of the maximum dry density as determined by Part 4 Clauses 3.3/3.4 BS 1377:1990.

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

The road surfacing shall be temporarily reinstated with 25mm finished thickness of asphaltic concrete. The asphaltic concrete shall be laid and compacted so as to achieve a dense smooth and even surface using a roller of not less than 12 tonne mass.

The surface shall be maintained until the end of the period of Maintenance or until instructions are given for the permanent reinstatement to be carried out. The surface shall not be topped up above the original surface level to allow for settlement.

225 Temporary Reinstatement of Unmade Roads

In all unmade roads the trenches shall be refilled and compacted as specified in the Contract to within 150mm of the surface.
The trench shall be surfaced with 150mm compacted thickness of base layer material as specified above.

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

226 Permanent Reinstatement of Asphaltic Roads

Where instructions are given that permanent reinstatement is to be carried out then the temporary asphaltic concrete surface and part of the foundation layer shall be removed to a minimum depth of 200mm and the surface of the foundation shall be rolled, all dust and debris removed, joints cut straight and vertical.

The permanent reinstatement shall comprise crushed limestone material to a total compacted thickness of 150mm and the wearing course 50mm compacted thickness of 14 mm nominal size dense wearing course asphaltic concrete. The laying and finishing of the coated macadam shall be carried out so as to achieve a dense, smooth and even surface using a roller of not less than 12 tonnes mass.

227 Forming Banks and Filled Areas

The filling to be used in the embankments and filled areas shall be material selected from that arising from surplus excavation (unless otherwise defined in the Particular Specification), the material being placed according to its nature as shall be directed by the Project Manager. The fill shall be placed in layers not exceeding 150mm thick, each layer being thoroughly compacted by

an approved roller to the satisfaction of the Project Manager.

228 Restoration of Borrow Areas, Spoil Tips and Quarries

Any spoil tips, quarries or other borrow area developed by the Contractor for the purpose of the Works shall be finished to safe and fair slopes to the approval of the Project Manager.

229 Top soiling and Grassing

Where required surfaces shall be soiled with fine sifted soil or silt not less than 100 mm compacted thickness which shall be raked and brought to a fine tilth.

Surfaces required to be grassed shall be planted with approved local grass at a spacing of 200mm x 200mm. The grassed area shall be replanted if the first or subsequent operation is unfruitful or if for any reason the grass is destroyed. Grassed areas shall be watered and attended until the grass has become well established.

The soiling and planting of the grass in slopes shall be carried out immediately the slope is formed and the grass shall be kept weeded and cut until the work is accepted at the time of the Certificate of Completion.

The Contractor shall supply attendance during the Defects Liability Period to ensure that all planted grass is kept weeded and cut, and if necessary watered.

230 Free Draining Fill

Free draining fill for use as backing to wall shall consist of sound hard stone or broken rock or concrete derived from demolition of structures. The particles shall be roughly cubiform and shall be between 75mm and 25mm in size. All smaller particles, Dust, rubbish and organic matter shall be excluded.

231 Hardcore

Hardcore shall consist of sound hard stone or broken rock or concrete derived from excavations or demolition of structures and shall be graded from 150mm to 50mm in size, except that sufficient but not excessive blinding materials of smaller sizes may be permitted at the discretion of the Project Manager.

Section 3. Concrete Works – General

301. Scope

The standard of materials and of workmanship shall not be inferior to the recommendations of the current:

(a)	British Standard Code of Practice BS 8110 The Structural Use of Concrete	
	Or	Whichever is applicable to the structures
(b)	British Standard Code of Practice BS 8007 Design of concrete structures for Retaining Aqueous Liquids	
(c)	Appropriate British Standards	
(d)	Approved Kenyan Standards	
	Or	
(e)	Other equivalent and approved international standards	

The requirements outlined in the above documents must be read with those of this Section of the Specification and where any conflict exists between the recommendations of the above and of this Specification, the requirements of the Specification shall prevail. As and when required by the Project Manager the Contractor shall prepare and submit, before commencing the work, a time chart (additional to the general programme) detailing the various operations for concrete work.

No material shall be used in the Works until prior approval for its use has been given by the Project Manager; neither shall any change in the nature, quality, kind, type, source of supply or manufacture be made without the Project Manager's permission.

Names of manufacturers and test certificates for materials not supplied by the Employer shall be supplied as soon as possible to the Project Manager.

The cost of providing samples and the cost of carrying out tests required by Clause 306 (except as otherwise provided in the Conditions of Contract) together with the cost of supplying equipment for sampling and site testing indicated in columns 3 and 4 of Table 3.8 of this Section of the Specification shall be borne by the Contractor.

During the progress of the Works, consignment notes for materials not supplied by the Employer shall be supplied to the Project Manager giving details of each consignment.

The Contractor shall provide all samples required by the Project Manager as soon as possible after contract award. No deliveries in bulk shall be made until the samples are approved by the Project Manager. All condemned material shall be removed from the site within 24 hours.

A competent person approved by the Project Manager shall be employed by the Contractor whose duty will be to supervise all stages in the preparation and placing of the concrete. All

cubes shall be made and site tests carried out under his direct supervision, in consultation with the Project Manager.

All materials which have been damaged, contaminated or have deteriorated or do not comply in any way with the requirements of these Preambles shall be rejected and shall be removed immediately from the site at the Contractor's expense. No materials shall be stored or stacked on suspended floors without the Project Manager's prior approval.

The use of the word "approved" in this Specification refers to the approval of the Project Manager or his delegates.

Cross-references between certain clauses of this Specification have been shown in brackets following the particular item.

302 Concrete

302.1 Requirements

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

The minimum cement contents and maximum water/cement ratios of designed mixes shall be as given in Table 3.1.

The maximum cement content in any mix shall not exceed 425 kg/m3 for normal structures and 500 kg/m3 for liquid retaining structures.

In all cases of mix proportioning, the added water shall be included with due allowance for the moisture contained in the aggregates and shall be the minimum consistent with the workability requirements.

Table 3.1 Minimum Cement Contents

Normal Conditions

Type of Structural Element	Exposure Conditions (BS 8110)	Minimum Cement Content (kg/m3) Maximum Aggregate Size			Maximum Water/Cement Ratio
		40 mm	20 mm	10 mm	
Liquid Retaining Structures, Shafts and Tunnel Linings	Severe	295	325	356	0.55
All Foundations and Buried Structures	Moderate	270	300	340	0.60
Building Super-structure	Moderate	270	300	340	0.60

Additional Requirements when Exposed to Sulphate Conditions (All Structural Concrete)

Concentration of Sulphates (expressed as SO3)		Minimum Cement Content (kg/m3) Maximum Aggregate Size				Maximum Water/ Cement Ratio
In soil (Total SO3)	In ground water Parts per 100,000	Type of Cement	40 mm	20 mm	10 mm	
≤ 0.2	≤ 30	No Special Precautions				-
0.2 - 0.5	30 - 120	OPC or CEM1,II or IV per KS1725	300	330	370	0.50
		SRPC	250	280	320	0.55
0.5 - 1.0	120 - 250	OPC or CEMI, II or IV per KS1725	Not permitted			-
		SRPC	300	330	370	0.50
1.0 - 2.0	250 - 500	OPC or CEMI, II or IV per KS1725	Not permitted			-
		SRPC	340	370	410	0.45
≥ 2.0	≥ 500	SRPC	Ditto but with protective coating			0.45

OPC - Ordinary Portland Cement
SRPC - Sulphate Resisting Portland Cement

302.2 Strength

The characteristic strength of concrete means that value of the 28-day cube strength below which 5% of all possible test results would be expected to fall.

The relationship between grade of the concrete and its characteristic strength shall be as given in BS 5328. The grade of concrete to be used in particular locations shall be as given in Table 3.2 unless noted otherwise on the drawings.

Table 3.2 Concrete Strength Requirements

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

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

302.3 Mixes

(a) Designed Mixes

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

Building Research Establishment and Bookshop
Garston
Watford
WD2 7JR
ENGLAND

Tel: +44 1923 894040
Fax: +44 1923 664010

Or other approved methods, for the requirements set out in this Specification.

For the purpose of determining the design mean strength of the concrete a margin shall be added

to the characteristic strength for the particular grade of concrete. This design margin shall be assessed on the degree of control reasonably to be expected in the manufacture of the concrete and shall neither be less than 5.0 N/mm2 nor less than 1.64 times the standard deviation. Until such time as the standard deviation has been assessed the margin shall be not less than 7.5 N/mm2.

Details of the designed mixes shall be forwarded immediately to the Project Manager for his approval.

(b) Prescribed Mixes

Proportions for the several grades of concrete shall conform to the requirements of Tables 3.3 and 3.4.

(d) Chloride Content

The total chloride content of the concrete mix shall comply with the requirements of BS 8500: Part 2: Section 5

302.4 Quality Control

The principal basis of control shall be by comparison of the results of the compression cube tests at 28 days, except for small quantities of concrete whose strength can be otherwise derived and which is permitted for use by the Project Manager. 40 sample cubes shall be made initially in eight samples each day for five days of concreting and thereafter one sample per 25 m^3 of concrete but not less than one sample for each day's concreting.

Where materials are of an unfamiliar grading or type, compression cube tests shall be carried out at 7 days and adjustments made in advance of the main control methods outlined above.

Cube test results will be examined individually in 10 consecutive sets of four and the standard deviation and mean strength of each set calculated. The concrete mix proportions will only be acceptable if all of the following requirements are complied with: -

(i) Not more than two results in 40 are less than the characteristic crushing strength.

(ii) No value of the average for any set of four results is less than the characteristic strength plus one-half of the design margin (Clause 302).

(iii) When 40 results have been obtained and the mean strength and standard deviation are calculated, the mean strength minus 1.64 times the standard deviation shall be greater than the characteristic strength.

Where the results do not conform to the above requirements the following action shall be taken:-

- Adjustments to the mix shall be made to obtain the strength required.

- In the case where any result is less than 80% of the characteristic strength the structural

implications shall be considered and action taken as ordered by the Project Manager (as provided for in Clause 305).

For those Prescribed Mixes required to be tested, requirements (i) and (ii) only will be applicable.

302.5 Production

Aggregates and cement shall be proportioned by weigh-batching, and water shall be proportioned by volume. Subject to the prior approval of the Project Manager volume-batching of aggregates may be used for small sections of works, but volume batching of cement will in no case be accepted. The Contractor may, however, so proportion the mix that each batch shall use a whole bag or bags of cement, the weight of which is known precisely. Where permission has been given for volume batching of aggregates, all gauge boxes shall be accurate and due allowance shall be made for the bulking of the aggregates in assessing the correct volume to be used.

The aggregates and the cement shall be thoroughly mixed in a clean mechanical mixer for a period of time agreed with the Project Manager and the water added on the basis of the approved design.

The amount of water added shall conform to the requirements of Clause 302.

Batching mixing machines shall comply with the requirements of BS 1305. They shall be provided in such numbers and of such capacity as to ensure a continuous supply of freshly mixed concrete at all times during construction.

Target strength for trial mix = 1.3 x Characteristic Strength

Target strength for works = 1.2 x Characteristic Strength

Continuous mixing machines shall be used only with the written permission of the Project Manager.

Not less than 30 days prior to the installation of the Contractor's plant and equipment for processing, handling, transportation, storing and proportioning ingredients, and for mixing, transporting and placing concrete, the Contractor shall submit drawings for approval by the Project Manager, showing proposed general plant arrangements, together with a general description of the equipment proposed for use.

After completion of installation, the operation of the plant and equipment shall be subject to the approval of the Project Manager.

Where these Preambles, the Bills of Quantities or the Drawings require specific procedures to be followed, such requirements are not to be construed as prohibiting use by the Contractor of alternative procedures if it is approved by the Project Manager, prior to use of such alternatives.

Approval of plant and equipment or their operation, or of any construction procedure, shall not

operate to waive or modify any provision or requirements contained in the Preambles governing the quality of the materials of the finished work.

Table 3.3 Prescribed Mixes - Mass of Dry Aggregate to be Used With 100 kg of Cement

Grade of concrete	Nominal maximum size of aggregate (mm)	40		20		14		10	
	Workability	Medium	High	Medium	High	Medium	High	Medium	High
	Range for standard sample (mm)	50-100	80-170	25-75	65-135	5-55	50-100	0-45	15-65
	Total aggregate	kg	kg	kg	kg	kg	kg	kg	kg
C7.5P		1080	920	900	780	N/A	N/A	N/A	N/A
C10P		900	800	770	690	N/A	N/A	N/A	N/A
C15P		790	690	680	580	N/A	N/A	N/A	N/A
C20P		660	600	600	530	560	470	510	420
C25P		560	510	510	460	490	410	450	370
C30P		510	460	460	400	410	360	380	320

N/A not applicable

Table 3.4 Prescribed Mixes - Percentage by Mass of Fine Aggregate to Total Aggregate

Grade of concrete	Nominal maximum size of aggregate (mm)	40		20		14		10	
	Workability	Medium	High	Medium	High	Medium	High	Medium	High
C7.5P} C10P} C15P}		30-45		35-50		N/A		N/A	
	Grading Zone 1								
C20P}		35	40	40	45	45	50	50	55
}	2								
C25P}		30	35	35	40	40	45	45	50
}	3								
C30P}		30	30	30	35	35	40	40	45
	4								
		25	25	25	30	30	35	35	40

N/A implies 'Not Applicable'

Notes on the use of Tables 3.3 and 3.4

NOTE 1. The proportions given in the tables will normally provide concrete of the strength in N/mm2 indicated by the grade except where poor control is allied with the use of poor materials.

NOTE 2. For grades C7.5P, C10P and C15P a range of fine-aggregate percentages is given; the lower percentage is applicable to finer materials such as zone 4 sand and the higher percentage to coarser materials such as zone 1 sand.

NOTE 3. For all grades, small adjustments in the percentage of fine aggregate may be required depending on the properties of the particular aggregates being used.

NOTE 4. For grades C20P, C25P and C30P, and where high workability is required, it is advisable to check that the percentage of fine aggregate stated will produce satisfactory concrete if the grading of the fine aggregate approaches the coarser limits of zone 1 or the finer limits of zone 4.

302.6 Cement

Cement shall, as a minimum, meet the requirements of CEMI-32.5, CEMII-32.5 or CEMIV-32.5 in accordance with Kenya Standard KS 1725 Part 1 (Composition, Specifications and conformity criteria for common cements) and Part 2 (conformity Evaluation). Concrete for power floated floors shall as a minimum meet the requirements of CEMI-42.5, CEMII-42.5 or CEMIV-42.5.

Approval to the use of cement manufactured to the above standards or any other approved standards shall be subject to the Contractor demonstrating that the resulting concrete shall meet the strength requirements as given in the drawings and the relevant sections of the Concrete Specifications.

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

Cement shall be fresh when delivered to Site and the consignments shall be used in the order of their delivery. The Contractor shall mark the date of delivery on each consignment and each consignment shall be stored separately and in such manner as to be easily accessible and identifiable.

No cement in bags or other containers shall be used unless these and the manufacturer's seals are intact at the time of mixing.

If the cement is delivered in bags it shall be stored in a waterproof shed or building at a temperature of not less than 8^{o}C and the bags shall be placed on dry boards above the floor to prevent deterioration or contamination from any cause.

Bulk cement may be used provided it is stored in an approved container.

The Contractor shall not use cement which has hardened into lumps, but subject to removal of the lumps by screening, the Project Manager may allow such cement to be used in non-structural concrete mixes.

Cement of different types shall be kept separate in storage and shall not be mixed together in the production of concrete.

302.7 Aggregates

The Contractor shall investigate the proposed aggregate sources in detail and shall submit a comprehensive report with technical information and data which shall include the following:

(a) Location. Only Sources equipped with facilities adequate for the production of the materials as specified and in such quantities as shall be required for the prompt execution of the Contract shall be approved.

(b) Petrology of sources and possible or likely variability during the Contract period.

(c) Method of production

(d) Schedule of available and proposed processed aggregates by size, including details of actual screen sizes to produce each aggregate.

(e) Test data as applicable for each aggregate type and size based upon representative samples and tested in accordance with the appropriate British Standards.

(f) A detailed statement of the aggregate proposed for use in each grade of concrete.

Samples of all aggregate, including fine aggregates and sand shall be submitted to the Project Manager for his approval. All samples shall be taken in accordance with BS 812 and shall weigh not less than the minimum weight indicated on Table 1 of that Standard.

The Contractor shall produce with each consignment or at intervals directed by the Project Manager a certificate signed by the Supplier, or other approved analyst, giving fully detailed chemical and physical properties of all aggregates together with a sieve analysis carried out in accordance with the appropriate British Standard.

Any changes in the particulars of the aggregates which occur during the course of the Contract must be notified to the Project Manager without delay.

The aggregates shall be stored on Site in separate stockpiles so arranged as to prevent the intermingling of the various aggregate sizes. The stockpiles shall be suitably protected to prevent contamination of the aggregates from the ground, rubbish or by leaves, dust or other windblown materials.

Aggregates shall conform to the requirements of "Acceptable Standards" of Table 3.8.

Building sand for mortar and similar uses and aggregates for concrete shall comply to BS 882 and shall be perfectly clean and free from all foreign matter and shall not consist of, nor contain argillaceous limestone or shells.

Where the nominal size specified exceeds 37.5 mm the grading shall be subject to the Project Manager's approval or in accordance with his directions.

Unless otherwise agreed with the Project Manager, single-sized aggregates shall be used in batching and mixing concrete.

The following impurities in both fine and coarse aggregates shall not exceed the limits stated in the following clauses.

The total chloride content of the concrete mix arising from the aggregate together with that from any admixtures and any other source, expressed as a percentage of chloride ion shall not in any circumstances exceed 0.1%.

Note: Marine aggregates and some inland aggregates contain chlorides. Both should be selected carefully and marine aggregates necessitate efficient washing to achieve the 0.1% chloride ion limit. Wherever possible, the total chloride content should be calculated from the mix proportions and the measured chloride content of each of the constituents.

Concrete made with some aggregates exhibit Alkali-Silica Reaction (ASR). This phenomenon is particularly detrimental in structures subject to wetting and their use will not be allowed in such structures.

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

The Project Manager may order further tests to be carried out on the aggregates proposed by the

Contractor for the structures in connection with this Contract before permission is given to use the aggregates proposed by the Contractor.

Where allowed by the Project Manager to use reactive or potentially reactive aggregates in certain structures the Contractor shall take all suitable measures to prevent deterioration of concrete due to alkali-silica reaction. Such measures shall include the use of cement with an acid soluble equivalent of sodium oxide content (Na2 O + O.658K2 O) of less than 0.6%. The reactive alkali content of the concrete mix shall in no circumstances exceed 3 kg/m³.

The Alkali-Silica Reaction (ASR) in hardened concrete is also affected by the water-cement ratio. Therefore, where ASR aggregates are used, with the permission of the Project Manager, the water-cement ratio shall be kept to a minimum (in the region of 0.4).

Aggregates required for use in the construction of concrete water retaining, water excluding and other similar structures shall have a low drying shrinkage and the water absorption shall not exceed 3%.

The absorption of the aggregates shall be measured in accordance with BS 812, Part 2.

Aggregates of rounded shape or otherwise capable of producing a concrete of good workability with the minimum addition of water shall be preferred.

Dust or flour resulting from crushing the aggregate shall not be allowed to contaminate the stockpiles. When, in the opinion of the Project Manager such contamination has taken place it shall be removed by an approved means or otherwise the aggregate shall be rejected.

For mass concrete, in order to improve the consistency of the mix, dust or flour resulting from crushing the aggregate, which may be subjected to test, be included in controlled quantities to supplement the fine aggregate.

Except where aggregates have been otherwise specified on the Drawings the grading of aggregates shall be as follows:

(i) Coarse Aggregate:

(a) 10 mm max. size, graded, for all "fine" concrete.

(b) 20 mm max. size, graded, for all reinforced concrete in beams and for walls and slabs not greater than 400 mm thick.

(c) 40 mm max. size, graded, for all reinforced concrete walls and slabs in excess of 400 mm thick.

(ii) Fine Aggregate:

(a) Where aggregates conforming to Zones 2 or 3 of BS 882 are available they shall be used.

(b) For Prescribed Mixes, Zones 1, 2, or 3 aggregates only shall be used.

Fine and coarse aggregates shall be as defined by and be of the quality and nature required by BS 882.

In addition they shall be chemically inert to alkali reaction.

302.8 Water

The Contractor shall supply all water, make all arrangements and pay all charges in respect of such supply. Where water can be obtained from a public water supply it shall be used.

Where water cannot be obtained from a public supply it shall be tested in accordance with BS 3148 and if necessary shall be treated to assure compliance therewith.

Water for washing and curing shall be such that it will impair neither the strength of the finished concrete nor its appearance.

302.9 Admixtures

(i) General : The quantity and method of using admixture's shall be in accordance with the manufacturer's recommendations and in all cases shall be subject to the approval of the Project Manager. Unless otherwise specified or approved by the Project Manager, an admixture shall comply with one of the following :-

BS 1014 (Pigments for Portland cement and Portland cement products).

BS 5075 (Concrete admixtures except chloride based admixtures).

In all cases the Contractor shall provide the following information for the Project Manager's approval :-

(a) the quantity to be used, in kilograms per kilogram of cement and in kilograms per cubic metre of concrete;

(b) the detrimental effects caused by adding a greater or lesser quantity in kilograms per cubic metre of concrete;

(c) the chemical name (s) of the main active ingredients;

(d) whether by the Project Manager, the Contractor shall demonstrate the action of an admixture by means of trial mixes.

(ii) Calcium chloride. The use of calcium chloride in any form is prohibited.

302.10 Control of Alkali-Silica Reaction

The risk of cracking and expansion due to alkali-silica reaction shall be minimised by compliance with the specification and guidance notes set out in Technical Report No. 30 of the Concrete Society, Riverside House, 4 Meadows Business Park Station Approach, Blackwater, Camberley, Surrey, GU17 9AB Fax: +44 (0) 1276 607141, Website: www.concrete.org.uk.

303 Reinforcement

303.1 Steel

Reinforcement shall be:

(a) Plain round mild steel or High Yield steel bars conforming to BS 4449.

(b) Cold worked steel bars conforming to BS 4449: 1988.

(c) Fabric reinforcement made of cold drawn high tensile bars conforming to BS 4483.

The Contractor shall obtain from his suppliers certificates of the mechanical and physical properties of the reinforcement and shall submit them to the Project Manager for approval, except where reinforcement has been supplied by the Employer. The frequency of sampling and the method of quality control shall be in accordance with Table 4 and Clause 20 respectively of these British Standards. All high yield and cold worked bars (except in welded fabric reinforcement) shall be deformed bars complying with Classification Type T2 for bond strength in accordance with BS 4449. Where galvanised reinforcement is specified, galvanising shall comply with the requirements of BS 729, Part 1.

303.2 Storage

Reinforcement shall be stored on Site under cover and supported clear of the ground and in such manner as to make identification easy. Supports shall be such that distortion of the steel is avoided and contamination and corrosion prevented.

303.3 Bending and Fixing

The Contractor shall provide on Site facilities for cutting and bending reinforcement whether he is ordering his reinforcement bent or not and shall ensure that a token amount of straight bar is available on Site for bending as and when directed by the Project Manager.

Reinforcement shall be wire brushed and cleaned at the Contractor's expense, before and/or after it is placed in position, if required by the Project Manager.

The bars shall be cold bent in strict accordance with the drawings and the Contractor shall be responsible for the accuracy of the bending. Bending dimensions shall be worked to the tolerances indicated in BS 4466 and BS 8110 table 3.28. Bars in which any errors in bending are beyond the limits of the foregoing tolerances shall be replaced at the Contractor's cost by correctly bent new bars, or, may be straightened and rebent cold subject to the Project Manager's prior approval. Any discrepancy or inaccuracy found in the drawings shall be notified to the Project Manager immediately.

After bending, reinforcement shall be securely bundled and labelled with weather-proof tags or shall be marked with other approved signs by which it can readily be identified.

Before assembling or fixing the reinforcement the dimensions to which it has been bent shall be checked by the Contractor against the drawings.

The reinforcement shall be fixed in strict accordance with the drawings as regards cover, spacing and position, and suitable precautions shall be taken by the Contractor to prevent the displacement of reinforcement during the placing and compaction of concrete.

During concreting a competent steel fixer must be in attendance to adjust and correct the positions of any reinforcement which may be displaced. The vibrators are not to come into contact with the reinforcement.

Where required to support and retain the reinforcement in its correct position the Contractor shall provide templates, stools or other supports at his own cost. He shall allow for cutting to correct length all corner lacer bars included in the bar schedules as standard lengths.

Precast concrete support blocks for reinforcement shall be manufactured from Grade C30D "fine" concrete to ensure the correct cover thickness. They shall be well cured before use and carefully stored on Site to avoid contamination. Plastic and metal supports, chairs, etc. may be used and shall be subject to the Project Manager's prior approval.

In the case of mild steel, a lap of not less than 40 diameters of the smaller bar shall be provided at the junction of two bars for which the lap is not specifically detailed on the Drawings and, in the case of High Yield steel, a lap of not less than 50 diameters.

All intersections of bars in walls and slabs and all connections between binders or links and main bars in columns or beams shall be tied with soft iron wire ties or with fixing clips which shall not be allowed to make contact with the formwork or to project materially into the specified cover.

Unless permitted by the Project Manager, welding of bar reinforcement at intersections or for the joining of bars is prohibited. Where permission is granted, welding shall be carried out in accordance with the recommendations of the Institute of Welding for the welding of reinforcing bars for reinforced concrete construction.

When fixed reinforcement is to be left exposed for more than eight weeks, it shall be thoroughly cleaned and painted with neat cement grout.

Where galvanised reinforcement is used any damage suffered by galvanising shall be made good by the application of an approved galvanising formulation, before concrete placing is commenced.

No concreting shall be commenced until the Project Manager has inspected the reinforcement in position and until his approval has been obtained and the Contractor shall give adequate notice of his intention to concrete.

303.4 Couplers

Couplers for reinforcement shall be either Standard Swaged Splices or Type II Alpha Couplers manufactured by CCL Systems, Unit 4, Park 2000 Millennium Way, Westland Road, Leeds, LS11 5AL, Telephone: +44 (0) 113270 1221, Fax: +44 (0) 113 277 8977, email: sales@cclstressing.com or similar approved. Where bars of different diameters are to be joined a CCL Reducer Sleeve or similar shall be used.

Couplers shall be suitable for the type and size of reinforcing bars and shall be capable of developing 115% of the characteristic strength of the smaller of the reinforcing bars being joined in both tension and compression. Couplers shall be installed in accordance with the manufacturer's recommendations. Square twisted reinforcing bars shall not be used with couplers.

304 Formwork

304.1 Requirements

The term "formwork" shall be taken to include centering, formwork, strutting, bracing and the like.

When called upon to do so by the Project Manager the Contractor shall submit his formwork proposals for checking and approval by the Project Manager in advance of the concreting.

Formwork shall be of such accuracy, strength and rigidity as to carry the weight and pressure from the concrete to be placed on or against it, together with all constructional, wind or other loads likely to be imparted to it, without producing deformation of the finished concrete in excess of the tolerances outlined in Clause 304 and Table 3.5.

All formwork shall be sufficiently tight, without plugging, to prevent loss of grout during the vibration of the concrete. When required by the Project Manager, joints between formwork facing boards shall be sealed with foam rubber, sealing strips or other approved material. A foam rubber or polyurethane strip shall be provided around the tops of all walls and columns before affixing the forms for the next lift.

Faces of formwork shall be clean, free from projecting nails, adhering grout and other imperfections or defects which would prevent the specified surface finish from being attained. They shall be treated with approved mould oil before positioning. Great care shall be exercised to prevent reinforcement or steelwork from being contaminated by the oil during erection of the formwork.

Formwork, which as a result of prolonged use or general deterioration does not, in the opinion of the Project Manager, conform to the particular requirements set out in this clause, shall not be used.

Through-bolts or ties will not be permitted in liquid-retaining structures. The Contractor shall use only such bolts or ties as are capable of being removed in whole or in part so that no part remaining embedded in the concrete shall be nearer the surface of the concrete than the specified thickness of cover to the reinforcement.

Beam soffits shall be erected with an upward camber of 5 mm for each 3 metres of span.

Top formwork shall be counterweighted or otherwise anchored against flotation.

Boxes for forming holes shall be constructed so as to be easily removable without damaging the concrete during removal. They shall be properly vented to permit the escape of entrapped air, and shall be capable of being sealed, subsequently to prevent the loss of grout. The use of polystyrene blocks for the forming of holes, sinkings, etc. will not be allowed except by express permission of the Project Manager.

On all external edges risers of the concrete 20 mm chamfers shall be formed.

Openings for inspection of the inside of beam, wall, column and similar formwork and for cleaning-out purposes shall be formed so that they can conveniently be closed before the placing of concrete.

All props shall be supported on adequate sole plates and shall not bear directly on or against concrete. They shall be capable of being released gently and without shock from the supported formwork. No appliance for supporting the formwork shall be built into the permanent structure without the Project Manager's prior approval. Props for upper level support shall be placed directly over those at lower levels, and the lowermost props shall bear upon work sufficiently mature to carry the load.

Formwork shall be such as to allow for its removal without damaging the concrete, and in the case of suspended floors, for the removal of the beam sides and slab soffits without disturbing the beam-bottom boards and their props.

Before concreting, the areas which are intended to receive the concrete shall be cleaned by jetting with compressed air, and all water and extraneous material removed.

Where timber is used for formwork it shall be properly cured, free from warp, straight, clean and free from loose knots.

Where metal forms are used for formwork they shall be of the type strengthened by intermediate ribs or cross bracing.

Moving formwork may be used where in the opinion of the Project Manager it is appropriate.

304.2 Sawn Formwork

Sawn formwork shall produce an ordinary standard of finish consistent with normal good practice for use where the face of the finished concrete will not be exposed. The face in contact with the concrete shall consist of sawn timber boards, sheet metal or other approved material.

304.3 Wrought Formwork

Wrought formwork for use on exposed faces and water retaining faces shall produce a high standard of finish consistent with the best practice. The face in contact with the concrete shall consist of wrought and thicknessed boards tongued and grooved of not less than 30 mm finished thickness, framed plywood or metal panels or other approved material. Joints between boards and/or panels shall be arranged in a uniform pattern.

304.4 Special Wrought Formwork

Special wrought formwork shall provide the highest standard of finish where the face of the finished concrete is to form a particular feature. The face in contact with the concrete shall consist of large smooth sheets, unless otherwise specified, arranged in an approved uniform pattern, with joints coinciding with possible architectural features, sills, window heads, or changes in direction or surface. Accurate alignment of all joints shall be maintained. Wrought boarding and standard steel panels shall

not be used unless specially faced.

304.5 Tolerances

Unless otherwise indicated on the drawings, the tolerances of the finished concrete with respect to the dimensions shown on the drawings shall not exceed the limits set out in Table 3.5.

Table 3.5 Tolerances of Dimensions for Finished Concrete

Items	Tolerances (mm)
Overall dimensions and Levels	±5
Column sizes) Beam sizes) Wall sizes)	±5
Vertical lines out of plumb	5 mm ± 15 mm in every 15 m height

Except that in the case of Sawn Formwork the dimensions of the finished concrete shall be not less than those shown on the drawings.

304.6 Striking and Removal

The recommendations set out in Table 3.6 are given as a minimum requirement for striking formwork:-

Table 3.6 Striking of Formwork

Item	Sulphate Resisting and Ordinary Portland Cement CEM I to KS 1725 Normal Weather (16^{o}C and above) Days	Rapid Hardening Cement Normal Weather (16^{o}C and above) Days	Portland Pozzolana Cement or CEM IV to KS 1725
Beam Sides, Walls, Columns	1	1	1
Slabs (props left under)	4	3	5
Beam Soffits (props left under)	7	5	9
Removal of props to slabs	8	5	10
Removal of props to beams	16	8	18.5
Shafts and Tunnels	1	1	1.5

The removal of props to slabs and beams shall, if directed by the Project Manager, be subject to satisfactory results of the relevant 7-day cube crushing tests.

The above striking times are for normal conditions and before deciding on the actual time for each case, the Contractor shall consider and extend the period as tabled if:-

(a) the span of the structural member under consideration exceeds 6 metres for beams and 3 metres for slabs. An additional period of one day for each 500 mm of additional span shall then be allowed;

(b) the dead load of the structural member under consideration forms a large proportion of the total design load;

(c) constructional loads coming on to the structural member under consideration are being placed soon after the concreting operations and these loads form a large proportion of the total design load;

(d) the setting of the concrete has been retarded for any reasons;

(e) the temperature falls below 8°C. An additional period of half a day shall be added for each day on which the temperature falls below 8°C. For temperatures falling below 3°C the additional period to be added shall be one day for each day on which the temperature falls below 3°C;

(f) any combination of the above points and other considerations which would call for such a precaution to be taken.

(g) the span concerned is part of a continuous spanning system and the adjacent two spans have not been cured sufficiently.

Information regarding paragraph (b) above will be supplied by the Project Manager; any other design information relevant to the above shall be obtained by the Contractor from the Project Manager.

305 Concreting

305.1 Requirements

The finished concrete shall be dense, durable, impervious to the ingress of water, free from cracks and honeycombing, and resistant to wear and mild chemical attack. Special concretes will be the subject of their own particular sections of Special Concrete.

305.2 Transporting

Concrete shall be transported to the place of final deposit by approved means.

Barrows, spades and other equipment used in the process of transporting concrete shall be thoroughly cleaned before each day's work or after a long interruption and they shall be free from hardened concrete.

Concrete shall be transported as soon as possible after mixing, by methods which will prevent the segregation, loss or contamination of the ingredients.

Proper bridging arrangements for traffic over reinforcement shall be provided so that the reinforcement is not distorted, damaged or displaced.

Where approval is obtained for concrete to be conveyed by chutes, these shall have a slope (not exceeding 1 vertical to 2 horizontal) such as to ensure a continuous flow of concrete. Additional water shall not be introduced to assist the flow. If deposition is to be intermittent the chute shall be arranged to discharge into a storage hopper. In no case will a clear fall of more than 1 m be permitted at the discharge end of the chute.

Where approval is obtained for pumping the concrete, the pump manufacturer's recommendations shall be followed. The pumps used shall be of adequate capacity and power to ensure delivery of a continuous supply. The Contractor shall provide adequate alternative arrangements for transporting the concrete in case of a breakdown of the pumping equipment.

Wherever transport of concrete is interrupted for any length of time (periods of over half an hour shall be treated as such) the chutes, pumps, pipes and any other means of distribution shall be thoroughly flushed out and cleaned. These shall also be flushed out immediately prior to resumption of concreting and shall be kept free from hardened concrete. All washwater used shall be discharged outside the formwork and clear of any freshly placed concrete.

305.3 Placing and Compaction

No concrete shall be placed until the Contractor has obtained approval to do so from the Project Manager. When the Contractor intends to place concrete he shall inform the Project Manager in sufficient time to enable him to inspect the reinforcement, formwork and surface on which the concrete is to be placed and the Contractor shall provide all facilities for such inspection.

This approval shall be sought by presenting two copies of the completed “Structural Concrete Approval Form” (SCAF) to the Project Manager’s Representative at least 24 hours before intending to concrete. (See sample page 23).

Concrete shall be placed within 30 minutes of mixing, to uniform level, in layers not exceeding 500 mm deep in such manner as to avoid segregation, and each layer shall be compacted by means of approved vibrators to form a dense material free from honeycombing and other blemishes. Compaction by hand may be used only with the prior approval of the Project Manager.

At least one internal vibrator shall be operated for every four cubic metres of concrete placed per hour and at least one spare vibrator for every three shall be maintained on Site in case of breakdown during concreting operations.

Vibration time, the effective radius and other vibration characteristics shall be in accordance with the vibrator manufacturer's recommendations.
If internal vibrators are used, they shall be withdrawn immediately water or a thin film of mortar begins to appear on the surface of the concrete. Withdrawal shall be carried out slowly to avoid cavitation.

Internal vibrators shall not be inserted between layers of reinforcement less than one and one half times the diameter of the vibrators apart. Contact between vibrators and reinforcement and vibrators and formwork shall be avoided.

Vibrators shall not be used to move concrete from place to place in the formwork.

Where two distinct batches of concrete, placed at different periods of time and forming part of the same concreting operation are required to be formed monolithically with each other, the more mature concrete shall be penetrated by the vibrator to a sufficient depth to effect plastic movement between the two batches. Where the concrete does not respond to the action of the vibrator, it shall be deemed to have set, and no further disturbance will be permitted. Unless otherwise instructed by the Project Manager the condition shall be treated as for a "stoppage of work" and the marrying up of the two concretes shall be effected only when both concretes have properly set.

If external vibrators are used, the formwork shall be strong enough to withstand the forces of vibration.

Temporary or permanent stoppages of work shall be made only against stop ends (Clause 305).

Unless otherwise specified, before placing new concrete against concrete which has already hardened, the face of the older concrete shall be prepared by the removal of any laitance and loose aggregate and shall be cleaned by a jet of compressed air.

When displacers are permitted to be used, they shall be so placed that no displacer is within 300 mm of any finished face or within 500 mm of any other displacer. On completion of any lift, displacers shall be so arranged that they project for half their height above the surface.

STRUCTURAL CONCRETE APPROVAL FORM (SCAF)
(To be filled in duplicate before any concrete pour)

Contract Details

Job _____ Job No _____

Contractor _____ Site Engineer _____

Section and Concrete Details

Section / Block _____

Level _____ Member _____

Date / Time of Request_____ Date / Time of Pour _____

Concrete Class____ Mix: Design / Nominal (delete one) Batching: Site / Ready Mix (delete one)

Check List

Description of Check	Checked	Remarks
Reinforcement Fixing		
Chairs / Links, etc.		
Reinforcement Cover		
Shutters / Stop ends		
Shutter Props		
Tie Bolts		
Plumbness / Slope		
Dimensions		
Line and Level		
Preparation hacking of joints		
Water Stops		
Moulds for Cubes		
Materials for Curing		
Any other checks (specify)		

Approval

Approved ☐ Not Approved ☐

Date: _____Signature: _____

Note: Approval by the Project Manager or his Representative does not relieve the Contractor of any of his contractual obligations.

305.4 Concreting in Deep Lifts

(i) Limitations

Any height exceeding 2.5 m from which concrete is poured into formwork to form sections of wall will be considered within the terms of this Clause.

Concrete in columns may be placed to a height of 4.0 m with careful placing and vibration and satisfactory results. Where the height of the column exceeds 4.0 m suitable openings must be left in the shutters so that the maximum lift is not exceeded.

Deep lift construction will not be permitted where the reinforcing bars are to be placed closer than 100 mm to one another in any direction or, where the clear width at the point of admitting the concrete between one layer of reinforcement and another (or in the case of singly reinforced walls between reinforcement and formwork) is less than 200 mm.

The method shall only be used where trial sections revealed that, in the Project Manager's opinion it can be satisfactorily employed, in which case the requirements of this Specification shall apply except where they conflict with the requirements of this particular clause, when the latter shall prevail.

(ii) Concrete

In order to prevent segregation of aggregates, concrete mixes shall be designed for increased cohesion, or, where suitable, on a gap-graded basis. The use of approved admixtures may be made to achieve this end (302).

At the same time, the mix shall be such as to limit the amount of bleeding in the concrete, and where in the opinion of the Project Manager the quantity of free water rising to the surface is excessive, the mix shall be corrected before further concreting is undertaken.

In order to offset any increase in the water-cement ratio at the upper levels, the Project Manager may require the concrete mix to be modified for the upper depositions.

A slump of 80 mm shall not be exceeded.

(iii) Reinforcement

In order that reinforcement is not distorted or displaced during construction as a result of it being used for gaining access in or out of the formwork, all intersections of vertical and horizontal steel shall be properly fastened.

All obstructions caused by spacer blocks or chairs shall be eliminated so as to permit an unobstructed passage for the concrete to the bottom of the formwork. The Contractor may use sliding timber spacers instead of fixed concrete or plastic spacer blocks to position the reinforcement.

(iv) Formwork

In view of the high pressures to be expected from this form of construction extra attention shall be paid to the strength and stability of the formwork, to the prevention of loss of grout, and to the prevention of displacement of adjacent panels.

The use of through-bolts and other accessories which might interfere with the free passage of concrete between and around the reinforcement shall be reduced to a minimum by the use of properly designed formwork.

(v) Concreting

Particular attention shall be paid to the concreting of the initial sections at the bottom of the formwork to prevent segregation caused by rebound from the hard surface of the kicker, base and/or lower sections. The initial depositions shall therefore be made by using trunking methods, or by placing the concrete through openings formed in the sides of the formwork. Such openings shall not be higher from the hard surface than 2.5m.

In order to reduce differential settlement, and consequently, cracking between two sections of concrete placed at different intervals of time, concreting between one section and another shall be carried out on a gap-construction basis (Clause 305). The gap shall subsequently be concreted in distinct lifts each not exceeding 2.5m in height. For the same reason, when concreting two adjacent sections placed at the same time but of different heights (e.g. where boxing out is included), the difference in height shall not exceed 15% of the height of the deeper section.

Concreting from the upper level of the formwork shall be carried out in such manner as to ensure that concrete is admitted centrally between the faces of the formwork. For this purpose the Contractor shall make use of trunking or shall use funnel-shaped hoppers extending for a distance of not less than 1.5 m into the formwork. A sufficient number of such hoppers shall be provided, and/or they shall be capable of movement along the length of the formwork, to enable the concrete to be placed in contiguous heaps at the base of the pour. Such heaps shall not exceed 460 mm in height.

Where excessive bleeding is in evidence, the excess water shall be removed before placing further concrete.

(vi) Compaction

Compaction shall be carried out where possible by manual operation of poker vibrators within the formwork. Where this is not possible poker vibrators shall be suspended in sufficient numbers to ensure uniform compaction along the length of wall receiving the concrete, without the need for their withdrawal and re-insertion. The means of suspension shall be such that the vibrators may be progressively and systematically lifted as the concreting proceeds to ensure that every section of placed concrete is married into adjacent and underlying sections.

The use of vibrators to reposition deposited concrete is prohibited. Surface vibrators attached to the formwork may be used only to supplement the main means of compaction.

305.5 Continuous Concreting

Where the Contractor desires to use continuous concreting method in large sections (rafts and walls),

he shall submit a written request to the Project Manager for approval. In the request he shall attach details which shall include but not be limited to the following :-

- Total amount of concrete to be placed in the shift.
- Stock of approved concrete materials on site.
- Capacity of the batching plant.
- Number and type of truck mixers to be deployed for the exercise and movement logistics.
- Number of skilled and other manpower to be deployed for the exercise in shifts.
- Number and capacity of plant to be used in placing concrete (pumps, vibrators, buckets, etc).
- Method(s) of monitoring and dealing with the heat of hydration.
- Details of protection against rain and floodwaters and how to cope with it.

The Project Manager shall consider the above details and other parameters (e.g. weather, satisfactory records of cube test results, availability of adequate working sections where reinforcement placement and the necessary formwork have been approved etc), before making his decision. The Project Manager may order that additional concrete cube moulds be made available as well as arrangements be made for cube crushing with an approved laboratory to cope with the increased demand.

The Project Manager may order that the concreting works be stopped immediately if in his opinion the quality of the works is threatened for whatever reason.

305.6 Hot Weather Concreting (for temperatures above 20 Degrees Centigrade)

Concreting shall not be permitted if its temperature at placing is in excess of 35^{o}C. In order to maintain the temperature of the concrete below this value the following precautions shall be taken wholly or in part as instructed by the Project Manager:-

(i) All aggregate stockpiles, water lines and tanks as well as the mixer shall be protected from the direct rays of the sun;

(ii) Coarse aggregate shall be cooled by constant watering where possible;

(iii) Mixing water shall be cooled by the addition of ice to the storage tanks where necessary;

(iv) Rapid-hardening cement shall not be used;

(v) Where the above precautions are inadequate concreting shall be carried out during the cooler parts of the day or during the night as may be directed by the Project Manager.

When the air temperature is above 20^{o}C loss of mixing water by evaporation shall be considered in arriving at the amount of water to be added to the mix (Clause 302). In order to maintain the water/cement ratio within permissible limits an approved water-reducing agent shall be included in the mix (Clause 302).

The maximum water/cement ratios indicated in Clause 302 may be increased with the Project Manager's permission by 0.05 (or 2.5 litres/50 kg of cement) during mixing, but on no account shall water be added to concrete directly or indirectly once it has left the mixer.

In order to reduce premature drying of the concrete during transporting and placing, all chutes, formwork and reinforcement shall be cooled by watering when possible, or shall otherwise be protected from the direct rays of the sun. Any water so used shall be removed by jetting with compressed air before placing the concrete in close contact.

As soon as possible after concreting, the formwork shall be stripped (Clause 304) and the surface of the concrete shall be treated in accordance with Clause 305.

Where drying winds are encountered, wind shields shall be positioned as directed by the Project Manager to protect exposed surfaces of the curing concrete.

305.7 Wet Weather Concreting

Concreting during periods of constant rain shall not be permitted unless aggregate stockpiles, mixers and transporting equipment, and the areas to be concreted are adequately covered.

During showery weather, the Contractor shall ensure that work can be concluded at short notice by the provision of stop ends. On no account shall work be terminated before each section, between one stop end and another, is complete. Adequate covering shall be provided to protect newly placed concrete from the rain.

305.8 Holes, Cavities and Fixings

The Contractor shall be responsible for the co-ordination of all requirements of his Sub-contractors as regards provision of holes, chases, cavities and fixings and shall, if required by the Project Manager, prepare drawings giving details of his and his Sub-contractor's requirements and shall send copies of such drawings to the Project Manager prior to construction.

Holes, etc. shall be accurately marked and boxed-out for before concreting operations commence and, without the Project Manager's prior approval, no such holes, etc. shall be formed after the concrete has set.

Where bars, if placed to specified spacing would foul holes of size less than 250 mm x 250 mm the full length of the bar shall be moved to one side and in the case of holes exceeding 250 mm x 250 mm the bars shall be cut on site and lapped with additional equivalent bars, or as otherwise indicated on the drawings.

Wherever possible, the Contractor shall build in all pipework, ironwork, etc. which passes through walls and floors, and the pipework, ironwork, etc. shall first be thoroughly cleaned and freed from any deleterious matter, and every care shall be taken to ensure that it is thoroughly encased in concrete.

Unless otherwise instructed by the Project Manager all electrical conduits to be positioned within the reinforced concrete shall be fixed inside the steel cages of beams and between the top and bottom steel layers in slabs and similar members.

The proposed position of all conduits 25 mm and over in diameter which are to be enclosed in the concrete shall be shown accurately on a plan to be submitted to the Project Manager, whose approval shall be obtained before any such conduit is placed.

Bolts, hooks and other fixings shall be embedded in concrete, or holes shall be drilled and fitted with threaded expanding anchors to receive the bolts. The Contractor shall ensure that bolts, hooks, etc. are accurately positioned. Holding down bolts for machinery shall be set by means of a template.

Where brick or stonework is to form a facing to the concrete or where the end of a brick or stone wall butts against a concrete face, galvanised metal ties of approved manufacture to BS 1243 shall be incorporated. The distance between ties shall be gauged with due regard for the bonding of the walls, and at intervals required by the Project Manager.

305.9 Protection and Curing

Newly placed concrete shall be protected by approved means from rain, drying winds, sun and contact with substances which can adversely affect it.

No traffic or constructional loads shall be permitted on newly placed concrete until it has hardened sufficiently to take such traffic or load, and only then with the approval of the Project Manager.

Concrete shall at no time be subjected to loading (including its own mass) including compressive stress until it has reached 0.40 of its specified 28-day strength.

Any concrete surfaces, risers and treads of stairways which might be damaged during the construction of the Works shall be adequately protected.

All structural concrete shall be cured using methods approved by the Project Manager.

The method of curing shall prevent loss of moisture from the concrete. Immediately after compaction and for 7 days thereafter concrete shall be protected against harmful effects of weather, including rain, rapid temperature changes and from drying out.

The curing time shall be the number of days given in Table 3.7 unless the average temperature of the concrete during the required number of days falls below 10oC in which case the period of curing shall be extended until the maturity of the concrete reaches the value given in the table.

Table 3.7 Normal Curing Methods

Minimum period of protection for different types of cement

Conditions under which concrete is maturing	Number of days (where the average temperatures of the concrete exceed 10°C during the whole of the period)			Equivalent maturity (°C hours calculated as the age of the concrete in hours multiplied by the number of degrees Centigrade by which the average temperature of the concrete exceeds -10°C)		
	Type IV	Type I or Type V	Type III	Type IV	Type I or Type V	Type III
1. Hot weather or drying winds	7	4	2	3500	2000	1000
2. Conditions not covered by 1.	4	2	1	2000	1000	500
	Type IV - Low Heat Portland Cement/Portland - Pozzolana Cement Type I - Ordinary Portland Cement Type V - Sulphate-resisting Portland Cement Type III - Rapid-hardening Portland Cement Hot weather - Temperature over 16oC					

Curing shall be carried out using either of the following basic methods, or any other method agreed with the Project Manager. Methods involving the use of dampened hessian coverings shall not be used. The method adopted for any particular situation shall be agreed with the Project Manager.

A. Membrane Applied by Spray

Liquid membrane compounds shall be applied to moist concrete surfaces as follows:-

(i) Unformed Surfaces

The compound shall be applied immediately after the free water has left the surface.

(ii) Formed Surfaces

The compound shall be applied immediately after removing the forms. If there is appreciable drying, the surface shall be mist sprayed with water to produce a uniformly damp appearance before the compound is applied.

The compound shall be applied in one or two separate applications to produce complete and uniform coverage of the surface. If the compound is applied in two increments, the second application shall follow the first within 30 minutes. The method and rate of application shall be in accordance with the compound manufacturer's instructions.

If rain falls on the newly coated surface before the film has dried sufficiently to resist damage, or if the film is damaged in any other manner, a new coat of compound shall be applied to the affected area equal in curing value to that originally applied.

Compound applied to construction joint surfaces, or to other surfaces to which concrete is to be bonded, shall be removed prior to placing the fresh concrete.

Depending on the surface to which it is to be applied the compound shall conform to the following requirements of AASHTO M148.

(i) Exposed and vertical concrete surfaces - Type I-D (clear compound with fugitive dye).

(ii) Unexposed top surfaces of foundations and superstructures - Type 2 (white pigmented).

B. Polythene Sheeting

The concrete surfaces shall be covered with white polythene sheeting as follows:-

(i) Unformed Surfaces

The sheeting shall be laid over the surface as soon as possible without marring the surface, and not until initial stiffening has taken place if a brushed or tamped finish is required.

(ii) Formed Surfaces

The surfaces shall be covered immediately after the removal of the forms.

The sheeting may be in contact with the concrete or made into portable shelters on light weight frames. In both cases, the sheeting shall be jointed and sealed against the concrete surfaces to prevent wind blowing between the sheeting and the concrete.

The white polythene sheet shall conform with the requirements of AASHTO M171. On no account shall clear or any other colour of sheeting be used.

C. Other Curing Methods

These shall be agreed with the Project Manager. Methods involving the use of damped hessian coverings shall not be used, unless at least 2 layers of continuous hessian are used and they are kept continuously wet and protected from winds which cause accelerated drying.

Where the thickness of concrete placed exceeds 1.5 m, the Contractor shall submit for the Project Manager's approval proposals to ensure that, during the curing period:-

(a) the rate of rise of temperature in the concrete does not exceed 15^{o}C per hour for the first 3 hours;

(b) thereafter the rate of rise and fall of temperature in the concrete does not exceed 35^{o}C per hour;

(c) the maximum temperature in the concrete does not exceed 70^{o}C; and

(d) the maximum difference in temperature between the core and the surface of the concrete does not exceed 20^{o}C.

The proposals shall include consideration of:-

(a) concrete mix design;

temperature of mix at time of placing;

(c) method of curing.

Where required by the Project Manager, the Contractor shall carry out temperature measurements in the concrete. The method and procedure of temperature measurement shall be agreed with the Project Manager.

305.10 Joints

(i) Construction Joints

The position of construction joints, when not shown on the Drawings or otherwise required by this Specification, shall be decided on site having regard to the plant and labour made available by the Contractor for the manufacture, placing and compaction of the concrete as well as its curing, the climatic conditions prevailing at the time of concreting, the nature and size of the formwork, and the conditions of operation of the work. Waterstop shall be provided to all construction joints on water retaining or excluding structures. The Contractor shall submit his proposals to the Project Manager for his approval at least fourteen days before commencing the work.

Construction joint surfaces shall be treated by the "wash-off" method explained below, except where it cannot be practically effected, in which case they shall be treated in accordance with Clause 305 as for the placing of new concrete against hardened concrete.

When expanded metal lathing is used for the formation of construction joints a rebate will not be required to be formed. The expanded metal lathing shall be left in the work and shall not extend closer to the finished surface of the concrete than 25 mm. It shall be securely fixed to the reinforcement.

The following particular requirements shall also be observed:-

* Slabs supported on the ground

In order to ensure control in the placing of concrete the Contractor shall provide control boards to form panels not larger than 15 m2 in area. These shall be lifted as the concreting proceeds except where they are of expanded metal in which case they may be left in position as part of the permanent works, provided that they shall not extend closer to the finished surface of the concrete than 25 mm. In the event of a breakdown in the supply of concrete the Contractor shall ensure that an alternative supply of concrete is made available (to finish the work against the control boards acting as stop ends). The joint so formed shall then be treated as a construction joint. Where Ready-mixed concrete is permitted the control boards shall be positioned so as to enclose a volume of concrete equal to that delivered by each truck.

Construction joints and control joints shall be formed normal to the surface of the retained concrete.

* Suspended Beams and Slabs

T-beams shall be formed to their full depth integrally with the adjacent slab and without horizontal joints.

* Columns

Where kickers are indicated on the drawings these shall be cast together with the slab or beam below. On no account shall kickers be cast as a separate operation. Alternatively, the Contractor may adopt "kickerless construction" methods providing he can satisfy the Project Manager that his system is reliable and does not compromise workmanship.

* Walls

Horizontal construction joints in walls shall be formed along straight lines coinciding with the full height of the formwork. The height of the formwork thus controlling the height of the pour shall be determined with reference to the availability of concrete, the size and amount of reinforcement and the means of compaction available.

Unless otherwise indicated on the drawings or otherwise permitted by the Project Manager for the construction of circular tanks, concreting shall be carried out continuously for the full circumference without vertical joints. Where permission is granted for the use of vertical joints the Project Manager may order, at no extra cost to the Employer, the inclusion of an approved type of water stop.

In the case of rectangular tanks, vertical joints shall not be positioned closer to any corner than one metre. They shall be formed with properly rebated stop ends or, where conditions permit, by the use of expanded metal lathing. Unreinforced manholes shall be constructed without vertical joints.

(ii) The "Wash-off Method" of preparing Construction Joints

As soon as possible after concreting, and while the surface is still green, the surface of the concrete forming the joint shall be freed of loose aggregate and sprayed with a fine spray of water to prevent the formation of laitance. Subsequently all excess water shall be removed by a jet of compressed air and the surface left clean to receive further concrete.

Where expanded metal lathing is used for construction joints, this method of surface preparation shall be used in every case.

(iii) Movement Joints

These shall include contraction and expansion joints and shall be as indicated on the drawings.

Contraction joints will be either full contraction joints or partial contraction joints. Where partial contraction joints are specified a period of at least five days shall elapse between the concreting of the section on each side of the joint.

Where the drawings indicate a contraction gap to be formed in any panel (this gap will not exceed one

metre), concreting on either side of the gap shall be carried out so as to form partial contraction joints at each side of the gap. Prior to the concreting of the gap section, the joint surfaces shall be cleaned but otherwise left untreated. The concreting of the gap section shall not be carried out until a period of at least five days has elapsed after completion of the adjacent sections.

Alternate panel construction (other than contraction gap construction outlined above) will be permitted only with the approval of the Project Manager, or in those cases where either the reinforcement is not continuous through the joint or where the panels are separated by expansion or contraction joints.

Unless otherwise specified or permitted by the Project Manager all waterstop shall consist of rubber or PVC. Jointing of waterstop shall be by vulcanising, except where PVC is specified or permitted in which case joints shall be by fusing or welding. Materials shall be obtained from an approved manufacturer whose recommendations as to jointing shall be fully complied with.

(iv) Waterstop and Jointing Materials

Waterstop and jointing materials shall be obtained from an approved manufacturer.

All waterstop and jointing materials which are not required for immediate use shall be stored at all times in a cool damp place.

Waterstop shall be manufactured of rubber or PVC (polyvinylchloride) as shown on the drawings, and shall be of the type and size shown on the drawings. Site joints shall be made strictly in accordance with the manufacturer's instructions and all intersections and junctions shall be obtained prefabricated from the approved manufacturer.

Joint filler shall be manufactured of natural bonded cork or other approved material which remains serviceable when wet. Joint filler shall be cut and trimmed accurately to suit the joint profile and shall be maintained accurately in position by means of an approved adhesive. The compressibility of the filler shall be such that it can be compressed to 50% thickness with a pressure of not less than 0.07 N/m square and no greater than 0.4 N/mm square. After 50% compression, the material should recover to at least 70% original thickness within 30 minutes. On no account shall fibreboard or similar be used as filler.

Joint sealing compounds shall be approved polysulphide based compounds suitable for sealing joints in horizontal and vertical/sloping concrete surfaces as appropriate. Sealing compounds shall be applied strictly in accordance with the manufacturer's instructions and shall completely fill the joint recess. Surface primers shall be from the same manufacturer as the sealants themselves. Joint sealing compounds shall be entirely suitable for contact with potable water where these are used in water retaining structures.

Waterstop shall be located and maintained accurately in position and details of the proposed method of fixing shall be submitted to the Project Manager for approval. On no account shall waterstop be secured by nails or by any other means involving puncture of or damage to the waterstop material unless purpose made nailing flanges are incorporated in the design of the waterstop.

(v) Slip Membrane

The slip membrane shall be "slipstrip" as supplied by Serviced Limited, Ajax Avenue, Slough, Berkshire, UK or similar approved material. The slip membrane shall be not less than 1.5 mm thick and shall be a plastic preformed strip with low coefficient of friction specifically manufactured for use as a separating membrane in sliding joints between concrete surfaces. Each sliding joint shall comprise two layers of the membrane unless otherwise shown on the drawings.

The concrete surface to which the slip membrane is to be fixed shall be finished with a steel float to provide a smooth true surface free from dust and loose particles.

(vi) Expandafoam

Expandafoam shall be as supplied by Expandite Limited, 1-9 Chase Road, London, NW10 6PS, UK or similar approved material. Expandafoam is a closed cell flexible polyethylene joint filler used where a readily compressible low load transfer joint filler is required. Expandafoam shall be fixed in position using a suitable adhesive.

305.11 Finishes - General

All exposed faces of concrete unless otherwise specified shall be hard, smooth and free from honeycombing, air and water holes and other blemishes.

All projecting imperfections shall be rubbed down with carborundum stone or by other approved means and grit and dust therefrom shall be thoroughly washed off with clean water.

Surface Finishes

(a) Wood float finishes shall be formed by smooth floating the accurately levelled and screeded surface. Care shall be taken to ensure that the concrete is worked no more than is necessary to produce a uniform surface free from screed marks.

(b) Steel trowel finishes shall be formed while the concrete is still wet by means of a steel trowel applied to an accurately levelled and screeded surface (see also Clause 307).

(c) Granolithic finishes shall conform to the recommendations laid down in "Specification for Granolithic floor toppings laid in-situ concrete", as published by the UK Cement and Concrete Association with special reference to monolithic construction.

(d) Screeded finishes shall be formed by levelling and screeding the concrete to produce a uniform, plain or ridged surface as specified; surface hardners shall be applied strictly in accordance with the manufacturer’s recommendations.

(e) Bush-hammered or pattern-worked finishes.

When exposed aggregate is to be the surface texture, the Contractor shall ensure that a uniform distribution of the coarse aggregate takes place at the face. The formwork shall be removed as soon as possible from the face to be treated; the surface shall be thoroughly wetted and wire brushed, and bush-hammered or pattern-worked as and when instructed. Surface retarders shall be used only when permitted by the Project Manager.

Bush-hammering or pattern-working shall not be relied upon to obscure any defects in the concrete face which arise from formwork imperfections.

Making Good

On no account shall any faulty honeycombed or otherwise defective concrete be repaired or patched until the Project Manager has made an inspection and issued instructions for the repair.

Honeycombed or damaged surfaces of concrete, which in the opinion of the Project Manager, are not such as to warrant the cutting out and replacement of the concrete, shall be made good as soon as possible after removal of the formwork as follows:-

1:1.5 Portland Cement and sand mixture shall be worked into the pores over the whole surface with a fine carborundum float in such a manner that no more material is left on the concrete face than is necessary to fill the pores completely so that a uniformly smooth and dense surface of uniform colour is finally presented.

Removal and Replacement of Unsatisfactory Concrete

The Contractor shall on the Project Manager's instructions to do so cut out and replace any concrete in any part of the structure if in the Project Manager's opinion:-

(a) the concrete does not conform to the Specification, or

(b) deleterious materials or materials which are likely to produce harmful effects have been included in the concrete, or

(c) the honeycombed or damaged surfaces are too extensive, or

(d) the finished concrete sizes are not in accordance with the drawings within permissible tolerances, or

(e) the setting-out is incorrect, or

(f) the steel cover has not been maintained, or

(g) the protection, including curing, of the concrete during the construction was inadequate, resulting in damage, or

(h) the work of making good or other remedial measures the Project Manager may indicate are not carried out to his satisfaction, or

(i) undue deformation of or damage to the works has taken place due to inadequate formwork, or to premature traffic or to excessive loading, or

(j) any combination of the above points has taken place resulting in unsatisfactory work.

306 Testing

306.1 Sampling and Testing - (see also Clauses 301 and 302)

The Contractor shall provide on the Site equipment, staff and labour for carrying out the sampling and testing outlined in columns 3 and 4 of Table 3.8, and he shall carry out any or all of these tests at such times and with such frequency as may be requested by the Project Manager.

All equipment shall be calibrated and checked from time to time by an approved agency, as the Project Manager may require.

The Contractor shall provide all samples required by the Project Manager. Those samples to be tested in an offsite laboratory shall be carefully forwarded by the Contractor to an approved laboratory. Results of laboratory and site tests shall be kept on site and copies of all test reports shall be forwarded in duplicate to the Project Manager.

Each cube shall be marked with a distinguishing number (numbers to run consecutively) and the date, and a record shall be kept on Site giving the following particulars:-

(a) Cube No.

(b) Date and time made

(c) Temperature and weather conditions

(d) Location in work

(e) 7-day Test

Date :

Strength

(f) 28-day Test

Date :

Strength

Cubes shall be forwarded, carriage paid, to an approved Testing laboratory in time to be tested two at 7 days and two at 28 days. No cube shall be dispatched within 3 days of casting.

Authentic copies of all Work Test results shall be forwarded to the Project Manager directly from the testing laboratory and one shall be retained on the site. The test certificates shall indicate all properties as required by BS 1881.

The Contractor must allow in his rates for concrete test cubes for all expenses in connection with the preparation and conveyance to the Testing Laboratory and testing of test cubes and no claim in respect

of his failure to do so will be entertained.

Any batch of concrete which fails to achieve the required characteristic strength shall be removed and made good in accordance with this Specification. The Contractor shall carry out all such work at his own cost.

Frequency of tests and the number of samples required will be governed by the results of the previous tests, the quality of the materials revealed during the tests, and the uniformity of that quality (see Clause 302). Should it become evident that the quality of concrete is deteriorating the Project Manager may require additional samples to be taken and test cubes to be made and tested to determine the cause.

306.2 Loading Tests

The Project Manager may direct that a loading test be made on the works or any part thereof if he deems such test to be necessary for one or more of the following reasons:-

(a) failure of "Site Cubes" to attain the strength requirements of Clause 302;

(b) premature removal of formwork;

(c) overloading of structure during construction;

(d) improper compaction and/or curing of concrete;

(e) any other circumstances attributable to alleged negligence on the part of the Contractor, which, in the opinion of the Project Manager, may result in a structure being of less than the required strength;

If the loading test is ordered to be made solely or in part for reasons (a) to (d) the test shall be made at the Contractor's own cost.

If the loading test is ordered to be made for reason (e), the Contractor shall be reimbursed for the cost of the test if the result is satisfactory. No extensions to the Contract Duration shall be granted for delays and disruption resulting from these tests.

Loading test shall be carried out in accordance with the requirements of BS 8110 – 2 Section 9.

If the results of the test are not satisfactory, the Project Manager will direct that the part of the work concerned be taken down or removed and reconstructed to comply with the Specification, or that such other remedial measures as he may think fit be taken to make the work acceptable and the Contractor shall carry out such work at his own cost.

Table 3.8 Sampling, Testing and Acceptance Standards

Materials	Test	Site Sampling	Testing	Accepted Standards	Remarks
1	2	3	4	5	6
Cement	Ordinary Portland Rapid Hardening Sulphate Resisting		BS 4550	BS 12 BS 12 BS 4027 KS1725	Manufacturer's Test Certificate
Aggregates	Description and Classification		BS 812 Sec 2	BS 882	
	Particle Size	BS 812 Sec 1	BS 812 Sec 3	BS 882	
	Particle Shape	BS 812 Sec 1	Visual and BS 812 Sec 3		Mix
	Specific Gravity	BS 812 Sec 1	BS 812 Sec 3		Design
	Density	BS 812 Sec 1	BS 812 Sec 3		Requirements
	Voids	BS 812 Sec 1	BS 812 Sec 4		
	Absorption	BS 812 Sec 1	BS 812 Sec 4	BS 8007 Cl 6.2.2	See Freeze-thaw Test in this table
	Organic Impurities	BS 812 Sec 5			
	Moisture Content	BS 812 Sec 5			For adjustment of added water for concrete making
	Mechanical Properties	BS 812 Sec 6	BS 882		Ten per cent fines value
Water	Suitability	BS 3148	BS 3148	BS 3148	Not required for potable water
Concrete	Compacting Factor	BS 1881 Pt 101	BS 1881 Pt 103		Workability Test
	Slump		BS 1881 Pt 102		
	Crushing		BS 1881	BS 5328, BS 8110	Cube test

Materials	Test	Site Sampling	Testing	Accepted Standards	Remarks
1	2	3	4	5	6
	Water Absorption		BS 1881 Pt 122	BS 7263	Precast concrete Clause 308
	Freeze-thaw	BS 1881	BS 812 Sec. 1		Durability test for aggregate not complying with moisture absorption requirements of BS 5337 Cl. 21.2
	Electrolytic Efflorescence				As required for salt-containing aggregate or saline water
	Cores	BS 1881 Pt 6 BS 1881 Pt 120	BS 1881 Pt 6 BS 1881 Pt 120	BS 1881 Pt 120 with ref to concrete strengths this Specification	See Clause 306
Admixers	Compatibility with cement	As required by Laboratory			Tests to be carried out by independent Laboratory as required

The Project Manager may also instruct the Contractor before a loading test takes place to take out cylindrical core specimens from the structures concerned and have them tested. The cutting equipment and the method of doing the work shall be to the Project Manager's approval. The specimens shall be dealt with in accordance with BS 1881. Prior to testing, the specimens shall be available for examination by the Project Manager. If the cores are ordered to be taken solely or in part for reasons (a) and (d) above, the work involved and the testing shall be made at the Contractor's own cost. If the cores are to be taken for reasons (b), (c) and (e) above, the Contractor will be reimbursed the cost if the loading test described in the previous paragraphs proves satisfactory.

307 Special Concrete

307.1 No-fines Concrete

No-fines concrete for use in subsoil drainage shall consist of a 1:8 cement/aggregate mix by volume. Aggregate shall be 20 mm to 10 mm graded with no more than 5% passing the 10 mm sieve. Only sufficient water shall be added to ensure complete coating of the aggregate. One half of this water shall be placed into the mixer first, after which the aggregate and cement shall be admitted. After partial mixing the balance of the water shall be added until a consistency of mix is achieved.

Preliminary tests shall be carried out on the site to prove the suitability of the finished concrete, and adjustments made to the proportions and or grading as may be required by the Project Manager.

307.2 Air-Entrained Concrete

Concrete for roads and those structures where specified, shall include an approved air-entraining agent capable of producing a 5% air-entrainment with a tolerance of 0.5% (Clause 302).

The mix shall be purposely designed, having regard for the nature of grading of the aggregates and air-entraining agent being used.

Preference shall be given to the use of air-entraining agents which can be administered in fixed calibrated amounts through a dependable mechanical dispenser or sachet, and which are added to the mixing water.

Frequent air meter tests shall be carried out and the consistency of the air-entrainment maintained to the above tolerances by adjustments in the mix, as may be necessary.

307.3 Concrete in Benching

Concreting for benching in manholes, pumping stations and works structures shall consist of Grade C25P concrete unless otherwise specified. It shall be placed with low workability to the approximate shape required and, while still green, shall be finished with not less than 50 mm of Grade C25P concrete to a steel trowelled finish and to the contours indicated on the drawings.

307.4 Ready Mixed Concrete

Unless otherwise stated the relevant clauses of BS 5328 shall apply.

Ready mixed concrete shall only be used with the prior approval of the Project Manager. The Contractor shall not be relieved of his obligation to provide concrete to the standard laid down in this Specification by virtue of any approval given for the use of concrete supplied by others, and the Project Manager reserves the right to withdraw his approval at any time consequent on any deterioration in the quality of the Concrete, or unsatisfactory delivery or any other reason he considers detrimental to the Works.

Ready mixed concrete manufactured off the site shall be transported in a revolving drum and shall be continuously agitated until it is used in the work unless otherwise approved. The time interval between adding water to the drum and placing shall not exceed 90 minutes. The time interval between completion of mixing and placing shall comply with Clause 305.

307.5 Granolithic Concrete

Refer to Clause 305.

307.6 Pneumatically Applied Mortar (Gunite)

(i) Requirements

The pneumatic application of mortar shall be carried out only by Contractors experienced in this type of work and who are in possession of proper Plant and equipment. Nozzlemen employed on the works shall be skilled operators.

The finished product shall be dense, of even texture and colour, and to the requirements of strength, tolerance and finish set out in this Specification.

(ii) Strength

After curing, the mortar shall be capable of producing cored samples with a 28-day characteristic strength of not less than 27.5N/mm2.

(iii) Materials

Sand, cement and water shall comply with the requirements of Clause 302 of this Specification except that the sand shall conform to the grading of Zone 2 of BS 882.

(iv) Proportions

The proportions to be used in the mix shall be determined with reference to the requirements outlined in sub-clause 307(i) and the mix shall be not weaker than one part of cement to four parts of sand by volume,

having regard to the adjustments for bulking of the sand.

(v) Operation

Air and water pressures shall be such as to permit the proper application of the mortar, and shall be determined with reference to hose lengths and nozzle diameter.

Mortar rebound, recovered, cleaned and uncontaminated with extraneous matter, may be re-used but not for water-retaining structures. It shall be regarded as an equivalent volume of sand which shall not exceed 20 per cent of the total sand requirement. Rebound which has lodged in the formwork or between reinforcement shall be removed by compressed air.

Reinforcement shall be completely embedded in the mortar by the proper direction of the nozzle and the mortar shall be applied as a steady and uninterrupted flow from the nozzle.

Mortar application shall be discontinued at any section of the work where sagging of the mortar is in evidence.

(vi) Joints

These shall be formed by sloping the surface to a thin edge. Before applying new mortar, the surface shall be thoroughly wetted. Laitance shall be removed by the initial discharge of fresh mortar.

(vii) Tolerances

The thickness of applied mortar shall be not less than the dimensions shown on the Drawings nor greater than 10 mm over those dimensions, unless otherwise indicated on the Drawings or otherwise permitted.

(viii) Protection and Curing

Shall be carried out in accordance with the requirements of Clause 305.

(ix) Finishes

Unless otherwise specified all surfaces shall be brought to a granular textured finish by means of a wooden float.

(x) Cold Weather Work

No application of mortar shall be made against frozen surfaces nor when the air temperature is below 5oC.

(xi) Making Good

Any defective work shall be cut out immediately and made good with fresh mortar pneumatically applied.

307.7 Cement Grouts

Cement grout shall be mixed in the relevant proportions indicated in the following table using the minimum quantity of water to ensure the necessary fluidity and to render it capable of penetrating the work.

Class	Nominal Mix by Mass	
	Cement	Sand
G1	1	-
G2	1	3
G3	1	10

Cement grout shall be used within one hour of mixing, except where containing a retardant admixture.

307.8 Pumped Concrete

Where pumping of concrete is permitted to be used no relaxation of the requirements of this Specification will be permitted. Particular attention shall be paid to the proper grading of aggregates to prevent bleeding and/or segregation during the pumping operations. The inclusion of water-reducing additives or other materials, including flash, to improve the flow characteristics of the concrete will only be permitted where it can be shown that they do not adversely affect the concrete either in the plastic phase or in the finished work.

308 Precast Concrete Units

308.1 Requirements

Unless otherwise agreed in writing by the Project Manager, all precast concrete units shall be manufactured on site and shall be true to dimension and shape, with true arises and with perfectly smooth exposed faces free from surface blemishes, air holes, crazing and other defects, whether developed before or after building-in. They shall comply with the appropriate BS. (Note: Coping blocks and similarly exposed units are particularly susceptible to crazing when the concrete is manufactured using high water/cement ratios)

The maximum size of coarse aggregate in precast concrete shall not exceed 20 mm except for thicknesses less than 75 mm where it shall not exceed 10 mm.

The compacting of precast concrete shall conform with requirements given elsewhere in this Specification except for thin slabs where use of immersion type vibrators is not practicable. The concrete in these slabs may be consolidated on a vibrating table or by any other methods approved by the Project Manager.

Steam curing of precast concrete will be permitted. The procedure for steam curing shall be subject to the approval of the Project Manager.

The precast work shall be made under cover and shall remain under the same for seven days. During this

period and for a further seven days the concrete shall be shielded by sacking or other approved materials kept constantly wet. It shall then be stacked in the open for at least a further seven days to season before being set in position. Where steam curing is used these times may be reduced subject to the approval of the Project Manager.

Precast concrete units shall be constructed in individual forms. The method of handling the precast concrete units after casting, during curing and during transport and erection shall be subject to the approval of the Project Manager, providing that such approval shall not relieve the Contractor of responsibility for damage to precast concrete units resulting from careless handling.

Repair of damage to the precast concrete units, except for minor abrasions of the edges which will not impair the installation and/or appearance of the units, will not be permitted and the damaged units shall be replaced by the Contractor at his own expense.

Except where precast work is described as “fair face” or as having “exposed aggregate” or terrazzo finish the moulds shall be made of suitable strong sawn timber true in form to the shapes required. Unless otherwise described, faces are to be left rough from the sawn moulds.

Where precast work is described as “fair face” the moulds are to be made of metal or are to have metal or plywood linings or are to be other approved moulds which will produce a smooth dense fair face to the finished concrete suitable to receive a painted finish direct and free from all shutter marks, holes, pittances, etc. Where precast work is to have an “exposed aggregate” or terrazzo finish the moulds shall be constructed to the requirements given for moulds for “finished fair” work.

The method of achieving the exposed aggregate finish shall be “aggregate transfer” or other approved method.

308.2 Kerbs

Precast concrete kerb shall conform to BS 7263: Part 1: 1990, except that coarse aggregate shall conform to BS 882: 1983. Fine aggregate shall consist of sand resulting from the natural disintegration of rock.

Approved air-entraining agents may be permitted to be used providing that approved adjustments are made to the mix with regard to water and fine aggregate proportions (Clause 302). In such cases the moisture absorption limits set out in BS 340 may be neglected subject to the concrete satisfying the freeze thaw test laid down under the heading "Weir Blocks and Sills".

308.3 Paving Slabs

Paving slabs shall conform to BS 368 and shall be 50 mm thick unless otherwise specified.

308.4 Other Blocks

Blocks used for building work and filter bed walls shall conform to BS 6073: Part 1: 1981.

308.5 Wall Units

L-shaped wall units shall conform to the requirements of BS 8110. Where it is not intended to use coping blocks for the protection of the upper exposed surface of the units, the uppermost 150 mm, for the full width of the unit, shall be formed with concrete composed of aggregate complying with BS 882: 1992. Such concrete shall be formed integrally with the main body of the concrete.

308.6 Other Items

Manhole ring units, tapers, cover slabs, segments and concrete pipes are referred to under their particular heading.

309 Site Books And Standards

309.1 Instructions to be Recorded

The Contractor shall provide and keep permanently on the Site a numbered triplicate book wherein the Contractor shall record all instructions relating to concrete work issued by the Project Manager. One copy of every entry therein shall be sent to the Project Manager on the same day as the entry is made.

309.2 Site Diary

The Contractor shall provide and keep permanently on the Site a continuous entry diary wherein the Contractor shall record details of formwork, construction, placing of reinforcement, concreting and curing operations, striking of formwork, making good and daily temperature and weather conditions. This diary shall always be available for inspection by the Project Manager.

309.3 Copies of Standards and Codes

The Contractor shall provide and keep permanently on the Site copies of the following Standard Codes of Practice:-

BS 812
BS 882
BS 1881
BS 4466
BS 5328
BS 5628
BS 8007
BS 8110
KS1725

The Contractor shall in addition provide and keep permanently on the Site copies of such other Standards, Codes, Notes and Specifications as may be required by the Project Manager.

310 Water Retaining Structures - Special Clauses

Note: In the event of any differences between the "Special Clauses" and the previous Specification under Section 2.3 the provisions of these "Special Clauses" shall have precedence.

310.1 Making Good

The cement mortar used in filling recesses in the concrete formed by bobbins in connection with formwork shall contain an approved expanding admixture.

310.2 Construction Joints in Water Retaining Structures

In water retaining structures PVC waterstops not less than 130 mm wide manufactured by an approved manufacturer shall be built into all construction joints in external walls and construction joints in roofs of potable water retaining structures. Construction joints shall be formed at positions agreed by the Project Manager.

The cost of forming construction joints shall be included by the Contractor in his general concrete rates.

310.3 Watertightness of Structures

The Contractor shall be solely responsible for the watertightness of structures and any remedial measures necessary.

310.4 Hydrophilic Rubber Sealer

Hydrophilic rubber sealer shall be co-extruded from chloroprene and hydrophilic rubbers into a cellular strip approximately 25 mm x 7 mm thick which expands as it absorbs water. The strip shall incorporate an expansion delay coating to prevent activation during setting of the surrounding concrete.

Hydrophilic rubber sealer shall be applied to the perimeter of all pipes to be built into concrete structures, to existing concrete walls and slabs at or below water levels which have been demolished and require extension, and to other locations as indicated on the Drawings.

The strip sealer shall be bonded to the pipe diameter or on to the face of demolished structures on to which new concrete is to be placed so as to be at least 100 mm from the wall surface. Where dowel bars are incorporated in bonding new concrete to old, the sealer shall be placed above the dowel bars on the "wet" side of the structure. Bonding shall be accomplished using proprietary neoprene or epoxy adhesives to ensure the sealer is not disturbed during placement of the concrete.

The sealing strip shall be from an approved supplier and application shall be strictly in accordance with the

manufacturer's recommendations.

310.5 Waterproof Membranes for Concrete Roofs and Gutters

Concrete roofs and gutters shall be waterproofed by the provision of a membrane to be laid on top of the slab. The membrane shall be a cold applied preformed waterproof laminated layer comprising a HDPE carrier film with a solar reflective surface and a self-adhesive rubber bitumen compound complying with the requirements of BS 8102. The membrane shall exhibit a tear resistance of at least 250 N/mm when tested in accordance with ASTM D1004. Adhesion to primed concrete to itself shall exceed 1.75 N/mm when tested in accordance with ASTM D100, and a puncture resistance of 290 N 65 mm when tested in accordance with ASTM E154. Membranes shall exhibit a water resistance of not more than 0.14% after 24 hours when tested in accordance with ASTM D574. The contractor shall submit proposals for waterproof membranes for approval, together with manufacturer’s catalogues and technical literature.

Waterproof membranes shall be installed entirely in accordance with the manufacturer's instructions. Membranes shall be continued up the internal face of the parapet wall and finished centrally under the coping. Adjacent strips of membrane shall be overlapped to provide a waterproof joint. The provision of a waterproof membrane on the roof slab shall not relieve the Contractor of his responsibilities to produce a waterproof roof slab which shall have successfully passed a watertightness test before the membrane is installed.

Section 4 Pipelines, Pipework

401 General

401.1 Equivalency of Goods, Materials and Plant

Wherever reference is made in the Contract, including Specifications, Drawings and Bill of Quantities, to specified manufacturers or suppliers for the supply of goods, materials and plant for the Works, goods, materials and plant from alternative manufacturers and suppliers will be permitted, unless otherwise expressly stated in the Contract, providing these other goods, materials and plant are substantially equal or of a higher quality than those of the specified manufacturer or supplier and are approved in writing by the Project Manager. Differences between the specified goods, materials or plant and the proposed alternative shall be described in writing by the Contractor and submitted to the Project Manager, together with such manufacturer's or supplier's technical literature and samples as the Project Manager may reasonably require. At least 28 days prior to the date when the Contractor desires the Project Manager's consent. In the event the Project Manager determines that such proposed alternative goods, materials or plant do not ensure substantially equal or higher quality, the Contractor shall obtain the goods, materials or plant from the manufacturer of supplier specified in the Contract.

401.2 Materials

Any material which will come into contact with potable water or water to be used for potable supply shall comply with the UK regulations on the use of materials for potable water supply. Water Supply (Water Quality) Regulations 1989 and 15th Statement of the Department of Environment Committee on Chemical and Materials of Construction for use in public water supplies and swimming pools, published by the Department of the Environment, UK or national standards adopted for use in Kenya.

401.3 Approval

As soon as possible after commencement of the Contract, the Contractor shall submit to the Project Manager for his approval a list of his proposed suppliers, sources of materials and proposed standards. No materials, plant or equipment shall be procured for the Contract without first obtaining the Project Manager's approval. Samples of materials shall be submitted to the Project Manager for approval as required by the Project Manager. Materials subsequently supplied shall conform to the quality of the samples which have been approved by the Project Manager. No standards, method of manufacture or specification shall be changed without the approval of the Project Manager. Where possible, plant shall be supplied to the same standards or to compatible standards.

The Contractor shall provide secure storage for all samples submitted to the Project Manager.

401.4 Dimensions

Plant and materials shall be supplied to the general arrangements and dimension, or to suit the dimensions, shown on the Drawings or otherwise indicated in the Contract. Where no such dimensions are shown the Contractor shall be responsible for sizing the Plant. Any redesign, extra design, additional construction or any other costs resulting from the use of Plant to other arrangements or to other dimensions shall be the responsibility of the Contractor.

401.5 Packaging and Protections

All items shall be adequately crated or packaged to withstand damage and prevent deterioration due to shipping, handling and storage. The methods of protection and shipping shall be to the approval of the Project Manager.

401.6 Marking

All Plant shall be marked in accordance with Clause 5 of BS EN 545 and Clause 37 of BS 5163. Before shipping, all items shall be clearly marked. Crates or packages shall be marked on two sides with indelible paint with the name of the project, the Employer and the Contract number shall bear marks indicating the contents.

401.7 Receipt, Storage, Handling and Transportation

Plant, equipment and materials shall be stored in such a manner as to preserve its quality and condition to the standards required by the Contract. The Project Manager shall refuse to accept or shall reject any materials of Plant that in his opinion is defective or otherwise fails to comply with the standards required by the Contract. All such defective items shall be removed from the Site as directed by the Project Manager. Repairs shall be carried out in accordance with procedures approved by the Project Manager and shall be completed to the Project Manager's satisfaction.

401.8 Manufacturer's Certificates

The Contractor shall furnish the Project Manager with a manufacturer's certificate conforming compliance to the specification in respect of all items of Plant, equipment and materials. The original and one copy of the manufacturer's certificate shall be delivered to the Project Manager not later than 14 days prior to the intended date of delivery of the item to Site.

401.9 Proprietary Materials

Proprietary materials shall be supplied in suitable containers and in appropriate batch sizes for the work to be undertaken. The containers shall be marked with the following information:

i. Storage instructions
ii. The manufacturer's name
iii. Shelf life and dates of manufacture
iv. Material identification
v. Batch reference number
vi. Net weight
vii. Mixing instructions
viii. Any warnings or precautions concerning the contents and their safe use.

The Contractor shall supply with each consignment of proprietary material delivered to the Site, certificates furnished by the manufacturer or his agent stating:

i. The manufacturer's name and address
ii. The agent's name and address where applicable
iii. Material identification

iv. Batch reference numbers, size of each batch and the number of containers in the consignment
v. Date of manufacture.

401.10 Rejected Materials

Should any item of plant, materials or manufactured articles be in the judgment of the Project Manager, unsound or of inferior quality or in any way unsuited for the purpose in which it is proposed to employ them, such items, materials or manufactured articles shall not be used upon the Works but shall be branded, if in the opinion of the Project Manager this is necessary, and shall forthwith be removed from the Site.

402 Samples and Storage of Materials

Where required by the Project Manager the Contractor shall submit to the Project Manager for approval samples of pipes, fittings and materials prior to procurement. The Contractor shall only store pipe, fittings and other material at places approved by the Project Manager and shall at all times provide adequate supervision and watchmen to prevent theft or damage. Any loss or damage incurred will be the Contractor's responsibility.

Pipes shall not be stacked higher than recommended by the manufacturer. The area on which the pipes are to be stacked shall be free draining, the grass or other vegetation shall be kept cut and suitable timber cradles shall be provided on which the pipes shall be laid. End stops to all stacks shall be provided.

Fittings and valves shall not be stacked more than one tier high and they shall be supported off the ground by suitable timbers.

Air valves, rubber joint rings, gaskets, bolts and similar fittings and materials shall be kept in approved locked premises and such fittings and materials shall not be distributed to the trench side until immediately prior to laying, fitting, jointing or assemble thereof. All rubber joint rings and gaskets must be stored in a cool damp location and all fittings and materials shall at all times be stored in the shade under cover and protected from the weather to the satisfaction of the Project Manager.

403 Flanges

Flanges shall be faced and drilled to conform to the dimensions specified in BS 4504. Flanges shall be compatible with the pressure rating of the adjacent pipework or as stated on the drawings. Bolts, nuts and washers (two washers per bolt) shall be to BS EN 1092-3; 2003. No bolt shall project less than two full threads beyond its nut after tightening. In no circumstances shall the shortening of excessively long bolts by cutting be allowed.
Gaskets shall comply with replaced by BS EN 1514 (1997) and replaced by BS EN 681-2 (200) and BS 681-1 (1996) Type W. Flanges shall be painted with two coats of epoxy resin paint. Puddle flanges shall be fitted to all pipework passing through water-retaining structures and manholes greater than 2.5m deep.

404 Mechanical Couplings

Unless otherwise specified or shown in the Drawings pipes and fittings shall be supplied with flexible joints. Mechanical couplings shall be of the Dresser, Viking Johnson type without a centre register. Joints rings used shall be of the ethylene propylene rubber (EPDM) or other material approved by the Project Manager. All mechanical couplings and flange adapters including nuts, bolts and washers shall be supplied with

'Rilsan' nylon thermoplastic polyamide applied by fluidized bed dipping or similar approved.

405 Materials for the Assembly of Flexible Joints

Lubricant shall be of a kind not conducive to the growth of bacteria and shall have no deleterious effects on either the joint rings or pipes. Lubricants for water supply shall not impart to water, taste, colour, or any effect known to be injurious to health.

406 Ductile Iron Pipes

406.1 General

Ductile iron pipes and fittings for water supply shall comply with BS EN 545 (1995). Pipes and fittings shall have spigot and socket joints unless otherwise specified. Pipes shall be class K9. Spigot and socket flexible joints shall be of the push-fit type with gaskets of ethylene propylene rubber (EPDM). The Contractor shall supply 5% of the straight pipes suitable for cutting on site and these shall be clearly marked.

406.2 Corrosion Protection

Pipes and fittings shall be protected externally with an extruded polyethylene or polyurethane coating complying with DIN 30674 Part 1. Pipes and fittings shall be lined internally with centrifugally applied cement mortar and complying with DIN 30674. Joint areas shall be coated with epoxy or polyurethane to DIN 30674. All lining and coating materials shall be approved for contact with potable water by an internationally recognized body like the Drinking Water Inspectorate of UK.

407 Galvanised Steel Pipes

Galvanised steel pipes shall be medium duty manufactured to BS 1387.

408 Steel Pipes

408.1 General

Steel pipes shall be manufactured to BS EN 10224 or AWWA C200 and shall be suitable for the pressure ratings required by the Contract. Fittings shall conform dimensionally to BS EN 10224, AWWA 208-59 or AWWA M11. Unless otherwise specified or necessary to meet the requirements of the Contract steel pipes shall be manufactured as follows:

a) DN300mm and below shall be manufactured to minimum of Grade L235 or API 5L Grade B
b) DN350mm and above shall be manufactured to a minimum of Grade L275 or API 5L Grade X42.

The pipes and fittings of diameter 600mm or less shall be supplied with push-fit spigot and socket type joints with integral gasket of EPDM rubber or similar to BS EN 10224 or BS CP 2010. Pipes greater than 600mm shall be supplied with ends cut square suitable for use with flexible couplings and the external weld ground back sufficiently.

The Contractor shall supply 5% of the straight pipes as half length pipes (not exceeding 6m).
Each pipe shall be supplied complete with a coupling for jointing.

408.2 Corrosion Protection

Steel pipes and fittings shall be protected externally at the manufacturer's works with fusion bonded epoxy resin in accordance with AWWA C213. Pipes greater than 600mm and all fittings shall also be lined

internally with fusion bonded epoxy to AWWA C213. Pipes 600mm or less shall be lined with cement mortar to AWWA C205 or BS EN 10298. All lining and coating materials shall be approved for contact with potable water by an internationally recognized body like the Drinking Water Inspectorate of UK.

Where required by the Bills of Quantities, the Supplier shall also price for the provision of an alternative 3LPE coating to DIN 30670 or AWWA C215 of a triple wrap system of fusion bonded or sprayed epoxy primer, an intermediate polymer adhesive layer and an extruded high density polyethylene coating in general conformance with ISO/DIS 21809-1 Class B as appropriate.

409 Glass Reinforced Plastic (GRP) Pipes and Fittings

Glass reinforced plastic (GRP) pipes and fittings for pressure water supply shall be high stiffness and shall comply with the relevant provision of BS 5480. The minimum pipe stiffness shall be 5,000 N/m2.

Pipes and fittings shall be marked in accordance with Clause II g. BS 5480.

Pipes shall only be cut by techniques which can be shown not to impair the pipes pressure regression performance. Where any pipe is cut the exposed fibres at the cut pipe end shall be resealed to prevent potential long term degradation. Methods of cutting and resealing exposed fibres shall be submitted to the Project Manager for Approval. Elastomeric sealing rings and foils shall comply with BS EN 681.

On delivery to site and immediately prior to installation each pipe shall be visually inspected both externally, and where possible, internally for damage such as star cracking of the gel coat layer. Where any damage extends through the pipe wall the pipe shall be rejected or the damaged section cut out and replaced in accordance with repair methods approved by the Project Manager. If in the Project Manager's opinion the pipe is not suitable of repair it shall be rejected and removed from site.

410 uPVC Sewers and Pressure Pipes and Fittings

Unplasticised PVC pipes and fittings for water supply pressure pipes shall comply with British Standards 3505 current but also superseded by BS EN 1452 and 4346. They shall be obtained from an approved manufacturer and shall be minimum pressure rated (12 bars) unless otherwise stated.

Unplasticised PVC pipes and fittings for gravity sewers and drains shall comply with British Standards 4660 or 5481 and shall be obtained from an approved manufacturer. Restrained rubber ring type push fit flexible joints shall be used unless otherwise stated. Solvent weld joints will not normally be permitted. Pipes and fittings shall be protected from the direct rays of the sun at all times by means of reflective cover sheets.

411 Concrete Pipes, Bends and Junctions

Concrete pipes, bends and junctions for use in sewers shall be made with sulphate-resisting cement. Pipes, bends and junctions shall conform to the requirements of BS 5911 for the particular class of pipe required to be used. The internal dimensions shall be true and regular and the internal surface smooth and free from surface blemish. The actual diameter of the pipe shall be not less than the nominal diameter. All joints shall be of the gasket type with flexible spigot and socket approved by the Project Manager. Gaskets shall be elastomeric complying with BS EN 681.

The main pipe and branches of all junctions shall be of the same strength classification and shall have the same internal dimensions as the pipes with which they are to be used.

The pipes, bends and junctions delivered to the Site shall be certified by the pipe manufacturer to have complied with BS 5911, or other approved standard and one copy of the certificate shall be delivered to the Project Manager before the goods are unloaded.

Unless otherwise specified pipes are required to be of Extra Strength; they may, unless otherwise specifically called for, be reinforced either with cast-in steel or by an external wrapping of fibre glass and resin, applied by an approved manufacturer.

The Contractor shall provide all facilities for and shall carry out jointly with the Project Manager (if so required) a full visual inspection of all pipes, bends and junctions for manufacturer's defects and other faults or damage. Before any pipe, bend or junction is laid it shall again be carefully examined and sounded with a wooden mallet. Any pipe found to be cracked or otherwise defective shall not be used on the Works.

Concrete pipes shall be internally coated with a 100 percent solids coal tar epoxy lining 70 percent minimum epoxy content. Coat thickness 300 micron minimum.

412 HDPE Pipes and Fittings

412.1 General

Polyethylene pipes up to nominal size 63mm for below ground use shall be coloured blue and comply with the relevant provisions of BS 6572. Polyethylene pipes for use in nominal diameters greater than 63mm shall be as specified below.

The pipes shall be clearly and indelibly marked to show the name of the manufacturer, diameter, pressure class and date of manufacture.

House connection pipework downstream of the manifold shall be PE80; all other HDPE pipework shall be PE100.

412.2 Compound Material

The material from which the pipes are made shall be in accordance with ISO 4427-1. All pipes shall be manufactured using pre-compounded carbon black, bimodal, high density polyethylene MRS 10.0 material (PE100). The use of natural PE100 with a Carbon black master batch is strictly not allowed.

Carbon black should be well dispersed to give outstanding UV resistance, and should have a minimum carbon content of 2%. Pipes should be manufactured from certified PE100+ material with batch certification available with pipe delivery.

412.3 Identification compound

The compound used for identification stripes shall be manufactured from a PE polymer manufactured from

the same type of base polymer as used in the compound for pipe production.

412.4 General appearance

When viewed without magnification, the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities and other surface defects such as would prevent conformity of the pipe to ISO 4427. The pipe ends shall be cut cleanly and square to the axis of the pipe.

412.5 Color

The pipes shall be black with coloured identification stripes.

412.6 Dimensions

The dimensions of the pipe shall be measured in accordance with ISO 3126. Manufacturing shall be to ISO 4427 Standard, as per the approved dimensions chart.

Pipes should be manufactured in machinery capable of ultrasonic wall thickness detection with production reports provided with delivery of pipes. Where coiling is possible, the minimum internal diameter of the coil shall not be less than 18d.

The lengths shall be supplied to minimize the number of joints to be done in the field, and the size that is allowed to be legally transported on Kenyan roads by the traffic department.

412.7 Markings

All pipes shall be permanently and legibly marked in such a way that the marking does not initiate cracks or other types of failure and such that normal storage, weathering, handling, installation and use does not affect the legibility of the marking.

The colour of the printed information shall differ from the basic colour of the product. The marking shall be such that it is legible without magnification. The frequency of marking shall not be less than once per metre. Markings should be made using a hot embossed foil stamp printing.

Each pipe shall a minimum of 3 equispaced blue longitudinal stripes indicating medium of fluid transported in the pipes. A summary of marking requirements are given in the table below.

Minimum required marking

Aspect	Markin
Standard Number	ISO 4427
Manufacturer's identification	Name or symbol
Dimensions (dn × en)	e.g. 125X11.4
SDR series (for DN > 32)	e.g. SDR 11
Material and designation	PE 100
Pressure rating in bar	e.g. PN 16
Production period (date or code)	e.g. 0204[a]
Country of Production	Kenya

Aspect	Markin
Coils shall be sequentially marked with the metreage, indicating the length remaining on the	
[a] - In clear figures or in code providing traceability to the production period within year month and, if the manufacturer is producing at different sites, the production site.	

412.8 Jointing of Pipes

Unless otherwise specified or approved by the Project Manager, Polyethylene pipes shall be electro fusion welded. Joints between polyethylene pipes supplied from different manufactures or not manufactured from the same grade of polymer shall only be jointed by electro fusion or by push fit mechanical couplings. Mechanical couplers and compression type fittings shall incorporate a serrated internal liner to support the pipe against compression loads exerted by the fitting and to prevent pullout under axial load.

Butt or socket fusion joint techniques shall only be applied between pipes supplied from single source and manufactured from the same grade of base polymer. Fusion welding of polyethylene pipes shall only be undertaken by skilled operatives using appropriate specialized tooling. Pipes to be jointed shall be free from contamination and care shall be used to protect fusion jointing operations from wind and against the effects of inclement weather. Mechanical jigs or other approved methods shall be used to ensure correct alignment of the pipe when making butt fusion joints. Details of fusion welding procedures including details of tools, operatives, materials and method statements shall be submitted to the Project Manager for approval prior to any jointing.

Steel and iron pipe fittings shall comply with the relevant provision of BS EN 545 (1995) replaced by BS EN 10224 but also current.

412.1 General

Polyethylene pipes up to nominal size 63mm for below ground use shall be coloured blue and comply with the relevant provisions of BS 6572. Polyethylene pipes for use in nominal diameters greater than 63mm shall be coloured blue High Density Polyethylene (HDPE) suitable for a working pressure of 12 bars.

The pipes shall be clearly and indelibly marked to show the name of the manufacturer, diameter, pressure class and date of manufacture.

House connection pipework downstream of the manifold shall be PE80; all other HDPE pipework shall be PE100.

412.2 Joints

Unless otherwise specified or approved by the Project Manager Polyethylene pipes shall be electro fusion welded. Joints between polyethylene pipes supplied from different manufactures or not manufactured from the same grade of polymer shall only be jointed by electro fusion or by push fit mechanical couplings. Mechanical couplers and compression type fittings shall incorporate a serrated internal liner to support the pipe against compression loads exerted by the fitting and to prevent pullout under axial load.

Butt or socket fusion joint techniques shall only be applied between pipes supplied from single source and manufactured from the same grade of base polymer. Fusion welding of polyethylene pipes shall only be undertaken by skilled operatives using appropriate specialized tooling. Pipes to be jointed shall be free from contamination and care shall be used to protect fusion jointing operations from wind and against the effects of inclement weather. Mechanical jigs or other approved methods shall be used to ensure correct alignment of the pipe when making butt fusion joints. Details of fusion welding procedures including details of tools, operatives, materials and method statements shall be submitted to the Project Manager for approval prior to any jointing.

Steel and iron pipe fittings shall comply with the relevant provision of BS EN 545 (1995) replaced by BS EN 10224 but also current.

413 Gate Valves

413.1 General

Valves for normal duty on water pipelines with pressure ratings up to PN25 shall be key operated cast iron flanged gate valves for waterworks purposes generally complying with the requirements of BS 5163 (Type B). All Gate Valves shall be supplied with a 10 year manufacturer's warranty.

Cast iron gate valves for pressure ratings to PN14 shall be cast iron flanged valves complying with BS 5150 replaced by BS EN 1171 (both BS 5150 and BS 5151) or cast iron parallel slide valves complying with BS 5151.

Butterfly valves for pressure ratings of up to PN14 shall be double flanged wafer type butterfly valves complying with BS 5155.

Unless otherwise specified valves for use on steel pipes shall be flanged, where butt-weld ends are specified valves shall comply with BS EN 1984, or BS EN 13709.

413.2 Wedge Gate Valves for Manual Operation

Valves up to and including DN 300 shall be of the resilient seal type and valves larger than DN 300 shall have metal seals.

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. The valves shall be constructed of the following materials:

body	-	cast iron;
spindle	-	forged bronze or stainless steel;
metal faces and seal	-	Gunmetal.

The valves shall be suitable for the unbalanced head as specified or indicated in the schedules.

Suitable gearing and anti-friction devices such as ball bearing thrust collars shall be provided as necessary to enable opening and closing by manual operation at the pressure stated, using an effort no greater than 26kg on the tee key or hand wheel supplied. Hand wheels shall not exceed 500mm diameter. A bypass with gate valve forming an integral part of the valve shall be provided where recommended by the valve manufacturer for the pressures specified.

Gearing on valves of DN 300 and less shall be enclosed in a sealed gearbox suitable for buried installation and operated with a tee key. Except where shown in the Drawings, all valves exceeding DN 300 shall be provided with bevel gearing and hand wheels. Valves to be used for washouts and isolating air valves shall have screwed seats.

Extension spindles shall be galvanized or stainless steel adequately supported with cast iron brackets, and of sufficient diameter to prevent any whiplash effect through twisting when being used to operate the valves. The spindles shall be capped for key operation. Valve caps shall be fitted with hexagonal set screws.

Valves shall be coated with an approved epoxy complying with DIN 30674. Keys for valve operation shall be of sufficient length so that the valves can be operated by a man standing, but shall not exceed 1.2m in length, and shall have a detachable cross bar.

414 Butterfly Valves

414.1 General

Butterfly valves shall conform to BS EN 593. All Butterfly Valves shall be supplied with a 10 year manufacturer's warranty.

414.2 Construction

Butterfly valves shall have a high grade cast iron body to BS EN 1561 designed to the specified working and test pressures. The pressure rating valve shall be cast in the valve body. The disc shall be of high grade cast iron to BS EN 1561 or nodular cast iron to BS 2789 to the defined working and test pressures. It shall have a convex shape designed to achieve low head loss characteristics. The valve shafts shall be of stainless steel operating in self-lubricating bushes in the body.

The valve seat shall be of gunmetal to BS 1400. The sealing ring shall be a renewable Ethylene Propylene Diene Monomer (EPDM) rubber attached to the disc edge by a sectional bronze retaining ring to form a resilient and durable seal.

The valves shall be fitted with hand wheel actuators not exceeding 500mm diameter incorporating gearing to allow opening and closing by manual operation at the pressure stated using an effort no greater than 36kg on the hand wheel supplied.

In all cases the gearing shall be designed to close the valve, from fully open to fully close in a period of not less than ten minutes with this effort. Actuators shall be designed so as to close the valves when the hand wheel is turned in a clockwise direction; the direction of closing shall be clearly cast on the hand wheel. Position indicators shall be fitted to all actuators.

Where required valves shall be electrically actuated with a manual override. Remote actuation shall be provided with a visual indication of valve open, valve closed and percentage opening together with fault indication.

414.3 Valve Performance

A performance curve, relating percentage valve travel, open area and discharge coefficient shall be submitted to the Project Manager. The head loss coefficient with valve fully open shall be defined.

414.4 Testing

All valves shall be tested in accordance with BS EN 593 and pressure and material test certificates shall be submitted to the Project Manager for approval.

415 Air Valves

Air valves shall be either:

a. Single (small) orifice valves (SAV), for the discharge of air during the normal operation of the pipeline.

b. Double orifice valves (DAV), consisting of a large orifice and a small orifice. These shall permit the bulk discharge of air from the main during filling and air inflow when emptying in addition to the discharge of small quantities of air during normal operating conditions.

Air valves shall be supplied with an independent isolating butterfly valve (DAV) or cock (SAV) which permits the complete removal of the air valve from the main, without affecting the flow of water in the main.

Each air valve assembly shall be suitable for connection to a flange on the pipeline.
At the connection between the air valve and its isolating valve a BSP tapping shall be made suitable for fitting of a pressure gauge. All tapings shall be sealed by a brass plug and copper compression ring gasket.

Air valves shall operate automatically and be constructed so that the operating mechanism will not jam in either the open or closed positions.

416 Non-Return Valves

416.1 Swing Check Valves

Non-return valves shall be suitable for waterworks purposes and shall be manufactured to comply with the general requirements of BS EN 12334. They shall be double flanged type, non-slamming and recoilless on flow reversal.

Valves of DN 700 and larger shall be of the multi-disc type or tilting disc type. The valves shall have a high grade cast iron body and cover to BS EN 1561 Grade 220/260 with gun metal nickel bronze alloy door seating. The hinge pin shall be of stainless steel carried on non-corrodible bearings.

416.2 Nozzle Check Valves

Nozzle check valves shall be slam free closing with a streamlined cross section as manufactured by Mannesmann Demag or similar.

417 Flow Control Valves

Flow controls unless otherwise specified shall be butterfly valves. They shall be installed complete with a headstock and position indicator showing the degree of opening.

418 Pressure Reducing Valves

Pressure reducing valves shall automatically reduce a higher inlet pressure to a steady lower downstream pressure regardless of changing flow rate or varying inlet pressure. The valve shall be a hydraulically operated pilot controlled diaphragm type, globe or angle valve.

The main valve shall have a single removable seat and a resilient disc.

419 Ball Float Valves

Ball float valves which are to be installed within reservoirs shall be the delayed action type to eliminate inflow at small valve openings. They shall be fitted with a stilling chamber, auxiliary float valve and inlet bellmouth with regulating valve. The main valve shall be fitted with a long actuating lever to provide a long float travel for slow valve closure.

Valves shall be of the right angle pattern type with flanged inlet and have a resilient synthetic rubber disc which forms a drop tight seal against a removable seat insert. Valves shall be free of cavitation and vibration under the specified working conditions. Flanged tapers shall be provided on the inlets as necessary to suit the size of valves proposed.

Valves shall be capable of withstanding the maximum static pressure and of passing the maximum flow rate shown. Orifice plates shall be provided as necessary to absorb excess working pressure at the initial flow rates indicated.

The pressure rating of the valve shall be cast into the body of the valve.

420 Constant Flow Valves

Constant flow valves shall maintain a constant rate of flow regardless of fluctuations in upstream pressure.

Valves shall be hydraulically operated, diaphragm actuated globe pattern. They shall have a resilient synthetic rubber disc which forms a drop tight seal against a removable seat insert. The diaphragm assembly and valve stem shall be fully guided at both ends by bearings in the valve cover and valve seat. The diaphragm shall consist of nylon fabric bonded with synthetic rubber. Packing glands and stuffing boxes are not permitted and there shall be no pistons operating the valve or pilot controls.

The pilot control shall be direct acting diaphragm valve designed to close when the actuating differential increases beyond the spring setting. The actuating differential pressure shall be produced by a thin edged orifice plate installed in an orifices flange downstream of the valve.

Any necessary repairs to the valve shall be accomplished without removing the valve from the main.

Valves shall be sized to pass the maximum continuous flow stated on the drawings at the working pressure given. The pressure rating of the valve shall be cast into the body of the valve.

421 Surface Boxes and Chamber Covers

Surface boxes and chamber covers shall be either cast iron or ductile iron and coated with black bituminous solution.

Surface boxes over gate valves shall be hinged and chained and shall generally comply with BS 5834.

In roads, tracks, verges: Heavy duty with 150 x 150mm nominal clear opening.
In fields and areas subjected to light wheeled or pedestrian traffic: Medium duty with 150 x 150 mm nominal clear opening.

Surface boxes for hydrant chambers shall have a 150 x 150mm clear opening and shall comply with BS 750 and shall be suitable for heavy traffic loading.

Covers to air valve and other chambers shall be to the dimensions and loading requirements shown on the Drawings or as stated in the Bill of Quantities.

Covers shall be suitable for the following maximum safe centre static loads:

Light duty	- 250kg
Medium duty	- 1500kg
Heavy duty	- 5000kg

Where applicable, covers shall comply with BS EN 124 or other appropriate Standard.
Lifting keys shall be provided for each type surface box or cover supplies. One set of keys shall be provided for every ten surface boxes or covers subject to a minimum of ten sets of keys or the actual number of covers if less than ten.

422 Gully Gratings and Frames

Road gully gratings and frames shall be of approved type and manufacture in cast Grey Ductile Iron and shall be of Heavy Duty Non-rocking Pattern designed for wheel load of 11.5 tonne and generally in accordance with BS EN 124. Single gullies of nominal size 1050mm x 750mm. Inlet gratings of other plan dimensions shall have a minimum water way area of 49% of the total inlet grating area.

Gully frames shall be set in cement mortar and haunched with Class C25 concrete. It shall be the Contractor's responsibility to establish the finished road levels from the appropriate authority and fix the gratings accordingly.

423 Manhole Safety Chains

Mild steel chain shall be 8 mm nominal size Grade M (4) non-calibrated chain, Type 1, complying with BS withdrawn. After manufacture, mild steel safety chains shall be hot dip galvanized in accordance with BS EN 124.

424 Manhole and Chamber Access Covers

The manhole and chamber access covers shall comply with BS 497 Part 1 and be obtained from an approved manufacturer and shall be to the internal minimum clear opening as detailed in the Contract.

All manhole and chamber access covers in road shall be to an approved Heavy Duty pattern and in footpaths shall be medium/heavy duty unless otherwise specified. The frame and lid shall have key holes formed with sealed pockets underneath to prevent ingress of sand, grit and surface water and shall be of an approved non-rocking pattern. The covers and frames shall have accurate seating faces to prevent rocking and the ingress of sand or water, and it shall be tight fitting to resist overflow conditions or unauthorized removal. The seating faces shall be coated with graphite grease before installation of the cover.

A supply of keys for use with every type of manhole cover and surface box shall be handed over by the Contractor at the completion of the Contract on the basis of one set of keys for each 50 covers or part thereof.

Manhole and chamber cover frames shall be set in cement mortar and haunched with Class C30/10 concrete and shall be set to the camber or fall of the finished road surface. It shall be the Contractor's responsibility to establish the finished road surface levels from the appropriate authority and to fix the covers accordingly.

425 Manhole Step Irons

Manhole step irons shall be of galvanized malleable iron and shall conform in all particulars to BS EN 13101.

Section 4B. Pipeline Construction

426 General

The requirement of this section shall apply to the construction of potable and raw water pipelines and pipework.

Within this section 'Plant' refers to pipe fittings, valves, surface boxes and chamber covers, and other such materials required for pipelines, mains and pipework at reservoirs and elevated tanks.

All Plant shall be suitable for waterworks purposes for the conveyance of potable water in the climatic conditions prevailing in Kenya and in particular at the location of the Works.

The Project Manager shall provide details of each pipeline diameter, pressure rating, hydraulic characteristics and the approximate alignment. The Contractor shall, in consultation with the Project Manager set out the proposed pipeline alignments, making any changes that the Project Manager may deem necessary, confirming also the exact locations of all manholes, valves, air valves, washouts, hydrants, and the like.

427 Topographic Surveys

Topographic surveys along pipeline routes shall be either:-

- Plan and profile surveys, or
- Line and level traverse surveys,

as instructed by the Project Manager.

Plan and profile surveys shall cover a strip of 10.0m wide centrally on the proposed centre line of the pipeline. The survey shall be carried out in accordance with the specification detailed in Clause 106.

Line and level surveys shall comprise a traverse line along the centre line of the pipeline as established by the Project Manager.

428 Handling and Transport of Pipes and Fittings

The loading, transporting, unloading and handling of pipes and fittings shall be carried out such that no damage is caused. All in accordance with the recommendations of the manufacturer and to the approval of the Project Manager. The use of lifting hooks is not permitted. Pillows shall be provided between lashing (ropes, wires or chains) and the pipes. All cradles and lashings shall be of such widths as to prevent damage to the coating of the pipe, or distortion of the pipes.

Valves and fittings shall be transported in timber packing and where possible in the manufacturer's original packaging.
Protective cover and other protective materials provided by the manufacturer shall not be permanently removed until immediately prior to installation.

In the event of any damage being caused to a pipe, the Project Manager shall determine whether damaged

piece shall be replaced or repaired. Repair to coating only shall be allowed and shall be as directed by the Project Manager.

In all instances when along trench sides, ferrous pipes shall be supported within 1 metre of either end on sand filled bags such that no part of the wall of the pipe touches the ground, and in the case of pipes over 6 metres long with additional central sand bags.

When pipes are being loaded into vehicles care shall be taken to avoid their coming into contact with any sharp corners such as cope irons, loose nail heads, etc. Whilst in transit, pipes shall be well secured over their entire length and not allowed to project unsecured over the tailboard of the lorry.

Pipes may not be offloaded from lorries by rolling them, suitable carnage shall be used. Pipes shall not be rolled or dragged along the ground.

429 Stringing and Examination of Pipes Prior to Laying

All DI and Steel Pipes and their coatings and linings shall be carefully inspected on Site prior to laying.

Inspection of the pipe will be made by the Project Manager after delivery and again immediately prior to laying. Any pipe shall be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the site.

All pipe or fittings shall be examined before laying and no piece shall be installed which is found to be defective. Any damage to the pipe linings or coatings shall be repaired as directed by the Project Manager. Handling and laying of pipe and fittings shall be in accordance with the Manufacturer's written instructions and as specified herein.

Before lowering into the trench or placing in position each ductile iron pipe or casting shall be slung and sounded with a mallet to test for hair cracks. Pipes that do not ring true will be discarded.

All cement mortar linings shall be visually inspected for defects such as cracking or spalling and crack widths shall be measured to confirm that width is such that natural re-sealing will occur once put into service; otherwise cracks as well as any spalling shall be made good before laying in accordance with the manufacturer’s written instructions.

All epoxy linings and all coatings shall be subjected to holiday detection tests, in accordance with NACE RP 0490, the voltage of the holiday detector being selected appropriate for the material and its thickness. No pipe shall be laid having failed the holiday tests until the defective area is made good in accordance with the manufacturer’s written instructions and retested satisfactorily before use.

All pipe and fittings shall be thoroughly cleaned before laying, and shall be kept clean until they are used in the work, and when laid, shall conform to the lines and grades required. Pipe shall not be laid unless the trench is free of water and in a satisfactory condition. Ductile iron pipe and fittings shall be installed in

accordance with the requirements of AWWA C600 except as otherwise provided herein. If any defective pipe is discovered after it has been laid, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense.

When laying is not in progress, including any work break exceeding 30 minutes, the open ends of the pipe shall be closed by watertight plugs or other approved means. Good alignment shall be preserved in laying. The deflection at joints shall not exceed that recommended by the Manufacturer. End caps shall not be removed until such time as the pipe is to be inspected and laid.

Where the pipeline crosses roads, tracks or any other access or where directed by the Project Manager, the Contractor shall place the pipes so that access to the public is not in any way prohibited.

Shortly before laying or fixing any valve, pipe or fitting, the Contractor shall examine each valve, pipe and fitting to ascertain that there is no damage or defect. The Contractor shall give the Project Manager not less than 48 hours notice of his intention to undertake such examination. The Contractor shall not lay such pipes and fittings until he has received approval from the Project Manager.

Linings shall be inspected prior to laying and any defect made good.

430 Laying Pipes

Immediately before any pipe is lowered into the trench the plug shall be removed from the end of the last pipe laid and the new pipe shall be carefully lowered into the trench.

Each pipe and fitting shall be laid true to alignment curve and gradient in accordance with the Drawings or as directed by the Project Manager. The minimum gradient shall not be flatter than 1 in 500.

Pipes shall be boned to gradient and sight rails shall be provided for this purpose at intervals not exceeding 50m and at all changes in grade. No dips or summits shall be permitted other than as shown on the Drawings.

430.1 Embedment and Compaction

All ductile iron and steel pipes shall be embedded using a sand or coarse grained soil with less than 12% fines, which if necessary shall be imported if excavated material is found to be unsuitable:

In areas prone to water logging or where specifically called for on the Drawings or in the Bills of Quantities a single size or graded gravel shall be used as a special lower bedding, with grading as indicated below.

Nominal Pipe Diameter (mm)	Grading for Special Lower Bedding [to ASTM Sieve Sizes]	
	Single size Gravel	**Graded gravels**
< 200	10 or 14 single-size gravel	14 to 5 graded
200 to 500	10, 14 or 20 single-size gravel	14 to 5 graded or 20 to 5 graded
> 500	10, 14, 20 single-size crushed rock, or gravel	14 to 5 graded or 20 to 5 graded

The suitability of as-dug trench material as an embedment material and where imported, the source shall be approved by the Project Manager. Any delays as a result of not seeking this approval in good time shall be entirely to the Contractor's account

All layers of the embedment shall be thoroughly compacted, and shall not exceed 150 mm and be raised evenly on both sides of the pipe as it is placed. A minimum compaction of 90% MPD shall be achieved at all times, this being confirmed by sampling and testing at intervals on different levels of embedment at intervals of not more than 50 m with testing in accordance with BS 1377 or ISO 22476 using the "sand replacement" method.

Should any results fail to achieve this absolute minimum level, then the pipes, embedment material and layer shall be removed for an equal distance on either side of the failed test, the total distance being equal to the length between adjacent sampling locations, and re-laid appropriately but with compacted layer thickness halved. In addition the distance between sampling and testing shall also be halved until in the opinion of the Project Manager's Representative a sufficient number of consecutive passes allows both individual layer thickness and the distance between sampling and testing to be returned to the previous thickness and spacing.

All backfill soil above the embedment shall be free from clay lumps, boulders and rock fragments greater than 50 mm and as far as practicable, given the nature of the soil, 90 % MPD shall be attained. However, this requirement may be relaxed to 85% MPD by the Project Manager's Representative if he considers the circumstance warrant it.

430.2 Pipes Laid in Trench

Pipes and fittings laid in trench shall have at least the minimum cover stated in the Drawings.
Long radius curves in buried pipelines shall be negotiated by deflections taken up in the joints of one or more pipes. The deflection at joints shall not exceed 75% of the manufacturer's maximum specified limits. Designs have been based upon the use of 6m long pipes. If the Contractor provides longer pipes sufficient short lengths shall be provided to enable the proposed pipe curvature without additional bends or deep excavation.

Pipes shall not be dragged along the trench bottom. Pipes laid in trenches shall be laid and firmly bedded on an even and uniform bed. Where pipes are not laid on a granular bed, the bottom of the trench shall be smooth and free from stones or other projections.
Joint holes shall be excavated below the trench bottom and shall be as small as possible and shall be filled

in and compacted after the pipes are laid and before the refilling of the trench is commenced.

430.3 Pipe Bedding and Surround

For polyethylene, uPVC and GRP pipelines, Class S bedding shall be used where the cover is equal to or greater than 1.0m. Where there is less than 0.6m cover, Class A concrete surround shall be used. In between the Project Manager shall decide upon the bedding type dependent upon the assessed risk of damage to the pipe.

430.4 Pipes Laid Above Ground

Pipelines to be laid above ground shall be constructed of flanged ductile iron pipes with mechanical type expansion joints. Supports shall be provided at a maximum spacing of one pipe length and adjacent to the flanged joints.

The expansion joints shall compensate for a variation of ambient temperature between zero and 40º C on the adjoining pipeline. Anchorages shall be provided immediately uphill of each expansion joint and at each change in vertical and horizontal alignment. The ground/rock surface under the pipeline shall be re-graded as necessary to allow a satisfactory vertical alignment of the pipeline.

The Contractor may propose, as an alternative to the use of mechanical expansion joints, either of the following methods for accommodating thermal expansion:

(1) A zigzag pipeline alignment whereby the thermal movement is accommodated by deflection of the bends.
(2) A rigid form of construction with the thermal movement being constrained within the pipe walls by the use of substantial anchor blocks.

Joints shall be made in compliance with the manufacturer's instructions as approved by the Project Manager. Care shall be taken to ensure the absolute cleanliness of the pipe ends and joint components. Only the recommended approved lubricants shall be used.
Jointing shall only be carried out by experienced personnel under close supervision by the Contractor.

The Contractor shall ensure that no dirty water or other extraneous matter is allowed to enter the pipes during or after laying. In the event of dirty water or extraneous matter entering the pipes the Contractor shall immediately carry out cleaning and disinfection as directed by the Project Manager.

Except when necessary for jointing, the end of the last pipe laid shall be kept plugged to the satisfaction of the Project Manager to prevent the ingress of dust, dirt, rocks and other debris.
The Contractor shall be liable for any damage caused to the Employer's Plant and apparatus or other equipment as a result of foreign matter of any kind not having been cleared out of pipelines before Taking-Over.

Pipe trenches shall not be backfilled until approved by the Project Manager. Once approved trenches shall be backfilled without delay to at least the minimum extent required for pressure testing.

431 Cutting Pipes

The edges of the cut pipes shall be clean, true and square. Ductile iron pipes shall only be cut with an approved mechanical pipe cutter in conformity with the pipe manufacturer's recommendations. The use of oxyacetylene flame cutter will not be permitted. The edges of the cut together with those parts of the pipes from which the coating has been removed shall be given two coats of bituminous paint and the internal lining repaired. When the cut pipe is to be inserted in a "Tyton" type joint it shall be bevelled for 10mm at 30^{o} to pipe the axis.

Asbestos Cement, HDPE, uPVC and GRP pipes shall be cut with an approved mechanical pipe cutter and in conformity with the pipe manufacturer's recommendations. Where the cut end of the pipe is to be incorporated in a joint the pipe shall be turned down to the correct diameter required for forming the joint by and approved mechanical turning machine. The length of turning shall be accurately bevelled by mechanical means to the dimensions specified in the manufacturer's recommendations.

Steel pipes shall be cut by using a mechanical pipe cutter approved by the Project Manager. The use of an oxyacetylene flame cutter will not be permitted. The edges of the cut shall be given two coatings of liquid epoxy compatible with the original coating. The external coating and the internal lining shall be repaired to the approval of the Project Manager. The cut end shall be bevelled as required to suit the form of joint used.

432 Proprietary Joints and Couplings

Proprietary joints and couplings shall be assembled in accordance with the manufacturer's instruction as approved by the Project Manager. Where pipes are laid above ground and jointed with bolted couplings the joint shall be protected against vandalism by sheathing with an approved heat-shrink moulding as manufactured by Raychem of Swindon UK or similar approved.

433 Flanged Joints

Flanged joints shall be made with two washers per bolt, one under the bolt head and the other under the nut. The tightening of the bolts shall be carried out in the sequence and to the torque recommended by the manufacturer. A torque wrench shall be used.

Buried flange joints shall be protected by painting with approved bitumen paint and by wrapping using 'Denso' paste, mastic tape and outer wrap, or similar approved materials all in accordance with the manufacturer's instructions as approved by the Project Manager, unless supplied with epoxy coating and galvanized bolts.

Flanged adaptors and mechanical couplings shall have a RILSAN nylon coating applied by the manufacturer.

434 Steel Pipelines Welded Joints

If specifically required under the contract pipes shall not be welded. If permitted by the Project Manager for particular conditions the Contractor shall submit to the Project Manager a detailed method statement for constructing the pipeline using welded joints which shall include, but not be limited, to:

(i) details of the Contractor's skilled labour and supervision staff who have direct experience in the construction of welded steel pipe;

(ii) details of the Contractor's plant to be deployed;
(iii) details of temporary staging, access and craneage;
(iv) procedure for construction of supports and anchorages, and welding joints;
(v) quality assurance proposals for testing the integrity of the welds.

These details shall be submitted to the Project Manager for his approval not later than 21 days before the Contractor wishes to commence pipe laying.

All field welds shall be inspected visually with special attention given to the line up and down the root run or stringer beads. Non destructive testing of the completed weld shall be carried our using radiographic methods with procedures in accordance with BS 2910.

On completion and inspection of joint welding, remedial works shall be carried out on the internal lining and external coating. No more than five pipe joints shall be welded without completion of remedial works to joints.

435 Fixing Valves and Penstocks

Valves, penstocks and other fittings shall be securely fixed. Extension spindles and headstocks shall be properly aligned and fixed in a vertical position and valve caps shall be fixed securely using the locking nut.

436 Thrust and Anchor Blocks

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

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

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

437 Concrete Surround to Pipes

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

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

438 Flotation of Pipelines

The Contractor shall ensure that flotation of the pipeline does not occur during construction. Sufficient backfill shall be placed over each pipe after laying and before testing to prevent flotation.

439 Pressure Rating

The pressure rating of pipes shall be as indicated on the drawing or Bill of Quantities or if not indicated then selected such that the maximum pressure in the pipeline inclusive of surge pressures shall not exceed the maximum allowable sustained working pressure rating of the pipe;
The surge pressure amplitude (the difference between maximum and minimum surge pressures) shall not exceed one half of the maximum allowable sustained working pressure rating of the pipe.

440 Testing of Water Supply Pipelines

All pressure pipelines shall be hydrostatically tested. Site test pressures shall be1.5 times the maximum working pressure or allowance pressure plus 5 bar whichever is the smaller measured at the lowest part of the pipeline, unless otherwise specified on the drawings.

The Contractor shall give the Project Manager not less than 48 hours notice of his intention to carry out a pressure test. Testing shall not commence without the Project Manager's approval. Before a length of pipe is tested, each pipe shall be securely anchored. All thrust and anchor blocks shall have been constructed and, the barrel of each pipe shall be backfilled to the extent necessary to prevent flotation or movement of the pipeline and shall be not less than 600mm.

Normally joints shall be left exposed until pressure testing has been satisfactorily completed. Any need to backfill a pipeline before pressure testing shall not relieve the Contractor of his responsibility to excavate to locate and repair any leaks.

Pressure testing shall be carried out as the work proceeds in such lengths as are convenient but not exceeding 500m. The ends of the length of pipeline under test shall be closed by means of securely anchored caps or blank flanges. Pipeline valves shall not be used for this purpose. All washout valves shall be fitted with blank flanges and the valves opened before the commencement of any pressure test. At each air valve location, a special air release arrangement shall be provided to allow manual release of air during filling operations. Pressure testing shall not be carried out with permanent air valves in place.

The pipeline to be tested shall be filled slowly with water in such a manner that all air is expelled. Air vents shall be checked to ensure that no air is trapped at high points.

The pressure in the pipeline shall slowly be raised to the working pressure, the test pump disconnected and the pipeline left charged under pressure with air valves opened for a period of not less than 24 hours to allow air in the pipeline to be expelled and pipe linings and pipe walls of absorbent materials to become saturated. At the end of this period of time air valves shall be closed and the test pump shall be reconnected and the pressure in the pipeline raised to the test pressure and this pressure maintained for a period of 24 hours or such other period as directed by the Project Manager.

Throughout this period the pressure in the pipeline shall not be allowed to fall or rise more than 6m head of water above the test pressure and this shall be accomplished by pumping water into or releasing water from the pipeline as required. The volume of water pumped into or released from the pipelines shall be carefully measured. At the end of the test period the pressure in the pipeline shall be adjusted to the test

pressure by pumping water into or releasing water from the pipeline as required.

The apparent leakage from the pipeline shall be ascertained from the net volume of water that has been pumped into the pipeline during the test period. The permissible loss shall not exceed 2 litres per metre nominal bore per kilometre length per m head per 24 hours.

During the pressure test exposed joints shall be inspected and any leakage or seeping joints shall be remedied. All signs of leakage shall be remedied whether total apparent leakage from the pipeline under test is less than the apparent allowable leakage or not. Should any length of pipeline fail to pass the pressure test the Contractor shall at his own expense carry out all work necessary to locate and remedy the faults and to retest the pipeline until it satisfactorily passes the test.

A low pressure air test (not exceeding 0.3 bar) may be used as a preliminary joint tightness test prior to backfilling and hydrostatic testing. The water used for pressure testing shall be provided by the contractor and shall be free from impurities and of such a quality which will not pollute or injure the pipeline. The Contractor shall be responsible for obtaining the water, transporting it and for its safe disposal on completion.

441 Cleansing and Sterilizing of Pipelines

After the pipelines have been completed and pressure tested satisfactorily as herein specified the Contractor shall flush out and cleanse the pipelines. Where water is provided by the Employer, the cost of this will be reimbursable under a provisional sum.

Diameters 300 mm and greater:

Pipelines shall be cleansed in sections and this shall be carried out by means of passing through polyurethane foam swabs. The swabs shall be to the approval of the Project Manager.

Diameters less than 300 mm:

Pipelines shall be cleansed in sections by flushing with potable water, for a period of time to be decided by the Project Manager's Representative.

Cleansing of any section shall be repeated as required by the Project Manager's Representative in the event of the initial or subsequent operation not being to his satisfaction. The cost of such water shall be charged to the Contractor.

The Contractor shall supply all necessary equipment for the cleansing and sterilizing operations, including all swabs and swab detectors which shall be handed over to the Employer on completion of the Works.

Swabs shall be passed through pipelines at speeds of between 0.2 and 0.4 metres per second to obtain. the best cleaning results with the minimum number of passes. Should it be apparent from the debris collected by the swab that damage to the lining has occurred, the Contractor shall be wholly responsible for repairing the lining to the satisfaction of the Project Manager's Representative.

The swabbing operation shall be controlled by an experienced Project Manager to ensure that no undue

surges in the pipeline, heavy docking of the pig or pressurising of the pipeline occur causing damage to any of the permanent works. Any damage caused shall be made good by the Contractor to the satisfaction of the Project Manager's Representative.

The Contractor shall make all necessary arrangements for the transportation of water from the point of supply from the Employer to the required location, and make all arrangements for the disposal of the water. All disposal methods and locations shall be to the approval of the Project Manager's Representative.

When the pipelines have been cleansed to the satisfaction of the Project Manager's Representative the Contractor shall introduce at a slow rate of water flow by a portable chlorinator or other approved means of a solution of sterilizing agent in such quantity and of such strengths as will result in the concentration of chlorine throughout the length of the pipelines of not less than 30 parts per million. This sterilizing charge shall be allowed to remain in the pipelines for 24 hours after which time the pipelines shall be thoroughly flushed using the supply water to remove chlorine in excess of that in the supply water.

When this flushing has been satisfactorily completed samples of water will be taken by the Project Manager's Representative for bacteriological analysis by the Employer. If any of the results of the analyses are unsatisfactory when compared with those of the control sample of the supply water the sterilizing process shall be repeated until satisfactory results are obtained. On completion of sterilizing and flushing the pipelines shall be left full of supply water.

The Contractor shall be solely responsible for the provision of all labour, materials and chemicals necessary for carrying out the foregoing operations.

The cost of water used for repeated cleansing, sterilizing and flushing pipelines in accordance with this clause of the Specification will be charged to the Contractor and the Contractor shall be responsible for all temporary works and other arrangements in connection with cleansing, sterilizing and flushing the pipelines.

The costs of the initial sampling analyses and preparing reports on the bacteriological quality of the water shall be borne by the Employer but the costs of any subsequent sampling analyses and preparing reports should the initial reports be unsatisfactory shall be borne by the Contractor.

442 Painting

All steel or ductile iron pipes and fittings exposed to view including above ground pipelines shall be painted after making good the external protection with two coats of “Bitumastic Aluminium solution D. 5909” manufactured by Wailes Dove Bitumastic Ltd, Hebburn, Durham, England, or similar approved.

Pipes and fittings in chambers shall be painted with two coats of “Bituros Solution” manufactured by Wailes Dove Bitumastic Ltd, or similar approved. Valves and Surface Boxes shall be similarly painted.

443 Connections to and Diversions to Existing Pipework

443.1 General

The Contractor shall be responsible for connecting new pipework and service connections laid under the Contract to existing pipework, and for blanking-off existing pipework and service connections. The connection shall be made in a manner to minimize any disruption to supply.

Before blanking-off or making a connection to existing pipework the Contractor shall notify the Project Manager in writing no less than 14 days in advance of the date on which he proposes to carry out the work. After giving such notice the Contractor shall obtain from the responsible Authority agreement on the precise date, times and method that the connection will be made. The connection or blanking-off shall be made at such times of the day or night as stipulated by the Project Manager.

The Contractor shall prepare a detailed method statement, programme of the work and a schedule of all plant and materials to be used and shall obtain the approval of the Project Manager not less than 72 hours before commencement of the work. The programme shall allow for the immediate re-commissioning on completion of the work.

The Contactor shall be responsible for locating the exact line and level of the existing pipework and service connections and shall agree with the Project Manager and the responsible Authority the precise location of the connection or blanking-off.

443.2 Materials

Before commencing the connection the Contractor shall excavate trial pits as necessary and shall check the outside diameter of the existing pipework and ensure that the couplings to be used for making connections to the existing pipework and the materials used for blanking-off existing pipework are dimensionally suitable.

The Contractor shall ensure that all the materials are on site not less than 24 hours before the commencement of the work.

443.3 Personnel

The Contractor shall ensure that at least one senior member of his field supervisory staff, who is experienced in such operations and fluent in both English and the language of his labourers is on site throughout the duration of the work.

The Contractor shall also ensure that all necessary skilled artisans and an adequate number of labourers for the operation are on site throughout the work.

443.4 Preliminary Work

The Contractor shall execute all works possible before disconnection of the supply including:-

a. Excavation and supports to the excavation.
b. Blinding with concrete the immediate working areas, but not less than the whole of the bottom of the excavation.
c. Putting in all drains, or where this is not possible a sump of adequate size from which a pump

may operate.

d. Casting the floor of any chamber which is later to be constructed around any of the works.
e. Casting the thrust blocks or any other works which may be required.
f. Exposing and cleaning pipes in readiness for the work.

443.5 Carrying out the Work

The Contractor shall be responsible for emptying the section of existing pipework on which the work is to be carried out, by a method agreed with the Authority and approved by the Project Manager.

The Contractor shall take all precautions necessary to prevent dirt and other foreign matter entering the pipelines.

The Contractor shall provide at the Site a sufficient quantity of clean water containing approximately 10 parts per million (10mg/l) of chlorine before proceeding with the cutting of the existing pipeline. Each item of pipework including the joints shall be submerged in the solution for a minimum period of 15 minutes immediately prior to installation.

443.6 Water Pipes and Chambers to be abandoned

Where existing water pipes are to be replaced with new pipework the existing pipework is to be abandoned. Where new works conflict with existing pipework to be abandoned, abandonment of pipework shall consist of removal and disposal to a site approved by the Project Manager. Water supply pipework shall not be abandoned until suitable alternative means of supply are in place and ready for connection.

Where chambers are to be abandoned these shall be broken down and disposed of and the void filled and compacted with suitable material approved by the Project Manager. Chambers deeper than 1 metre will be broken down to 1 metre below finished ground level and the remaining void filled and compacted with suitable material approved by the Project Manager.

Section 4C. Drains, Sewers and Manholes

444. Excavation for Drains, Sewers and Manholes

The ground shall be excavated to the lines and depths shown on the drawings or to such other lines and depths as the Project Manager may direct. Trenches shall be of sufficient width to enable the pipes to be properly laid and jointed. In case of pipes of greater diameter than 300mm, the width of trench shall be external diameter of pipe, plus 400mm.

When any excavation has been taken out and trimmed to the levels and dimensions shown on the drawings or as directed by the Project Manager, the Project Manager shall be informed accordingly so that he may inspect the completed trench and no excavation shall be filled in or covered with concrete until it has been so inspected and the Contractor has been authorised to proceed with the work. All surplus materials from such excavations not required for refilling shall be carted away to tips, or otherwise disposed of, as directed.

All excavations shall be kept dry, and all bailing and pumping, timbering, shoring and supporting of sides that may be required, and any refilling, ramming and disposal of surplus materials necessary in carrying out the excavations and backfilling of trenches shall be taken to provide a solid and even bed for barrels of the pipes and, where a concrete bed is not specified, the floor of the trench shall be properly shaped to receive the sockets and the backfill must be thoroughly rammed along the sides of the pipe.

445. Supports for Pits, Trenches and Other Excavations

The sides of pits, trenches and other excavations shall, where necessary, be adequately supported to the satisfaction of the Project Manager, and all such excavations shall be of sizes sufficient to enable the pipes and bedding to be laid accurately, and proper refilling and compacting to be carried out.

The Contractor shall take all precautions necessary for the safety of adjoining structures and building by shoring, opening in short lengths or otherwise, during the time the trenches are open.

446. Rock Cutting in Trenches for Pipes

Where solid rock is met within trenches, it shall be cut out to a depth of 100mm below the intended level of the bottom of the pipes, and replaced with 100mm of approved material as specified. In measuring such rock excavation the Contractor will be allowed a width of 400mm more than the external diameter of the pipes to a level of 100mm below the bottom of the pipes. The Contractor shall dispose of all surplus material arising from rock excavation in a manner to the approval of the Project Manager.

447. Water in Trenches for Pipelines

Trenches shall be kept free from water at all times during construction of works until, in the opinion of the Project Manager, any concrete or other works therein are sufficiently set, and the Contractor shall construct any sumps or temporary drains that the Project Manager may deem necessary.

The Contractor shall be responsible for the removal and disposal of all water entering the excavations from whatever source and shall deal with and dispose of such water in a manner approved by the Project Manager so as to ensure that excavations are kept dry while ensuring that the disposal of this water does not cause a nuisance to adjacent plot holders or works. The Contractor shall provide all plant, labour and materials

required for such work.

448. Laying and Jointing Rigid Jointed Concrete Pipes

Concrete pipes shall be laid true to line and level, each pipe being separately boned between sight rails.

For spigot and socket joints, the spigot of each pipe shall be placed home in the socket of the one previously laid, and the pipe then adjusted and fixed in its correct position with the spigot of the pipe accurately centred in the socket. A ring of tarred rope yarn shall next be inserted in the socket of each pipe previously laid and driven home with a wooden caulking tool and wooden mallet, such yarn when in position shall be 25mm in depth. The socket shall then be completely filled with cement mortar 1 to 2 and a fillet of the same worked all round the side. The fillet shall be levelled off and extend for a length of not less than 50mm from the face of the socket.

For 'Ogee' jointed pipes, the joints shall be thoroughly cleaned before laying, and cement mortar, shall be applied evenly to the ends for jointing so as to completely fill the joint. The pipes shall then be neatly pointed with a band of cement mortar approximately 125mm wide and 20mm thick. The inside of each joint shall also be pointed up as the work proceeds.

Special care shall be taken to see that any excess of cement mortar etc. is neatly cleaned off while each joint is being made and any earth, cement or other material cleaned out of the pipes by drawing a tight-fitting wad through them as the work proceeds, or by other approved means. A properly fitting plug shall be well secured at the end of the last laid pipe and shall be removed only when pipe laying is proceeding. The trenches, pipes and joint holes shall be kept free from water until the joints are thoroughly set.

Where shown on the drawings or directed by the Project Manager, concrete pipes shall be bedded and haunched or surrounded with concrete.

449. Pipes Laid with Open Joints

O.G. porous concrete pipes shall be laid unjointed with a space of 12mm between the spigot and the inner end of the socket.

All pipes shall be packed and surrounded as directed by the Project Manager with approved broken stone, sand or gravel aggregate, to the gradings as shown on the drawings or stated in the Bill of Quantities.

450. Drains to be Left Clean on Completion

On completion, all drains, manholes, etc. shall be flushed from end to end with water from an approved source and left clean and free from obstructions.

451. Refilling Trenches

Trenches shall be refilled with suitable excavated material of 100mm surround but not before the work has been measured and approved by the Project Manager. For pipes which are not surrounded with concrete, the first layer of filling material shall be free from stones and shall not be thrown directly on to the pipes, but shall be placed and packed with care all round them. All filling shall be deposited and compacted in layers, not exceeding 225mm loose depth, to a dry density not less than that of the adjoining soil. The last

450mm of filling must be returned in the order in which it has been removed. Timber and framing shall be withdrawn ahead of the layer to be compacted, care being taken to keep the sides of the trenches solid and to fill all the spaces left by the withdrawn timber.

452. Connections of Existing Sewers and Drains

Where shown on the drawings, existing sewers and drains shall be properly extended, connected and jointed to new sewers, culverts, drains or channels. All such connections shall be made during the construction of the main sewer, drain or other work and a record of their positions kept for future use or reference. Where pipe connections are made to a sewer, stone pitched or lined channel, the pipes shall be well and tightly built into the concrete, or masonry work and be so placed as to discharge in the direction of the main sewer, drain or channel and with the end of the pipe carefully cut to the necessary angle. Where the connections are between pipe sewers or drains, special connecting pipes as shown on the drawings shall be supplied and be truly laid and properly jointed.

453. Manholes and Inspection Chambers

Manholes and inspection chambers shall be constructed in accordance with the drawings and in the position shown on the drawings or directed by the Project Manager. The side walls shall be fair faced or rendered internally as specified on drawings. They shall be brought up vertically to receive a precast slab formed of concrete of the appropriate classes specified and reinforced all as shown on the drawings. Cast iron manhole covers and frames shall be provided and frames shall be bedded in cement mortar 1 to 3 and so set that the tops of the covers shall be flush at all points with surrounding surface of the footway, verge or carriageway, as the case may be. Any slight adjustment of the slab level which may be necessary to accomplish this shall be effected by topping the side walls with concrete integral with the slab.

If required, half channel pipes, bends and junctions as specified shall be laid and bedded in cement mortar 1 to 3 to the required lines and levels, and both sides of the channel pipes shall be benched up with concrete of the appropriate class and finished smooth to the slopes and levels as shown on the drawings or directed by the Project Manager. The ends of all pipes shall be neatly built in and finished flush with cement mortar 1 to 3. Where the depth of the invert exceeds 1 metre below the finished surface of the carriageway or the adjacent ground, iron steps shall be built in with alternate steps in line vertically and with such additional hand irons as the Project Manager may direct.

All manholes when completed shall be watertight and to the satisfaction of the Project Manager. The prices inserted in the Bill of Quantities shall include for excavation, provision of all materials, construction, refilling and disposal of surplus.

454. Precast Concrete Manholes

Precast concrete manholes shall be supplied and laid generally in accordance with the drawings.

455. Gully Connections

Connections from gullies to sewers and surface water drains or ditches shall consist of concrete pipes and fittings jointed with cement mortar 1 to 3. All pipes, bends and junctions shall be laid to the lines and levels shown on the drawings or as directed by the Project Manager.

456. Surface Boxes, Covers Etc.

Surface boxes, manholes and other covers lying within the site of the works, shall be raised, lowered, altered or removed as directed by the Project Manager.

457. Gullies

Gullies complete with gratings and with rodding eyes where necessary shall be supplied and laid in accordance with the drawings. Where directed by the Project Manager, precast concrete gullies shall be laid on and surrounded with 100mm of concrete of the appropriate grade. The concrete surround is to be brought up to the underside of the frame or flush with the top surface as the case may be. Masonry gullies shall be constructed from 225mm building stone and rendered internally. Gullies shall be trapped where leading into foul sewers or into combined foul and surface water sewers.

458. Completion of Drainage Works

All sub-soil and surface water drains shall be completed in advance of the construction.

459. Temporary Stoppers

Junction pipes which are laid but not immediately connected to gullies shall be fitted with temporary stoppers or seals, and the position of all such junctions shall be clearly defined by means of stakes or training wires properly marked and labelled.

460. Provision for Future Connection to Manholes

Inlet pipes of the required diameters shall be built into the walls of manholes and elsewhere for future use and shall be of the diameters shown on the drawings. The external ends of all such connections shall be sealed off with temporary stoppers, approved by the Project Manager. The pipes shall be laid and jointed and during the placing of the concrete they shall be adequately supported.

461. Surrounding or Haunching of Pipes with Concrete

Surrounding or haunching of pipes shall be carried out using fine concrete. In carrying out this work the Contractor shall take care to pack the concrete under and around the pipes to ensure even bedding and solidity in the concrete and the concrete shall not be thrown directly on to the pipes. The upper surface of the concrete shall be struck off with a wooden screed or template and neatly finished off.

462. Invert Block and Stone-Pitched Drains

Precast concrete invert blocks and side slabs shall be formed of concrete of the appropriate grade and dimensions shown on the drawings. Each course of side slabs required in the Bill of Quantities shall be interpreted as one complete row of side slabs to one side of the channel concerned. Stone used for channels shall be 225mm x 100mm building stone. Drains should not normally be laid to a radius of curvature less than 10 times the actual width of the drain.

Invert block and stone-pitched drains shall be constructed in the positions and to the levels and dimensions shown on the drawings and laid to true line and even fall. Where under-filling is required it shall be in 100mm maximum thickness layers of compacted murram. The earth sides to such channels shall be neatly finished to a slope of 1 to 1 or such other slope as the Project Manager may direct.

Invert blocks and side slabs shall be laid on a 100mm minimum thickness of compacted murram and be neatly jointed with cement mortar 1 to 3 as the work proceeds. The excavation, murram bedding, providing, laying and jointing invert blocks or stone, backfilling and disposal of surplus shall all be as specified and all in-situ connections shall be in concrete of the appropriate grade.

463. Testing of Jointed Pipes and Manholes

Sealed jointed drains, up to and including 600mm diameter shall be tested in sections (e.g. between manholes) by filling with water under a head of not less than 1 metre. Drains found to be water-tight after a period of 30 minutes will be passed as satisfactory but the water must be retained in the pipes until a depth of at least 450mm of filling has been deposited and compacted on top thereof. Drains failing to stand the test shall be taken out and the pipes re-laid and re-jointed until completely water-tight.

Drains exceeding 600mm in diameter shall be tested by means of a smoke test before they are covered up. Both ends of the lengths of drain to be tested shall be sealed to the satisfaction of the Project Manager, and smoke shall then be pumped into the section from an approved machine. Should any joint in the section show an escape of smoke, the section shall be taken out and the pipes re-laid and re-jointed until there is no further escape of smoke.

Should the Project Manager so direct, manholes shall be tested by completely filling with water, and there shall be no appreciable loss over a period of 2 hours.

On completion of the works, or at suitable intervals during construction, infiltration tests will be carried out. The permissible amount of infiltration shall be 1 litre per hour per linear metre of nominal internal diameter.

The Contractor shall provide all labour and apparatus for the above tests.

All testing will be done in accordance with the procedure of the British Standard Code.

464. Pipes with Rubber Ring Joints

Rubber rings shall be entirely suitable for the pipe being used and will be provided by the Contractor. They will be laid in the socket and the pipes then jointed as specified. The jointing of pipes shall be carried out in accordance with manufacturer's instructions and in conformity with any modifications proposed by the Project Manager.

465 Laying, Jointing and Backfilling for Flexible Jointed Pipes

The Contractor shall ensure that any hard spots and loose stones are removed from the formation prior to laying of bedding materials. The Contractor shall lay a bed of thickness 100mm consisting of granular material i.e. sand, gravel, or approved soil of friable nature.

After laying of pipes the Contractor shall lay bedding material on the sides of the pipe compacted by tamping into soffit of sewer.

After completion of this operation the Contractor shall lay the bedding material on top of the pipe in 150mm layers to a thickness of 300mm. The material is to be compacted by tamping. However, precautions are to be taken to avoid excessive tamping on top of the pipe. The remaining trench excavation is to be backfilled.

The pipes shall be laid with flexible ring seal joints provided that solvent cement joints could be used for fittings where necessary subject to the approval of the Project Manager. Pipes and fittings shall be checked for deformities prior to laying. Deformed pipes and fittings shall not be accepted.

Flexible Rubber Ring Joints

The Contractor shall ensure that the spigot end is free from grit, dust or dirt and sealing rings should be seated evenly in the socket grove. Pipe lengths and fittings are supplied with a chamfer on the spigot. Where pipes are to be cut or are supplied without a chamfer on the spigot end the Contractor shall ensure that the pipe is cut square and then form a chamfer on the spigot end with a medium file to an angle of 15 degrees. Remove saw flashing by scraping with a pen-knife.

Expansion Gap

It is necessary to leave a gap between the edge of the spigot end and the base of the socket to allow for expansion. Moulded fittings are supplied with an embossed line indicating the correct depth of insertion. In other cases where the marking is not done, the Contractor shall ensure that an expansion gap of at least 3mm per metre length of pipe or at least 15mm per pipe length is provided. This can be done by marking spigot ends or by pushing spigot fully home, making a small mark on pipe and then withdrawing the pipe by 15mm.

After completing jointing the pipe shall be laid on the prepared bed making sure that a suitable depression is created in the bed for the socket.

Solvent Cement Joints

For solvent cement joints make sure that mating surfaces are clean and free of grease and dirt. Roughen mating surface with sandpaper, clean both surfaces with cleansing fluid using a clean cloth. Apply solvent cement on both mating surfaces. Without delay bring mating surfaces together and hold in position firmly for a few seconds. A layer of cement should be visible at the edges. Joints should not be disturbed for at least 10 minutes after assembly.

Section 5. Building and Structures

501 Concrete Building Blocks

Concrete building blocks shall be of approved manufacture and shall be formed in a press. The blocks manufactured in Class C30 concrete shall be cured for at least 10 days before use.

Blocks shall be well and evenly formed with true corners and unbroken arises, and shall be carefully handled and stacked.

502 Laying Building Blocks

Joints between blocks shall be filled solid with mortar and shall be of regular thickness of 5 to 10mm. The blocks shall be laid in level courses and bonded so that each vertical joint is midway above the face of the block below, except at junctions and piers where a bond of not less than 100mm shall be provided. The walls shall be raised in lifts not exceeding three metres in height in any one day, and truly vertical. All blocks shall be wetted before being laid.

Joints of exposed work shall be raked out and neatly flush-pointed in the same mortar. The whole of the visible faces of the walls shall be left perfectly cleans and all surface mortar and droppings shall be removed before they have set.

Joints in work to be rendered shall be raked out to a depth of 8mm to provide a key for the rendering.

Blockwork shall be tied into adjoining structural members at the same level as blockwork reinforcement using 150mm long butterfly tangs or equivalent fixed and mortared into proprietary vertical strips.

503 Precast Concrete Units Generally

All precast concrete units shall include all fixing plugs and strips to enable screw ties or other fixing devices to be firmly attached. For all precast units to be set in block of masonry walls the plugs and strips shall be so positioned as to provide fixing at course and in no case exceeding 450mm centres.

504 Masonry Using Natural Irregular Stones

Stones shall come from selected quarry layers to the approval of the Project Manager. They shall be homogeneous, frost resistant, flawless, free of any cracks or bousins, solid, and of equal grain and shall have all the required quantities to give a regular facing. They shall give out a clear sound when hit by a hammer.

Mortar shall be removed from the external surface of the wall. The Contractor shall prepare a wall sample approved by the Project Manager which shall be kept at the construction site until all the masonry is completed.

505 Screen Walling

Screen walling shall consist of perorated precast concrete blocks 100mm thick of approved shape, design and manufacture laid to an approved pattern in cement mortar wit perfectly even joints which shall be neatly flush or recess pointed as directed.

506 Damp-Proof Course

All external walls of buildings are to be provided with damp-proof course (DPC) of textured PVC strip of

width equal to the total thickness of the wall and any external rendering. The DPC is to be lapped with the damp-proof membrane and bedded in mortar specified for the type of block used. The greatest lengths possible are to be used for the DPC's but any end laps required are to be at least 200mm long made dry without intervening mortar. Piers are to have complete DPC's lapped with the wall DPC.

507 Damp-Proof Membrane

Damp-proof membranes shall be laid, as directed by the Project Manager, beneath all floor slabs resting on the ground. They shall be composed of single sheets of minimum thickness 0.300mm black polyethylene film of an approved manufacturer specially made for use as damp-proof membrane.

The film shall be laid on sand and turned up around all edges of the slab and with 150 mm margin above the top of the slab to be tucked into the perimeter walls of the building. Where the building is so large as to exceed the maximum sheet size available, several sheets shall be used and the joints shall be lapped 150mm and fused together using a welding tool designed for that purpose. Every care should be taken by the following trades to prevent perforation of the membrane but in the event of the puncture the perforation shall be covered by a patch of similar material of dimensions exceeding the area of the puncture by 300mm and the two sheets welded together as described above.

508 Composition of Mortars

a. Cement mortar for bonding concrete shall be composed of cement and sand mixed in the proportion of the jointed concrete.

b. Cement mortar for setting precast concrete or pitching shall be composed of cement and sand mixed in the proportion of 50kg of cement to 0.14m3 of sand, with the addition of an approved plasticizer.

c. Cement mortar for blockwork in concrete blocks shall be composed of cement and sand mixed in the proportion of 50kg of cement to 0.14m3 of sand.

d. Sand and Cement for mortars shall be as described in the specification for concrete.

509 Mixing of Mortars

The materials of mortars shall be measured out in their correct proportions and shall first be thoroughly mixed together in a dry state by turning them over upon a clean wooden stage until they are of a homogeneous appearance in consistency and colour. Clean water shall then be added while the mixture is being turned over until it attains a suitable consistency. Plasticizer shall be added in accordance with the manufacturer's recommendations as approved by the Project Manager.

The mortar shall be used immediately after it has been mixed. No mortar which has commenced its first set shall be used, or mixed up again. Mortar shall, where possible in hot weather, be protected from too rapid action by covering with impervious material such as polyethylene film.

Mixing by hand will be allowed only if the Project Manager gives specific approval. Mixing by machine using the same sequence of operations described above shall be carried out whenever possible.

510 Cement Rendering

Rendering shall be in a 50 kg to 125kg cement: sand mix but where approval had been given to the use of a plasticizer or other additives these proportions may be modified to the approval of the Project Manager.

All surfaces to receive a finishing coat of cement rendering or fine concrete shall be thoroughly prepared and cleaned and the rendering or screeding shall be placed immediately after such surfaces have been thoroughly wetted.

All rendering shall be put to a minimum of two coats, the first being left rough to a minimum of 10 mm thickness, but the second coat shall be trowelled up to a fair faces as soon as possible after it is applied.

All internal rendering shall be finished to an even and polished surface with a float, trowel or other suitable tool, special care being taken to obtain perfectly smooth and glazed faces. It shall not be less than 15mm thickness when finished unless instructed otherwise.

All external rendering shall be brought to an even surface with a wood float following which a tyrolean finish of approved colour shall be applied unless otherwise stated.

All rendering shall be protected from sun and rain by adequate and suitable coverings which shall be supplied and fixed in advance of these conditions arising. The renderings shall be kept damp while setting and protected from drying winds.

511 Tanking to Buried Concrete Surfaces

External concrete surfaces to be tanked shall be coated with a bituminous waterproofing membrane 3mm minimum thick. The tanking shall be dressed into structure as shown in the Drawings and be protected by non-rotting boarding prior to backfilling.

512 Waterproof Rendering

Waterproof rendering slurry shall comprise a 50kg to 125kg cement sand mix with an approved waterproofing admixture such as styrene arcrylate copolymer.

The material shall block capillaries and minor shrinkage cracks to prevent water ingress while allowing the passage of water vapour through the structure.

The render shall be applied to a total thickness of not less than 20mm the first coat shall be applied levelled scratched and left to dry for not less than 3 days.

513 Grouting in Ironwork

All brackets, rag-bolts and other ironwork for which holes have been boxed out or left in the concrete of a structure shall be carefully grouted in to their correct positions in all particulars. The grouting in shall be carried out with cement and sand grout in such a manner that there shall be no apparent difference in the texture or colour throughout the face of the finished structure and that there shall be no seepage of water either between the ironwork and the set grout or between the set grout and the surrounding structure.

The above instructions shall apply also to the building-in of pipes except that Class C25/10 concrete shall be used in lieu of cement grout.

All holes left for building-in shall be free from any sign of infiltration of water before the building-in is carried out. No reliance shall be placed upon the building-in process for the sealing of such leakage.

514 Cable Duct Covers and Frames

514.1 Recessed Covers

Cable duct covers recessed for flooring finishes shall be provided with galvanized rolled steel angles of height equal to the thickness of the floor finishing and fixed to the surface of the structural floor slab along all edges of the trenches so that the top edge is level with the finished floor level. The angle shall be laid so as to form seating for duct covers and all additional galvanized rolled steel tee sections shall also be provided to support the duct covers.

The duct covers shall be galvanized to suit the ducts and the seating described above. A lightweight galvanized steel mesh shall be fixed to the upper surface of the trays to provide a key for floor finishes. The seating and trays shall be so laid that the finished floor is perfectly level and all trays fully supported at all edges without the use of loose packing. At least one tray in every series of trays covering a length of duct shall be provided with cast-in lifting eyes and a pair of suitable lifting keys shall be handed to the Project Manager on completion.

514.2 Checker Plate Covers

Checker plate covers shall be hot dipped galvanized mild steel fitted flush with the floor surface and fully supported.

515 Fences and Gates

Fences generally shall be in accordance with the relevant parts of BS 1722 Part 1: 1986. Chain link fencing shall be Type PL.213 Grade A with 1.8 m high plastic covered chain link mesh. The mesh and line wires shall be galvanized prior to being plastic covered. The posts shall be reinforced concrete.

The straining posts, intermediate posts and struts shall be manufactured and erected complete as specified in BS 1722. The fencing shall be true to line and vertical, following profile of the ground, previously graded so as to prevent access beneath the bottom wire. Gates shall be hung on adequate post, and shall be truly vertical.

Ornamental fabricated metalwork fences and gates shall be constructed of mild steel bar, strip or tube in accordance with the Drawings. All welded joints and drillings for bolts shall be made before painting, and all bolts, nuts and washers shall be galvanized or plated in an approved manner. Any metalwork sunk into the ground shall be treated with two coats of bituminous paint.

516 Joint Sealing Compound and Sealants

Joint sealing compounds shall be impermeable ductile materials of a type suitable for the conditions of exposure in which they are to be placed, and capable of providing durable, flexible and watertight seal by

adhesion to the concrete throughout the range of joint movement.

Hot poured joint sealants shall comply with BS 2499, Ordinary Type A1 sealant.
Cold poured polymer-based joint sealants shall comply with BS 5212: Part 1, Normal Type N sealant.

Two part polysulphide based sealants shall comply with the relevant provisions of BS 4254. Pouring Grade shall be applied to horizontal upward facing joints and Gun Grade to joints of any other aspect or inclination. Other two part polymer based sealants of Gun or Trowel Grade shall comply with the physical and test requirements of BS 4254.

Silicon bases building sealants shall comply with the relevant provisions of BS 5889. Primers for use with joint sealants shall be compatible with, and obtained from the same manufacturers as, the adjacent sealant. Primers shall have no harmful effects on the concrete.

Sealants and primers which will be in contact with water to be used for potable supply shall not impart to water taste, colour, or any effect known to be harmful to health, and shall be resistant to bacterial growth. Sealants and primers which will be in contact with sewage or sewage sludge shall be resistant to biodegradation.

517 Openings in Walls, Floors and Ceilings

The Contractor shall chase put and/or cut openings through walls, floors and ceilings for the passage of pipes and cables where described in the contract shall provide and fix in position approved tube sleeve cut off flush with the finished surface. All openings and ducts shall be sealed on completion to prevent the passage of toxic or explosive gases.

518 Structural Steelwork

Material for structural steel work shall comply with BS EN 10137 and workmanship with BS 5950. The steelwork shall be securely fixed to the foundations or building and designed to have such strength and stiffness that its deflection and movement under the loads to be applied shall be within tolerable limits.

All bolts and nuts shall comply with the requirements of BS 3693 except for High Strength Friction Grip Bolts which shall comply with BS 4395.

Mild steel electrode shall comply with the requirements of BS EN 499 and High Yield Steel with BS 2540.

All structural steel fabrication shall conform to the requirements of BS EN 5400. The use of High Strength Friction Grip Bolts shall be in accordance with BS withdrawn.

All structural steel work shall be fabricated using welded joints where possible for shop joints and bolted joints for field assemble.

519 Open Mesh Walkways and Covers

Open mesh type walkways, platforms and covers shall be of aluminium or galvanized steel, suitable for a superimposed load of not less than 6kN/m2. The walkways, platforms and covers shall include all necessary

supports not detailed on the Drawings.

Open mesh panels shall be trimmed with full depth nosing bar along all edges and bolted to each other when in place to help ensure a firm walkway. Panels shall be cut in such a way and fixing so as to provide a continuity of pattern.

Covers shall incorporate a hinged lockable open mesh access panel with a 750 x 750mm clear opening, strong durable hinges and heavy duty non-corrodible padlock. Openings for valve keys shall be just sufficient in size for the valve key and shall incorporate a cover hinged only.

All panels shall be securely bolted to the supporting structure. Where the supporting structure is concrete, galvanized mild steel angle curbs shall be provided and securely grouted into rebates left in the concrete such that the tops of the panels are flush with the top of the concrete.

520 Handrailing

Hand railing shall be approximately 1000mm in height with an intermediate horizontal rail with standards not more than 2000mm apart. Hand railing shall be designed for a horizontal loading of not less than 220N/mm. Hoops shall be welded on where required for fixing guard chains. Standards and rails shall be manufactured from black mild steel tube to BS 1387:1985, from steel tubing to BS 1775 or from extruded aluminium alloy approved by the Project Manager. The nominal bore of steel tubing shall be not less than 32mm. Adequate provision shall be made for thermal movement. Steel hand railing shall be hot dipped galvanized after fabrication.

521 Guardrail

Guardrails shall be 750mm in height with a single top rail. In all other respects it shall comply with the specification for hand railing.

522 Chains

Chains across openings in handrails at tops of ladders shall be galvanized mild steel having 3 SWG x 3 links per 100mm and shall be supplied complete with 'S' hooks and split rings.

523 Steel Access Covers

Steel access covers shall be to the duty required and sized to suit the opening shown on the Drawings. They shall be complete with frame and shall be weatherproof (prevent ingress of water) when closed and shall in all respects be strong and durable.

The covers shall be hinged and lockable and provided with stays to prevent the covers opening more than 105º. The Contractor shall provide with each cover a heavy duty non-corrodible padlock and four keys. The covers and frames shall be galvanized.

524 Isolation of Aluminum

All items of aluminium construction shall be isolated from concrete by the use of bituminous felt or DPC material or two coats of bituminous paint. The aluminium shall be isolated from dissimilar metal by the use of fibre washers and spacers.

525 Galvanising

Where galvanizing has been specified the items shall after fabrication be hot dipped galvanized in accordance with BS 6530 Part 1 to a thickness of 0.15mm (005'). All items to be protected shall be prepared as specified in the above standards. Articles altered at the manufacturer's works in any way after galvanizing are to be re-galvanized as specified. Articles subject to minor alternations at site or requiring minor repair at site shall be wired brushed to remove all rust and coated with 3 coats of approved zinc rich cold galvanizing compound.

526 Fixings to Structure, etc.

Where fixings to structures previously constructed are to be made by setting a bolt system into performed holes, such fixings shall be made either by Rawlbolt Projecting Bolt Type or by using an approved proprietary resin anchor system. Where performed holes have not been provided a self-drilling expanding bolt system shall be used.

Where thin sections are involved or where stresses are likely to be set up which might cause damage to the structure the use of the resin anchor system only will be permitted. Only in special circumstances will the Project Manager or the Project Manager's Representative permit rawlbolts to be uses. Performed holes shall be accurately set to template prior to placing the surrounding concrete and shall be kept rigidly in place until the concrete has properly set.

Where resin anchorage is used the Contactor shall ensure that the setting time of the resin is appropriate to the requirements for setting up, plumbing and aligning the work before is sets. Bolts shall be set to template and hole diameters shall conform to the recommendation of the suppliers. Whatever system is used, all bolts shall be plated to resist corrosion.

Section 6. Roads and Surfacing

601 Access Tracks

Permanent access tracks shall be constructed only where shown on the Drawings. Tracks shall be unsurfaced. Filling to bring formation to the required level shall be locally excavated material which shall be placed in layers and compacted by tracking with the excavation plant. The road formation shall be tracked and graded with a dozer blade or bucket to give a cross fall of not less than 1 in 40. Surface undulations shall not exceed 200mm over a length of 3.0m, unless otherwise approved by the Project Manager.

The maximum gradient shall not exceed one vertical to 6 horizontal and the minimum tuning circle radius measured to track centre line shall not be less than 15.0m.

602 Access Roads

The road formation shall be the surface obtained after completion of any earthworks. Filling to bring the formation to the required level shall be selected material. It shall be laid and compacted in layers not exceeding 150mm in thickness, the compaction being carried out by a roller of not less than 8 tonne weight.

The Employer and the Contractor may at any time after the completion of the access road (after 14 days in the case of concrete surfaces) use them or allow their use by their employees or sub-contractors.

At such times during the Period of the contract of Period of Maintenance as the Project Manager may direct, the Contractor shall at his own expense make good any deterioration which may have occurred in the condition of the roads, whether as result of the use of roads by the Employer or otherwise. In particular, any parts of the foundations into which soil has penetrated shall be dug out and replaced with clean materials.

602.1 Macadam Roads and Macadam Hardstandings

(i) The sub-base shall consist of 150mm compacted thickness of free draining granular material conforming to the grading limits specified in the contract. The plasticity index shall be 0-6% maximum and the California Bearing Ratio at maximum density (Test 12, BS 1377:1990) shall be 25% minimum. The material shall be compacted to 95% of the maximum density as determined by Test No. 13, BS 1377:1990 (heavy compaction) by means of a roller of not less than 8 tonnes weight.

If the quality of foundation soil is considered inadequate, the Project Manager may direct that the sub-base be 300mm thick, in which case construction shall be carried out as described above but as two 150mm thick layers.

The road base shall consist of 150mm compacted thickness of free draining crushed limestone conforming to the grading limits stated in the Contract. The plasticity index shall be 0-6% maximum and the California Bearing Ratio at maximum density (Test 13, BS 1377:1990) shall be 80% minimum.
The base shall have a prime coat applied not more than seven days after the completion of the base and not later than twenty four hours after approval by the Project Manager. The asphalt used for the prime coat shall generally conform to the relevant AASHTO specification.

Before laying the tarmacadam base course onto the primed base, all loose blinding material shall be brushed off the road and removed. The tarmacadam base course shall consist of 60mm compacted thickness of 20mm nominal size dense base course macadam. The aggregate and asphalt shall be generally in accordance with the relevant AASHTO specification.

A tack coat shall be applied between successive layers of asphalt material and shall generally conform to the relevant AASHTO specification. Machine laying shall normally be used and compaction shall be carried out with a roller of not less than 12 tonnes weight so as to achieve a dense, smooth and even surface. Where new road construction is to be joined to an existing road, the surface shall be cut back to a straight line and primed.

(ii) Should the Contractor wish to lay Macadam on the roads early in the
Contract for use by the construction traffic, he may do so provided construction is stopped at completion of the Macadam base course and this single layer blinded with bituminous grit to seal the surface.

When all concreting, earth moving and heavy crainage and haulage has been completed, and in general towards the end of the Contract, the base course so provided shall be thoroughly cleaned off and repaired, and re-levelled where necessary, and a suitable cold bituminous emulsion tack coat generously applied by spray in accordance with the manufacturer's instructions, care being taken to avoid spattering kerbs or other adjacent concrete. The wearing course may then be laid and blinded as described in sub-section (i) above. Any additional costs involved in the adoption of the method of laying described in this sub-section shall be included by the Contractor in his rates for road making.

(iii) Notwithstanding the time of placing of the roadworks, the condition of the finished road at the completion of the Contract shall be of 'as new' quality, with clean, accurately profiled, rolled and sealed surface throughout, free from concrete spotting or staining, patch marks, trench outlines, paint, oil or fuel spillages or other visible or structural defects.

602.2 Unsurfaced Roads and Hardstandings

Unsurfaced roads and hardstandings shall be constructed from 300mm of crushed lime stone conforming to the grading limits specified in the Contract, laid in two layers of 150mm.

Each layer shall be compacted to 95% of the maximum density (Test 12, BS 1377:1990).

602.3 Pea Shingle Surfaced Areas

The sub-base to pea shingle areas shall be as defined in 801.1 above. Pea shingle consisting or 20mm thick 5mm nominal single sized stone laid and raked to a level finish.

603 Precast Concrete Kerbs and Channels

Kerbs shall be laid before the adjacent carriageway is constructed and sufficiently in advance to meet the Project Manager's requirements. Kerbs shall be bedded solidly and accurately in their concrete foundations before the initial set of the concrete has started. Each kerb shall be set solidly and accurately to the required line and level with joint no more than 6 mm wide, neatly pointed with cement mortar and filled for their full depth with cement grout as specified. At every tenth kerb joint, the pointing and grout shall be omitted.

A piece of 4mm thick approved jointing material shall be placed in these joints, neatly trimmed to be flush with the face of the kerb. The bedding shall be well haunched up to the back of the kerb, to within 100mm of the top of the kerb. All cutting shall be neatly formed so as to show no damage to the exposed faces and to leave the ends square for the full width of the kerb.

The kerbs and channels shall be 130mm wide by 250mm deep. Kerbs shall be half battered. Kerbs damaged at the exposed faces will not be accepted.

604 Precast Concreting Edging

Edging shall be 50mm x 150mm in size. Edging shall be laid in the same manner as kerning and in short lengths, where required to be circular on the plan.

605 Footpaths and Paving

For surfaced footpaths and similar paved the base material shall be laid on hard fill or selected materials as directed by the Project Manager's Representative and compacted by a roller of 0.75 to 3 tonnes weight. The footpath base shall be formed of crushed rock graded from 50mm to 10mm suitable for the purpose and laid as wet-mix or dry macadam and rolled or compacted to the final form and grading of the final surfacing to a thickness of 100mm.

The base course shall consist of 100 mm compacted thickness of bituminous macadam of 14mm nominal sized material. After laying and rolling the base course, a wearing course shall be laid to provide a final finish. This shall consist of 15mm compacted thickness of 100mm nominal size bituminous macadam. As soon as possible after laying the wearing course, it shall be blinded with bituminous grit (fine cold asphalt) to weather-seal.

For concrete paving, the precast concrete flags shall be of approved colour and size not less than 30mm thick unless otherwise indicated. They shall be laid and bedded in cement mortar upon a 100mm thick bed of compacted crushed limestone.

The Contractor will be required to lift and relay at his expense flags which have sunk through consolidation of settlement of the ground beneath and the Project Manager's maintenance certificate will not be issued until such work has been completed to his satisfaction.

606 Laying to Grade

All new and reinstated roads, alleyways and hard standings shall be completed in a manner that ensures cross-falls are towards the storm water drainage intakes.

Section 7 Safety, Health and Environment

701 Introduction

The prevention of injury and/or illness to the site personnel and the public, damage to the Works and to public and private property, protection of the environment, and compliance with applicable laws, are primary objectives of the Employer. Because of the importance the Employer places on meeting these objectives, selected minimum requirements are outlined in these Safety, Health and Environmental Specifications with which Contractors shall comply while working on this contract. Given that these Specifications cannot cover every eventuality, the Contractor shall be expected to exercise good judgment in all such matters, even though not mentioned in these Specifications, and shall take any and all additional measures, as required or necessary, to meet his responsibility for safety, health and environmental matters during the period of the Contract.

The Employer nor its representatives shall not be held liable for any actions taken by the Contractor that are attributed to following the minimum requirements stated hereinafter.
The Contractor shall throughout the execution and completion of the Works and the remedying of any defects therein:

(a) have full regard for the safety of all persons on the Site and keep the Site and the Works in an orderly state appropriate to the avoidance of danger to any person;

(b) know and understand all laws governing his activities along with any site requirements and work site hazards. Such information shall be communicated by the Contractor to his personnel and subcontractors;

(c) take all necessary measures to protect his personnel, the Employer's personnel, other persons, the general public and the environment;

(d) avoid damage or nuisance to persons or to property of the public or others resulting from pollution, noise or other causes arising as a consequent of carrying out the Works.

702 Compliance with Specifications

The Contractor shall comply with the requirements of these Safety, Health and Environmental Specifications and all other applicable regulations or requirements under Kenyan laws, laid down by relevant authorities or issued by the Employer or the Project Manager concerning safety, health and the environment, in force or introduced or issued from time to time during the period of the Contract.

In so far as these Specifications are applicable, they shall apply to sites and personnel outside the Site associated with the performance of the Contract.

The Specifications equally apply to subcontractors and all other parties engaged by the Contractor and their personnel. The Contractor shall ensure all such parties are fully aware of and comply with the Specifications.

The Contractor shall comply with all notifications and written or verbal instruction regarding safety issued pursuant to these Specifications by the Employer, Project Manager or relevant authorities within the time specified in the notification or instruction.

The Contractor shall adopt a positive approach, awareness and responsibility towards safety, health and the environment, and take appropriate action, by:

(a) ensuring the Specifications are enforced and followed by the Contractor's personnel. Any failure by the Contractor's personnel to follow the Specifications shall be regarded as a failure by the Contractor.

(b) paying attention to possible injury to unauthorized persons entering the site, particularly children.

Whenever in these Specifications the Contractor is required to provide test certificates for equipment and personnel and to comply with the relevant authorities' requirements and no independent test facilities are available or no relevant authorities exist in Kenya, the Contractor shall provide:

(a) in lieu of independent test certificates:
- for equipment – details of the tests that have been carried out by the Contractor and a written statement that the Contractor has satisfied himself that the item of equipment is fit and safe for use;
- for personnel – details of the training and experience of the personnel and a written statement that the Contractor has satisfied himself that they have the required level of competency;

(b) in lieu of relevant authorities' requirements – details of the Contractor's own rules, regulations, requirements and procedures regarding safety, health and the environment.

If the Project Manager is dissatisfied with the details provided by the Contractor, the Contractor shall provide further details or carry out further tests or provide further written statements as may be reasonably required by the Project Manager.

When the Project Manager has satisfied himself regarding the Contractor's own rules, regulations, requirements and procedures provided in accordance with (b) above, such rules, etc. shall be deemed to form part of these Specifications and to which Clause 3 shall equally apply.

703 Failure to Comply with Specifications

703.1 General

Should the Contractor fail to comply with any of the Specifications or requirements of the Project Manager:

(a) the Project Manager may suspend the Works of part of the Works until the Contractor has taken the necessary steps, to the satisfaction of the Project Manager, to comply with the Specifications or requirements.

(b) the Employer may, following written notice to the Contractor, carry out themselves or arrange for another contractor to carry out such measures as they may consider appropriate on behalf of the Contractor. Any such actions by the Employer shall not affect or diminish the Contractor's obligations or responsibilities under the Contract.

(c) the Project Manager may, by written notice of suspension to the Contractor, suspend all payment to the Contractor under the Contract if the Contractor fails to rectify any breach of the Specifications within the period specified by the Project Manager, provided that such notice of suspension:

(i) shall specify the nature of the failure or failures; and
(ii) shall request the Contractor to remedy each such failure within a specified period after receipt by the Contractor of such notice of suspension.

Such suspension of payment shall remain in force until such time as the Contractor has rectified the breach or breaches to the satisfaction of the Project Manager. No interest shall be paid on the suspended payments.

Failure to comply with the Specifications or requirements shall be considered a breach of the Contract by the Contractor and may result in termination of the Contract by the Employer. In the event of the Employer taking action based on this Clause, the Contractor shall not be entitled to any additional costs or extension to the Contract Completion Date. All costs incurred by the Employer pursuant to Sub-Clause 703.1.1 (b) shall be deducted from the amounts otherwise due to the Contractor.

704 General Requirements

704.1 Preamble

All references to safety shall be deemed to include health and the environment.

704.2 Safety Officer

The Contractor shall appoint a competent Safety Officer who shall be responsible for safety, health and the environment. The Safety Officer shall be given sufficient time by the Contractor to carry out his duties; minimum requirements shall be as follows:

Workforce on site of over 250	-	full time Safety Officer;
Workforce on Site of 100 – 250	-	50% of Safety Officer's time;
Workforce on site below 100	-	as required for the Works but a minimum of 5 hours per week of Safety Officer's time where more than 20 workers.

The Contractor shall provide the Safety Officer with appropriate identification, including a white hard hat with red cross symbol and an identification badge. The appointment of the Safety Officer shall be in writing

and copied to the Project Manager. The appointment shall include specific instructions to enforce these Specifications and delegated authority to take any action, measure or to issue instruction regarding their enforcement. All persons on Site shall be made aware of the name and authority of the Safety Officer and instructed to comply with any instruction or direction in safety matters, verbal or in writing issued by the Safety Officer.

The Safety Officer shall be provided with a mobile phone or other similar means of communication. The Safety Officer shall be accessible and available at all times including normal working hours.

704.3 Safety Training

The Contractor shall provide safety induction training for all site personnel upon starting on site.

The Contractor shall provide safety refresher/reinforcement training at regular intervals for his staff.

704.4 Safety Meetings

The Contractor shall hold regular safety meetings to provide safety instructions and receive feedback from site personnel on safety, health and environmental matters. A weekly safety Meeting shall be chaired by the Safety Officer and minutes shall be taken of the meeting. The meeting/minutes shall be given to the Project Manager. The Safety Officer should attend the Contractor's weekly site meetings and "Safety" shall be an item on the agenda.

704.5 Safety Inspections

The Safety Officer shall make regular safety inspection of the work site. The Safety Officer shall prepare a report of each inspection. This report shall include details of all breaches of these Specifications and any other matters or situations relating to safety found during the inspection, instructions issued by the Safety Offices and actions taken by the Contractor. A copy of the Safety Officer's reports shall be given to the Project Manager.

704.6 Control of Substances Hazardous to Health

Hazardous materials shall be stored in approved safety containers and handled in a manner specified by the manufacturers and/or prescribed by relevant authorities.

Only properly trained and equipped personnel shall handle hazardous materials.

704.7 Potential Hazards

The Contractor shall inform employees of potential hazards, take the appropriate steps to reduce hazards and be prepared for emergency situations. The Contractor shall make an assessment of every operation involving hazardous substances. The assessment shall be recorded on a Hazardous and Flammable Substances Assessment Method Statement which shall be submitted to the Project Manager prior to the delivery and use of the substance on Site.

704.8 Accident Reporting

The Contractor shall report all accidents and dangerous occurrences to the Project Manager. The Contractor shall prepare a report on each accident or dangerous occurrence and a copy of the report, together with

witness statements and any other relevant information, shall be submitted to the Project Manager. A reportable accident or dangerous occurrence shall include any accident to any person on site requiring medical attention or resulting in the loss of working hours or any incident that resulted, or could have resulted, in injury, damage or a danger to the Works, persons, property or the environment.

In the event of an accident or dangerous occurrence, the Contractor shall be responsible for completing all statutory notifications and reports. Copies of all statutory notifications and reports shall be passed to the Project Manager.

All accidents and dangerous occurrences shall be recorded in a Site Accident Book. The Site Accident Book shall be available at all times for inspection by the Project Manager.

The Contractor shall immediately rectify any situation or condition that could result in injury, damage or a danger to the Works, person, property or the environment. If the situation or condition cannot be corrected immediately, the Contractor shall provide temporary barriers and appropriate warning signs and devices and/or take other appropriate action necessary for the protection of persons, property and the environment.

704.9 Notices, Signs, Etc.

All safety, health, environmental and other notices and signs shall be clearly displayed and written in English. All requirements, instructions, procedures, etc. issued by the Contractor concerning these Specifications shall be printed in English and displayed and readily available to the Contractor's personnel.

704.10 First Aid and Medical Attention

The Contractor shall have comprehensive First Aid Kit(s) on Site at all times. First Aid Kits shall be conveniently located and clearly identifiable.

The Contractor shall have one employee on site trained in first aid for every 25 employees. Such persons shall be provided with appropriate identification, including a red hard hat with a white "red cross" symbol; and an identification badge.

The Contractor shall make contingency arrangements for calling a Doctor and transporting injured persons to hospital. The telephone numbers of the emergency services and the name, address and telephone number of the Doctor and nearest hospital shall be prominently displayed in the Contractor's site office.

704.11 Employee Qualification and Conduct

The Contractor shall employ only persons who are fit, qualified and skilled in the work to be performed. All persons shall be above the minimum working age. Contractor's personnel shall use the toilet facilities provided by the Contractor.

The Contractor shall ensure:

(a) that no firearms, weapons, controlled or illegal substances or alcoholic beverages are brought onto the Site and that no personnel under the influence of alcohol or drugs are permitted on Site.

(b) That all personnel obey warning signs, product or process labels and posted instructions.

(c) That drivers or operators of vehicles, machinery, plant and equipment follow the rules for safe operations. Drivers shall wear seat belts and obey all signs and posted speed limits.

705 Safety Requirements

705.1 Personal Protective Equipment

The Contractor shall provide personal protective equipment, including hard hats, safety glasses, respirators, gloves, safety shoes, and such other equipment as required, and shall take all measures or actions for the protection and safety of Contractor's personnel.

Non-metallic hard hats shall be worn at all times by all personnel at the worksite with the exception of those areas where the Project Manager has indicated it is not necessary to do so. Safety glasses shall meet international standards and be available for use and worn in specified worksite areas. As a minimum, safety glasses shall be worn for the following types of work: hammering, chipping, welding, grinding, use of electrically powered or pneumatic equipment, insulation handling, spray painting, working with solvents, and other jobs where the potential of an eye injury exists. Face shields and/or goggles shall be worn where possible exposure to hazardous chemicals, cryogenic fluids, acids, caustics or dust exists and where safety glasses may not provide adequate protection.

When handling acids, caustics and chemicals with corrosive or toxic properties, suitable protection, such as acid suits or chemical resistant aprons and gloves, shall be worn to prevent accidental contact with the substance.

Personnel shall not be permitted to work whilst wearing personal clothing or footwear likely to be hazardous to themselves or others.

The wearing of safety shoes with steel reinforced toes is recommended for all Contractor's personnel on site. In all cases, Contractor's personnel shall wear substantial work shoes that are commensurate with hazards of the work and the work site area.

Hearing protection, including muffs, plugs or a combination thereof, shall be provided for all personnel operating in areas where the noise level exceeds 90 decibels. Such protections shall also be provided for operators working with equipment exceeding such a level. This may include equipment such as excavators, shovels, jackhammers, saws, drills, grinders and the like are being used.

The Contactor shall encourage employees to wear substantial work gloves whenever practical and safe to do so.

705.2 Fire Protection and Prevention

The Contractor shall comply with fire protection instructions given by the Authorities having jurisdiction in regard to fire protection regulations. The Contractor shall, upon moving on site, provide to the Project Manager and the Authorities a fire prevention and evacuation plan. This shall include drawing(s) showing

the fire assembly points. The fire prevention and evacuation plan and drawing(s) shall be updated from time to time as the Works progress. The Contractor shall ensure all personnel are fully informed on escape routes and assembly points and any changes thereto. Fuel storage will not be permitted in construction work areas. Contractors may establish fuel storage tanks in specified areas set aside for the purpose and approved by the Project Manager. Storage tanks shall be adequately bunded to control spillage. Fire extinguishers shall be provided and installed in a suitable nearby location.

Highly combustible or volatile materials shall be stored separately from other materials and as prescribed by relevant authorities and under no circumstances within buildings or structures forming part of the permanent Works. All such materials shall be protected and not exposed to open flame of other situations which could result in a fire risk.

No combustible material shall be located inside or within 10 metres of a building if structure forming part of the permanent Works. Where units have to be used in these circumstances, they shall be constructed of non-combustible materials and have a half-hour fire rating inside to outside and outside to inside. Non-combustible furniture shall be used where practical.

All temporary accommodation and stores shall be provided with smoke detectors and fire alarms.

Smoking shall be banned in high risk areas.

Expanded polystyrene with or without flame retarding additive, polythene, cardboard and hardwood shall not be used as protection materials. Plywood and chipboard shall only be used as protection on floors. Vertical protection shall be non-combustible. Debris netting and weather protection sheeting shall be fire retardant.

When using cutting or welding torches or other equipment with an open flame, the Contractor shall provide a fire extinguisher close by at all times. All flammable materials shall be cleared from areas of hot works or work locations prior to welding or oxy/gas burning operations. All hot works shall cease half an hour before the end of a work shift to allow for thorough checking for smouldering materials. Where appropriate, areas of hot works are to be soused in water before the shift ends.

An adequate number of fire extinguishers of types suited to the fire risk and the material exposed shall be provided. These shall be placed in accessible, well-marked locations throughout the job site. Contractor's personnel shall be trained in their use. Extinguishers shall be checked monthly for service condition and replaced or recharged, as appropriate after use.

Only approved containers shall be used for storage, transport and dispensing of flammable substances. Portable containers used for transporting or transferring gasoline or other flammable liquids shall be approved safety cans. Fuel burning engines shall be shut off while being refuelled. Adequate ventilation to prevent an accumulation of flammable vapours shall be provided where solvents or volatile cleaning agents are used.

Flammables shall not be stored under overhead pipelines, cable trays, electrical wires or stairways used for

emergency egress. Paints shall be stored and mixed in a room assigned for the purpose. This room shall be kept under lock and key.

Oily waste, rags and other such combustible materials shall be stored in proper metal containers with self-closing lids and removed every night to a safe area or off site. Every precaution shall be taken to prevent spontaneous combustion.

705.3 Electrical Safety

All temporary electrical installations, tools and equipment shall comply with current regulations dealing with on-site electrical installations. The Contractor shall establish a permit-to-work system for work in or in proximity to energized circuits of any voltage. Contractor's personnel shall not commence work on such circuits unless a permit to work has been issued and adequate safety measures have been taken and the work operation has been reviewed and approved by the Project Manager.

Only authorized personnel shall be allowed to work or repair electrical installations and equipment. Portable tools and equipment shall be 240 volt, unless otherwise agreed by the Project Manager.

When portable or semi-portable equipment operates at voltages in excess of 240 volts, the supply shall be protected by a Residual Current Device (RCD) regardless of any such device fitted to the equipment. The RCD must have a tripping characteristic of 30 milliamps at 30 milliseconds maximum.

All static, electrically powered equipment, including motors, transformers, generators, welders and other machinery, shall be properly earthed, insulated, and/or protected by a ground fault interruption device. In addition, the skin metal buildings and trailers with electric service shall be earthed. Metal steps, when used shall be securely fixed to the trailer.

Lampholders on festoon lighting shall be moulded to flexible cable and be of the screw in type. Clip on guards shall be fitted to each lamp unit.

All tungsten-halogen lamps shall be fitted with a glass guard to the element. These lamps must be permanently fixed at high level.

Electrical equipment shall be periodically inspected and repaired as necessary by competent persons.

Any work in electrical equipment and systems shall be made safe through locking, tagging, and/or isolation of the equipment before work commences. Prior to the start of the work, the equipment or systems shall be tested to ensure that they have been properly de-energised and isolated.

Electrical repair work on energized systems shall be avoided whenever possible.

Electrical trouble shooting shall be conducted only after getting written approval of the Project Manager.

Unauthorized personnel shall not enter enclosures or area containing high voltage equipment such as switchgear, transformers or substations.

705.4 Oxygen/Acetylene/Fuel Gases/Cartridge Tools

Compressed oxygen shall never be used in the place of compressed air. Flash-back (Spar) arrestors shall

be fitted to all gas equipment. Liquid petroleum Gas (LPG) cylinders shall not be stored or left in areas below ground level overnight. Cylinders must be stored upright.

The quantity of oxygen, acetylene and LPG cylinders at the point of work shall be restricted to a maximum of one day's supply. Cylinders shall be kept in upright vertical rack containers or be safely secured to a vertical support.
Cartridge tools shall be of the low velocity type. Operators must have received adequate training in the safe use and operation of the tool to be used.

705.5 Scaffolding/Temporary Works

No aluminium tube shall be used, except for proprietary mobile towers, unless otherwise agreed with the Project Manager.

Drawings and calculations shall be submitted to the Project Manager, prior to commencement of work on the site, for all Temporary Works, including excavations, falsework, tower cranes, hoists, services and scaffolding. Designs shall conform to international standards.
The Project Manager will not approve Temporary Work designs but the Contractor shall take account of any comments on such designs made by the Project Manager.

The Contractor shall inspect and approve all Temporary Works after erection and before access, loading or use is allowed. Completed and approved Temporary Works shall be tagged with a scaff-tag or similar safety system and the Safe Structure insert displayed. For scaffolding, one tag shall be displayed every 32 m2 of face area. A central record system shall be kept on all Temporary Work. Temporary Works shall be inspected weekly and similarly recorded.

All mobile scaffold towers shall be erected in accordance with the manufacturer's instructions and a copy of these shall be submitted to the Project Manager prior to any use on site. Additionally, all towers shall be erected complete with access ladder, safety rails and kick boards whatever the height.

The Contractor shall repair or replace, immediately, any scaffold, including accessories, damaged or weakened from any cause.

The Contractor shall ensure that any slippery conditions on scaffolds are eliminated as soon as possible after they occur.

All scaffolds used for storing materials, for brick or block laying, for access to formwork or for any other purpose where materials may be accidentally fall, shall be provided with wire mesh guards of a substantial material, in addition to kick boards.

705.6 Use of Ladders

Manufactured ladders shall meet the applicable safety codes for wood or metal ladders. Metal ladders shall not be used where there is any likelihood of contact with electric cables and equipment. All metal ladders shall be clearly marked: "Caution – Do not use around electrical equipment". Job made ladders shall not be permitted.

Extension or straight ladders shall be equipped with non-skid safety feet, and shall be no more than 12 m in height. The maximum height of a step ladder shall be 2 m. Ladders shall not be used as platforms or scaffold planks.

Ladders rungs and steps shall be kept clean and free of grease and oil.
Extension and straight ladders shall be tied off at the top and/or bottom when in use. Only one person shall be allowed in a ladder at a time.

Defective ladder shall be taken out of service and not used. Ladders shall not be painted and shall be inspected for defects prior to use.

705.7 Elevated Work

The Contractor shall provide all personnel, while working at an elevated position, with adequate protection from falls. Details of such protections shall be submitted to the Project Manager.
The Contractor shall carry out daily inspections of all elevated work platforms. Defects shall be corrected prior to use.

- **705.7.1 Roofing and Sheet Metal Laying**
  (a) A Method Statement detailing the procedures to be adopted shall be submitted to and agreed with the Project Manager prior to commencement of work on the site.
  (b) Mobile elevating work platforms or the equivalent shall be used to install roofing and sheet materials wherever practicable and a suitable base is available.

- **705.7.2 Erection of Structures**
  (a) A Method Statement detailing the procedures to be adopted shall be submitted to and agreed with the Project Manager prior to commencement of work on the site.
  (b) Safety harness and lines shall be provided by the Contractor for use by the erection personnel and worn at all times.
  (c) Mobile elevating work platforms or the equivalent shall be used to erect structures wherever practicable and a suitable base is available.

- **705.7.3 Mobile Elevating Work Platforms**
  Operators shall be trained in the safe use of such platforms and hold a current Certificate of Competence.

- **705.7.4 Hoists**
  (a) A copy of the current Test Certificate shall be submitted to the Project Manager before any hoist (personnel or material) is brought into operation on the site. Where the range of travel is increased or reduced a copy of the revised Test Certificate shall be submitted.
  (b) Each landing gate shall be fitted with a mechanical or electrical interlock to prevent movement of the hoist when any such gates is in the open position.
  (c) Safety harness must be worn and used by personnel erecting, altering and dismantling hoists.

- **705.7.5 Suspended Cradles**
  - (a) Suspended cradles shall be installed, moved and dismantled by a specialist contractor.
  - (b) Suspended cradles shall comply with local regulations.
  - (c) All powered suspended cradles shall incorporate independent safety lines to overspeed braking devices and independent suspension lines for personal safety harness attachment.

705.8 Use of Temporary Equipment

The safe design of any piece of equipment shall not be exceeded, nor shall the equipment be modified in any manner that alters the original factor of safety or capacity. Mobile equipment shall be fitted with suitable alarm and motion sensing devices, including back-up alarm, when required. The Contractor shall ensure that the installation and use of equipment are in accordance with the safety rules and recommendations laid down by the manufacturer, taking into account the other installations already in place or to be installed in the future.

The contractor shall inspect Equipment prior to its use on the Works and periodically thereafter to ensure it is in safe working order. Special attention shall be given to such items as cables, hoses, guards, booms, blocks, hooks and safety devices. Equipment found to be defective shall not be used and immediately removed from services, and a warning tag attached.

Natural and synthetic fibre rope made of material such as manila, nylon, polyester, or polypropylene shall not be used as slings. Only trained, qualified and authorized personnel shall operate equipment. All drivers and operators shall hold a current Certificate of Training Achievement for the equipment being used. A safety observer shall be assigned to watch movements of heavy mobile equipment where hazards may exist to other personnel from the movement if such equipment, or where equipment could hit overhead lines or structures. The observer shall also ensure that people are kept clear of mobile equipment and suspended tools.

When mobile or heavy equipment is travelling onto a public thoroughfare or roadway, a flagman shall ensure that traffic has been stopped prior to such equipment proceeding. While the mobile or heavy equipment is travelling on a public roadway, a trailing escort vehicle with a sign warning of a slow-moving vehicle that is dangerous to pass shall be provided.

705.9 Cranes:

(a) The Contractor shall give a minimum of 48 hours' notice to the Project Manager prior to bringing a crane on site.

(b) No cranes shall be erected in the site without the prior approval of the Project Manager. The Project Manager may direct the Contractor as to location where cranes may not be located. The Contractor shall take such directions into account when submitting his proposals for crane location points, base footings, pick up points and swing radius. Compliance with any such direction shall not entitle the Contractor to any extension of the Period of Completion or to any increase of the Contract Price.

(c) Safety harness shall be worn and used at all times by personnel engaged on the erection, alterations and dismantling of tower cranes.

(d) The Contractor shall provide a copy of the current Test Certificate (see Sub-Clause 702) to the Project Manager before any crane (tower or mobile) is brought into operation on the Site.

(e) All lifting tackle must hold a current Test Certificate. All lifting tackle must be thoroughly examined every 6 months and an inspection report raised.

(f) All fibrous/web slings shall be destroyed and replaced 6 months after first use.

(g) All crane drivers/operators shall hold a Certificate of Training Achievement for the class of crane operated.

(h) All banksman/slingers shall hold a Training Certificate from a recognized training agency.

(i) The maximum weekly working hours of a crane driver or banksman shall be restricted to 60 hours.

(j) Under no circumstances shall a crane or load come within 4 m of any energized overhead power line or other critical structure.

705.10 Locking-out, Isolating and Tagging Equipment.

Equipment that could present a hazard to personnel if accidentally activated during the performance of installation, repair, alteration, cleaning, or inspection work shall be made inoperable and free of stored energy and/or material prior to the start of work. Such equipment shall include circuit breakers, compressors, conveyors, elevators, machine tools, pipelines, pumps, valves, and similar equipment.

Where equipment is subject to unexpected external physical movement such as rotating, turning, dropping, falling, rolling, sliding, etc., mechanical and/or structural constraints shall be applied to prevent such movement.

Equipment which has been locked-out, immobilized, or taken out of services for repair or because of a potentially hazardous condition shall be appropriately tagged indicting the reason it has been isolated and/or taken out of service.

Where safety locks are used for locking out or isolating equipment, the lock shall be specially identified and easily recognized as a safety lock.

705.11 Installation of Temporary or Permanent Equipment

During installation and testing the Contractor’s specialists Project Manager shall be in attendance. All control mechanism panel and wiring diagrams shall be available and printed in English.

705.12 Laser Survey Instruments

Details of the types and use of laser instruments shall be submitted and agreed with the Project Manager.

705.13 Working in Confined Spaces

Confined spaces, including tanks, vessels, containers, pits, bins, vaults, tunnels, shafts, trenches, ventilations ducts, or other enclosures where known or potential hazards may exist, shall not be entered without prior inspection by and authorization from the Site Safety Officer and the issuance of a Hazardous Work Permit.

Prior to entering the confined space, the area shall be completely isolated to prevent the entry of any hazardous substances or materials which could cause an oxygen deficient atmosphere. All equipment that could become energized or mobilized shall be physically restrained and tagged. All lines going into the confined space shall be isolated and/or blanked.

Personnel working in a confined space where emergency escape or rescue could be difficult, shall wear a safety harness attached to a lifeline. A qualified attendant(s), trained and knowledgeable in job-relater emergency procedures, shall be present at all times while persons are working within the confined space. The attendant shall be capable of effecting a rescue, have necessary rescue equipment immediately available, and be equipped with at least the same protective equipments as the person making entry.

All equipment to be used in a confined space shall be inspected to determine its acceptability for use. Where a hazard from electricity may exist, equipment utilized shall be of law voltage type. The atmosphere within the confined space shall be tested to determine if it is safe to enter. Acceptable limits are:

- oxygen: 19.5% lower, 22% higher;
- flammable gas: not to exceed 10% of lower explosion limit;
- toxic contaminants: not to exceed the permissible exposure limit.

Subsequent testing shall be done after each interruption and before re-entering the confined space, as well as at intervals not exceeding 4 hours. Continuous monitoring is preferable and may be necessary in certain situations.

Adequate ventilation shall be provided to ensure the atmosphere is maintained within acceptable limits.

705.14 Demolition

A detailed Method Statement detailing the demolition procedures/techniques to be used shall be submitted to and approved by the Project Manager prior to commencement of work on site.

The Method Statement must include full details of measures to be taken to ensure that there are no persons remaining in the building/structure and to distance members of the public and Contractor’s personnel from the building/structure prior to demolition.

705.15 Use of Explosives

The Contractor shall not use explosives without the written permission from the Project Manager and

relevant authorities.

The Contractor shall observe all regulations regarding proper purchasing, transportation, storage, handling and use of explosives.

The Contractor shall ensure that explosives and detonators are stored in separate special building. These secured buildings shall be constructed, located and clearly marked in English:

"DANGER – EXPLOSIVES"

all as approved by the Project Manager and relevant authorities. The Contractor shall ensure that all possible precautions are taken against accidental fire or explosion, and ensure that explosives and detonators are kept in a proper and safe condition. The contractor shall ensure that explosives and detonators are always transported in separate vehicles and kept apart until the last possible moment and that metallic tools are not used to open boxes of explosives or detonators.

Blasting Procedure: the contractor shall carry out blasting operations in a manner that will not endanger the safety of persons or property. The Contractor shall, along with other necessary precautions:

(a) clear all persons from building and the area affected by the blasting. All such persons shall be given adequate notice of the actual time and date of blasting;

(b) ensure that police and other local authorities are kept fully informed, in advance, of the blasting programme so that they may be present when blasting takes place if they so require;

(c) erect warning notices around the area affected that blasting operation are in progress;

(d) carry out a thorough search of buildings and the area affected prior to blasting;

(e) ensure that blasting is only carried out by experienced shot firers. Priming, charging, stemming and shot firing shall be carried out with greatest regard for safety and in strict accordance with the rules and regulations of the relevant authorities.

(f) ensure that explosive charges are not excessive, charged boreholes are properly protected and proper precautions are taken for the safety of persons and property.

The Contractor shall maintain an up-to-date inventory of all explosives and explosive devices and shall submit a monthly report to the Project Manager, detailing the use of all explosives by date and location.

705.16 Excavation and Trenching

An excavation permit signed by the Project Manager must be issued before excavation proceeds in any work location. The contractor shall investigate and identify the location of existing services by study of the drawings, a visual/physical study of the site, sweeping by appropriate detection equipment and where necessary hand excavation of trial holes.

Following this investigation, the Contractor shall submit a written request for an excavation permit to the Project Manager.

The Project Manager will return the permit signed and dated to indicate:

- services which are to be maintained.
- services which are to be isolated.
- any special precautions to be taken.

A sample Excavation Permit is given in Annex 1 to this Specification. The issue of an Excavation Permit by the Project Manager shall not relieve the Contractor of his responsibilities under the Contract.

The side of all excavations and trenches which in the opinion of the Project Manager might expose personnel or facilities to danger resulting from shifting earths shall be protected by adequate temporary supports or sloped to the appropriate angle of repose.

All excavations, slopes and temporary supports shall be inspected daily and after each rain, before allowing personnel to enter the excavation.

Excavations 1.3 metres or more in depth and occupied by personnel shall be provided with ladders as a means for entrance and egress. Ladders shall extend not less than 1 metre above the top of the excavation.

The Contractor shall provide adequate barrier protection to all excavations. Barriers shall be readily visible by day of night.

Excavated or other materials shall be stored at least 0.65 metres from the sides of excavations.

705.17 Concrete Reinforcement Starter Bars

The Contractor shall ensure concrete reinforcement starter bars are not a danger to personnel. Where permitted by the Project Manager, starter bars shall be bent down. Alternatively, the starter bars shall be protected using either hooked starters, plastic caps, plywood covers or other methods agreed with the Project Manager.

706 Environmental and Health Requirements

706.1 Contractor environmental and social management plan

The Contractor shall develop his own Environmental and Social Management Plan to ensure actions and mitigation necessary to protect the environment as contained in the Project ESIA Report and License, are incorporated into all site procedures. At a minimum, the contractor's ESMP must address the following:

- Policy
- Planning
- Implementation and Operation

706.1.1 Policy

The Contractor shall develop an environmental policy that includes, as a minimum, the following:

- A commitment to comply with applicable regulations and other requirements that the construction company subscribes to;
- A commitment to provide a safe work environment;
- A commitment to provide the training and equipment necessary for employees to conduct their work safely;
- A commitment to continuously improve performance and to pollution prevention; and
- A commitment to communicate the policy to all persons working for and on behalf of the company.

706.1.2 Planning

Environmental issues and the legal and other requirements in construction of the project have been identified in the project's ESIA Report. The Contractor must demonstrate within his plan that he has read and understood the ESIA Report and its provisions for environmental management and monitoring.

706.1.3 Implementation and Operation

Roles, responsibilities and authorities must be defined, documented and communicated to ensure effective environmental and social management. A specific management representative with requisite qualifications shall be assigned the responsibility for ensuring that the ESMP is established, implemented and maintained and shall be responsible for reporting performance, reviewing the Plan and making recommendations for improvement. Documented confirmation is required that the training needs of all persons working for or on the company's behalf whose work pose significant hazards to their health and safety and/or may create a significant impact on the environment has been identified. Records of all training must be maintained.

Management, supervisory, and employee responsibilities must be communicated to all employees through training, formal job descriptions, work experience, hiring practices, etc. Awareness training shall be provided that include the importance of conforming to the policy and procedures, the significant environmental issues, and the roles and responsibilities of management and staff.

Records shall be legible, identifiable and traceable to the activity. Records shall be stored and maintained in such a way that they are retrievable and protected against damage, deterioration or loss.

The Contractor shall establish, implement and maintain procedures to identify potential emergency situations and potential accidents that can have an impact on the environment, surrounding communities, the employees, and/or the public.

The Contractor shall be prepared to respond to actual emergency situations and accidents and prevent or mitigate associated adverse environmental or social impacts. The ESMP must also address how the Contractor will receive, document and respond to external interested parties.

706.2 Protection of the Environment

The Contractor shall be knowledgeable of and comply with the Environmental Management Plan (EMP) and with all environmental laws, rules and regulations for materials, including hazardous substances or wastes under his control. The contractor shall not dump, release or otherwise discharge or dispose of any such materials without the authorization of the Project Manager.

Any release of a hazardous substance to the environment, whether air, water or ground, must be reported to the Project Manager immediately. When releases resulting from Contractor action occur, the Contractor shall take proper precautionary measures to counter any known environmental or health hazards associated with such release. These would include remedial procedures such as spill control and containment and notification of the proper authorities.

706.3 Air Pollution

The Contractor, depending on the type and quantity of materials being used, may be required to have an emergency episode plan for any releases to the atmosphere. The Contractor shall also be aware of local ordinances affecting air pollution.

The Contractor shall take all necessary measures to limit pollution from dust and any windblown materials during the Works, including damping down with water on a regular basis during dry climatic conditions.

The contractor shall ensure that all trucks leaving the Site are properly covered to prevent discharge of dust, rocks, sand, etc.

706.3 Water Pollution

The contractor shall not dispose of waste solvents, petroleum products, toxic chemicals or solutions on the city drainage system or watercourse, and shall not dump or bury garbage on the Site. These types of waste shall be taken to an approved disposal facility regularly, and in accordance with requirements of relevant Authorities. The Contractor shall also be responsible for the control of all run-offs, erosion, etc.

706.4 Solid Waste

706.4.1 General Housekeeping

(a) The Contractor shall maintain the site and any ancillary areas used and occupied for performance of the Works in a clean, tidy and rubbish-free condition at all times.

(b) Upon the issue of any Taking-Over Certificate, the Contractor shall clear away and remove from the Works and the Site to which the Taking-Over Certificate relates, all Contractor's Equipment, surplus material, rubbish and Temporary Works of every kind, and leave the said Works and Site in a clean condition to the satisfaction of the Project Manager. Provided that the Contractor shall be entitled to retain on Site, until the end of the Defects Liability Period, such materials, Contractor's Equipment and Temporary Works as are required by him for the purpose of fulfilling his obligations during the Defects Notification Period.

706.4.2 Rubbish Removal and Disposal

(a) The Contractor shall comply with statutory and municipal regulations and requirements for the disposal of rubbish and waste.

(b) The Contractor shall provide suitable metal containers for the temporary storage of waste.

(c) The Contractor shall provide suitable metal containers from site as soon as they are full. Rubbish containers shall not be allowed to overflow.

(d) The Contractor shall provide hard standings for and clear vehicle access to rubbish containers.

(e) The Contractor shall provide enclosed chutes of wood or metal where materials are dropped more than 7 meters. The area onto which the material is dropped shall be provided with suitable enclosed protection barriers and warning signs of the hazard of falling materials. Waste materials shall not be removed from the lower area until handling of materials above has ceased.

(f) Domestic and biodegradable waste from offices, canteens and welfare facilities shall be removed daily from the site.

(g) Toxic and hazardous waste shall be collected separately and be disposed of in accordance with current regulations.

706.4.3 Asbestos Handling and Removal

The Contractor shall comply with all local regulations regarding the handling of asbestos materials. In the absences of local regulations, relevant International Standards shall apply.

706.4.4 Pest Control

The Contractor shall be responsible for the rodent and pest control on the Site. If requested, the contractor shall submit to the Project Manager, for approval, a detailed programme of the measures to be taken for the control and eradication of rodents and pests.

706.5 Noise Control

The Contractor shall ensure that the works is conducted in a manner so as to comply with all restrictions of the Authorities having jurisdiction, as they relate to noise.

The Contractor shall, in all cases, adopt the best available plant/and or machinery shall be used. All equipment shall be maintained in good mechanical order and fitted with the appropriate silencers, mufflers or acoustic covers where applicable. Stationary noise sources shall be sited as far away as possible from noise-sensitive areas and, where necessary, acoustic barriers shall be used to shield them. Such barriers may be proprietary types, or may consist of site materials such as bricks or earth mounds as appropriate.

Compressors, percussion tools and vehicles shall be fitted with effective silencers of a type recommended

by the manufacturers of the equipment. Pneumatic drills and other noisy appliances shall not be use during days of rest or after normal working hours without the consent of the Project Manager.

Areas where noise levels exceed 90 decibels, even on a temporary basis, shall be posted as high noise level areas.

707 Additional Requirements for Work in Public Areas

707.1 General

Those additional requirements shall apply to all works carried out in Public Areas.
Public Areas are defined as areas still used by or accessible to the public. These include public roads and pavements, occupied buildings and areas outside the Contractor's boundary fencing.

All work in Public Areas shall be carried out to minimize disturbance and avoid dangers to the public.

Before commencing work, the Contractor shall ensure that all necessary resources, including labour, plant and materials will be available when required and that the works will proceed without delays and be completed in the shortest possible time. Period of inactivity and slow progress or delays in meeting the agreed programme for the Works, resulting from the Contractor's failure to provide necessary resources or other causes within the control of the Contractor, will not be accepted. In the event of such inactivity, slow progress or delays, the Contractor shall take immediate action to rectify the situation, including all possible acceleration measures to complete the works within the agreed programme. Details of the actions and acceleration measures shall be submitted to the Project Manager. If the Project Manager is dissatisfied with the Contractor's proposals, the Contractor shall take such further actions or measures as required by the Project Manager. All costs incurred shall be the responsibility of the Contractor.

707.2 Method Statement

The Contractor shall submit to the Project Manager a method statement for each separate area or work in Public Areas. The Method Statement shall include:

(a) a general description of the Works and methodology of how it will be carried out.

(b) Details of the measures and temporary works to minimise disturbance and safeguard the public. These shall include temporary diversions, safety barriers, screens, signs, lighting, watchmen and arrangements for control of traffic and pedestrians and advance warning to be given to the public.

(c) Details of temporary reinstatement and maintenance of same prior to final reinstatement.

(d) For works involving long lengths of trenches or works to be completed in sections, the lengths or sections of each activity (e.g. up to temporary reinstatement, final reinstatement) to be carried out at any one time.

(e) Details of the availability of necessary resources (labour, plant, materials, etc.) to complete the work.

(f) A programme showing start and completion dates and period for all activities of each length or section, including temporary works, and the works overall.

(g) Such further information as necessary or required by the Project Manager.

The Contractor shall not commence work, including temporary works, until after the approval of the Contractor's Method Statement by the Project Manager.

Method Statements shall be updated bases on actual progress or as and when required by the Project Manager.

707.3 Closure of Roads, Etc.

The closure or partial closure of roads, pavements and other public areas will only be permitted if approved by the Project Manager and Relevant Authorities. The Contractor shall detail for each closure the extent of area to be closed, the reasons and duration of the closure, and where appropriate, proposed diversions. A sample Street Closure Permit is given at Annex 2 to this Specification.

707.4 Trench and Other Excavations

The requirements covering trench and other excavations will depend on the location and type of the excavation and the potential risks to the public.

The following guidelines apply particularly to trenches but shall also apply to other types of excavations:

(a) before commencing work the Contractor shall:

- notify the Project Manager of the location and duration of the work. An excavation permit signed by the Project Manager must be issued in accordance with Sub-Clause 705.16 before excavation proceeds in any work location;
- obtain permission from relevant authorities including the police when required;
- erect all temporary works such as barriers, warning signs, lighting, etc.;
- have available adequate materials for temporary supports to sides of excavations and necessary labour, plant and materials to complete the work within the shortest possible time.

(b) in carrying out the works the Contractor shall, unless otherwise permitted or required by the Project Manager:

- not open more than one excavation within a radius of 250 metes;
- limit the length of trench excavation open at one time to 150 metres;
- maintain and alter or adapt all temporary works including supports to sides of excavations;
- remove all surplus excavated material the same day it is excavated;
- complete the works, including final reinstatement within ten days;

- where final reinstatement is not achieved within the required time, to carry out temporary reinstatement;
- ensure that any temporary reinstatement is maintained at the correct level until final reinstatement is achieved.

The above guidelines shall not relieve the Contractor of his obligations and responsibilities.

707.5 Safety Barriers

Safety barriers shall be provided to the perimeter of work areas and to trench and other types of excavations and to existing openings such as manholes, draw pits and the like. When exposed to the public, safety barriers shall be provided to both sides and ends of trenches and around all sides of openings.

The Contractor shall provide details of the type or types of safety barriers for each excavation for the approval of the Project Manager prior to commencing work. No work shall commence until the safety barriers are in place.

The type of safety barrier used shall be appropriate to the particular location and the potential risks to the public. Examples of different types of safety barriers are given below:

- Type 1 - excavated material;
- Type 2 - non-rigid barrier of rope or florescent tape strung between metal rods driven into the ground;
- Type 3 - rigid barrier of timber, steel or concrete. Such barriers could be in the form of horizontal rail(s) or sheet material secured to posts driven or concreted onto the ground.

The following are guidelines on the type of safety barriers that could be used in differing situations. They apply particularly to trenches but also apply to other types of excavation, existing openings onto the perimeter of work areas:

- areas not subject to vehicular traffic - Types 1 or 2;
- roadways (low traffic speed) - Types 1 or 2;
- roadways (high traffic speed or where excavation are greater than 2 m) - Type 3.

The above examples of the types of barriers and the guidelines on situations in which they could be used shall not relieve the Contractor of his obligations and responsibilities.

Section 8 Contractor's Site Check List

801 Contractor's Site Check List

A sample Contractor's Site Check List is included in Annex 1,2 & 3 to this Specification. This is included to assist contractors should they wish to introduce such a system as part of their site management procedures. The list is not exhaustive and further items will need to be added by the Contractor.

The list is issued for guidance only, and does not, in any way, revise or limit the requirements covered elsewhere in these Specifications.

Annex 1
Sample Excavation Permit

To: ……... (Project Manager)

From: …….. (Contractor) Date: …….

Contract No:
Request for Excavation Permit No: ……

Please give approval for excavation to proceed in the following area:

Work to start on:

Existing services have been checked and identified by:

Drawings # Physical Survey #

Catscan # Trial Holes Excavation #

Signed (Contractor): ……

Approval by Project Manager

The above excavation may proceed, subject to the following:

Service to be maintained:

Services to be isolated before work proceeds:

Other matters:

Signed (Project Manager): …….

Date: ……

Annex 2
Sample Street Closure Permit

To: ……... (Project Manager)

From: …….. (Contractor) Date: …….

Contract No:
Request for Street Closure Permit No: ……

Please give approval for the closure of the following street(s) from …… to …… (dates)

Street(s):

Reasons:

Proposed diversions:

Signed (Contractor): …….

Approval of the Project Manager

The above street(s) may be closed for the periods stated subject to the following conditions:

Approval has been given by the relevant authorities and the police;

Other:

Signed (Project Manager): …….

Date: ……..

Annex 3

Sample Contractor's Site Check List

Safe Access:

- arrangements for visitors and new workers to the site
- safe access to working locations
- walkways free from obstructions
- edge protection to walkways over 2m above ground
- holes fenced or protected with fixed covers
- tidy site and safe storage of materials
- waste collection and disposal
- chutes for waste disposal, where applicable
- removal or hammering down of nails in timber
- safe lighting for dark or poor light conditions
- props or shores in place to secure structures, where applicable

Ladders:

- to be used only if appropriate
- good condition and properly positioned
- located on firm, level ground
- secure near top. If not possible, to be secured near bottom, weighted or footed to prevent slipping
- top of ladder minimum 1 metre above landing place

Scaffolding:

- design calculation submitted
- proper access to scaffold platform
- properly founded uprights with base plates
- secured to the building with strong ties to prevent collapse
- braced for stability
- load bearing fittings, where required
- uprights, ledgers, braces and struts not to be removed during use
- fully boarded working platforms, free from defects and arranged to avoid tipping or tripping
- securely fixed boards against strong winds
- adequate guard rails and toe boards where scaffold is 2m above ground
- designed for loading with materials, where appropriate
- evenly distributed materials
- barriers or warning notices for incomplete scaffold (i.e. not fully boarded)
- weekly inspections and after bad weather by competent person
- record of inspections

Excavation:

- underground services to be located and marked, precautions taken to avoid them
- adequate and suitable timber, trench sheets, props and other supporting materials available on site before excavation starts
- safe method for erecting and removal of timber supports
- sloped or battered sides to prevent collapse

- daily inspections after use of explosives or after unexpected falls of materials
- safe access to excavations (e.g. sufficiently long ladder)
- barriers o restrict personnel/plant
- stability of neighbouring buildings
- risk of flooding
- materials stacked, spoil and vehicles away from top of excavations to avoid collapse
- secured stop blocks for vehicles tipping into excavations

Roof Work:

- crawling ladders or boards on roofs more than 10 degrees
- if applicable, roof battens to provide a safe handhold and foothold
- barriers or other edge protection
- crawling boards for working on fragile roof materials such as asbestos cement sheets or glass. guard rails and notices to same
- roof lights properly covered or provided with barriers
- during sheeting operations, precautions to stop people falling from edge of sheet
- precautions to stop debris falling onto others working under the roof work

Transport and Mobile Plant:

- in good repair (e.g. steering, handbrake, footbrake)
- trained drivers and operators and safe use of plant
- secured loads on vehicles
- passengers prohibited from riding in dangerous positions
- propping raised bodies for tipping lorries prior to inspections
- control of on-site movements to avoid danger to pedestrians, etc.
- control of reversing vehicles by properly trained banksmen, following safe system of work

Machinery and Equipment:

- adequate secured guards in good repair to dangerous parts, e.g. exposed gears, chain drives, projecting engine shafts

Cranes and Lifting Appliances:

- weekly recorded inspections
- regular inspections by a competent person
- test certificates
- competent and trained drivers over 18 years of age
- clearly marked controls
- checks by driver and banksman on weight of load before lifting
- efficient automatic safe load indicator, inspected weekly, for jib cranes with a capacity of more than one tonne
- firm level base for cranes
- sufficient space for safe operation
- trained banksman/slinger to give signals and to attach loads correctly, with knowledge of lifting limitation of crane
- for cranes with varying operating radius, clearly marked safe working loads and corresponding radii
- regular maintenance

- lifting gear in good condition and regularly examined

Electricity:

- measures to protect portable electric tools and equipment from mechanical damage and wet conditions
- checks for damage to or interference with equipment, wires and cables
- use of correct plugs to connect to power points
- proper connections to plugs; firm cable grips to prevent earth wire from pulling out "permit-to-work" procedures, to ensure safety
- disconnection of supplies to overhead lines or other precautions where cranes, tipper lorries, scaffolding, etc. might touch lines or cause arcing

Cartridge Operated Tools:

- maker's instruction being followed
- properly trained operators, awareness of dangers and ability to deal with misfires
- safety goggles
- regular cleaning of gun
- secure place for gun and cartridges when not in use

Falsework/formwork:

- design calculations submitted method statement dealing with preventing falls of workers
- appointment of falsework coordinator
- checks on design and the supports for shuttering and formwork
- safe erection from steps or proper platforms
- adequate bases and ground conditions for loads
- plumb props on level bases and properly set out
- correct pins used in the props
- timberwork in good condition
- inspection by competent person, against agreed design, before pouring concrete

Risks to the Public:

- identify all risks to members of the public on and off site, e.g. materials falling from scaffold etc., site plant and transport (access/egress) and implement precautions, e.g. scaffold fans/nets, banksmen, warning notices, etc.
- barriers to protect/isolate persons and vehicles
- adequate site perimeter fencing to keep out the public and particularly children. secure the site during non-working periods
- make safe specific dangers in site during non-working periods, e.g. excavations and openings covered or fenced, materials safely stacked, plant immobilized, ladders removed or boarded

Fire – General:

- sufficient number and types of fire extinguishers
- adequate escape routes, kept clear
- worker awareness of what to do in an emergency

Fire – Flammable Liquids:

- proper storage area
- amount of flammable liquid on site kept to a minimum for the day's work
- smoking prohibited; other ignition sources kept away from flammable liquids

- proper safety containers

Fire – Compressed Gases, e.g. Oxygen, LPG, Acetylene:

- properly stored cylinders
- valves fully closed on cylinders when not in use
- adopt "hot work" procedures
- site cylinders in use outside huts

Fire – Other Combustible Materials:

- minimum amount kept on site
- proper waste bins
- regular removal of waste material

Noise:

- assessment of noise risks
- noisy plant and machinery fitted with silencers/muffs
- ear protection for workers if they work in very noisy surroundings

Health:

- identify hazardous substances, e.g. asbestos, lead, solvents, etc., and assess the risks
- use of other substances where possible
- control exposure by means other than by using protective equipment
- safety information sheets available from the supplier
- safety equipment and instructions for use
- keep other workers who are not protected out of danger areas
- testing of atmosphere in confined spaces; provision of fresh air supply if necessary. Emergency procedures for rescue from confined spaces

Manual Handling:

- avoid where risk of injury
- if unavoidable, assess and reduce risks

Protective Clothing:

- suitable equipment to protect head, eyes, hands and feet here appropriate
- enforce wearing of protective equipment

Welfare:

- suitable toilets
- clean wash basin, hot/warm water, soap and towel
- room or area where clothes can be dried
- wet weather gear for those working in wet conditions
- heated site hut where workers can take shelter and have meals with the facility for boiling water
- suitable first aid facilities

Work in Public Areas:

- all risks to the public identified
- method statement approved
- road closures approved
- temporary diversions in place
- safety barriers erected/maintained

- labour, materials, plant and other resources sufficient to meet programme
- temporary reinstatement completed and properly maintained
- permanent reinstatement completed at earliest possible date.

Section 9. Works Components

901 Sewerage General

The Limuru Sewerage works to be constructed will covers Limuru Town, Kwa Mbira, Misirii, Karanjee and Industrial area.

The scope of works for the Limuru Project Component comprises the following works:

Rehabilitation of existing oxidation ditches
Rehabilitation and upgrading of existing sewerage network
Construction of 2 number oxidation ditches and 4 number settling tanks
Sludge beds
Extension of sewers OD300 Upvc 2.9km and OD250 Upvc 29km
Bibirioni Sewer line 8km
Construction of water distribution pipes as:

- Kamangu Line 160mm= 10.7Km
- Tigoni - Tiekunu Line 160mm=12.2Km
- Karanjee addition Distribution Lines 50mm= 1.58Km

The rehabilitation works as identified by Posch/Norken study will include:

- Aerator- new Jet Aerators 4nr;
- Clarifier Scrapers- new circular bridge scrapers (galvanized steel);
- Sludge screw pumps- replace with new submersible pumps and modify the respective chambers.
- The study identified the following items that were missed out in the original construction/installation:
    - Faecal station;
    - Interception chamber - that can bypass stormwater to polishing pond directly (without passing to oxidation ditch);
    - Grit chamber -that trap silt (which currently clog the bioreactor);
    - Coarse screen- to be replaced by new equipment;
    - Fine screens to be replaced with modern screens that have automatic capability for self-cleaning.

<u>Process Description</u>

The Pasveer ditch system combines the processes of oxidation and sedimentation by means of mechanical aeration and final clarification. The untreated wastewater is introduced into the ditch where it is mechanically aerated by a paddle wheel or brush aeration rotor. The rotor is mounted on a revolving horizontal shaft that is partly submerged in the wastewater for oxygenation and circulation of the ditch contents. The ditch effluent is clarified and the settled sludge is returned to maintain a desirable MLSS concentration. The MLSS concentration generally ranges from 3,000 mg/l to 5,000 mg/l; however, this is dependent upon the surface area provided for sedimentation, the rate of sludge return, and the aeration process.

Pre-treatment

Generally, no primary clarification is required for this process. Screening is done to remove coarse materials from the flow stream that could;-

- Damage subsequent mechanical process equipment's such as rotors and pumps
- Reduce the overall treatment process reliability and effectiveness
- Eliminate materials that may inhibit the beneficial reuse of biosolids

Grit removal is necessary where the inflow contains sand, gravel, cinders or other heavy solids materials that have subsiding velocities or specific gravities substantially greater than those of the organic putrescible solids wastewater.

Design of Oxidation Ditch

BOD removal in properly operated oxidation ditch is consistently greater than 95%.

The tank design is purely empirical and is based on the Sludge loading factor which is the weight of BOD5 applied to the ditch liquor suspended solids per day. It is measured in grams of BOD5 per gram solids per day (day-1).

The volume of the oxidation ditch is based on a maximum loading of 250 kilograms of BOD5 applied daily cubic metre of channel or on retention time; whichever requires the greater volume.

A hydraulic retention time or aeration period of 24 hours is recommended based on an average daily wastewater flow rate exclusive of recirculation. The retention time may be reduced to a minimum of 16 hours where the raw influent BOD5 is less than 200 mg/l or when adequate rotor aeration and efficient suspended solids separation in the final clarifier are provided. In the cold climates, the temperature drop in the system must be considered when selecting long retention times. Normally liquid temperatures below 10 degrees centigrade reduce the bacterial activity in the channel and increase the clarifier effluent suspended solids concentration

Trapezoidal rather than rectangular channel cross sections are recommended as these form a closed ring-shaped circuit which does not create eddies or dead areas.

The channel depth is in the range 1 and 1.5 metres in depth. Inlet and outlet control devices are provided for adjusting the liquid levels and to allow the oxidation ditch to be operated intermittently or

continuously. Inlets are normally submerged and directed downstream from the outlet or overflow device to minimize short-circuiting.

A minimum of 300 millimetres of freeboard is provided at the maximum liquid depth.

Channel ends should consist of 180 degrees or well-rounded bends to prevent eddying and stagnant zones. Median strip is provided in a manner such that the radius of curvature will not severely increase the frictional resistance to retard the liquid flow.

A minimum flow through velocity of 0.3m/s is provided throughout the entire cross- sectional area of the channel, with the travel time between the aerator(s) not exceeding 3 to 4 minutes.

The channel are concrete constructed, except when package plants are utilized for small installations; then other impervious, durable, and corrosion resistant materials may be considered.

Oxygen is required at a rate of 1.5 – 2.0 g O2/g BOD5 applied. Such a rate includes an allowance for the endogenous respiration of sludge and maintains aerobic conditions along the entire length of the ditch.

A minimum of two complete rotor installations are desirable such that each rotor installation is designed to meet the oxygen demand with average design conditions. Under average design conditions, it is desirable that the rotor installations maintain dissolved oxygen (DO) content of 2 mg/l except between the raw wastewater inlet and the immediate downstream rotor. The DO content in the ditch should never be less than 1.0 mg/l.

Majority of the mechanical aerators are rated in terms of oxygen transfer rate expressed in kilograms of oxygen per kilowatt-hour (Kg O2/ KW.h). Testing and rating of these equipment’s is done at standard conditions of temperature and pressure

Settling Tanks

Sedimentation as applied in the various types of wastewater treatment processes is aimed at reducing the concentration of Settleable and suspended matter.

The BOD5 removal rates in sedimentation tanks (clarifiers) are in the range 35 to 45% for 2 to 4 hours retention time. Suspended solids removal is in the range 60 to 70% at the same retention times.

Settling characteristics of the mixed liquor solids is considered in design of secondary clarifiers for liquid – solids separation. The clarifier design is based on provision of adequate clarification of the effluent and solids thickening for the activated sludge solids.

902 Pipe Hunching

The pipes would be laid on 150mm thick Class 20 concrete bedding. All the bedding types would be similar or equivalent to Nairobi City types A, B, C, or D.

902 Manholes

Manholes have been provided for all sewer junctions, at changes in slope, changes in direction, changes in size, and ensuring that the spacing between successive manholes does not exceed 60 m. The design recommends for adoption of ring manholes.

The Manhole Covers shall be GRP. This are made using thermoset material for long term durability. The material comprises of cross-linked polyesters combined with Fibreglass reinforced materials to sustain against wear-n-tear for heavy load vehicular traffic. It is 40% lighter than traditional Precast Concrete and Cast Iron covers. Provides upto 5 times more compressive strength. This resilient material withstands constant exposure to weather or sun without sacrificing security or aesthetics.

The recommended load capacity as per EN-124 are:

LIGHT DUTY - Test load-2.5 Ton

Suitable for use within residential complexes, for areas accessible to pedestrians and bicycles and occasional Light Motor Vehicle traffic. These manhole covers can also be used for 'Inspection Chambers'.

MEDIUM DUTY-Test load-10 Ton

Suitable for use under medium-duty vehicular traffic, passenger cars and vehicles of comparable weight including car parking areas.

HEAVY DUTY-Test load-20 Ton

Suitable for use in carriageways with fast moving traffic, including trucks, city trunk roads, bus terminals with heavy duty vehicular traffic.

903 Proposed Sewerage Treatment System

The sewage treatment system has been designed to meet WHO standards for BOD5 and Coliform count, with the permissible limits being:-

BOD5 at 20oC = 50 mg/l

Suspended solids = 30 mg/l

Coliform = 5,000 per 100 ml

From the inlet works, the wastewater flow is split into two parallel streams, with each stream comprising of an oxidation ditch and an upflow settling tank.

Treated effluent from the sedimentation tanks is collected in a drain and passes through an outlet structure before discharging in to the maturation ponds

The sedimentation tanks are fitted with mild steel scrappers which direct the sludge to a drain at the bottom of the tanks. The drain leads to a sludge screw pump that lifts the sludge to four sludge drying beds. The filtrate from the sludge drying beds is directed back to the inlet system of the oxidation ditches.

A controlled amount of sludge from the screw pump will be returned to the oxidation ditches activated sludge in gentle manner.

904 Pipe Lengths

The following are the sewer summary

Item	Description	Unit	Length
1	225mm diameter uPVC Reticulation sewers	m	9,234
2	225mm diameter uPVC Additional Reticulation sewers	m	19,740
3	300mm diameter uPVC Line P sewers	m	1,715
4	250mm diameter uPVC sewers (Bibirioni)	m	8,000

The sewers have been designed for the ultimate 2040 capacity.

905 Plot Connection

The designs and costing of the proposed sewers have not included for individual plot connections. It is assumed that these will be the responsibility of the resident water service provider.

906 Maturation Ponds

Two number Maturation ponds measuring 90m x 150m x 1.5m deep will be constructed. The ponds have outlet weir that outfalls to an outlet manhole before the effluent is discharged to the river.
maturation ponds with indicative sizes as shown below:

Slope Protection Slabs in Maturation Ponds

The Contractor shall construct a concrete beam at the bottom of the proposed embankment 100mm slabs with A142 BRC mesh, to hold them in position in all the ponds. The Contractor shall submit a method statement giving comprehensive details of his proposal for implementation of the slope protection slabs, flow control and the intended sequence of operations

Filling of Pond Embankments

Material for filling of embankments shall be placed and compacted in layers not exceeding 150 mm compacted thickness to the profiles shown on the Drawings. The filling shall be built up and compacted thoroughly and evenly and shall be maintained at all times with a sufficient cross fall to enable surface water to drain freely from it. Surplus excavated material shall be used wherever possible subject to the approval of the Project Manager.

Suitable imported natural material for filling shall consist of uniform readily compactible material free from roots, vegetable matter, building debris, clay lumps retained on a 75 mm sieve and stones larger than 25 mm.
Granular fill shall consist of material having the following characteristics: 100% by weight passing a 40mm sieve, not more than 12% by weight passing a 12 mm sieve and Compaction fraction not exceeding 0.2.

Filled surfaces of embankments which are to be the final surface shall be trimmed and regulated to form an even surface free from slurry, loose material or debris and compacted as specified.

Rock fill, if required, shall consist of rock, broken stone, concrete or other hard inert material of a suitable size.

Compaction of Fill in Embankments and Pond Bases

Each layer of fill shall be thoroughly and evenly compacted by means of an approved vibratory roller to the satisfaction of the Project Manager. The fill shall be compacted to an average of at least 95% of the maximum dry density.

Where water has to be added to achieve the optimum moisture content it shall be applied in an even manner. The rate of application shall be such that no transverse or longitudinal flow occurs. The previously compacted surface shall be prevented from drying out by watering prior to placing of the next layer.

Where the finished levels of the pond bases or banks are below existing ground levels, the base or banks shall be compacted to an average of at least 95% of the maximum dry density for a depth of 150 mm below the finished levels.

Security and Manoeuvrability at the Pond Site

The Contractor shall ensure that the site of the works shall be adequately protected by temporary or permanent fencing and gates to inhibit the access of members of the Public, and also livestock and wildlife, from entering the site and being exposed to danger. The Contractor shall ensure that the secure site can accommodate sufficient operating space for heavy-duty trucks.

Earthwork, Permeability Test and Clay Lining for Ponds

All fill shall be carried out in layers not exceeding 200mm and will be compacted to 95% maximum dry density (MDD) at optimum moisture content (OMC). All finished cut surfaces shall be scarified and compacted to 95% MDD at OMC.

Upon completion of the earthworks the Contractor, shall carry out, at his cost, permeability tests to identify 'K" coefficient of permeability. Each test should cover an area not exceeding 200sqm of the pond bottom surface. Where 'K' is ≤ 10-6m/s, the Contractor shall scarify and compact the surface in this area. Permeability test will be repeated in this area.

Clay lining, shall consist of imported CL (clayey silt) classification and will be spread to a thickness of 100 mm and compacted to 98% MDD at OMC.

Alternative use of High Density Polyethylene (HDPE) Lining for Ponds instead of Pond Lining Clay

HDPE lining for ponds should meet the specifications given in the table below:-

Property	Test Method-ASTM	Units	Values
Thickness	D5199	mm	1.3
Minimum Density	D1505	g/cm3	0.94
Tensile Properties	D638 Type IV		
Yield Strength	D638 Type IV	KN/m	19
Break Strength	D638 Type IV	KN/m	35
Yield elongation	D638 Type IV	%	12
Break Elongation	D638 Type IV	%	700
Tear resistance	D1004	N	162
Puncture Resistance	D4833	N	420
Stress crack resistance	D5397	hr	200
Carbon black content	D1603	%	2
Carbon black dispersion	D5596	Cat	1,2
Oxidative induction time OIT)	D3895	min	100

Disposal of Surplus Excavated Material

All surplus excavated material shall be disposed off the site. The Contractor shall be deemed to have

allowed for haulage in his tender rate. Overhaul shall not be carried out until approval has been given by the Project Manager.

Commissioning of Ponds

The Contractor may not commission the ponds until such time when he notifies the Project Manager of his intent to do so and receives written approval from the Project Manager to proceed.
The Contractor shall ensure that all flow controls are correctly set before commencing commissioning.

The Contractor shall take appropriate care when filling the ponds, to prevent erosion of the pond base at the point of impact of the initial inlet flows upon the pond base and side slopes. The commissioning of the ponds will involve filling up all the ponds with liquid to a minimum depth of 1 m to avoid growth of any grass and to permit the gradual development of the algal and bacterial populations. The Contractor may propose certain herbicides to prevent such growth of grass between the period of completion of the works and commissioning of the ponds.

Weepholes

Where shown on the Drawings or directed by the Project Manager, the Contractor shall cast weepholes into concrete walls. The Contractor shall provide and place plastic pipes of the diameter shown on the Drawings to form weepholes which will be firmly held in position during the placing of the concrete. A 500 mm x 500 mm square of approved filter fabric shall be placed, central on the weephole between the concrete wall and backfill material.

Debris Screens

Where shown on the Drawings, the Contractor shall fabricate and install debris screens across the full width of the drain channel cross-section. The screens shall be fabricated using galvanised mild steel complying with BS 729. They shall be mounted on R.C. supports and incorporate a safe access platform to facilitate manual clearing of debris as shown on the Drawings.

907 Ancillary Works

The civil and ancillary works proposed for the treatment works site include the following:-

- Gravel standard access road to the STW;
- Grit storage;
- Sludge drying beds;
- Fencing of the entire sewage treatment works and gate;
- Flood lighting of the STW;
- Storm water drainage infrastructure at the STW;
- Water supply to the STW;
- Laboratory equipment;
- Afforestation and landscaping around the treatment works i.e planting of trees and creation of bunds for both aesthetics, wind break, safety and odour control;

908 Rehabilitation of Limuru WWTP

Currently, there is an existing oxidation ditch, 2 nr settling tanks, 2nr screw pumps, sludge drying beds and polishing natural wet land. The existing treatment system will be rehabilitated by installing new aerators, submersible pumps, grit chambers and modern screens.

The existing Limuru WWTP is non-operational due to the fact that main equipment is beyond its useful lifetime, missing process units and hydraulic overload.

Subject to Tender is the rehabilitation of the existing facilities in order to provide sound wastewater treatment capacity for secondary wastewater treatment with anaerobic sludge stabilization for an additional design life of 15 years.

Rehab Documents to Be Prepared By Contractor for Engineer Approval

Drawings

The detailed content of engineering documents, which shall be prepared by the Contractor and submitted for the approval of the Project Manager shall be adequate for the purpose.

Approval of the technical and equipment installation engineering documents by the Project Manager is a mandatory requirement prior to the ordering of any material and equipment. The Contractor shall not commence manufacture or construction of any part of the works before the final approval of the Employer to the relevant designs, drawings, specifications or other documents has been given and shall not make any changes on the approved drawings without the knowledge of and written approval by the Employer. No work shall commence on any structure until complete submissions showing all details affecting its size or location have been approved.

Documents and drawings shall be numbered following a system (numbering convention) approved by the Project Manager. Any abbreviations used in drawings and documents shall be explained.

Documents submitted, other than drawings and manufacturers' literature, shall be A4 in size. Only SI units shall be used.

The Contractor shall submit all drawings, schedules, calculations and other documents for which approval is required in English language in three (3) hardcopies each. Digital submittal of Contractors documents (softcopy) shall be in pdf-format (organized and structured, with appropriate table of contents, drawings incl. Adobe-layer management).

A programme for submitting drawings, schedules, calculations and other required documents shall be submitted by the Contractor to the Project Manager in accordance with the Contract. The programme shall identify the stages of submission and the drawings, schedules, calculations and other documents to be submitted for approval as required by the Specifications and the Conditions of Contract.

Project Manager's review of Submissions Items submitted for review by the Contractor and returned by the Project Manager will be categorised as follows:		
	Category	Description
1	"**Approved**"	Subject to its full compliance with the Specifications and conformity with the overall design, the Project Manager has no comment on the submission.
2	"**Approved with Comments**"	Subject to its general compliance with Specifications and conformity with the overall design, the Project Manager has comments on the submission but they are not such as to necessitate formal re-submission
3	"**Rejected**"	Subject to its incompliance with the Specifications. The Project Manager will indicate the grounds for rejection; the Contractor shall amend or revise the submission accordingly and re-submit the item for review.
In the case of first submissions by the Contractor to the Project Manager for review, each design, drawing and document shall reach the Project Manager in time to allow the required review period in accordance with the Conditions of Contract by the Project Manager before return to the Contractor.		
Re-submissions by the Contractor to the Project Manager of the same design, drawing and document shall reach the Project Manager in time to allow the required review period in accordance with the Conditions of Contract by the Project Manager before return to the Contractor.		

All Drawings, whether produced in the conventional manner or on CAD systems, shall be in the form of black lines on a white background and shall bear the information as specified under **Error! Reference source not found.** within the title block and such other information as is required to be shown to comply with the Contractor's Quality Assurance Specifications.

All drawings, including any Sub-Contractors, must be listed on a submittal schedule and the schedule shall be sub-divided into parts, i.e. for process, structural, electrical, HVAC, SCADA and MEICA.

All layout and arrangement drawings shall be to scale and shall include a graphical scale to aid the use of photographic reproductions. All dimensions shall be given in SI metric units, paper format shall be preferably be A1 and/or A3 paper sizes unless this is impracticable and shall comply with the Specifications of the Project Manager. All line thicknesses and colour; text height and text style shall comply with ISO standards. Calculations and other documentation shall include a cover page giving at least the same information as required to be shown on the drawings.

All drawings and technical documents to be submitted by the Contractor shall be in English language with separate copies in Kenyan language (drawings, lists and bills bi-lingual); in three (3) hardcopies each. Digital submittal of Contractors documents (softcopy) shall be in pdf-format (organized and structured, with appropriate table of contents, drawings incl. Adobe-layer management).

Working Design

Within the period stated in the Contractor's Programme, and following Employers/Engineers approval of the final design, the Contractor shall update his design and supplement the following working design information's, reports and drawings, and shall submit for approval before commencement of construction.

Working design documents, with the following additional scope; but not limited to:

- Mechanical equipment in detail, performance, connections, materials used, product type and casing broken down to machine units;
- Electrical equipment, instrumentation and SCADA components in detail, performance, connections, materials used, product type and casing, etc.;
- Electrical calculations including power supply sizing, incl. cable schedules;
- Small power and lighting calculations and drawings;
- Protection discrimination curves and calculations for the whole Plant including co-ordination with the local Electricity Company's supply and protection;
- Routing and single line diagrams for all services, switchboards/cubicles details;
- MDB and MCC panel drawings and detailed information;
- Structural, hydraulic and pipeline calculations;
- Structural details, drawings and reinforcement bending schedules (Civil Design);
- Pipeline layout, components and connection details;
- Longitudinal pipeline sections;
- Landscaping and fencing details.

Documents to be filed and submitted accordingly. Drawings and other information submitted at the previous stages, which have been revised or updated, shall be marked and re-submitted, accordingly. Previous versions of documents shall be rubberstamped "superseded".

Final design documents are subject to Engineers approval prior to commencement of works.

Method Statements

The Contractor shall provide in writing a general description of the arrangements and methods, which the Contractor proposes to adopt for the execution of the Works. This shall be submitted to the Project Manager at the same time as the Contractors Works Programme. Detailed method statements for major and special works which shall show in detail the methods proposed by the Contractor for carrying out the principal activities of construction shall be successively submitted together with the detailed design and Contractors workshop design.

In particular the Contractor shall indicate the resources (plant, personnel, materials, periods) to be allocated, their timing and sequencing, emergency/contingency measures, and any other information required to clearly detail the proposed methods, including design brief with location drawing, method description and

calculations, reference standards, detailed drawings and documentation, a risk assessment and health and safety arrangements etc., documents to be filed and submitted as specified.

Each method statement shall comprise a step-by-step schedule of specific operations or activities with descriptions, dates, times and duration of each step. Sketches, diagrams or other supportive detail as necessary to enable a clear understanding of the method and significance of each step of work or operation shall support the method statements. Each method statement shall be submitted to the Project Manager for review at least 14 days prior to the programmed activity commencement.

Work Programme

The Contractors work program shall be in full compliance with the Conditions of Contract under consideration of the contractually agreed periods for the Works, and sections of the Works as well as under consideration of the contractually periods for commissioning and testing, trial operation and taking over, defects liability period.

The programme for the works shall take into account climatic conditions, flows in existing sewerage and/or drainage systems, groundwater, geo-technical data and other conditions, to ensure the completion of the works in accordance with the Contact. The Contractor shall allow in his programme reasonable amount of time for work to be carried out by Public Utility Services Authorities and the Employer. The Employer will provide all necessary assistance in liaising with such authorities.

The program shall be detailed for each building and structure of the works, latest with submittal of the detailed design documentation and shall be subject to successive update in order to add details in accordance with the progress of the works.

The work program shall not be subject to revisions of completion periods but tracking Contractors monthly progress; planned and actual monthly rates of progress, critical path calculations for commencement and completion of each major item or work for the various stages of construction. The Contractor shall also submit a resource schedule with the work programme.

The Contractor shall not be permitted to commence any construction work on that part of the works until the Project Manager approves the drawings and calculations.

Workshop Drawings

The Contractor shall prepare and submit all additional drawings and workshop drawings, including details for the construction and completion of the works on request from the Project Manager. These additional drawings shall be based on the format and principles adopted for the Engineering Documents and Contract Drawings and shall be produced and submitted to the Project Manager for his approval.

The additional drawings prepared by the Contractor shall cover the following aspects of the works:

- Location and arrangement of the Constructor’s buildings and offices, including access facilities and fencing;

- Location and arrangement of work-yards, workshops, depots and stores for equipment, fuel and materials, including access facilities, electricity, water and telephone connections and fencing;
- Location of and proposals for the temporary works required for constructing the Works;
- Working drawings and calculations for all the temporary works proposed by the Contractor for constructing the works;
- Full working drawings indicating the Contractors proposed method of construction together with supporting calculations where applicable;
- General arrangement detail drawings showing access to safety equipment and emergency escape plans.

Operating and Maintenance Manuals

The Contractor shall prepare and submit for the approval of the Project Manager operating and maintenance procedure manuals in English and Kenyan language which shall describe the complete functions and Specifications for start-up operations, system control, wastewater quality control, maintenance, safety, record keeping, emergency response and shut down. These manuals shall deal separately with operation and maintenance. The O&M Manuals shall be submitted in draft format at least 28 days before the start of the Tests on Completion.

All information in these manuals shall apply specifically to the equipment being supplied. The documentation shall be free from irrelevant matters such as might be contained in the manufacturer's general literature (complete copies of suppliers standard documentation will be rejected)!

The manuals shall be arranged to provide separate volumes for each principal section of the works.

Manuals shall relate to as-built conditions and shall include all necessary drawings and diagrams for a proper understanding of the Works.

They shall include at least the following information's:

- Descriptive overview of the whole of the Treatment Plant;
- Description of all process and other plant, with relevant design and operating parameters;
- Descriptions of all systems installed, including mechanical, electrical, air systems, heating, ventilating and air conditioning, water supply, drainage, sewerage etc.;
- Description of all equipment supplied including manufacturers' leaflets, which are to be scheduled for easy reference, giving duties, electrical loads, etc.;
- Schedule of all equipment suppliers (and their local agents) including names, addresses, telephone, telex and fax numbers;
- Start-up, operation, and shutdown instructions for all parts of the Treatment Plant. These shall include process control, hydraulic control, power, and auxiliary systems;
- Procedures to deal with breakdown and emergencies;

- Safety Specifications;
- Full maintenance instructions for all equipment including planned maintenance schedules or charts giving daily, weekly, monthly, quarterly, half yearly, annually and overhaul instructions, together with recommended lubricants and spares. These should also include details of routine maintenance work that will be within the competence of the normal maintenance staff, and notification of maintenance work that will have to be done by the manufacturer, his agent or other specialist operator;
- Step by step procedure for the dismantling, repair and re-assembly of all items of equipment which shall be complemented by photographs and exploded diagrams;
- Spare parts list and supplier's details in Kenya and outside;
- Fault finding charts;
- Record drawings of all systems installed, including general arrangements, conduit and wiring trunking systems, plant room details, air and water systems flow sheets, wiring diagrams, control schematics and valve charts, etc. to a reduced scale;
- Certified suppliers drawings of all equipment supplied, which are to be scheduled for easy reference;
- Site test reports for all electrical, electronic, and mechanical and water systems. Site test process reports for proving tests, commissioning reports, and suppliers test certificates;
- Copies of performance curves of equipment;
- List of settings of all parameters (operation terminals of the PLC) for Plant automation and control at the time of handing over the Plant to the Employer.

The draft copy of each O&M manual and handbook shall be submitted for Engineers approval 3 months before commissioning is started. The final version, modified if necessary in accordance with the comments of the Project Manager and taking into account any changes made during commissioning, shall be presented before the issuing of the Taking-Over-Certificate in accordance with the Specifications elsewhere in.

Each volume shall be durable and permanently bound within a stiff binder of a design to be approved by the Project Manager. They must each permit the subsequent incorporation of revisions to be necessary during the Defects Liability Period. The cover of each binder shall be finished with a black waterproof and greaseproof material and the title printed gold block in well readable lettering on the front and on the spine.

The Contractor shall arrange the complete O&M documentation for digital submittal as (AutoCAD, MS Office, etc.) on CD's [3 sets].

Commissioning of Rehab Works

The commissioning period shall commence at such date determined by the Project Manager and after the Contractor has successfully realised all functional and works tests on completion and put the Works into operation.

The commissioning shall not be commenced until the required quantity of wastewater flow is available and the Project Manager has approved the Contractor's proposal and program for commissioning the works.

Subject to the approval of the Employer the works may be subdivided into the wastewater treatment section, the sludge treatment section and the pumping stations and sewer connection facilities, which may be commissioned successively.

The Contractor shall supervise the working of the mechanical and electrical plant and shall provide technical supervision continuously to effect any adjustment and remedial works that may be necessary. The Contractor shall co-operate and render all assistance necessary as required by the Project Manager during the commissioning of the plant.

The services to be provided during the commissioning period shall include but not be limited to the following:

- Conduction of the start-up of the Collector Mains and the WWTP in accordance with the commissioning work plan approved by the Engineer;
- Provision of all skilled personnel for the commissioning of the plant using the O&M manuals to demonstrate that the installation is capable of meeting the specified design and performance criteria. The Contractor shall maintain on site all necessary specialists on commissioning and technical personnel for a period of fourteen days after the successful commissioning to effect any adjustment that may be necessary;
- Assisting in supervising operation of the plant under a series of selected routine and non-routine process modes and conditions to determine the performance of individual elements and provide a base record of the capabilities of the WWTP for future reference;
- Assisting in supervising the operation and maintenance of the WWTP using various operating and maintenance procedures to test alternatives and determine optimum methods of operation.

The operating trials shall include but not be limited to the following;

- Screen cleaning intervals;
- Grit and grease separation operating periods;
- Aeration tanks oxygen supply and tank mixing;
- Surplus sludge withdrawal rates, aeration tank MLSS optimisation;
- Sludge pumping system characteristics at different sludge densities and compositions;
- Sludge thickening and dewatering systems characteristics at different sludge flows and water contents;
- Power consumption minimisation.

Commissioning shall include monitoring, reporting and referring of problems, which cannot be resolved on-site to the Project Manager and recommend alternatives to correct the problems.

Site Testing of Aeration Equipment

The following test procedure shall be applied for the performance tests on the aeration systems for each aeration basin or as approved by the Project Manager:

1) Each aerator shall be temporarily tested with its own gearbox and motor to determine that the aeration capacity and the oxygen transfer efficiency (ON) of each system. For each test three measuring points shall be provided, located in accordance to the expected flow. The oxygen intake curves of each measuring point shall be recorded by recording instruments. Before assembling the oxygen electrodes shall be faithfully calibrated above the zero and the saturation value. The calibration shall occur with the use of the connected recording instruments.
2) Before each series of tests is carried out with a fresh filling of water, cobalt salt shall be added to the test tank water to give a concentration of 0.5 mg/l cobalt ion to catalyse the reaction between sulphite ions and dissolved oxygen. The maximum salt concentration shall not exceed 2.0 mg/l.
3) Before starting each test it shall be ensured that the motors and gears have reached operating temperature and a constant water temperature is provided.
4) Before each test a solution of sodium sulphite shall be added to the water at a point close to and preferably under the aerator to remove dissolved oxygen from the whole of the test water.
5) Aeration shall take place until oxygen growth is less than 0.2 mg/l during a 10 minute period. The temperature of water shall be measured with a laboratory thermometer and shall be recorded.
6) Out of the recorded oxygen content, values shall be taken in equal temporary steps of 0.1 to 1 minute. A minimum of 50 values shall be taken.
7) The test results shall be determined separately for each measurement point as follows:

As-Built and Record Drawings

The as-built documentation drawings shall include all electrical and mechanical installations and all buildings inclusive site layout, Specifications and drawings, incorporating all the modifications/revisions effected during construction.

Six (6) copies (bilingual) of each set of final as-built drawings shall be submitted with the O&M Manuals.

Each copy shall be durably bound in a volume or volumes depending on bulk. Volume titles shall be clearly inscribed on the front cover and on the spine of the cover. Drawings and documents shall be marked “AS-BUILT”.

All drawings shall be filed on CD as AutoCAD Drawings, DWG format and in Adobe pdf-format. The CD shall be handed over to the Employer 3-fold.

Description of the existing WWTP (As-Build)

The existing Limuru WWTP has been designed and completed as a conventional oxidation ditch with extended aeration and sludge drying beds under consideration of two different design horizons defined as implementation Phase I & II.

- Phase I with a nominal design capacity of 6.100 P.E. was completed and commissioned in 1978;
- Phase II for a total design capacity of 14.300 P.E. was not build.

The WWTP was designed to serve a population of 4.500 (population equivalent of 6.100 P.E.) in Phase I. Phase II was dimensioned to increase the capacity of the treatment plant to serve a population of 11.000 (population equivalent of 14.300 P.E.)

The hydraulic load for Phase I was based on a dry weather flow of 550 m^3/d and a peak stormwater flow of 7.340 m^3/d for the existing plant and these figures were to be increased up to 1.130 m^3/d and 13.100 m^3/d after completion of Phase II.

The design load for Phase I was 330 kg BOD_5/d with provision for increasing the capacity to 790 kg BOD_5/d under Phase II. The corresponding figures for TSS are 440 kg/d and 1.030 kg/d respectively (Gauff... 1976).

The main units of the treatment plant are:	New Area Code:	
1. Screens	150	Screening Unit
2. Oxidation ditch equipped with TNO cage rotors	210	Oxidation Ditch
3. Two settling tanks with mechanical scrapers	220	Final Clarifiers
4. Two screw pumping sets	221	Sludge Pumps
5. Sludge thickener	310	Sludge Thickener
6. Eight sludge drying beds.	320	Sludge Drying Beds

The following major malfunctions were identified:

- Backwater from Polishing Pond (240) and Overflow Structure (250) coursing flooding of the Final Clarifiers (220) that prevents clarifiers from regular operation;
- The entire hydraulic design of the polishing ponds with effluent structure is inadequate and requires modification;
- Hydraulic overload and silting of Oxidation Ditch (210) and Final Clarifiers (220) due to missing stormwater overflow and missing Grit Chamber (140) that shall be added to the process;
- Malfunction of electro-/mechanical equipment of the activated sludge system comprising Oxidation Ditch (210), Final Clarifiers (220) and Sludge Pumping Station (221) that shall be replaced in order to establish the wastewater and sludge treatment process;
- Out-dated and obsolete electrical installations and missing control equipment that shall be added to the process in order to allow automatic operation of the WWTP;
- Missing or broken Laboratory and Workshop equipment which is necessary for supervision of the treatment process and maintenance of equipment;

- Outworn infrastructure facilities due to the long period of use and general weariness of buildings that shall be renovated, acc. to standards;
- Missing O&M documentation and lack of training that shall be considered in acc. with the specified design modifications and new MEICA equipment.

Details for description of the as-build situation are provided in – Works Requirements Drawings.

Design Parameters

The existing WWTP shall be rehabilitated in order to comply with original process requirements. The original treatment process for secondary wastewater treatment is the conventional activated sludge process for biological treatment (200) with sludge treatment (300).

Biological treatment is established by Oxidation Ditch (210) technology with final clarifier (220) for simultaneous aerobic sludge stabilization by extended aeration for the following average design criteria and load scenarios:

1.	**Design Horizon**		**Design Horizon**	**Phase I**
1.1	**Nominal Capacity**[1]	(incl. septage)	P.E.	6,140
1.2	**Hydraulic Capacity**	Q.DWF	m^3/d	550
	- specific WW-flow (incl. commercial flows)		l/P.E./d	*90*
1.3	Dry Weather Flow	Qdw.h	m^3/h	**34**
1.4	Stormwater Flow	Qrw.h	m^3/h	83

2.	**Wastewater Pollution and Composition**	Phase I
2.1	**Specific Pollution Loads**	

	Biological Oxygen Load	BOD5	g/P.E./d	**55**
	Chemical Oxygen Load	COD	g/P.E./d	110
	Total Suspended Solids	TSS	g/P.E./d	65
	Total Ammonia Load	tot-N (TKN)	g/P.E./d	10
	Total Phosphorous Load	tot-P (PO4-P)	g/P.E./d	1.6
2.2	**Pollution Loads**			
	Biological Oxygen Load	LBOD5	kg/d	340
	Chemical Oxygen Load	LCOD	kg/d	680
	Total Suspended Solids	LTSS	kg/d	400
	Total Ammonia Load (TKN)	Ltot-N	kg/d	62
	Total Phosphorous Load	Ltot-P	kg/d	10
2.3	**Load Concentrations**			
	Biological Oxygen Demand	CBOD5		618
	Chemical Oxygen Demand	CCOD	mg/l	1,235
	Total Suspended Solids	CTSS	mg/l	727
	Total Ammonia Concentration	Ctot-N	mg/l	113
	Total Phosphorous Concentration	Ctot-P	mg/l	18
	ph-value		-	
	Faecal Coliform		CFU/100 ml	
	Sewerage Temperature	Tmin[2]	°C	12
		Tmax	°C	20
	Ambient Temperature	Tmin	°C	15
		Tmax	°C	30

Effluent Requirements

Effluent requirements are adopted in line with EU Urban Wastewater Directive 91/271 EEC defining internationally accepted treatment requirements under consideration of secondary wastewater treatment for discharge into non-sensitive receiving water.

3.	**Effluent Requirements**			**Phase I**
	Classification of Receiving Water acc. UWWD 91/271/EEC			**Non-sensitive**
	BOD5 - Concentration	XBOD5	mg/l	≤ 25
	COD - Concentration	XCOD	mg/l	≤ 125
	TSS - Concentration	XTSS	mg/l	≤ 60
	tot-N - Concentration[1]	Xtot-N	mg/l	n.a.
	tot-P - Concentration[1]	Xtot-P	mg/l	n.a.
	ph-value		-	7.5

24 h composite sample

Constrains

In order to provide the required treatment efficiency, the following considerations shall be observed:

- Influent flows shall be adjusted to the hydraulic capacity of the existing treatment facilities;
- Connection rate (Population Equivalent - P.E.) of the WWTP is limited to the present capacity of the biological wastewater treatment facilities (Oxidation Ditch (210), Final Clarifiers (220));
- Design verifications consider municipal wastewater characteristics, only (acc. Gauff);
- Site arrangement of facilities (layout of WWTP) remains unchanged.

Rehab General Scope of Works

The scope of works shall include the rehabilitation works for the WWTP as specified in this Works' Requirements including the Bill of Quantities, comprising manufacture and supply, installation and commissioning of all works & supply, equipment and materials for within and between process units belonging to the treatment and/or transportation process; including sewer connections.

It shall apply but not limited to the following:

- Any and all necessary detailed and workshop design encompassing process, civil, structural, mechanical, electrical, SCADA (incl. programming with relevant program-licences), etc. and other "non-construction" activities for the WWTP;
- Site surveys, measurements and additional geological surveys; co-ordination of the design with all necessary and competent Authorities for final and detailed design;
- Assistance to the Employer in order to obtain all necessary permits according to the relevant National regulations for supplying the WWTP with electricity, potable water, telephone, a.s.o.;
- Assistance to the Employer in order to obtain building and construction permits;
- Safeguarding the existing facilities (as required for continued operation of the WWTP) during the whole construction period;
- Demolishing, dismantling of existing facilities on the site of the WWTP as specified; incl. buildings, structures, cables, sewers and MEICA equipment; earth works and reinstatement works, incl. sound disposal of surplus materials (not used for filling) and equipment and obtaining of all necessary permits and certificates;
- Construction and installation, erecting and commissioning of the works for the WWTP, incl. flow diversion and connections to existing sewerage system and utilities;
- All channels and interconnecting pipework as specified within and between process units, structures and for inlet systems, bypass systems, outlet, washout systems, service water systems, process related piping and connections to the channels and pipe system; within the limits of the Contract as required, including pipes and drains of any description and of all materials with all fittings, penstocks, valves and pipe protection, both coating and lining;

- Mechanical, Electrical, Instrumentation, Control and Automation (MEICA) equipment, including motors and pumps;
- Laboratory equipment, furniture and reagents as listed;
- Workshop equipment and furniture as listed;
- Supervisory Control and Data Acquisition (SCADA) System, incl. IT infrastructure and equipment as specified;
- Testing, commissioning and taking over and as-build documentation;
- O&M documentation, incl. operation manual for the WWTP;
- Trial operation and training of the Employers staff, incl. supervision, management and operation of the new equipment during two (2) weeks trial operation period before issue of the Taking-Over-Certificate.

The Works under the Contract shall furthermore include (inter alia) mobilisation and demobilisation of staff and equipment, provision of site installations, provision of temporary facilities during construction, housing for Contractor's staff, provision of all site offices and vehicles including running costs, purchase, receipt, storage of all material required for the Works, incl. setting out, the construction in accordance with the Specifications, Specifications and Schedules.

In particular, the Contractors proposal and scope of works shall cover, but not limited to the following:

Rehab Civil Engineering Works

The term "Civil Engineering Works" shall mean the obligations of the Contractor under the Contract to cover all manufacturing, excavation, building, structures, sewers, process units and other construction Works, which shall be performed by the Contractor.

The following shall be included, but not limited to, within the limits of the Works:

- During the construction of the civil works the Contractor shall ensure that the operation of the existing WWTP is not interrupted and that close coordination is maintained between the Contractor and Operators personnel.
- Preparatory works, including detailed and workshop design, coordination of the works with other contractors and the Municipality;
- Topographical, hydrogeological and soil investigations (surveys and studies) of the site;
- Demolishing, earth works and reinstatement works, incl. site levelling, excavation, fill and other earth works of all abandoned structures in accordance with the Specifications;
- Rehabilitation of the existing civil works including making good any problems within the structures, providing new roofing, access platforms, stairs, internal and external doors, fencing, a.s.o.;
- Completion of water retaining structures (WRS) and buildings containing the functional and process units of the WWTP, incl. sludge treatment facilities and associated sewerage connections as well as related infrastructure works;

- Excavation and protection of trenches, laying of pipes, welding and protection of the pipes, backfill and reinstate, transport and disposal of excess and demolished materials;
- Maintenance, administration and all other ancillary and non-process related buildings;
- Civil works related to complete drainage systems and structures necessary for the disposal of process waste, overflow, and drainage water, waste or used chemical solutions (including from any laboratory) sludge and storm runoff to receiver;
- Landscaping and similar area works with plant roads, temporary roads, and site facilities;
- Any indoor and outdoor sewerage systems including all sanitary installations inside the buildings;
- Any water supply plumbing, fixtures and fittings inside buildings (installations);
- Complete any ventilation/air-conditioning systems for all buildings and process units, which shall conform to these Specifications;
- Necessary equipment and material for all storm water and plant internal wastewater drainage system, including those to be separately provided for such as wastes from laboratory, waste or used chemical solutions;
- All other works whether specified in the Contract Documents, (including the Contractor's proposal) or not, as necessary for the completion of the Works and the operation thereof, and as required under the terms of the Contract;
- All temporary and provisional works necessary for proper erection of the plant (temporary roads, keeping excavation free of water, excavation sheeting and bracing, etc.).
- Completion of all works which shall be provided under the Contract, whether specified in the Contract Documents or not, and whether specified therein in part, incomplete or incorrect or not explicitly described or only implied.

Rehab Mechanical Installations

The term "Mechanical Installations" shall mean the obligations of the Contractor under the Contract to cover all manufacturing, delivery, assembling and installation, testing and commissioning of the required mechanical equipment and machinery for the process units and buildings, which shall be performed by the Contractor.

The following shall be included, but not limited to, within the limits of the Works:

- During the installation of the new mechanical equipment the Contractor shall ensure that the operation of the existing sewerage system is functional and safely by-passed any treatment stage subject to works and that close coordination is maintained between the Contractor and Operators personnel.
- All materials and equipment for the Wastewater Treatment Plant (WWTP) within and between process units structures including connection force mains and effluent system, such as inlet structures,

mechanical treatment facilities, biological treatment facilities, sludge treatment facilities or other facilities belonging to the treatment and/or transport process;

- Mechanical equipment and machinery, including motors and pumps;
- Parts of the piping system, incl. armatures and fittings;
- Workshop equipment;
- Laboratory equipment ;
- All other auxiliary materials of any description and all materials.
- Dismantling and removal of all abandoned mechanical equipment (handed over to the Operator).

Rehab Electrical Systems

The term "Electrical Systems" shall mean the obligations of the Contractor under the Contract to cover all manufacturing, delivery, assembling and installation, testing and commissioning of the required power supply, power distribution and sub-distribution systems for the process units and buildings, which shall be performed by the Contractor, incl. all co-ordination and technical clarification with the responsible power supply utility.

The following shall be included, but not limited to, within the limits of the Works:

- During the installation of the new electrical work the Contractor shall ensure that the operation of the existing WWTP is not interrupted and that close coordination is maintained between the Contractor and Operators personnel.
- Power supply, check and replace transformer if necessary, MV-switchgear;
- High and medium voltage systems, complete with (c/w.) transformer stations at all load centres with transformers of sufficient size, medium high voltage switch gear stations, low voltage main distributions, reactive power compensation units, battery systems, safety and protection devices, etc.;
- Low voltage systems, c/w separate low voltage distributions at all process stages with switch gear panels; control systems for manual, automatic, local and remote control; PLC units; marshalling cabinets; safety and protection devices, etc.;
- Emergency power supply system of sufficient size and number to operate all important consumers on a continuous basis; uninterruptible power supply units to operate all important instrumentation and automation systems during power failure, etc.;
- Dismantling and removal of all abandoned electrical equipment (handed over to the Operator).

Rehab Electrical Installations

The term "Electrical Installations" shall mean the obligations of the Contractor under the Contract to cover all manufacturing, delivery, assembling and installation, testing and commissioning of the complete

lighting, telephone and anti-burglar alarm systems for indoor and outdoor (at/in all buildings, streets, ways, places, structures, etc.), incl. emergency lighting, sub-distributions, switches, light sensors, clock timers, poles, fittings and fixtures, etc., which shall be performed by the Contractor.

The following shall be included, but not limited to, within the limits of the Works:

- Complete system of power outlet sockets for indoor and outdoor at/in all buildings, streets, ways, places, structures, etc. incl. sub-distributions, earth-leakage circuit-breakers, etc.;
- Complete high voltage-, medium and low voltage-, communication-, signalling-cable-systems and wiring, incl. all connecting, mounting, routing, labelling and testing, a.s.o.;
- Telephone and telecommunication system for the WWTP, incl. all co-ordination and technical clarification with the responsible telephone company; all telephone instruments, exchanges, etc.;
- Complete earthing (earth bonding), lightning and overvoltage protection and potential-equalisation-systems, etc. for the new MEICA equipment.

909 Construction Environmental Management Plan

A Construction Environmental Management Plan (CEMP) is a practical and achievable plan of management to ensure that any environmental impact during the design, planning and construction phase are minimised. CEMP's have been proposed to deal with the following issues during Project construction:

Compensation and land take
Physical setting, flora and fauna;
Interruption of key infrastructure installations;
Water quality and energy management;
Dust and air quality;
Occupational health and safety;
Noise and vibration; and
Waste management.

Detailed CEMP's are presented below

CEMP for Compensation and land take

Objective	To ensure that the land owners are properly compensated and avail land for the proposed Project.			
Management strategy	Since compensation is an integral part of Project design ensure it is dealt with from the earliest stages of Project preparation and comply with the laws of Kenya.			
	Activities	Responsibility	Timing	Costs (KES)
Actions	Land take should be minimized where feasible, exploring all viable alternative Project designs e.g. realignment of the pipeline may significantly reduce compensation; and Where displacement is unavoidable, compensation and resettlement plans should be developed with adequate compensation under guidance of various lead agencies including Ministry of Lands, TWSB, Local Councils and the District Development Committees.	Proponent	Prior to construction	TBD
Performance indicators	Lack of complaints / Complaints.	Proponent	Construction Phase	
Monitoring requirements	Documentation; and Land easement	Proponent	Construction Phase	
Reporting	Documentation	Proponent	Construction Phase	
Corrective actions	Implement recommendations.	Proponent	Construction Phase	
Interface	Ensure compliance with the Law of Kenya and the requirements of any donors involved in the Project.	Proponent	Construction Phase	

CEMP for Physical setting, flora and fauna

Objective	Maintain the existing balance within the physical, fauna and flora components in the Project area setting.			
Management strategy	Provide for appropriate measures that guarantee the protection of habitats, flora and fauna.			
	Activities	Responsibility	Timing	Costs (KES)
Actions	Provide structures that will not hinder free movement of animals and dispersal of propagation components; Maintain as much as possible the natural drainage systems and patterns; Grade sites to original levels to maintain topography; As much as practical limit the amount of vegetation cleared during works; Discourage bush meat hunting; In the event that considerable damage to vegetation is envisaged, set out a plan for replacement or grading to encourage natural rejuvenation; and Design and plan for use of wayleave by pedestrians and non-motorised systems.	Consulting Engineers Contractor PROJECT MANAGER	Planning. Design & construction	TBD
Performance indicators	Presence of a good balance of flora and fauna; and Minimal or no flooding in Project area.	PROJECT MANAGER	Construction Phase	
Monitoring requirements	Baseline data/Project completion Baseline; and Changes in local hydrology.	PROJECT MANAGER	Commissioning stage.	
Reporting	Site log book and EMCA requirements.	Contractor	Construction Phase	
Corrective actions	Rehabilitation	PROJECT MANAGER	Commissioning stage	
Interface	EMP complies with the EMCA and other applicable laws.	PROJECT MANAGER	Construction	

CEMP for management of infrastructure installations

Objective	Plan construction activities to minimise interruptions of infrastructure and ensure smooth Project implementation while complying with the laws of Kenya			
Management strategy	Liaise with stakeholders in the project area to ensure that access on protected or private areas is granted in good time in order to achieve Project milestones.			
	Activities	Responsibility	Timing	Costs (KES)
Actions	Establish the nature of all stakeholders; Identify key interests of each of the stakeholders; Formally liaise with the stakeholder and communicate the Project details to them with a view of developing a work plan; Implement work plan; and Acquire notes on Satisfactory Completion of Works by each affected party.	PROJECT MANAGER Engineer Contractors	Planning, Design and Construction phase	TBD
Performance indicators	Level of complains.	All	Construction phase	
Monitoring requirements	Timely achievement of milestones; and Lack of interruption of services.	All	Construction	
Reporting	Site log book	Contractor	Construction phase	
Corrective actions	Investigate cause of interruptions; Implement corrective measures.	AWSB Stakeholders	Construction phase	
Interface	Comply with the EMP contained in this report.	Contractor	Construction phase	

CEMP for water and energy management

Objective	Minimise impact on water and energy resources within the Project area due to the construction works.			
Management strategy	Conserve water and energy resources, abate pollution and comply with the laws of Kenya.			
	Activities	Responsibility	Timing	Costs (KES)
Actions	Provide appropriate and adequate drainage infrastructure where required; Ensure machinery is regularly serviced to avoid leakages and/or spillages; Oils, fuels and other materials to be stored in accordance with the manufacturers' safety data sheets (MSDS); Train staff on spill response; Implement erosion and sedimentation controls; Proper handling/disposal of liquid waste; Energy management through use of sound/appropriate equipment; Application of rated equipment in welding and related works; and Use of efficient mechanical plant and energy savers on sites.	Contractor	Construction phase	TBD
Performance indicators	Minimal interference of water and energy resource in the area.	Contractor	Construction phase	
Monitoring requirements	Physical inspection; and Level of complains.	Engineer	Construction phase	
Reporting	Site activities log book.	Contractor	Construction phase	
Corrective actions	Implementation of monitoring findings and recommendations.	Contractor	Construction phase	
Interface	Comply with laws and guidelines.	Contractor	Construction phase	

CEMP for dust and air quality

Objective	Maintain the quality of the air and minimise any harmful emissions into the atmosphere and comply with the laws of Kenya			
Management strategy	Abate pollution of the atmosphere by airborne particulate matter.			
	Activities	Responsibility	Timing	Costs (KES)
Actions	Dampen work areas materials heaps and mulch bare ground to minimise dust emissions; Maintain equipment and machinery to manufacturers' specifications; Use environmentally friendly fuels; Minimise the period for machinery idling; Pursue good practices in energy use and sensitise staff; and Provide appropriate personnel protective equipment to site workers.	Contractor	Construction phase	
Performance indicators	Lack of complaints / Complaints; and Reports / Log book entries.	PROJECT MANAGER	Construction phase	TBD
Monitoring requirements	Physical inspection Site Log books	Engineer	Construction phase	
Reporting	Site logs of inspections and corrective actions.	Contractor	Construction phase	
Corrective actions	Implement recommendations	Contractor	Construction phase	
Interface	Review and comply with laws and regulations.	Contractor	Construction phase	

CEMP for occupational health and safety

Objective	Ensure the safety and health of all the Parties involved in the Project implementation and comply with the laws of Kenya			
Management strategy	Provide proper safety equipments, facilities and conditions that will eliminate or reduce the risk to the Project workers and all those present therein.			
	Activities	Responsibility	Timing	Costs (KES)
Actions	Comply to the OSHA; Provide for appropriate signage and warnings at work sites; Provide appropriate personnel protective equipment (PPE) to workers and any visitors; Provide for First Aid facilities as per the Occupational Safety and Health Act; Provide and clearly display emergency contacts; and Develop and implement a detailed and site specific Emergency Response Plans.	Engineer Consulting Engineers Contractor	Construction phase	TBD
Performance indicators	Health and safety awareness among staff; and Frequency of incidents/accidents and fatalities.	Engineer PROJECT MANAGER	Construction phase	
Monitoring requirements	Daily inspection of work sites; and Tool box meetings.	Engineer	Construction phase	
Reporting	Log incidents/accidents and fatalities; and Tool box minutes.	Engineer	Construction phase	
Corrective actions	Investigate incident/accidents and fatalities; and Follow up on complains and other issues from tool box meetings.	Engineer	Construction phase	
Interface	Updates on the OSHA and orders from Directorate	PROJECT MANAGER	Construction phase	

CEMP for noise and vibration management

Objective	Manage activities at construction sites to reduce impacts of noise on surrounding properties and comply with the laws of Kenya.			
Management strategy	Noise to be managed through administrative and maintenance controls during construction.			
	Activities	Responsibility	Timing	Costs (KES)
Actions	All construction activities to be limited to between 7am to 6pm; All equipment used during the construction phase to be regularly maintained to ensure efficient operation; Noise dampening materials to be used where excessive noise generating-equipment are in use; Use of appropriate cushioning for heavy equipment; and Use of personal protective equipment by operations staff.	Contractor	Construction phase	TBD
Performance indicators	Lack of complaints / Complaints.	Contractor	Construction phase	
Monitoring requirements	Periodic inspection of work sites; and Service log for equipment / machinery.	Contractor	Construction phase	
Reporting	Complaints / incidents should be recorded in a log book on location.	Engineer	Construction phase	
Corrective actions	Investigate cause of noise and vibrations; Implement corrective measures prior to commencement of works; and Consider possibility of rescheduling noise and vibration generating activities.	Contractor PROJECT MANAGER	Construction phase	
Interface	Ensure that if the Contractors or subcontractors have an EMP and that it complies with the EMP contained in this report.	PROJECT MANAGER	Construction phase	

CEMP for waste management

Objective	Minimise the potential for environmental impact of wastes generated due to the construction activities and comply with the laws of Kenya.			
Management strategy	Effectively manage the sites and activities that may lead to generation of wastes.			
	Activities	Responsibility	Timing	Costs (KES)
Actions	All wastes shall be contained on site prior to disposal using appropriate storage containers; All wastes shall be regularly cleared from the site and disposed of in approved manner; High level of housekeeping shall be maintained; and Staff shall be trained / sensitised about waste management at the start of the Project and regularly as may be found appropriate.	Contractor	Construction phase	TBD
Performance indicators	No waste at work sites except in approved and marked locations.	Contractor	Construction phase	
Monitoring requirements	Regular site inspections; and Waste disposal documentation and tracking.	Contractor	Construction phase	
Reporting	Review of waste handling slips and other related documentation.	Contractor	Construction phase	
Corrective actions	Provide reports, corrective actions and recommendations where non-conformities occur.	Contractor	Construction phase	
Interface	Ensure that Contractors or subcontractors EMP complies with the EMP contained in this report.	Contractor	Construction phase	

Section 11 Instrumentation and Control

1101 General

1101.1 Design and Electromagnetic Compatibility

All circuits and equipment shall be designed in accordance with good engineering practices and particular care should be taken to ensure that no component shall exceed its maximum voltage/current/power ratings at any time, including during transient surges.

All instrumentation equipment shall be protected from interference emanating from radio frequency transmissions, either radiated or cable borne, such that it shall not cause malfunction of the system or damage to the components.

All equipment supplied shall not radiate any form of electromagnetic energy in amounts that might interfere with external equipment or instrumentation.

The latest standards on interference shall be followed and the principles of electromagnetic compatibility (EMC) applied to the design and application of the plant.

1101.2 Interrelation with Other Sections

Requirements given in other sections shall be applicable whether relevant to equipment or materials specified in this Section.

Thus indicator gauges, metres, enclosures, panel construction, finish, components, wiring, terminations, cabling requirements and environmental operating conditions shall be in accordance with the relevant clauses of the Mechanical and Electrical Sections unless specifically amended in this Section.

1101.3 Interrelation with other Contracts

Where the location, installation or connection of any components of instrumentation are arranged by the Engineer under other contracts, it shall be the responsibility of the Instrumentation Contractor to advise and provide all relevant information on such matters to the Engineer in order that the correct and proper performance of the Contractors instrumentation is not prevented or impaired.

1101.4 Temperature and Humidity

All supplied equipment shall function without error and shall be constructed of such materials or so treated as to prevent the formation of mould, fungus or any corrosion over the ranges of temperature and relative humidity specified in the specific clauses for this site.

1101.5 Enclosure Protection

Instrumentation and hardware mounted in the field shall be contained in suitable enclosures to provide ingress protection to BS EN 60529 rating IP54 indoors and IP65 outdoors as a minimum. Sensors installed below water level or liable to submersion shall be rated IP 68. Where items are fitted in a panel or other enclosure, they shall preserve the design IP rating of that enclosure.

1101.6 Voltage and Frequency Tolerance

Equipment shall be capable of working from a supply whose voltage may vary ±15% and tolerate any transients that could be experienced in such an environment without programme corruption or system failure.

1101.7 Instruments

Each instrument and sensor shall be selected considering all the relevant performance parameters for the principle of measurement adopted, its intended use and the particular process in question.

All instrument output signals shall be volt-free, clean contacts rated at 220V AC 2A for digital and 4-20mA continuous proportional linear signal for analogue. Pulsed outputs suitable for integration counter drives shall be 24V DC.

1101.8 Inputs, Outputs and Signal Loops

Opto-isolation shall be provided on all input interfaces to card.

Digital signals shall be 24V DC with the power supply from either the associated power pack or the external instrument. Relays shall be used where more than one instrument including I/O are fed from a single signal.

Analogue signal shall be continuous linear scaled signals with a 4-20 mA operating range. Loops with instruments wired in series (e.g. panel mounted indicator and RTU input) shall have zener fitted across each subsequent instrument leg to ensure loop integrity.

1101.9 Terminals

Signal terminals shall be the disconnect type. Power supply terminals shall be shrouded and clearly marked with the appropriate warning tags. LED's shall be provided for fault tracing, if not supplied on the I/O cards. LED's in either case must be clearly visible from the front, with only the enclosure door open.

For each incoming screened cable, a separate earth terminal shall be provided for screen termination to earth.

All equipment, isolators, terminals and cables shall be clearly marked. 20% spare terminals shall be provided.

1101.10 Programming and Monitoring Unit

Hand-held portable devices shall be provided for the system allowing user configurable operation to enable the downloading or uploading of data or software and the local running of diagnostic software. For RTU plc's the device shall be fully compatible with the RTU and shall be supplied with:

- Software to enable the development of programmes and the subsequent downloading to the RTU.
- Software to enable full communications with the RTU and to:

- upload data or alter data in the RTU;
- access communications ports and I/O.

- Full page process mimic display capability.

1101.11 Discrete Components

All discrete resistors, capacitors, switches, relays, diodes, transistors and other electronic devices shall comply with the BS 9000 series specification for components of assessed quality.

The Engineer's agreement must be sought before using components that are not certified, but it will remain the Contractor's responsibility to ensure that all components are suitable for the application.

Similar types of components shall be of the same manufacture and design wherever possible.

1101.12Integrated Circuits

All integrated circuits shall be of a proven design and shall be clearly marked with the original manufacturer's identity and device number.

1101.13 Sub-Miniature Switches

Where DIL or other sub-miniature switches are used they shall be provided with a cover, or other means of protection, to prevent accidental switching during handling.

1101.14 Printed Circuit Boards

Printed circuit boards shall be made of glass fibre with copper trackwork, all exposed copper being tinned prior to assembly, and the board and components cleared of flux before a thin layer of clear varnish is applied for environmental protection.

The board and its components shall be identified by references relating to the corresponding circuit diagram which shall be printed on the component side of each board. Where a number of boards are mounted in a rack system, the rack and boards shall be clearly marked to identify each board to its particular position.

1101.15 Sockets and Connectors

The use of plug-in connectors for electronic equipment shall be kept to a minimum, and all circuit components including integrated circuit clips shall have soldered connections where this is permitted by the chip manufacturer.

Where sockets and connectors are incorporated in the design, they shall have self-cleaning, hard gold alloy plated, wiping action contact faces, and incorporate polarizing keys or similar means to prevent incorrect mating. Insulation displacement type connectors shall not be used.

All light current wiring having a cross-section of 1.0mm2 or less shall have tinned copper conductors.

1101.16 Test Facilities

The electronic equipment is to include built-in test facilities to permit the detection and replacement of faulty modules without the use of oscilloscopes, signal generators, or other sophisticated test equipment.

1101.17 Surge Protection

All telecommunication lines, data and signal cables and other items of equipment external to the building environment prone to damage resulting from induced surges due to lightning discharges, shall be fitted with lightning surge protection barrier devices at each end of the line to suppress and divert any transients likely to cause damage to the connected equipment.

All surge diverters/lightning arrestors fitted to telecommunication lines shall be of a design approved by the telecommunications authority.

Surge protection units shall be un-fused, solid state devices, designed to limit the transient over-voltages to mot more than twice the normal working voltage of the line. They shall have low in-line resistance and automatically return to normal operation after diverting a surge.

The units shall have provision for either DIN rail or individual panel mounting or direct bolted connection to a suitable copper earth bar.

The location of the units shall be arranged such that the earth connection shall be routed clear of the protected signal cables and have short, straight connections without sharp bends to the main earth points, using copper conductors not less than 16mm2 csa and not greater than 5 metres in length to provide a low impedance path.

Surge suppression devices to provide protection from mains switching or other supply network disturbances shall be incorporated or fitted to all sensitive monitoring or control devices. They shall be designed to filter un-wanted transients and limit the 'let-through' voltage to less than twice the working mains voltage, between all conductors and each conductor and earth. Protection monitoring status indication shall be fitted

1101.18 Control Panel

The contractor shall supply, install, test and commission an integral 1 No. Control panel for 5No.250 Kw, 2No. 60 kW, 2No. 18.5kW centrifugal Pumps and 0.75 Kw submersible pump , all located in the Pump House, 1No integrated control panel for 5 No. 40KW centrifugal pumps all located at Ole-Tepes. The control panel shall meet the below specifications. The Panel will include a frequency inverter for the 250 and 40Kw pumps to provide variable control during start-up of pumps and reduce the starting current. The starting method for the rest of the pumps will be as indicated on the pump schedule specified in other parts of this specification. The control panel shall incorporate input for two pressure transducers, duty and standby with automatic changeover in the event of failure of the duty unit. It shall also incorporate an allowance for remote transmission of alarm signals to user.

It shall also allow for fitting of a transducer to provide low water pump shut down protection to the pump set, with alarm signal.

The control panel will also incorporate run and fault indicator lights for each pump and as well as speed indication lights.

The Panel shall incorporate the following features:

- LCD panel with backlit dynamic buttons to enable the user to interrogate the panel.
- Automatic fans to cool down the cabinet if required according to EN60439-1
- Lockable mains breaker
- Individually breakers for each pump

Control panel functionality

The control panel shall operate the pumps to keep a required pressure at the discharge manifold. The system shall automatically start the required number of pumps to keep the required Pressure.

The system must ensure a minimum of pressure surges when starting and stopping pumps by ramping the pumps in according to a defined ramp.

On the control unit it must be possible to read out:

- Speed of individual pumps.
- State of individual pumps.
- Power consumption
- Energy consumption
- A measured or estimated flow rate.
- Process value and set point.

The Controller must incorporate a log that graphically shows the trend of:

- The Estimated/measured flow
- Speed of the pumps
- Set point
- Process value.

It must be possible to retrieve the data and open it in a spreadsheet.

The control shall store at least the last twenty fault conditions experienced by the pump set, for subsequent display when the panel is interrogated.

The alarms must be presented in plain text indicating the source of the alarm.

The control system shall incorporate password protection and shall fully segregate access to interrogate the pump operating history from the access level at which pump operating settings can be changed.

The control system shall incorporate automatic test run of each pump every 24 hours. The system must automatically ensure equal running hours of the pumps. It must be able to, once a day, evaluate the running hours of the pumps and alternate between them if an idle pump has less running hours than a running pump.

Standby pump

- It shall be possible from the controller to define a number of standby pumps.
- Where a pump is designated as standby it shall still be included in the duty change cycle.

1101.19 High Pressure protection

It shall be possible to program a "high-pressure" safety cut-out, set 1.5 bar above the duty pressure. The pumps set shall automatically shut down in the event of the above pressure being identified. Following a shut-down the controller shall (a) re-start the pump set automatically once the high condition has disappeared, or (b) will remain shut down until manually re-started by an authorised person. (The preferred option shall be agreed with the end user prior to hand over and the controller programmed accordingly).

1101.20 Low Pressure/pipe burst protection

It shall be possible to program a "Low-pressure" safety cut-out, set 1 bar below the duty pressure. The pumps set shall automatically shut down in the event of the above pressure being identified. Following a shut-down the controller shall (a) re-start the pump set automatically once the high condition has disappeared, or (b) will remain shut down until manually re-started by an authorised person. (The preferred option shall be agreed with the end user prior to hand over and the controller programmed accordingly).

1101.21 Soft pressure build-up

The panel shall incorporate a slow-speed/one-pump-only start up, following a power outage or maintenance shutdown to gradually fill up the pipeline and reduce risk of airlocks and water hammer.

1101.22 Redundant sensor

The controller shall have a feature that gives an alarm if there is incoherency between the two discharge sensor signals.

1101.23 Testing and Commissioning:

Once installed on site, with all necessary permanent water services, power supplies, control and alarm systems completed and tested. The panel manufacturer shall be invited to site to commission, test and demonstrate the operation of the panel to the full satisfaction of the Engineer and End User.

1102 Instrumentation

1102.1 General

Indicating instruments shall show the specified measured values in either electro-mechanical or electronic and analogue or digital form, as defined in the Specific Requirements.

Wherever possible, panel mounting indicating instruments shall be of matching size, appearance and orientation and suitably scaled, all in accordance with the general requirements for electrical panels.

1102.2 Strip Indicators

Strip indicators shall be provided for the specified functions and arranged as shown on the proposed panel layout.

The indicators shall be solid state electronic type employing a column of neon gas plasma bars, illuminated consecutively in proportion to the input signal. The scale length shall be at least 100mm and allow on-line span and zero adjustment.

All indications shall be driven from transducers or inputs giving analogue signals of 4-20 mA.

1102.3 Indicator/Recorders

Electro-mechanical indicator/recorder shall be a flush, panel, mounting, single/multi pen indicator/recorder, scaled and labeled as specified herein. The initiating signals for each pen and the trace colour(s) together with any event markers and/or alarm settings, shall be as specified.

Continuously running recorders shall run at a speed of 20mm/hour with date and time annotation at 4 hourly intervals. For intermittent running, as in storm pumping applications, the recorder chart speed shall be 60mm/hour and shall only be initiated when the level approaches the first pump start level and be stopped 30 minutes after the final pump cuts out. Starting and stopping times and dates shall be printed on the chart and each pump operation shall be individually annotated by means of a single trace for each pump showing its running time.

To provide minimum time lags between other channels on the recorder, dot print outs may be used where required.

The Z folded chart paper shall be 250/100mm wide, linearly scaled in half hourly divisions and the width shall be calibrated 0-50 divisions linearly or logarithmically scaled as specified to adequately show the normal range of operation and include the maximum possible signal. The chart shall run for a minimum period of 30 days and 24 spare charts shall be provided. Circular charts shall be 105mm wide, 7 day graduated.

Each channel shall provide a continuous ribbon strip visible indication over a calibrated scale (left hand zero) and an individually different coloured trace on the chart by means of either fibre tipped pens fed from disposable ink cartridges or electrical writing or sensitized paper.

Each input shall be separate and isolated from the conditioning amplifiers and all necessary computing modules shall be included in the unit to provide the required indications.

The following features shall be provided for the operator control, accessible from the front without withdrawing the unit during operation:

- Pen renewal (if relevant);
- Power on/off switch;
- Chart drive on/off switch;
- Chart replacement and adjustment.

Adjustable high and low, volt free alarm contacts shall be provided on each channel and incorporated into the control scheme as required to initiate the alarms as specified.

1102.4 Time Indicator

A mains driven synchronous type clock shall be suitable for front of panel mounting and resetting.

The display shall either be digital or analogue as specified and based on a 24 hour notation. The digital display shall be of white figures (not less than 55mm high), on a black background. The analogue display shall be dual scaled showing 0-12 hour black figures and 13-24 hour red figures on a white faced dial of not less than 220mm diameter.

The mains supply for the clock shall be via a suitable fused clock connector mounted in the panel, connected such that the clock is energized from the live side of the panel isolator.

1102.5 Capacitive Devices

Level monitoring shall be by means of a capacitance electrode suitable for the medium and environmental conditions specified such that the electrode capacitance varies in proportion to the immersed electrode length and be arranged to provide a 4-20mA output proportional to the specified level range on a scaled indicator giving a continuous read out.

Auxiliary switches shall be provided for high level alarm, low level alarm and control of external equipment. The position of all switches being adjustable over the level range.
Any fault in the electrode connection and in the electronic circuits shall provide an electrically isolated alarm signal for remote monitoring.

The electrode housing shall be a heavy duty pattern to IP 68 suitable for 2" flange mounting and incorporate a 20mm ET cable entry. The head shall be removable for cabling and servicing without disturbing the electrode mounting.

1102.6 Pressure Transducers

Pressure monitoring shall be by a transducer suitable for the medium and pressure/level range specified herein.

Each transducer shall be ranged to provide adequate sensitivity over the working range and be capable of sustaining a 400% overpressure without damage. They shall be of rugged and waterproof design, employing a pressure sensitive element within a stainless enclosure having an isolation diaphragm, suitable

for either free wire suspension in the medium or fitted with a BSP thread for external connection to the relevant pipe tapping.

Suspended sensors shall be mounted in accordance with the manufacturer's instructions within a uPVC 'stilling tube' of sufficient nominal bore to enable easy withdrawal of the sensor.

Sensors shall be enclosed to IP 68, offer a long life and shall be supplied complete with a suitable signal cable to reach the approved point of termination transmitter-converter without intermediate joints.

The position of the equipment shall be such that withdrawal and installation can be achieved easily.

Cable entry shall be integral sealed assembly or by 20mm conduit entry into a sealed watertight terminal enclosure with provision for transducer venting.

A transmitter shall be provided either integral with the transducer or separately mounted as specified, suitable for operation from the mains or battery supply specified (not greater than 24V) and converting the signals received from the transducer to a 4 – 20 mA signal proportional to the ranged specified which shall be used as follows:

To drive an indicator/recorder to give a continuous readout;
To operate separate on/off pre-set adjustable points.
The transmitter shall have provision for range and zero adjustment.

For use in hazardous areas as specified, the units shall be certified intrinsically safe Ex (1).

1102.7 Ultrasonic Devices

Flow or level monitoring by non-contact ultrasonic measuring devices shall incorporate ambient temperature compensation and adjustable datum setting facilities. Where specified, the output shall be computed to give a flow reading for the given parameters and/or control of pumps.

Transducer

The sensor head shall be protected to IP68, mounted to provide an unhindered beam path, prevent unwanted reflections, within easy reach of maintenance personnel and, where possible, be clear of flood conditions. For sewer or foul pumping sumps, the units shall be certified intrinsically safe Ex (i) for use in hazardous areas.

Signal Converter

The converter shall be suitable for operation from the specified power supply and convert the signals received from the sensor head to a 4-20 mA signal proportional to the range specified, to be used as detailed in the Specific Requirements.

The converter shall comprise a base unit and a programming device, all in a polycarbonate enclosure to IP 65. Communication between the programmer and the signal converter shall be in such a manner that the IP rate is not prejudiced.

A minimum of 3½ digit liquid crystal display shall be used to indicate key programming features, settings and output conditions, including flow calculations to BS 3680 for flumes and weirs.

Accuracy of the signal converter shall be better than ±1% of reading and shall have the following programmable outputs:

- mA proportional to user definable engineering units.
- SPDT relay contact output closing upon failure of the signal converter,
- lost echo or multiple echoes.
- Off SPDT contact outputs with independently set trip points. These
- outputs shall be programmed to energise upon high/low levels, rate of change or to allow a number of pump sequencing operations. Contacts rated at 5A 240V ac, non-inductive.
- Serial ports RS 232 for down-loading data.

1102.8 Electro-Magnetic Flow Meters

Electromagnetic Flow meters shall be sized and installed in accordance with the manufacturer's recommendations as approved by the Engineer, BS 5792 and BS 6739.
Flow meters shall be supplied with a calibration certificate. Electromagnetic flow meters shall be selected and sized to give a maximum velocity of between 1 and 7m/sec. The minimum velocity achieving the stated accuracy shall be not more than 0.1 m/sec.

The flow meters shall be of electromagnetic inductive type having a DC pulsed field with automatic zero error averaging and low power consumption. They shall have no moving or protruding parts nor cause any restriction in the flow path and be capable of setting adjustments without the need to stop the flow.
Each metering system shall comply with BS 5792 a
nd comprise a flow sensor mounted in the pipework line and a signal converter, wither integrally mounted or remotely located preferably within the main control panel.

The system accuracy shall be a maximum at normal operating flow with an error not more than 1% of the reading. When operating in the lower 30% of the meter range, the accuracy shall be within ±3%.
Flow sensors - these shall comprise electrodes located in ammeter tube which shall be of watertight construction, suitable for operation without loss of accuracy when totally submerged to a depth of 3 metres.

The meter tubes shall be made from a non-magnetic material lined with an inert material suitable for the medium and fitted with flanges to suit the pipework system, the lining material being applied such that it extends from the bore of the tube to fully cover the raised face of the tube flanges.

The measuring electrodes shall be continuously cleaned by means which do not interrupt the process flow or the measurement. A sensing electrode shall also be provided to detect when the flow meter is not fully charged with liquid.

The flow meter body shall be effectively bonded by non-corrodible, tinned copper braid links at each end, to the adjacent pipework to ensure a good connection between the body and the metered liquid, an earthing flange being inserted where non-conducting pipework is employed.

Signal Converter/Pulse Power Unit

These units shall be suitable for operation from the flow sensor into output signals having the following features:

Single flow rate range adjuster suitable for the flow sensor.

Independent output signals shall be provided for each flow direction as follows:

- +5/0/-5 volts d.c. signal for telemetry purposes with magnitudes directly
- proportional to flow.
- 4-20 mA current signal, to be used for indication of flow, quantity, etc.
- 24V impulse for integration counter drive.
- Works presettable system response time.
- Output driven downscale to zero on receipt of a 'flow meter empty' signal from the liquid sensing electrode.

The transmitter shall have the following programmable outputs:

- mA, proportional to use definable engineering units.
- off multifunctional SPDT relays. Individually programmed to allow a number of sequencing operations, rate of change or high/low flow indication. Contacts rated at 5A 240V ac, non-inductive.
- Serial port RS 232 for down-loading data.

Flow Meter Cabling

Where remote mounted converters are specified, cables shall be provided, installed and terminated between the sensor and converter/pulse power unit for the following purposes.:

- flow signal;
- reference signal;
- coil supply;

Such cables and sealing glands shall be suitable for submersible operation of the sensor to the depth specified. The length of each cable shall be as specified.

Spool Piece: A flanged steel spool piece shall be provided of the same diameter and length as the respective flow meter and flanged for insertion in the pipe should it be necessary to remove the flow meter.

Isolating valves shall be provided on either side of the flow meter.

Differential Pressure Flow meters and Differential Pressure Switches

Flow meters of the differential pressure type shall be designed and installed in compliance with ISO 5167-1 or an Approved Standard. Primary devices shall be insertion probe type or carrier-ring type orifice assemblies with stainless steel orifice plate, or venture tubes shall include two sets of gaskets and fixing bolts for each primary device. Gasket materials shall be appropriate to the metered fluid and service conditions. Full details of orifice or venturi tube calculations shall be supplied.

Orifices shall be square-edged and concentric. The upstream edges of orifices shall be sufficiently sharp that the reflection of a beam of light from the edge cannot be seen without magnification. Drain holes shall be provided. The diameter ratio shall be between 0.20 and 0.70. Orifice assemblies shall have identification tags showing the direction of flow, orifice diameter and position of drain hole. The identification tag shall be welded to the plat before the orifice is machined.

Insertion probe type installations shall follow the equipment manufacturer's recommendations. The probe shall be mounted to a standard sired ferrule or flange plate and include appropriate 3-way value block.
Differential pressure transmitters and switches shall have over-range protection up to 1.5 times the maximum line pressure.
Location of these devices should be such that no turbulence shall interfere with the measurement of pressure either side of the device.

Signal Converter
The sensor shall be of the inductive type giving an output of 4 -20 mA proportional and the flow rate and a totaliser. The sensor shall be protected to IP 66 and having the following characteristics:

- Accuracy: <±0,25% of FSD between 25 and 100% of the flow measured.
- Stability: 6 months period: ±0,25% of FSD
- Voltage supply: 200 Vac
- Sensitivity:0,005%/V at 50% flow and more

Differential pressure switches shall have contacts with differing "cut-in" and "cut-out" values. The nominal values at which differential pressure switches operate shall be fully adjustable over the whole range of the instrument and the set value shall be clearly indicated by means of a scale and pointer. Contacts of differential pressure switches shall be hermetically sealed.

1102.9 Mechanical Flow Meters
Mechanical flow meter shall be volumetric, jet or in-line helical vane (Woltman) type to Standards ISO4064/BS 5728 EEC Specification with integral strainer. Meters shall be designed for minimum maintenance and shall incorporate best quality rotor bearings to ensure long working life.

Meter bodies shall be cast in spheroidal graphite iron to BS EN 1563. All internal parts shall be manufactured from non-corrodible materials.

Meters are for the measurement of potable water flow with a normal working temperature up to 30ºC and a maximum working pressure of 16 bar.

Meters shall be generally in accordance with the following Table:

Meter Size (mm)	Q_{max}: PEAK Instantaneous Flow (minutes only) (m^3/h)	Qn: MAXIMUM Continuous Flow At ±2% measuring Error (m^3/h)	Qmin: MINIMUM Flow at ±5% Measuring error (m^3/h)
15	3.0	1.5	0.036
20	5.0	2.5	0.050
25	7.0	3.5	0.082
32	10.0	4.5	0.127
40	20.0	6.5	0.182
50	80	40	0.55
80	200	120	0.70
100	250	180	1.20.
150	600	400	3.00
200	700	550	5.00
250	1200	750	10.00
300	1500	1000	12.00
400	3000	2000	25.00

Measurement mechanisms shall be removable from the meter body without the necessity to remove the meter from the main. Meters shall be equipped with a register indicating flow in metric units a sweep hand and six figure counter. Dummy cover plates to seal the meter after the mechanism removal shall be provided.

Tapers shall be provided, or non-standard bearings and propellers, if required, to obtain the specified degree of accuracy at the specified flow rates.

The meters shall be suitable for working pressures up to 16 bar unless otherwise stated.

An extension drive and extended head shall be fitted to meters as required. The drive shaft bearings and gears shall be designed for long life under continuous operation, and normal wear shall not significantly affect the accuracy of the meter.

Meters shall have a circular dial and rate of flow indicator registering flow in litres/sec. A flow totaliser having at least six digits shall be incorporated in the head. The totaliser shall have a capacity of at least one years flow at maximum flow rate. A multiplying factor in multiples of 10 may be used in conjunction with the totaliser if required, however, if this is the case, the factor shall be clearly marked alongside the register.

Meters shall be individually flow calibrated at the manufacturer's works and shall be guaranteed to within 2% of true flow within the rated range of the meter. Each meter shall be supplied with a calibration certificate.

The spare parts shall include as a minimum spare gearing and bearings for each size of flow meter used.

1103 Electrical Works

Functional Precepts

1103.1 Plant Operation

The plant will be unattended and all constituent units shall be arranged to be fully automatic and maintained ready for service at all times.

In order to simplify operation and maintenance, all control schemes shall, as far as possible, follow the same operating pattern, have similar control cubicle layouts, and employ similar items to minimize spares holdings.

Electrical system design shall reflect the hydraulic system design as far as possible and shall be directed to making each major item of plant capable of running substantially independent of others. Where common equipment is employed, then every effort shall be made to ensure that no single fault can affect the entire plant and particular care must be taken to protect the overall integrity of the system.

Provided that the principle of segregation is not infringed, solid state or microprocessor based equipment may be incorporated within the various control panels in lieu of electromagnetic relays, timers, etc., in order to perform the necessary control functions. In this event, full details of the proposal to achieve segregation shall be submitted for approval with the Tender. All costs for programming, setting-up, providing and training of purchasers staff in the operation and maintenance of such equipment shall be separately identified in the Bill of Quantities.

1103.2 Power Supplies

The Supply Authority will be requested by the Employer to provide a reliable, secure and adequate power supply to each site. This supply may not be made during the period of the Contract and the availability of electrical power supplied cannot be guaranteed. The Contractor shall provide all necessary temporary power supplies, by use of mobile generators or otherwise, for purpose of construction, connection, installation, testing and commissioning of the Works. The Contractor shall be responsible for assessing the requirements, availability and reliability of all power supplies at each site and shall be deemed to have included in his tender for the provision of all necessary temporary electrical power supplies.

The electricity supply is a nominal 415 V, 3 ph, 50 Hz. The voltage may vary ±15% and equipment shall be rated to withstand this variation.

Power will be brought to the site by the client either at 11 kV or 415 V. Where the supply is at 11 kV, a stepdown transformer will be installed by the client. The Contractor shall provide all cabling and wiring from the transformer or from the client cut outs at the metering location. Buried cables within the station compounds shall be in duct.

The Contractor is responsible for ascertaining the exact details of the supply, including the type of earthing, the earth fault loop impedance external to the installation, and the prospective short circuit current.

The Contractor shall provide a certificate of completion from the Government Electrical Inspectorate (GEI) prior to the client installing the meter and cut-outs, and making the final connections.

The Contractor shall size all cables in accordance with the IEE Regulations or NEC. The Contractor shall submit all calculations for comment and approval prior to the installation being carried out. The Contractor

shall also provide a single line distribution diagram showing equipment and cable ratings, earth loop and prospective short circuit values.

1103.3 Pump Units

All pump units shall have means of isolation from their associated pipe work system.

In dry well installations, the suction valve will normally be left open, unless used for isolation when the pump is out of service.

The delivery side of the pump set shall include a non-return device to prevent back circulation when the set is not running. This shall be a fail-safe device such that in the event of pump failure or loss of external services, the device shall independently close. A gate valve will normally also be installed on the pump delivery side, downstream of the non-return device, for pump isolation.

1103.4 Pump Unit Control

The pump unit control panel shall include all control and indication elements for the pump motor, together with any associated valve actuators, lubricating systems and valves, cooling fans, flushing pumps and other ancillary control equipment required by a pump drive, all arranged to operate in a safe and proper sequence.

Where external services are fitted to open the delivery valve, the control system shall initiate the valve opening procedure as soon as the pump is up to a speed sufficient to overcome any existing delivery pressure.

Failure of the valve to open within the time allowed or closure occurring whilst running, shall initiate an alarm and shut down the pump set.

1103.5 Pump Duty Control (4 or more Pumps)

Each of the pump units shall be capable of operating in any combination of duty sequence. The Contractor should apply a clear and reliable method of pump duty allocation and duty rotation, to evenly distribute running times for each pump unit.

Any starting sequence, including those following restoration after a supply failure shall be time sequenced to prevent excessive load on the supply system. Each duty circuit shall include its own timer, arranged to be initiated in the selected duty sequence by the preceding duty, the delay periods between each restart being adjustable up to 20 seconds.

Where a microprocessor based pump control system is employed using common modules, two modules shall be provided, each capable of controlling at least 50% of the pumps available, the duty set points being interleaved between each module to limit the effect of failure of one module.

1103.6 Level Control

The water level shall be monitored by a system providing the necessary duty set points, each being adjustable over the full range of control specified.

To achieve performance stability under all environmental conditions and variations, all necessary signal compensation devices shall be included.

The monitoring system shall be damped to prevent spurious switching due to transient wave motion but shall respond sufficiently to allow adequate time for plant reaction to stabilize in order to prevent hunting.

The system shall include a duplicate back-up monitoring device or have a built-in self-monitoring circuitry with alarm facilities.

Any high settings which may be provided as part of a level control system may be linked with the independent high level alarm sensors specified.

1103.7 Alarms and Indicators

Separate indication of the following conditions shall be provided by means of annunciators grouped as indicated on the front of the panel. All indications shall have a lamp test facility.

Alarm annunciators shall be provided with accept ad rest facilities together with an audible alarm and an audible/mute selector switch.

Each of the alarm conditions specified shall initiate its individual annunciator with a flashing indication which shall become steady when “Accept” button is pressed and be extinguished by the “Reset” button once the alarm condition is removed.

In specified unattended locations, self-reset facilities shall be provided to enable the system to restore itself to normal operation after the fault has passed.

With audible/mute switch set to”Audible”, the audible alarm shall sound when the indication is flashing and be silenced when “Accept” button is pressed. In the”Mute” position the audible alarm shall be muted and any alarm initiation shall give a steady lamp indication only.

To prevent false alarms occurring during mains failures or on restoration of mains supply, the common alarms specified shall be supported by a battery backed supply, either directly or via an inverter.

1103.8 Control Selector

A three position Hand/Off/Auto selector switch shall be mounted on the front of the panel to give the following control facilities; the switch shall be lockable in each position by means of a barrel locking device incorporated in the handle and the switch handle shall clearly indicate the switch setting.

In the “Hand” position operation shall be by means of the “Start” and “Stop” push buttons mounted on the front to the panel with all plant protective devices retained in circuit.

In the “Auto” position the plant shall be operated automatically under the control system specified together with the plant protective devices.

1103.9 Emergency Stops

Where means of stopping are required adjacent to a motor of the driven plant to prevent danger, emergency stop push buttons, trip switched, or interlocks shall be provided, arranged to immediately isolate the supply, as long as a greater risk is not thereby introduced.

Emergency stop buttons shall have a stay-put lock off feature, with “twist to release” manually operated reset facility. Such a button shall be located on the motor starter panel. A key operated reset facility shall be provided where specified.

Where plant is normally enclosed or has fixed guards to prevent accidental contact from moving parts, stop buttons are not normally required adjacent to such parts.

Stop buttons shall be hard wired direct t all motor control circuits and not by way if any semi-conductor logic control circuitry.

Means of equipment isolation for maintenance purposes shall be provided. This may either be by use of key operated emergency stop buttons or lockable isolators, which may be at the control panel or local to the plant.

1103.10 Mains/Standby Supply Changeover

If the site is supplied from two alternative mains supplies, the changeover section shall monitor the three phase voltages of each of the two incoming supplies and automatically close the contactor to the healthy supply. The two incoming supply contactors shall be mechanically and electrically interlocked to prevent paralleling two healthy supplies.

Where a bus section switch is provided for manual switching arrangements to allow both supplies to be utilized without paralleling, the contactors must be electrically interlocked between each other and the bus-section switch. Voltage monitoring settings shall be adjustable and nominally set to operate on a rising voltage of 90% nominal, with low/high voltage settings at ±15% nominal on each of the three phases.

1103.11 Automatic Operation

Mains/Supply – Closing the incoming isolator or restoring a healthy supply will initiate the closing of the Mains contactor via the monitoring relays, subject to the generator operating condition.

Momentary supply drop-outs up to 5 secs. shall allow the plant to resume without further action. Breaks of supply greater than 5 seconds shall initiate the generator supply. Delayed start timer setting to be adjustable 0-3 min.

After any changeover of supplies, automatic or manual, the pump motor loads may be restored automatically or manually (remotely or locally) as specified but with sequential 20 seconds re-start delay timers incorporated in each pump starter circuit to prevent co-incidental starting surges.

1103.12 Voltage Drop

The volt drop within the installation shall not exceed a value suitable for the safe functioning of any fixed current-using equipment.

1103.13 Equipment and Cable Ratings

All busbars, cable, switchgear, fuses, motor starter,, relay, instruments, panel wiring, etc. shall be sized and rated in accordance with normal operational requirements of the associated plant and equipment, taking into account maximum load currents, volt drop, frequency or motor starting, maximum ambient temperature etc.

Where specific voltage or current ratings have been included on the drawings and in the description of individual items of equipment in the Specification and/or Bill of Quantities the values stated shall be deemed to be minimum values. It shall however be the responsibility of the Contractor to ensure that all

equipment supplied is properly insulated and adequately rated to handle operational loads and, in the case of fuse gear and circuit breakers, to deal with prospective fault currents.

a) Switchboard Components

1103.14 Panel Construction

Panels shall be constructed of sheet steel having a minimum thickness of 2.0mm (14 SWG) or other approved material, and similar equipment shall be of the same manufacture and units of the same type and rating are to be interchangeable. The use of toxic, hygroscopic or flammable materials shall be avoided.

LV Panels shall be damp and dust protected (IP52) for indoor situations and hoseproof (IP65) for outdoor or wet situations, or as otherwise specified under the specific requirements.

HV Panels shall have covers and partitions affording a degree of protection IP53 to BS 5447 or equivalent for drawout sections. Internal partitioning, instrument and control sections etc. shall be to IP52.

Switchboards shall incorporate a rigid steel frame and be suitable for ready extension at each end without further cutting or drilling. Composite switchboards shall be assembled by the principal electrical manufacturer and shall be sectionalized as necessary to facilitate handling.

Switchboards shall include barriers between each of their units to ensure safe maintenance on any circuit during normal operation with the remainder of the board live. When a functional unit is isolated and open, the degree of protection to any remaining live part shall be at least IP20. Barriers or covers to live components shall have warning labels attached.

If any compartments are provided within a section of outgoing units which are not fully equipped, they shall be arranged so that they can be fully equipped without de-energizing that section of the switchboard.

Cubicle type switchboards shall be totally enclosed, flush front and rear patter, arranged in a multi-tiered formation if practicable, with at least 300mm clearance between floor level and any operational item of fuse gear or control gear. Kicking strip protection shall be provided by a 100mm high plinth forming the base of the switchboard.

The overall height of control panels, including plinths, shall not exceed 2300mm. Isolator handles, control switches, push buttons indicator lamps and instruments shall be centred not more then 1900mm above finished floor level.

All components mounted on the front of the panel shall be of matching uniform appearance, orientation and colour, with all bezels and escutcheons finished black. The layout and grouping of components shall be as approved or specified.

Within each control cubicle a reduced size schematic diagram of the control circuit, printed on durable material, shall be permanently fixed.

1103.15 Doors and Covers

Each section or compartment shall be provided with full width access doors or covers, with individual doors or covers not exceeding 750mm width.

All doors and covers shall have returned edges for rigidity and incorporate dusts seals of flexible material secured in channel rebates. Covers exceeding 0.5m^2 in area shall be provided with a supporting lip within

the lower edge or have lift-off hinges. All doors shall be supported on strong hinges of non-corrodible material and shall be secured by adjustable quarter turn cams, operated by small TEE handles incorporating key operated barrel locking facilities or flush locks with drive key inserts. Covers shall be secured by similar fastenings or captive bolts.

All additional fittings such as handles, hinge brackets and locks shall be a black finish, polyamide moulding or epoxy coated metal.

Doors shall open at least 90º with the opening positively limited such that doors and their appurtenances are prevented from fouling adjacent panels when opened.

1103.16 Switchboard Rating and Busbars

Switchboard busbars, droppers, switchgear and its associated cable boxes shall be mechanically and electrically designed to withstand the fault level and duration specified herein and (except for LV switchboards rated less than 900A) shall be an ASTA certificated design rated at not less than 80kA RMS for 1 sec. or 50 kA for 3 sec. LV switchgear and motor control gear shall comply with BS 5486 Form 4 segregation of busbars, functional units and terminal chambers, unless otherwise specified.

Busbars and droppers shall each be air insulated and formed from solid drawn high conductivity copper bars, having a constant current rating with a uniform cross sectional area throughout their length. Each shall be clearly marked with the appropriate colours to indicate each phase, neutral and earth. Droppers shall be s short and as straight as possible. Busbar compartments shall be fully segregated and shrouded from all other sections of the switchboard.

All busbar connections shall have at least two bolt fixings, and due considerations shall be given to high stresses at bolted connections on high voltage equipment. Where flexible busbar connections are used these shall be secured by high tensile steel and nuts with anti-vibration locking devices.

1103.17 Earthing

All metal cases of meters, relays, instruments, starters, and control switches shall be connected to the switchgear frame earth terminal by means of green and yellow PVC insulated cable, not less than 2.5mm^2 cross section.

An earthing terminal or group of terminals shall be provided in the panel for termination of panel earthing connections and incoming cable earth or connection to a main earth bar.

A main earth bar of copper shall be provided to run the length of each board so that all cable sheaths and armouring may be bonded to it. Where the fault level at the switchgear is 33kA or less the minimum size shall be 31.5mm x 6.3mm x 6.3mm.

1103.18 Panel Preparation and Finishing

The whole preparation and paint system shall be suitable for the operating environment specified and a painting schedule giving details of preparatory treatments, types of paint, number of coats and method of application shall be submitted with the Tender. Proprietary items may be used in their standard finish subject to the approval of the Engineer.

The system proposed shall conform to the following minimum requirements.

- After all machining and forming has been completed all steelwork surfaces shall be thoroughly cleaned of rust, welding slag or spatter and other contaminations prior to any painting.
- Panels for indoor location shall, immediately after cleaning, have all surfaces protected by an approved zinc-based corrosion resistant primer, followed immediately by one intermediate and two finishing coats of pant to give a minimum total dry film thickness of 560 microns (0.002").
- Panels for damp situations or outdoors shall have the surfaces grit blasted and zinc sprayed within 4 hours to BS 2569 Part 1 to a thickness of 125 microns (0.005") at the works. The final paint finish shall be one of two pack epoxy primer and two coats of epoxy paint to give a minimum total dry film thickness of 75 microns (0.003").
- Steel fixings and fastenings shall be treated to prevent corrosion by hot dip galvanizing to BS 729 or sheradized to BS 4921 Class 1 before painting. Chromed fittings shall not be used.
- Any damage occurring to any part of a painting scheme shall be made good to the same standard of corrosion protection and appearance as originally employed. Any finish coat applied on site shall be considered for decorative purposes only.

1103.19 Paint Colours

The colours of the primer, intermediate and finishing coats of a paint system shall be easily distinguishable from each other and the materials used shall be suitable for the application employed and preferably be supplied by one manufacturer who shall ensure that all coatings are compatible.

Electrical control panels shall be gloss finished in the following final colours:

DETAILS	COLOUR	BS 4800 Ref:	BS 381C Ref:
Panel Exterior	as advised by the Engineer		
Interior Equipment	White	10 B 15	-
Trays	White	10 B 15	-
Bushbar Shutters	Signal Red	04 E 53	537
Circuit Shutters	Lemon Yellow	10 E 53	309

1103.20 Labels

Each switchboard shall be provided with a title label and have circuit designation labels fixed to the front and rear cover of each circuit compartment. Rear covers for more than one sub-section shall have labels for each sub-section. In all cases, the label shall be positioned so as to leave no doubt as to which item it refers.

All indicators, instruments, relays, control switches, push-buttons, fuses and other ancillary apparatus shall be provided with labels clearly stating their function.

Character sizes for mains title and circuit designation labels shall be at least twice those for ancillary items.

All label inscriptions shall be to the front of the switchboards/control panels/starters shall be of transparent Perspex with radiussed or chamfered front edges, reverse engraved with white infill then sprayed on the

rear to match the colour of the board. Other labels shall be sandwich type white/black/white, or yellow/black/yellow for Danger labels, or as approved by the Engineer.

All labels shall be fixed square to the equipment by means of screws or rivets of nylon or non-corrodible material. Labels affixed with adhesive will not be accepted.

1103.21 Cabling Facilities

Cable boxes and glands shall be accommodated within cubicles except where otherwise approved and all removable access, sealing and gland plates are to be provided with gaskets to form an adequate seal against the external atmosphere.

Adequate space within each compartment shall be allowed for external cable tails to be connected without stress on the terminations, bearing in mind the type and size of such conductors. Where multi-cores in excess of 95mm^2 or any single core cables are to be terminated, a minimum distance of 450 mm free space shall be allowed between the gland plate and the terminal connection point.

In multi-tier compartments, individual terminal covers and gland plates shall be provided for each circuit such that additional circuits may be terminated safely whilst the switchboard is energized.

For paper insulated cables, a suitable cable end sealing box shall be provided for each circuit as specified. Where the cable enters from beneath the panel, the bottom of the wiping gland shall be at least 150 mm above the panel floor level. Removable split ends sealing plates are to be provided for subsequent fitting around such cables.

Undrilled removable gland plates shall be provided for cables requiring compression glands entering from beneath the panel. The plate shall be located at least 300 mm above the panel floor level and shall form part of a compartment constructed within the panel to seal the interior of the panel. Access for glanding-off shall be provided by removable covers fitted to the available vertical sides which may extend the full width of the panel as necessary.

Where single core cables are to be accommodated, a non-magnetic or slotted gland plate shall be provided.

Terminals, studs or drilled holes shall be provided to accommodate all necessary cable terminal lugs and, prior to manufacture, The Contractor shall confirm cabling termination requirements with the Engineer.

1103.22 Panel Wiring

Panel wiring should be run neatly within the cubicle in suitable cable looms or panel trunking, and in the case of instrument, intrinsically safe or safety extra-low voltage circuits, run in separate groups accommodated within the cubicles. The looms or trunking shall be adequately secured without the use of adhesive material. Wiring carried across door hinges shall be neatly loomed and rolled in torision in the plane of the hinges to minimize flexing of the wiring, thus wiring shall enter and leave at different levels as widely spaced as practicable. Bushings or grommets shall be used where wiring passes through sheet metal or plastic.

All components and auxiliaries in repetitive units shall be wired in an identical pattern to match the arrangement of each component.

Wiring cables shall be adequately rated, tinned copper stranded conductors or not less than 1.0mm^2 (32/0.2) PVC insulated 600V grade, except wiring to PLC or other light current equipment which shall be not less than 0.5mm^2 (16/0.20).

Wring insulation shall be coloured as follows:

AC Circuits

Mains supply (LV)	- Black
Uninterruptible power supply (LV)	- White
ELV supplies (up to 50V AC)	- Yellow
Intrinsically safe circuits	- Blue

DC Circuits

Battery supply (ELV, not exceeding 120V DC) - Grey

Where various voltages exist within the above definitions, the colour coding shall be subject to agreement with the Engineer.

Each wire shall be terminated with suitable ring or spade crimps or bootlace ferrules and identified at both ends by means of white or resistor colour-coded ferrules imprinted to correspond with the diagram connections.

Wires linking common points in the circuit shall bear the same reference at each termination. Alternative identification methods require prior approval of the Engineer.

1103.23 Terminals

All terminal blocks for the connection of small wiring shall comprise shrouded anti-tracking mouldings or melamine phenolic or comparable material with provision for securing conductors either by high tensile screws and clamps or be solder tag connection.

Terminal blocks shall be arranged so that both terminals and wiring ends are readily accessible and have separate terminals provided for incoming and outgoing wire, together with insulated barriers between adjacent connections and transparent insulated covers. Blocks accommodated on common mounting rails shall have a foot designed to ensure s a secure fit to the rail. Foot springs shall be of stainless steel and have a locking device fitted to prevent accidental release of the block.

Each terminal shall be labeled to correspond with the diagram of connections and terminal identification labels shall be attached to the fixed portion of the terminal blocks only. Terminals for intrinsically safe circuits shall be clearly segregated and coloured blue.

Terminal which may be ‘live’ when the equipment is isolated from the main supply shall be adequately shielded from accidental contact and be clearly identified and inscribed accordingly.

1103.24 Current Transformers

Each current transformer shall bear a label showing the ratio, class, short time factor and accuracy limit factor. The inscription must be reasonable when the transformers are installed within the gear without the necessity of dismantling any equipment other than removing cover panels.

Bar type current transformers shall be supplied in preference to those with wound primaries. Short time current factors shall relate to the full fault level specified. For over-current protection, the product of VA rated burden and rated accuracy limit factor shall be 150 unless otherwise agreed with the Engineer.

One secondary terminal of each current transformer shall be earthed at the switchgear.

1103.25 Voltage Transformers

Voltage transformers shall be vacuum impregnated or encapsulated resin insulated type. Each transformer being fully isolatable and accessible for maintenance purposes and fitted with primary and secondary fuses.

1103.26 Indicating Instruments

All indicating instruments shall be of a similar flush vertical mounting, rectangular pattern, enclosed in black coloured, dust and damp-proof cases, one side being not less than 90mm (3.5") long or as specified. Scaling shall be in approved metric units normally ranged from zero to 20% - 40% above the system designed operating value,

except where finite limits exist (e.g. p.f. indicators, synchroscopes) or where restricted ranges are specified. Instruments having a mechanical movement shall provide at least 90º scaled arc. 240º arc scales shall be employed on principal specified indicators.

Ammeters for motor circuits shall have an extended scale to cater for the starting current. These shall be adjustable red pointers or red markings on the scale to indicate the normal circuit current for the associated plant and shall be connected to each of the three phases of a three phase motor circuit.

1103.27 Indication Lights

Indication lights shall be flush panel-mounted types with bodies fastened and keyed to that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lamp-holder or panel wiring. Lens colours shall be specified in the Specific Requirements. Bezels shall be coloured black.

All light sources shall be operated at Extra Low Voltage. Single units shall be dotted with MES caps and be illuminated by LED clusters where colours permit otherwise filament lamps shall be used.

To extend lamp life, filament lamps shall be arranged to operate approximately 20% below their rated voltage and details of voltage and type of indication lamp shall be submitted for the Engineer's approval. Particular consideration shall be given to circuits operated from a battery supply permanently floating across a charging circuit, where terminal voltage may be higher than the nominal voltage.

When annuciator style indicators are used they shall incorporate two lamps wired in parallel for each fascia which shall have a window area of not less than 48mm x 24mm. the engraved characters shall be not less than 3mm in height and shall be filled black on a translucent background coloured as specified.

Alternatively where specified (particular for unattended situations) self-contained LED annuciator display modules shall be used and configured for panel mounting. Legend plates shall be provided adjacent to each indicator. Where message display indicators are used, they shall have programmable legends and adjustable pulse rates.

1103.28 Push Buttons

Push buttons shall be heavy duty, double break pattern with fully shrouded moulded buttons having a spring return action through a flexible oil-tight seal. Each button shall be coloured in relation to its function accordance with Appendix 2 or as otherwise specified herein and bezels shall be coloured black.

Emergency stop buttons shall be arranged to de-energise without delay the drive motors for the whole of the associated plant whatever control mode of operation may be selected. They shall be of the 'stay put' type having a large red mushroom head with twist-to-release manual reset, suitably labeled and have at least two poles, 1 N/O and 1 N/C with contacts suitable for the circuit operation.

Where key reset heads are required, the key shall be common for all buttons.

1103.29 Control Relays

Control circuit relays for switching 5A/250V or less shall be of the multi-pin plug-in type having the following features:

- Neon or LED indication of relay energisation;
- mechanical ON/OFF indication;
- manual test button with provision for retention of the button in the operated condition for test purposes;
- legend plates on relays and base;
- relay retaining clip;
- be mounted on moulded bases having recessed screw terminals.

If sufficient contacts are not available in one relay, not more than two relays may be connected in parallel.

Any relay used to switch an external alarm circuit shall have a volt-free contact for the purpose.

1103.30 Protection Relays

Electro-mechanical protection relays and associated devices shall be provided as specified, suitable flush mounting in dust proof cases; withdrawable types being provided where they are fitted in fixed panels.

Where not mounted on a battery sourced alarm monitoring display, the relays shall have hand-reset flag indicators unless a self reset or electrically-reset facility is specifically called for. Hand-set indicators shall be capable of being reset without opening the relay case. Flag indicator relays shall be de-energised once the flag has fallen.

Where two or more elements are included in each case, separate indicators shall be provided for each element.

1103.31 Fuse Links and Holders

Suitable rated fuses shall be provided at all points necessary for circuit protection and isolation, separate fuses being provided for instruments, indication, alarm, heater and coil circuits. Fuse ratings shall be rationalized as far as possible to limit spares.

LV Fuses in circuits exceeding 50V shall, where practicable, be housed in all insulated carriers with fully shrouded bases of matching colour, which shall not be interchangeable with carrier and bases provided for removable solid links which shall be coloured white.

LV fuse links shall be HRC cartridge type to BS 88, Class Q1, having provision for screw fixings for attachment to the carrier.

Control and Instrument Fuses may be accommodated in moulded terminal blocks suitable for DIN rail mounting. Fuses rated up to 6.3A 250V shall be 20 x 5 mm (G type DIN 41660) having a hinged fuse carrier housing.

Fuses rated up to 13A 250V shall be 25 x 6.3 mm cartridge type to BS 1362, secured by a screw cap. The live connection being made to the lower terminal.

1103.32 Locks and Keys

Lockable selector switches or panel doors in a multi-unit installation shall employ a common interchangeable operating key but keys for each function may be non-interchangeable, subject to the approval of the Engineer.

For each key pattern employed, three keys shall be provided; each having a permanently attached brass identification label, embossed with the following:

- key number
- location of lock/item of equipment reference.

Lose padlocks and keys for security locking switchgear, isolators, shutters etc. shall not be included but will be provided by the Client to suit their master key suite to permit locking. Hasps shall not have less than 9mm diameter holes suitable for 6mm diameter shackles.

1103.33 Key Cabinets

Key cabinets shall be provided to accommodate, on suitably numbered/coloured, adjustable hook bars, one set of all the above keys and padlocks. The keys shall be fitted with corresponding number/colour coded tabs.

The cabinets shall be of stove enameled sheet material, suitable for surface wall mounting and be fitted with lockable hinged cover doors.

1103.34 Insulating Mats

Black rubber matting shall be supplied complying with BS 921 and shall be supplied for all indoor control or switch gear panel. It shall extend the complete length of the control panel and the minimum width shall be one metre.

b) HV Breakers and Disconnectors

1103.35 Circuit Breakers

For AC circuits, circuit breakers shall be triple pole of the vacuum interrupter, SF6 or air break type as specified, suitable for short circuit fault duty specified herein. Low voltage breakers shall incorporate a neutral link, unless in special cases a neutral pole is called for on the breaker under the specified requirements. Air or oil break circuit breakers shall be 'trip free' and the whole of the operating mechanism shall be suitable for such conditions of operation.

The whole equipment shall be robust and capable of withstanding repeated closing and opening impacts satisfactorily.

Each breaker shall be provided with the following:

- Mechanical 'Flag' indicator giving reliable indication that it is either "Off" (open) or "On" (closed);
- Means of isolation so that the breaker may be maintained with busbars alive;
- An operating handle that can be concealed when not required, ensuring a flush fronted appearance;
- An adequate number of auxiliary switches with the addition of one normally open and one normally closed spare switches, all to be wired to a terminal board of approved design in the fixed portion of the switchgear and arranged in the same sequence on all equipment;
- Protection relays and tripping devices as specified;
- Facilities for connection of appropriate auxiliary circuits when the circuit breaker is in the isolated position to permit operation of the breaker for test and indication purposes;
- Key operated interlocks between breakers as specified.

1103.36 H V Disconnectors

HV disconnectors shall be triple pole, oil free switch-disconnectors rated for fault making/load breaking duty to IC 265, mounted on a non withdrawable chassis and enclosed in a metal clad enclosure in accordance with BS 5527 or equivalent.

The contact breaking mechanism shall incorporate expulsion quenching techniques to ensure positive arc extinction and high closing speeds to enable the switches to close onto existing short circuits without harming the equipment or the operator.

The switches shall be either manually or electrically closed and manually or electrically tripped as detailed in the Specification Requirements. All operations shall be effected with the panel door closed and include an ON/OFF indicator. Contact separation shall be clearly visible through a viewing window on the cover.

1103.37 Safety Shutters

Where withdrawable circuit breaker units are used, the housing shall be arranged to accurately locate the movable portion prior to engagement and accommodate automatic safety shutters.

Each group of busbar and circuit spout orifices shall be fitted with an individual automatically operated safety shutter, the appropriate shutters being positively opened or closed when the circuit breaker is racked in or out.

When closed, the shutters shall effectively prevent any contact with either the busbar or circuit connections and seal the spouts against the ingress of dust. The shutters shall be painted in bold characters 'CIRCUITS' as appropriate, the busbar shutter being coloured red and the circuit shutter being coloured yellow (see Appendix 8).

For testing and inspection, each shutter shall be separately hand operated from the front of the unit and latched in the open position. Any movement of the circuit breakers either in or out of the housing shall automatically restore the automatic feature.

Provision shall be made for each shutter to be locked only in the closed position.

Non-withdrawable HV switchgear shall have a three phase test access point incorporated in the design such that cable tests may be carried out on each circuit. The test access point shall be fitted with a lockable cover and interlocked to prevent access to live circuits.

1103.38 Provisions for Earthing

Provision shall be made for earthing the busbars and each circuit outlet through the circuit breaker, either integrally of by means of a portable device as specified; such an arrangement being suitable to withstand the full short circuit rating of the switchgear.

Where integral earthing facilities are included, selection of the locating mechanism shall prevent the breaker being engaged into any position other then that selected. Visual indication of such circuit breaker locations shall be clearly marked, e.g. "CIRCUIT EARTH', "BUSBAR EARTH", "SERVICE/ON" and "ISOLATED/OFF".

Facilities shall be provided so that padlocks can be fitted to prevent the selection of either "EARTH" positions.

Facilities shall be provided for padlocking the circuit breaker while it is closed on to an earth circuit to prevent unauthorized tripping electrically or mechanically.

The circuit breaker truck (or carriage) and oil tank if applicable, shall be effectively earthed when in the "SERVICE/ON" position.

HV switched shall have facilities for earthing the circuit by means of a selector ad the ON, OFF and EARTH positions shall be visibly indicated, appropriately labeled and provided with locking facilities in each position. Inspection windows shall be provided so that the position and condition of the selector contacts and insulators can be observed.

1103.39 Interlocks

Each circuit breaker unit shall be provided with mechanical interlocks to prevent incorrect operation or accidental contact with live metal, and to protect the equipment and operator from the dangers of mal-operation and designed to prevent the following where relevant:

The circuit breaker being closed unless it is in the fully-engaged or fully-withdrawn position.

The circuit breaker being engaged and plugged into the busbar and circuit spouts unless the tank is bolted to the top-plate.

The circuit breaker being engaged or withdrawn unless the main contacts are open.

The circuit breaker unit being withdrawn from or pushed into the unit housing unless the breaker is in fully-withdrawn position.

The circuit breaker being positioned in the unit in any position other than that indicated on the locator.

Access to voltage transformers unless they are in the isolated position.

1103.40 Handling Track

For each switch boar and different type of breaker supplied, on purpose designed, manually operated lifting and handling track shall be provided to enable safe removal of a circuit breaker from its compartment.

1103.41 Switch Oil

The first change of switch oil shall be provided for each oil circuit breaker or switch. An oil level indicator shall be provided on each tank with maximum and minimum limits marked.

c) LV Distribution Switchgear

1103.42 Switches

Switches shall be of the air break patter, enclosed zinc sprayed heavy duty, cast metal or sheet steel cases providing enclosure protection to at least IP55 unless otherwise specified, suitable for industrial surface mounting or flush cubicle mounting as specified.

They shall berated in accordance with BS 5419 or equivalent and be fitted with solid or HRC fuse links as appropriate in each phase and a neutral ling, all contained within the switch case, with the terminals accessible from the front of the switch. Phase barriers and contact shrouds shall be provided with an interlock to prevent withdrawal or access when the fuse switch is in the 'ON' position.

Each switch shall have a free handle control mechanism to prevent inching and damage to contacts, be fitted with 'ON' and 'OFF' position indicators and have provision for locking in the 'OFF' position. When padlocked in the 'OFF' position, interlocks shall prevent the unit door being opened.

The moving contacts of fuse switches shall be readily withdrawable as a complete unit for maintenance when the remainder of the board is live.

1103.43 Distribution Fuseboards

Fuseboards shall be of the rust proofed, zinc sprayed, heavy gauge sheet steel, having a flush fronted door with concealed hinges and a resilient gasket, providing enclosure protection to al least IP 55 unless otherwise specified.

The interior shall be assembled from all-insulated shrouded fuse carriers and bases of the 380V patter, fitted with phase dividing barriers and all live parts being fully shrouded, all in accordance with BS 5486 or equivalent.

Circuit identification charts shall be fitted to the inside of all fuseboard doors.

All fuse carriers shall be fitted with fuse-links rated to suit the circuit duty. Spare ways shall have fuse links of the same current rating as the carrier, unless different current ratings are called for under the specific requirements. The Contractor shall however confirm fuse ratings with the Engineer before fitting fuses to the carriers. Fuse-links shall be of the HRC cartridge type to BS 88, Class Q1, having screw fittings to the carriers.

1103.44 Molded Case Circuit Breakers

Molded case circuit breakers shall be of the quick make, quick break, and trip-free type complying with BS 4752 and shall be complete with thermal/magnetic releases, except for those units serving as isolators only. Multiple breakers shall have a common trip bar and trip elements on each pole to ensure that any abnormal condition on any one pole will cause all poles to open simultaneously.

Visual indication of open, close trip conditions shall be provided. Facilities for padlocking in the 'OFF' position shall also be provided.

1103.45 Miniature Circuit Breakers

Miniature circuit breakers shall be of the quick make, quick break, trip-free type complying with BS 3781 Part 1. Circuit breakers shall be complete with thermal/magnetic or magnetic/hydraulic releases. Multiple breakers shall have a

common trip bar and trip elements for each pole to ensure that any abnormal condition on any one pole will cause all poles to open simultaneously.

Visual indication of open, close trip conditions shall be provided. Facilities for padlocking in the 'OFF' position shall also be provided.

1103.46 MCB Distribution Boards

Miniature circuit breaker distribution boards shall be totally enclosed, metal clad, flush fronted units, with a hinged front door, all in accordance with BS 5486 Pt 12. The interior shall be assembled from all-insulated miniature circuit breakers with bolted connections and with switch dollies arranged for vertical operation. Phase dividing barriers shall be provided and all live parts shall be screened from the front. Circuit identification charts shall be fitted to the inside of all distribution boards.

1103.47 Terminals

All terminal boards and terminal blocks shall provided a positive mechanical clamp type connection. Pinch screw type terminals shall not be used. Terminals for the connection of all external cabling shall be situated at least 100mm from their respective gland plate or further if the cable size requires a greater distance for dressing.

All main phase terminals shall be suitably marked to ensure correct phase identification.

1103.48 Labels and Circuit Lists

All electrical equipment enclosures shall be clearly labeled to indicate the plant designation.

Individual items not subject to switchboard requirements shall have labels of non-corrodible, Traffolyte sandwich type white/black/white, or yellow/black/yellow for danger labels or as approved by the Engineer.

They shall be fixed square to the equipment by means of screws or rivets of nylon or non-corrodible material. Labels affixed with adhesive will not be accepted.

Inscriptions on labels and circuit lists shall be in English and Arabic and be submitted for the approval of The Engineer. Abbreviation 'No.' shall not be used.

A list of circuits in approval form shall be supplied and fixed behind a "Perspex" sheet on the inside of the all distribution boards which are provided or rewired under this Contract.

1103.49 Residual Current Circuit Breakers

The circuit breaker shall be arranged to isolate each live conductor simultaneously within 30ms if the residual leakage current through the device exceeds 30mA.

It shall be housed separately or incorporated into other composite enclosures, include provision for testing the tripping operation under earth leakage conditions by means of a built-in resistor and push button, and require manual resetting.

d) Motor Starters

1103.50 General

Each starter shall contain all the necessary equipments to control the circuit load and isolate it from the supply in the event of a fault and shall be equipped to comply with the following general requirements unless otherwise specified under the relevant starter duties.

For starting LV Motors direct on line, the starter shall be rated for intermittent duty class 0.3 (up to 30 operating cycles/hour) and utilization category AC-3 in accordance with BS EN 60947, or as otherwise specified.

Unless otherwise specified for particular cases, pump starting shall be by autotransformer. Small motors may be direct-on-line or star-delta started as applicable.

The ratio of the starting intensity and the nominal intensity shall be inversely proportional to the power of the motor; the following values shall be used for determination of starting requirements:

For plant which is not supplied by a standby generator set:

$\frac{I_S}{I_N} = 6$ when the nominal current of the motor is between 15 an d40 A; and if the starting current lasts less than 1 second;

$\frac{I_S}{I_N} = 3$ when nominal current if the motor is between 40 and 125 A;

$\frac{I_S}{I_N} = 2.5$ when the nominal current of the motor exceed 125 A.

Where plant is supplied by a generating set, the above mentioned values are respectively the following: 4-2.5-2.

Unless stated otherwise, power factor correction shall be provided at all sites to give a power factor of not less than 0.9 lagging at duty point load. Except for smaller installations where the capacitors may be

located within the starter sections(s), power factor correction capacitors shall be generally housed in their own separate section, complete with a switch fuse isolator. Panel sections that are fitted with capacitors shall have a prominent warning label in English and Arabic stating that the capacitors may remain charged.

Power factor correction circuitry shall be arranged such that the capacitors are not in circuit whenever the panel is being supplied from a standby generator.

1103.51 Isolation

Each unit shall be housed in a separate compartment or enclosure and be completely isolated by means of an isolating switch interlocked with the door or cover to allow access only when the switch is open. The isolating switch shall be operated by means of an external handle and shall have provision for padlocking in the "OFF" position.

When in the "ON" position, interlocks shall prevent the unit door being opened. Any components still live after this switch has been opened shall be adequately shrouded and have warning labels attached thereto.

The switch shall be rated for making and breaking stalled motor current duty as specified in BS 5419. Off-load isolators shall be suitably interlocked to ensure that they do not make or break load currents and be provided with locking facilities in the "OFF" position.

Additional physical isolation by means of withdrawable units for ease of maintenance may be offered but is not a specific requirement. For such an arrangement the live poles shall be automatically shuttered when the unit is withdrawn and the shutters have provision for padlocking in the closed position.

1103.52 Contactors

All contactors shall be of the air-break electromagnetically held-on type. All contact pieces shall be readily replaceable and the necessary auxiliary contacts for control, indication and alarm shall be mounted in accessible positions and arranged in the same sequence on each contactor.

Vacuum interrupters shall be used for high voltage circuits. They shall be solenoid operated and designed to fail-safe, sot that in the event of failure of any part of the closing mechanism the contacts will open.

1103.53 Protection

Each starter shall be provided with an adjustable motor over-load and single phase protection device suitable for the motor load and have adjustable trip and rest delays provided, together with manual resetting facilities. Ambient temperature compensation shall be provided where relevant. Other protection features shall be as specified relevant to the particular drive.

Protection devices shall be arranged to trip the load and initiate the fault indications as specified and accept normal switching of load.

Where starters are fed directly from busbars or other systems having a high prospective fault level, suitably rated fuses or other means shall be provided within the started to limit the fault let through to a value within the rating of the starter components.

Protective overload devices shall be arranged to ensure that any such fault is cleared by such fuses and provide Type '2' co-ordinated protection to BS EN 60947.

1103.54 Control Circuit

All control circuits shall operate at not more than 110V and be derived from a double wound, screen earthed isolation transformer with one side of the secondary winding connected to neutral/earth. The primary supply shall normally be from one phase to neutral if available.

Individual transformers shall be provided for each starter but sequence groups of starters having a common isolator shall use a common control transformer.

Fuses shall be provided on each primary and secondary supply and be clearly labeled and segregated. A link shall be fitted in the neutral/earth connection.

The control circuit in the main supply must be isolated before opening the cubicle door but provision shall be made to re-energise the control circuit when the main supply to the cubicle is isolated, so that the operation of the control gear may be inspected without de-energizing the motor. The necessary control circuit Normal/Test switch shall be mounted within the cubicle and so arranged that it is not possible to close the door with this switch in the 'Test' position.

1103.55 Control and Monitoring

The method of control and operation shall be as called for under the specific requirements for the starter.

Control selector switches fitted to the front of starters shall have matching operating handles which are clearly shaped to show the selected position. Specified function switched shall have a key operated barrel locking device in the handle, or be key operated alone, with the key removable in each lockable position.

All fault conditions relevant to each mode of operation shall stop the drive and prevent it re-starting until the particular fault is cleared and individually reset; lock-out relays and a rest button being provided for any self-resetting devices such as excess torque switches etc.

Specified fault conditions shall be identified by separate indications on the starter. Volt-free contacts shall be provided and wired to terminals in each starter unit for remote signaling of all status indications specified. Minimum status indications shall be Auto Available/Un-available and Running/Fault.

Where the starter is to be remotely controlled by a remote terminal unit (RTU), interposing relays with 24 volt DC coils complete with back EMF suppression diodes shall be provided in each starter unit to facilitate remote control and watchdog capability (See Instrumentation and Control Specification).

"Hours-run" meters shall be of the non-resettable cyclometer type indicator having a flush fascia and driven by a synchronous motor controlled to show the hours (up to 99,999.9) run by the main motor. They shall incorporate visible indication of operation but need not necessarily be of the same bezel size as the instruments.

All starters of motors of 3 kW and above shall have ammeters, local' running' indicator lamps being provided for loads less than 3 kW.

1103.56 Heaters

Anti-condensation heater shall be fitted in each starter (and motor, where specified), fed from a separate fuse through the starter isolating switch and an auxiliary contact on the motor contactor, arranged so that the heaters are disconnected when the motor is running.

In multi-tiered starter panels, the heater shall be located at low level within each tier and fed from a clearly identified common distribution supply with local isolating links in each tier.

1103.57 Star/Delta Starters

Star/Delta starters shall be of the closed transition "Wauchope" type, having starting resistors, mechanically and electrically interlocked Star and Delta contactors plus a timing relay in addition to DOL starter requirements, all rated for up to 10 starts per hour.

1103.58 Protection

The thyristors shall be protected by high speed semi-conductor fuses and heat sink thermal cut-outs.

The device shall be shut down in the event of single phase loss or open circuited thyristors.

In the event of short circuited thyristors, the drive shall continue to run at full voltage by automatically transferring to an override condition.

1103.59 Indicators

Alarm indicators shall be provided for each of the above faults.

An auxiliary relay shall be used to control the function of the main contactor.

1103.60 Energy Saving Facility

For continuous running devices, an energy saving control shall be provided where the voltage applied to the motor is automatically matched to the actual power demand. The control shall be effective after run-up and a dwell time at full voltage has been allowed to enable the motor load to stabilize.

The device shall respond immediately to any sudden load changes to prevent a potential stall condition.

1103.61 Frequency Converters

The motor speed control shall be a frequency converter of an approved type and manufacture, providing a variable frequency of adequate capacity to drive the specified motor over the specified speed range and suitably matched to the starting torque and the speed torque characteristics of the driven plant. (Details to be determined by the Contractor from the driven plant/motor manufacturer during the Contract).

The converter unit with the associated control electronics shall be housed in a steel, free standing, drip protected (IP21) panel, mounted in the position specified. The unit shall be suitably air- cooled by means of an integral fan and all the components within the unit shall be readily accessible for easy servicing and removal without disturbing other components. Chassis units shall be suitable for rack mounting.

The incoming supply shall be via an isolator interlocked with the panel door and have suitable fuse protection.

The drive unit shall be capable of operating with the motor disconnected for test purposes. A current limiting circuit shall be incorporated to give short circuit and over-current protection in the output circuit, and under-voltage detection shall be incorporated

to protect the drive against fan failure. A thermostat shall be fitted for protection against fan failure and overheating.

1103.62 Harmonics

The unit shall be protected from any harmonic distortion or switching surges in the power supply system and incorporate contractors to automatically isolate the input and output and to protect the unit from component damage arising from a power supply interruption which shall, if necessary, include automatic shutdown. If the converter will not perform correctly when running from a specified standby generator an interlock shall be provided to prevent such operation.

To prevent disruption of the supply system wave from (and dependent instrumentation), harmonic voltage and current distortion introduced into the mains supply by the drive unit shall be within the limits specified in Electricity Council Engineering Recommendation G5/3. The point of common coupling shall be regarded as the output connection of the first upstream transformer.

The supplier shall list with the offer the expected harmonics generated by the drive under running conditions (worst case).

Where an input filter is used to limit the harmonic currents, the design shall minimize the possibility of resonance with any power factor correction capacitors fitted.

The supplier shall include any shielding necessary in accordance with BS 800, to prevent any interference that may affect other surrounding instruments.

1103.63 Monitoring and Control

The control of each of the variable drive unit shall normally be from a PLC outstation which will provide a start/stop facility and a 4-2mA speed control signal. Where the distance between the drive unit and PLC exceeds 20m, special care shall be taken to ensure radio frequency interference and distortion is kept to a minimum.

The following signals will be required from the drive unit and wired to clearly marked terminals:

- Common fault (motor overload, emergency stop operated etc.)
- Control status indicating Hand/Off/Auto
- Control ’on’
- Motor available
- Motor running
- RS 232 Serial Interface (where required by the specification).

The following items shall be included along with other control devices and instrumentation:

- Control potentiometer for speed setting on hand control, (scaled with liner graduations over the range and arrows indicating clockwise rotation to ‘INCREASE SPEED’ and anti-clockwise rotation to ‘DECREASE SPEED’);
- Output ammeter;
- Frequency/speed meter;

- Test and fault diagnostic card for circuit checking, having a front panel display and facility for serial link remote indication.
- Isolated inputs for 0-20/4-20mA auto control, stop/start, external reset, etc.
- Adjustments for ramp up/down, duration, frequency range, base/maximum speed, current limiting facility and economy made.

The following items shall be monitored for fault conditions:

- Phase failure;
- Earth fault;
- Over current;
- Over voltage;
- High temperature/fan failure;
- DC link fuse failure.

e) Rotating Electrical Machines

1103.64 General

Machine type and starting or driving arrangements together with type of enclosure protection shall be as specified herein. Vertically mounted machines shall be fitted with a drip-proof top end cowl and those fitted with skirts shall have a skirt depth in excess of the shaft extension.

Each machine shall comply with the current BS 4999 and the relevant parts of BS 5000 and shall be designed to run at a high power factor and efficiency at the prescribed plant duty.

1103.65 Rating

The output of each machine shall be a continuous maximum rating (Duty type S1) determined by the Tenderer in relation to the power requirements and the normal environmental conditions for the plant offered in accordance with this Specification.

The maximum temperature rise of any machine winding shall not exceed 90ºC above a 40ºC ambient when operating at the above rating. Where the insulation is rated up to 120ºC only, the maximum plant loading shall not exceed 95% of the rated output of the machine.

1103.66 Generators

Alternators shall be star connected machines producing a 3 phase 4 wire 50Hz supply at the specified rated voltage within a standard waveform deviation, when being driven at the rated speed and connected to the plant load specified herein.

1103.67 Regulation

The generator automatic voltage regulation system for single set running shall be capable of maintaining the voltage for all loads between no load and rated load at rated power factor.

Due allowance shall be made for the current peaks associated with starting the motor loads connected to the alternator, and the regulation system shall be designed such that the transient voltage reduction following the load application does not exceed 15% of the rated voltage and shall be restored to within 97% of rated voltage in less than 1.5 seconds. The transient voltage rise when the rated load is thrown off shall not exceed 25%.

Where voltage regulation equipment is mounted on the alternators, the components shall be readily accessible and detachable for servicing, having terminations separate from the main terminals.

1103.68 Excitation

The alternator shall be the brushless self-excitation type with rotating armature and verifier assembly mounted on the alternator shaft, electrically interconnected with field winding. Radio noise suppression shall be in accordance with BS 800 and the exciter field shall be safely discharged when the alternator is tripped.

1103.69 Motors

Motors shall be suitable for operation from a 3 phase supply having the star point earthed and the phase sequence running R-Y-B anticlockwise. Motors rates less than 0.5kW may be arranged for single phase operation.

The torque available during starting of each motor shall be at least 10% in excess of the maximum required at any speed to satisfactorily start and accelerate the mechanical plant load under all service conditions.

1103.70 Overspeed and Reverse Rotation

Each motor shall be capable of satisfactory performance during a period of 2 minutes whilst it is run at 1.2 times its rated speed and subsequently at normal speed continuously.

Where specified (to cater for backflow consequent upon delivery valve failure), pump motors shall be capable of reverse rotation p to these speeds without damage.

1103.71 Electromagnetic Brakes

Where an electromagnetic brake is fitted to drive, the brake shall be continuously rated. It shall be suitable for direction connection across the associated motor terminals or for individual supply and interlinked control, depending on the method of operation and control specified herein.

The brake shall be arranged to fail-safe by holding on under spring return passage when the coil is de-energized and have provision for hand easing for maintenance purposes. All control circuits for brakes shall be arranged to fail-safe.

Coil and terminals shall be totally enclosed in a fully waterproof housing.

1103.72 Power Factor Correction

Where specified, a power factor correction capacitor complying with BS 1650 and suitable for operation over the temperature range -10ºC/+40ºC shall be supplied, connected, tested and commissioned to improve the overall power factor of each machine to not less than 0.9 when running at full load.

Each capacitor bank shall be fitted with HRC fuse protection enclosed within a sheet steel housing having a terminal box with separate bolted access over an external earthing terminal.

Means shall be provided for monitoring fuse failure visually. For HV applications, striker pin fuses shall be provided and arranged to operate a trip bar which shall initiate an alarm contact for remote indication.

Resistors shall be fitted to the capacitors and motor terminal boxes, inscribed as follows:

"WARNING - EQUIPMENT CONNECTED TO STORED ELECTRICAL CHARGE. ISOLATE AND EARTH ALL TERMINALS BEFORE HANDLING."

1103.73 Submersible Pump Motor

The pump and its associated motor shall form a compact integral pumping unit suitable for installation within the area specified. The motor shall be of squirrel-cage construction suitable for starting method as called for in the particular specification, and rated for continuous submerged operation in water having a maximum temperature of 22ºC. Where a sealed coolant motor is used, the coolant shall be distilled water.

The stator winding shall be insulated against heat and humidity to Class F and shall incorporate at least three thermal overload devices.

A length of butyl rubber insulated, CSP sheathed flexible cable shall be provided and connected to the motor. Unless otherwise specified, the cable length shall be at least 20 metres without joints. The cable cores shall be phase coloured and be suitable to carrying the motor full local current under the specified operating conditions. The cabling sealing gland shall be a water tight design and, where included within the pressurized pipework, shall be capable of withstanding a water pressure of 1.5 times the closed valve head generated by the pumping plant.

1103.74 Terminal Boxes and Connections

Terminal boxes shall be provided, suitable for PVC/SWA/PVC cables for all external cabling connections.

All boxes shall be bonded to the main frame earth and the frame of each machine shall be provided with means of connecting an earth protective conductor.

Each machine rated 10kW or above shall have at the six ends of the stator winding extended to the terminal block with the necessary linking effected there, adequate clearance being provided between phase terminations to permit the use of cable sockets.

For high voltage machines the terminal assembly shall be capable of satisfactorily withstanding the full fault capacity specified herein for one second.

1103.75 Heaters

Anti-condensation heaters shall be provided in all non-submersible machines as an integral part of the machines and wired with butyl rubber insulated tails to a terminal box adjacent to the main terminal box, the cover being clearly labeled 'Heater Supply – 220V'.

Heaters shall be of the embedded element type having a low surface temperature and be impervious to moisture. They shall be arranged to operate on a 220V supply from the associated control unit when the motor winding is de-energised.

1103.76 Maintenance Facilities

Machines rated over 50kW shall have lifting ears or eyes forming part of the main frame of the machine lifting and pulling facilities with a single tapped hole in accordance with the tables given in BS 4999 (Part 10). Depth of tapped hole shall be 1.5 times the diameter.

1103.77 Bearings

Bearings shall be of the heavy duty ball or roller type greased for life enclosed in a substantial housing designed so that lubricant cannot escape on to the windings and fitted with adequate seals to prevent contamination or escape of lubricant down the rotor shafts. Means of lubrication shall be made available from outside the machine carcase of enclosure. The shaft shall be suitably located to prevent the rotor from moving out of magnetic centre while starting or running.

The rotor of any vertical spindle machine shall be provided with a suitable thrust bearing to support the weight of the rotor and its half coupling only.

1103.78 Slip Rings

All machines which incorporate slip rings shall be so designed that the slip rings and associated slip ring mountings shall form a single unit which can be readily detached from the shaft for repairs and replacements. The slip rings shall be continuously rated and of the totally enclosed type.

f) Cabling and Wiring

1103.79 Electrical Installation

The electrical installation shall comply with the current edition of the Regulations for Electrical Installations published by the Institution of Electrical Engineers (IEE Wiring Regulations) and the requirements specified herein where these differ from the IEE Wiring Regulations.

The installation shall be arranged in a neat and orderly manner which may involve running out of direct lines in order to conform to building outlines etc. and to utilize any holes provided for a\cabling purposes in the structure. Unnecessary crossing of cables will not be accepted and due care should be given to this when selecting runs. Each cable shall be in one continuous length and no straight through joints will be permitted except as agreed with the Engineer.

It should be the entire responsibility of the Contractor to programme the whole of his work and co-operate with other contractors to ensure that the various parts of the electrical installation are execute at the proper stages of the construction, special care being taken \with concealed work.

Care should be taken that sleevings and sheathings of cables are not damaged during installation. Should any part be damaged, the damage shall be made good to the entire satisfaction of the Engineer. Cables shall only be installed when the ambient and cable temperature is above 0ºC and has been for the previous 24 hours.

Cables shall, wherever possible, be arranged to enter equipment form below, particularly equipment located externally or in damp situations. Cables entering cubicles provided with sealed covers of timber or sheet steel shall be accommodated by drilling or dividing the covers with clearance holes as necessary to allow the cable to pass through and be terminated at glands or gland plates provided within such cubicles, so that the cover when replaced, prevent entry of dust and vermin.

1103.80 Protection of Exposed Cables

Where cables emerge through steel platforms or concrete floors, the Contractor shall provide and position protective curbing or sleeves made from galvanized material extending 75mm above finished floor level.

Sleeves shall be finished flush with the underside of the floor. Final details shall be agreed with the Engineer on site in respect of all situations.

Cables rising into or against floor mounted equipment shall be secured to the equipment in a neat manner to ensure that the cables are properly supported and that no undue strain is put on the cable termination or the plant. Where vibration or expansion is a consideration, adequate precautions and vibration loops shall be made at the appropriate position.

Where cables emerge in an area exposed to vehicular traffic and no overhanging projection exists up to one metre above ground level, a galvanized steel pipe or protection cover fabricated from 3.00mm (10SWG) galvanized mild steel (or heavier as appropriate) shall be provided and fixed to the associated structure for a minimum height of 1.5 metres above the local finished ground level.

1103.81 Selection of Cable Runs

The routes and arrangement of all cables and the position of equipment and wiring points shall be marked out on site by the Contractor and agreed by the Engineer before any work is put in hand. Where cable routes have been agreed, the Contractor shall be entirely responsible for measuring the lengths of cable to be ordered and ensuring that the cables are supplied in the correct length.

1103.82 Cutting away and Making Good

The Contractor shall be responsible making out the agreed positions of all chases, holes and fixings required for the passage of cables and conduit, and shall arrange with the Main Contractor for making good with a week mix of concrete.

The Contractor shall carry out all the necessary drilling for fixing up to 25mm diameter in the building fabric for the support and fixings of all items supplied or specified herein. Such work shall be carried out in a neat and workmanlike manner without unduly defacing concrete or brick surfaces. The use of stud fixings employing cartridge guns will not normally be permitted.

Where indicated on the Specification drawings, holes have been incorporated in the structures for the passage of cables and any additional cutting away and making good necessary to such structures will be done by the Main Contractor with the agreement of the Engineer.

1103.83 Cable Materials

Cables shall be of approved design from a BASEC approved manufacturer having a certificate of Assessed Quality Management. They shall be manufactured within the 12 months prior to delivery and be delivered to site on cable drums or with protective wrappings.

The overall sheath of the cables shall be coloured as follows:

- High Voltage - Red
- Low Voltage - Black
- Earth continuity conductor - Green/Yellow
- Instrument - Grey
- Intrinsically safe - Blue

Cables shall be of the voltage grade, conductor size and type detailed in the specific requirements. General specification of the cable type to be used are detailed hereunder:

Paper insulated mains cables shall be stranded plain annealed copper conductors, insulated with helically would paper tape, mass impregnated with non-draining insulting compound.

Multi-core cables shall be laid upon in a belted construction having a lead sheathing applied overall, protected by a steel wire armouring and having an extruded PVC sheathing overall (PLSW/PVC type).

Single core cables shall have a lead allow sheath without armouring but with extruded PVC sheathing overall (PLY/PVC type).

Cross-linked polyethylene cables shall have stranded, copper conductors with cross-linked polyethylene insulation. Multi-core cables shall be laid up in an extruded bedding, steel wire armored and sheathed overall PVC, to BS 5467 (XLPE/SWAP/PVC type).

Single core cables shall have aluminum wire amour. Cables rated over 6350V shall incorporate graded semi-conducting tapes and core screens in accordance with IEC 502.

Low smoke and fume emission cables shall be as above except that the bedding and sheathing shall be of low smoke and fume emission material, all in accordance with BS 6724 (XLPE/SWA/LSF type).

PVC armored cables shall have stranded copper conductors with extruded PVC installation, PVC sheathed, steel wire armoured and sheathed overall with PVC (PVC/SWAP/PVC type). Cables shall be in accordance with BS 6346. Conductors of 1.5mm^2 and 2.5mm^2 shall have stranded conductors (7/050 and 7/0.67 respectively).

PVC insulated wiring cables shall be 450/750 volt grade single core stranded copper conductors PVC insulated to BS 6004 (PVC wiring type).

Mineral insulated cables conductors and sheaths shall be solid annealed high conductivity copper separated by highly compressed mineral insulating powder. The cable shall be sheathed overall with PVC.

Light duty rated up to 600V, heavy duty up to 1000V, all as BS 6207 (MICS/PVC type).

Telephone cables shall be thermoplastic insulated multipair cables having twisted pairs of copper conductors (telephone type).

Instrumentation cables shall be polyethylene insulated copper conductors with twisted individual pairs screened, polyethylene bedded, steel wire armoured and PVC sheathed overall, all in accordance with BS 5308 Part 1 Type 2. Conductors shall be 0.5mm^2 stranded 16/0.2mm (PE/IS/SWA/PVC type).

Earth and bonding cables shall have stranded copper conductors PVC insulated and sheathed (PVC/PVC type).

Flexible cables shall have stranded, tinned, copper, flexible conductors, EP rubber insulated and CSP sheathed all in accordance with BS 6007 (flexible type).

Flame retardant cables shall be EP rubber insulated, tinned copper conductors in a CSP sheath, braided with galvanized steel wire (single cores having phosphorous bronze wire) and protected with a CSP sheath overall, generally in accordance with BS 6883.

The sheathing shall have heat and oil resisting characteristics to BS 6899 with an oxygen index value not less than 35 (HOFR type).

1103.84 Compression Glands for Cables

All the glands shall be supplied by the Contractor and shall be of the brass compression pattern, so designed that any strain on the cable is taken by the steel wire armouring. The glands shall incorporate watertight seals on both inner and outer sheaths and have a separate armour clamping ring to ensure a good mechanical connection for the earth continuity path. The glands shall be secured with heavy duty locknuts and the whole assembly is to be protected by an overall plastic sleeve, suitably sealed to prevent atmospheric attack.

Glands fitted to unthreaded gland or adaptor plates, non-metallic equipment, or where specified for circuits likely to pass high fault currents, shall include brass earthing tag and connections arranged to effectively bond the gland body via a protective conductor to an effective earth point. Where instrument cable screen terminations need to be isolated, insulated gland adaptors or non-metallic plates shall be used.

Glands and earthing tags shall be compatible with the gland plate and cable armouring materials to prevent electrolyte corrosion, e.g. brass for steel wire armouiring described above, but shall be classified EX (d) in accordance with BS 5501 Pt 5 and be suitable for use with Apparatus Groups IIA and IIB.

Where cables to BS 6346, BS 6116 or BS 5467 having extruded or taped bedding are used for direct entry into such apparatus Groups, a sealing stopper box or compound sealed barrier gland shall be used in accordance with BS 5345 Part 3.

1103.85 Termination of Glanded Cables

All cable compression glands shall be fitted by the Contractor, with the insulated conductors and sheathing being carried through the gland. The sheathing shall be preserved where required within the equipment and the insulated conductors properly connected to the terminals of the equipment concerned.

The armouring shall not be cut off short of the gland but shall be properly laid up and secured under the clamping ring provided. The gland shall be fitted finally with an overall PVC sealing sleeve.

All cable tails shall be of sufficient length to connect up to the equipment terminal boards, and in addition to making off the gland the Contractor shall strip, insulate, ring through and identify the individual cores,

fit suitable termination lugs, ring or spade crimps or bootlace ferrules as appropriate, and fit numbered reference ferrules, lace the tails in a workmanlike manner and finally connect up.

All spare conductors within multi-core cables shall be terminated as shown on the connection diagram or be folded back with sufficient surplus to allow them to be connected if required in the future.

1103.86 Wiring Ferrules

These shall be of durable materials suitable for permanently affixing to the cable cores and be of the interlocking slide-on type, such that the interpretation of the reference is unambiguous.

All control circuits consisting of more than two wires shall be identified by means of wiring ferrules attached to the individual cores at each end of the conductor where it is connected to any apparatus or junction box.

Unless otherwise specified, it shall be the responsibility of the cabling contractor to obtain interconnection terminal data and references from the equipment manufacturer to enable proper connections to be made.

1103.87 Cable Cleats

Cleats for fixing cables to walls, structures, etc. shall be of the non-corrodible hook and clamp type made of high impact plastic or cast aluminum comprising two halves fixed by means of galvanized rawlbolts or on to galvanized backstraps where the number of cleats makes this more economic.

All assemblies to be complete with necessary galvanized bolt, nut and washers. The spacings of supports or cleats for cables shall in any case be not greater than shown in the following table but, where circumstances merit, closer spacing arrangements may be required by the Engineer.

The vertical spacings shall be applied to runs sloping up to 30º from the vertical. For greater deviations, the spacing for horizontal runs shall apply.

For outdoor and damp situations, fixing bolts or studs for cleats shall not be less than 13mm overall diameter unless otherwise agreed by the Engineer.

1103.88 Cable Support Spacing (mm)

Cable Type	XLPE/SWA/PVC OR PVC/SWA/PVC with stranded copper conductors	
Overall dia (mm)	Horizontal	Vertical
Up to 15	350	450
15 – 20	400	550
21 – 40	450	600
41 60	700	90
Over 60	110	1300

1103.89 Segregation of Duties and Services

Cable of different circuit categories shall be segregated as defined in the IEE Regulations. Instrument control cabling shall as far as possible be routed separate from electrical power cables and long parallel runs to thes or pipework should be avoided. Where parallel routes and crossovers are necessary, a minimum separation of 250mm shall be maintained. Power cables shall not occupy the same ducts as instrument cables.

Similarly, separation between the three categories of instrument cables shall also be maintained as scheduled below:

Categories to BS 6739	**Cat 1**	**Cat 2**	**Cat 3**
CATEGORY 1	-------	200 mm	300 mm
Instrument power & Control			
(over 50V, under 10A, AC or DC			
CATEGORY 2			
High level signals	200 mm	-------	300 mm
(5V to 50V DC)			
CATEGORY 3			
Low level signals	300 mm	300mm	-------
(Less than 5V DC			

Only conductors carrying signals of the same category shall be contained within any one multicore cable. Similarly, conductors forming part of intrinsically safe circuits shall be contained within multicore cables reserved solely for such circuits.

All screens for instrument cables shall be earthed at one point only, preferably at the main control centre.

1103.90 Cables in Concrete Trenches

Where cables are run in concrete troughs or trenches, they shall be run on the floor of trenches less than 300 mm deep. In trenches deeper than 300 mm, cables shall be supported along the side of the trench on galvanized mild steel hangers, racking, cleats or on a suitable tray run supported from the side of the trench, whichever is specified. The spacing cleats or hangers shall be as specified under 'Cable Cleats'.

Where use is made of existing trenches with existing cables installed, it may be necessary to reposition certain existing cables so that the new cables can be laid in a proper manned and the whole of the cables (new and old) left in an arrangement which is tidy and fulfils engineering requirements. Such repositioning work shall be carried out to the directions of the Engineer.

1103.91 Galvanizing Fastenings

Where manufactured or purpose-made steelwork, ladder, racking tray supports and all fixings nuts, bolts and washers are specified as galvanized, this shall mean hot dipped galvanized finish to BS 729 as far as practicable. Bolts and nuts shall be in matched condition.

Fixings screws for boxes, saddles, clips and other accessories shall be of brass or other non-corrodible type e.g. cadmium plated steel.

1103.92 Racking

Cable racks shall be robustly constructed of mild steel, not less than 2.5 mm (12 SWG) in thickness and galvanized after manufacture. Where cleats are not used, the rack shall be provided with a toe at the outer end. Racks of proprietary construction may be used subject to approval.

Main rack supports, where fixed to brickwork of concrete, shall be secured with bolts of not less than 13mm diameter. The fixing bolts shall be of the self-securing type with expanding sockets and shall not require grout to hold them in position.

Where fixed to walls in places subject to dampness and in cable subways, the racks shall be set off from the walls by 35mm x 18mmm thick galvanized packers placed at the bolt fixing positions.

In cable basements, the lower tier of any row of racks etc. shall be not less than 100mm above finished floor level.

1103.93 Cable Ladders

Cable ladder shall be heavy duty type, fabricated from mild steel not less than 2mm thick and galvanized after manufacture. The side rails shall be at least 120mm deep with rungs set towards one edge, spaced at regular intervals of approximately 300mm and having elongated slots to accommodate the cable fixings.

Lengths of ladder shall be coupled and changes in direction, level and width shall be achieved by means of standard accessories designed for the system, such as radiussed risers and gusseted intersections. Cable tray shall be accommodated on the ladder system for cables less than 15mm overall diameter.

1103.94 Cable Channels

Cables requiring mechanical support across voids may be accompanied in not less than 40mm square galvanized channel sections fitted with plastic closure strips and suitable end caps in preference to tray, and subject to the Engineer's approval.

1103.95 Cable Tray

Cable tray shall be heavy duty pattern formed from galvanized sheet steel, perorated with elongated holes for cable fastenings. The tray shall have side flanges not less than 25mm deep with returned edges and be galvanized after fabrication. Material gauge shall be 1.5mm (16 SWG) minimum, except that for tray widths less than 400mm the gauge may be reduced subject to the flange depth and the approval of the Engineer. Factory made tee sections and bends shall be used where possible.

The cutting trays shall be kept to a minimum but where unavoidable, all cut edges shall be rounded or folded over and protected with zinc rich cold galvanizing paint, holes for cable shall be bushed with nylon/PVC strip edging material. Mushroom headed bolts and nuts shall be used to join sections of tray and accessories and arranged not to present any obstruction on the tray. Capacity amounting to 25% usable tray area shall be left spare.

Where specified herein for damp or corrosive conditions, the trays shall be of un-plasticized PVC with non-corrodible nuts and bolts.

1103.96 Cables on Tray of Ladder

Cables shall be laid flat and straight, properly dressed into position and fastened by cable ties or straps of metal reinforced PVCC strip material, secured at intervals not greater than 1m for horizontal and vertical runs. Where the runs is horizontal but arranged in the vertical plane, support spacing shall be as specified under 'Cable Cleats'. Care shall be taken to space the cables to allow adequate cooling. Not more than seven cables shall be embraced by one group tioe and not more than two layers of cables shall be run on one try.

1103.97 Cables in Ducts

Before drawing any cables in ducts, the Contractor shall ensure that they are clean and free from obstructions.

Adequately spaced temporary supports and cable rollers shall be provided for the drawing in of cables such that abnormal strains and damage to the cable is prevented; approved lubricants shall be used as necessary. Cable stockings shall be used for general drawing work, core pulling eyes being specially fitted for heavy hauls.

Stresses shall not exceed 10MN/m2 (1500 lb/sq in) on the lead sheath and 70MN/m2 (10,000 lb/sq in) on the core.

Maximum pulling tension shall not exceed 20 kN (4500 lb).

1103.98 Duct Seals and Cable Transits

After the cables are drawing, the Contractor shall seal the ends of all ducts, pipes or trenches leading into buildings, passing through walls or floors within buildings or underground chambers containing equipment for cabling associated with this Contract, whether occupied or not.

All cables, conduits or pipes shall be sealed into the ducts by means of a secure and effective water, gas, vermin and fore-proof material which will accommodate settlement and vibration. This may be a self-supporting non-settling mastic packed into the annuls to a depth at least equal to the sleeve diameter, or approved multicable tandit units with appropriate fillers and insert blocks. All steelwork on such transit assemblies and frames shall be hot dip galvanized.

Where shown in the Specification drawings, transit frames will be incorporated in the construction by the Civil works contractor.

1103.99 Cable Laid in Ground

Where cables are laid direct in the ground, they shall be well bedded in fine soil or sand and shall be covered with protective tiles. A minimum of 60mm thickness of fine soil or sand shall be supplied around the cables. All cables running along any one portion of route shall be laid at the same time and no extra payment will be made do re-excavation should any cable be overlooked at the time of laying. The Contractor shall be responsible for all excavation, for the supply of fine soil or sand for bedding, and for the backfilling and reinstatement of cable trenches along previously agreed runs. Trenches shall not be backfilled until the installed cables have been inspected by the Engineer.

1103.100 Clearance and Coverage for Buried Services

Trenches shall be excavated or ducts laid at such depth that where cables are laid in the ground the minimum coverage to the top of the duct of the cable shall comply with the following:

Minimum Coverage

Type of Service	Vehicular Roadways	Open Ground Footpaths
HV	1000mm	750mm
Others	750mm	500mm

Where possible, electric cables and their ducts shall be routed so that subsequent excavation to expose another service will not disturb cables and electrical ducts. Where separated routes are not practicable then the following clearance shall be ensured:

Minimum Clearances

Type of Cable	To HC Cable	To LV Cable	To Other Cable	To Gas/Water etc. Pipes
HV	150mm	300mm	300mm	300mm
LV	300mm	150mm	240mm	300mm
Others	300mm	250mm	150mm	300mm

The spacing of cables installed at the same time shall be generally in accordance with the above table, but where circumstances permit a more economical arrangement may be specified by the Engineer.

As far as possible electric cables shall avoid the same route as other services except where otherwise directed. Where such segregation is not possible then 50mm thick concrete slabs may be used as separators with the Engineer's approval. Adequate slack shall be left at each bend for cables laid direct.

1103.101 Protective Cover Tiles

These shall be of the concrete apex pattern engraved 'Danger – Electricity' or similar, of dimensions appropriate to protect the number of cables along a particular route.

Following the installation and compaction of the bedding soil or sand over the cable, covers shall be laid by the Contractor so that they overlap at approximately 30mm each side of the cable run. Where cables are displaced by no more than 300mm vertically, covers shall be installed only over the upper cable run.

1103.102 Backfilling and Reinstatement

Reinstatement of soil following laying of cable shall be effected by backfilling in 100mm layers. Hand ramming shall be employed for the first two layers and power ramming for subsequent layers.

After hand ramming to a depth of 200mm, a yellow coloured plastic tape approximately 150mm wide with the words 'CAUTON CABLE BELOW' shall be provided and run over the centre of the route of each cable run by the Contractor.

Top soil is to be placed and the level of the finished reinstatement shall not protrude more than 50mm above normal ground level.

All surplus spoil is to be removed from the site and areas surrounding the excavation shall be restored to their original condition.

Where tarmac surfaces have been excavate, the final 200mm backfilling after allowing the settlement shall consist of 120mm of compacted, graded hardcore, followed by a 60mm concrete screed and a 20mm top dressing of tarmacadam.

1103.103 Route Markers

These shall be of reinforced concrete with the words 'ELECTRIC CABLES' cast in one face. They shall either be of the flush block type approximately 300mm x 150mm or the pillar type approximately 600mm high erected with 300mm projecting above the ground, as directed by the Engineer.

As soon as site conditions allow, the location of each group of buried cables ad every joint shall be accurately marked. Concrete marker posts or blocks shall be set at the origin, changes of direction, joints and otherwise at intervals of 20 metres or as directed by the Engineer.

1103.104 Cable Identification

Identification labels of durable material shall be provided suitable for permanently affixing to the cable sheath by means of buckle type straps and shall carry the cable reference in PVC channel strip. The reference character sizes shall be not less than 4mm (5/32") high (Crtitchley Unilabel or similar).

Cable identification labels shall be fitted to each cable end below its respective gland, also where the cable passes through ducts or trenches and at each entry and exit to a room or building.

1103.105 Trunking Materials

All trunking, bends, cover plates, tees, flanges, supports, fixings, etc. shall comprise an approved complete system capable of adaption and erection without size modification and with compatible manufactured bends and accessories being used as far as practicable. The trunking access covers shall comprise easily removable convenient sized lengths retained over the entire length by clip-on features or suitable fastenings which shall not obstruct cable entries. Overlapping covers and internal flanges or coupling sleeves shall be provided at all trunking junctions. All cable supports, edges, sharp internal angles etc. shall be protected with PVC or formed to present a smooth edge.

Metal trunkings and fittings shall be zinc coated or galvanized mild steel not

less than 1.2mm thick (18 SWG). Copper earth bonding straps shall be fitted at the junction of adjacent lengths of trunking and fittings.

PVC trunkings and fittings shall be of high impact heavy duty rigid PVC.

1103.106 Trunking Installation

As far as possible, trunking shall be installed clear of other services and positioned so that future access is not restricted. Drawings detailing supports, terminations, sizes and centre lines of trunking shall be submitted to the Engineer for approval prior to commencement of the installation. Provision for expansion of the trunking materials shall be made in accordance with the manufacturer's instructions. Trunking shall include fire barriers of fiberglass wadding fitted at each point where the run passes through fire walls and floor levels. All cable and conduit exits shall be fitted with bushes without decreasing the effective cross-sectional area of the trunking.

When connecting adjacent sections of trunking or when fixing trunking to a wall or supports, round or mushroom headed bolts or screws shall be used such that no sharp edges project into the inside surface. When installed in damp situations the trunking shall be spaced from the wall by means of short tube collars.

All trunking shall be protected against damp and corrosion and where entries, joints and/or bends have been installed, cut and/or sawn edges exist, all damaged galvanizing shall be made good by a minimum of two coats of aluminum paint of an approved quality. For extensively damaged galvanized coatings the items shall be re-galvanised or replaced with acceptable components.

Conduit shall be connected to the trunking by means of couplings and male bushes to obtain a good earth connection.

To assist identification within trunking, final circuit wiring shall be formed into groups held by buckle clips or PVC straps. Each group shall be labeled where wiring enters or leaves the trunking and at intervals of approximately 600mm centres to be used as cable supports.

Separate conductors comprising the same circuit shall be run enclosed together throughout their length.

1103.107 Cables in Conduit

For wiring installations carried out with PVC insulated cables in conduit, the wiring throughout is to be on the ”looping in” system and no “Tee” or other intermediate joint between fittings will be permitted, and in no case must the cable be drawn into the conduits until all such conduits, bends, boxes, or other fittings have been fixed permanently in position and approved by the Engineer.

Any water which may accumulate in the conduit during erection shall be removed before any cables are drawn in. Sufficient slack shall be allowed at each point to ensure that all conductors are under no physical strain or tightness.

Separate conductors of the same circuit shall always be drawn into one conduit, but cables forming final circuits shall always be drawn into one conduit, but cables forming final circuits connected to different distribution boards shall not be drawn into the same conduit or box.

The cables shall be coloured RED or BLACK as required to distinguish opposite poles, a BLACK conductor shall be used throughout for neutrals and connected to the neutral pole of the supply system.

No reduction of the strands forming the conductors will be allowed at switch or other terminals; all the strands shall be efficiently secured by screws, nuts and washers or other approved means and all conductors shall be so proportioned that the drop of potential does not exceed that indicated by the IEE Wiring Regulations.

After the Contract award a Table (in duplicate) showing the proposed arrangement of wiring circuits and the size of cables to be used shall be submitted to the Engineer for his approval before any work is put in hand.

1103.108 Conduit Materials

i) Metal All conduits and fittings shall be Class 4, galvanized steel, heavy gauge welded and welded and screwed smooth bore tube employing threaded couplings and complying with BS 31 and BS 4568. As an exception, lengths of conduit completely encased in structural concrete may be finished with black enamel.

Conduit boxes shall be of malleable cast iron. For surface work the lid shall be of cast iron machined or ground to make good contact with the boxes. Adaptable boxes for surface work shall be of malleable iron.

ii) PVC All conduits and fittings shall be heavy duty gauge PVC in accordance with BS 4607.

iii) Flexible Flexible conduits shall be water proof metallic type PVC sheathed and adaptors to rigid conduit shall be of the internally rifled split brass type.

Flexible conduit shall only be used for bridging expansion joints in a building or for final connections from the rigid conduit system to the terminal boxes of equipment subject to vibration or adjustment. All such conduit shall have an earth continuity conductor connected through the flexible adaptor at each end. Individual lengths of flexible conduit should not exceed 400mm.

1103.109 Conduit Installations

The conduit system shall be continuous throughout so that the cables are fully protected. No conduit smaller than 20mm shall be used. Provision shall be made for draining condensed moisture where directed by the Engineer.

The conduit throughout shall be of adequate capacity in accordance with IEE Wiring Regulations, and shall be arranged with draw-in boxes to allow for easy draw in or out of any one or all the cables in the conduit. For multiple parallel conduit runs, draw boxes may be combined by an appropriately sized adaptable box provided segregation of services is maintained.

Wherever possible conduits shall be installed either horizontally or vertically and changes in direction shall be effected by easy or well formed sets without altering the section or opening joints; solid or inspection tees shall not be installed.

The inside surfaces of the conduit ends and all fittings shall be smooth and free from burrs and all other defects.

For surface work the conduits shall be fixed by means of spacer and saddles or substantial distance saddles. Where conduits pass directly through concrete or similar floors and where washing down is likely to occur, the conduits shall be sleeved. The sleeve shall be grouted flush with the underside of the floor and extend 75mm above the top surface of the floor. Where conduits are run on steel work, they shall be fixed by means of purpose-made clips. If the Contractor requires to drill any steel work, permission in writing must be obtained from the Engineer.

If exterior situations, all joint box lids etc. shall be made waterproof with compound or gaskets as appropriate.

Metal conduit installations shall be electrically continuous throughout, and at all terminations conduits shall either be screwed into approved spigot boxes or coupled by means of screwed couplings and smooth bore hexagon bushes. In no cases shall the length of the thread into which the conduit is screwed be less than the outside diameter of the conduit. Where tapped entries are provided and where internal space permits, a ring bush shall be used as a lock nut.

All exposed threads and damaged galvanizing shall be cleaned and thoroughly coated with zinc rich paint. If black enamel conduit has been approved for use, then where the black enamel is damaged the conduit shall be satisfactorily repainted to the approval of the Engineer.

Contact between conduit and gas pipes shall be prevented wherever possible by adequate spacing, or by means of insulating distance pieces. Where the conduit is or may be in contact with any other pipes or metal work and efficient metallic connection shall be made between the conduit and the pipes or metal work and the incoming gas, water and electricity services shall also be bonded together, all as required by the IEE Wiring Regulations.

PVC conduit installations shall have couplers and spouted fittings joined with a permanent solvent adhesive, and provision shall be made in surface conduit installations for expansion by using semi-permanent mastic jointing seal in expansion couplings as necessary.

Conduits shall be fixed by means of spacer bar saddles spaced as defined in the IEE Wiring Regulations.

These figures apply to surface runs at normal room temperature. Where high ambient temperature or rapid fluctuations are likely these spacings shall be reduced as agreed with the Engineer. Conduit shall also be secured 150mm either side of a bend.

The bending radius of PVC conduit shall be not less than 4 times the diameter of the conduit and bending shall be achieved by the use of the correct size bending spring.

If bending is to be carried out in temperatures below normal room temperature, frictional heat shall be applied to the conduit before bending commences.

Potentially Explosive Area conduit installation shall employ metal conduit andcomply with the relevant Parts of BS 5345 for the specified zone classification; Ex(d) projection for Zone 1 and Ex(n) protection for Zoone2 Applications.

All screwed joints whether entering into switchgear, junction boxes or couplings, must be secured by a standard lockout to ensure a tight and vibration-proof joint which will not be slacken during the life of the installation and thus impair continuity and flameproofness. The length of thread in the conduit must be the same as the fitting plus sufficient for the locknut. Due to the exposed threads, the use of running joints is not permitted and specially designed flameproof unions shall be used for securing conduit to an internally screwed entry. All unwanted outlets shall be plugged with approved blanking plugs.

When a conduit passes from a hazardous to a safe area, the flame-proof section must be terminated by a stopper box or sealing device mounted in the safe area.

All conduits entering directly into a flame-proof enclosure where exposed terminals are fitted shall be sealed at the point of entry by means of stopper boxes which must be entirely filled with a non-oxidising compound. Conduit boxes or indirect entry compartments not containing exposed terminals do not require sealing.

Conduit stopper boxes of certified design must be used, having splayed, plugged filling spouts in the cover to facilitate the entire filling of the interior with compound.

1103.110 Intrinsically Safe Conduits

Circuits complying with the requirements of BS 5345 for intrinsically safe circuits shall be arranged such that all cables are identified and segregated as detailed in BS 6739. Conductors forming part of an intrinsically safe circuit shall only be contained within multicore cables reserved for such circuits and must be terminated separately.

Intrinsically safe circuits shall be connected to a separate earthing system as detailed in BS 6739 and any shunt diode barriers shall be installed in accordance with the certification requirements.

1103.111 Mineral Insulated Cables

Cables shall be installed saddled to trays, run on the surface or as otherwise specified. The spacing saddles shall be in accordance with the IEE Regulations. Cable termination accessories and saddles shall be brass or copper and shall be supplied by a particular cable manufacturer. All cables shall have a temporary mastic seal applied during installation. Once cut to length, each cable shall be permanently terminated without delay by using an approved seal. Termination seals shall be anchored in approved glands and locked into screwed conduit entries or gland plates forming part of accessories or equipment.

Wherever possible, glands shall be locked in position with locknuts. Shrouds shall be fitted over glands except where they are encased in the structure of the building.

In cables where dampness may be present or where dissimilar metals are present, corrosion inhibiting paste shall be interposed in all voids between surfaces in contact.

Where MICS cable serves an inductive circuit liable to voltage surges or circuits subject to lightning surges, appropriate surge diverters shall be connected across the inductive sources (coil etc.) or between lines and earth at the point of entry in the case of lightning protection.

1103.112 Sealing Boxes for Lead Sheathed Cables

For terminations at plant items, these will be provided by others except as specified herein and will be of cast iron, compound filling type, provided with filing plugs in the appropriate position for filling with compound when mounted on the associated equipment. Each will be complete with wiping cone armour clamp. For through joints or tee joints, the Contractor shall provide suitable boxes as detailed herein.

All necessary jointing materials, filling compounds and earthing requirements shall be included for all joints to be made under this Specification.

1103.113 Lead Sheath Cable Terminations

The Contractor shall submit to the Engineer for approval the proposed method for terminating lead sheathed cables. Terminations must ensure that moisture cannot creep along the cores of the cable nor in between cores.

Where cable tails are to be brought out, cores shall be cut back below the level of the sealing compound and connected to the tails using a brass ferrule sweated to provide a solid damp and oil migration barrier between tail and core.

Paper insulated tails shall be double half lapped with an approved non-hygroscopic insulating tape. Alternatively for LV cables, instead of an approved tape, a length of temperature sensitive, PVC sleeving may be heat shrunk over the tail, joint and cores.

The continuity of armoured cables shall be maintained by an efficient bond between the cable armour and, the gland and the metalwork of the equipment at which the cable terminates, in order that a reliable path is provided for fault currents.

When the lead sheath has been wiped on to the cable gland, the steel armouring shall be brought over the wiped joint and clamped to the top of the gland to provide additional earth continuity and mechanical strength to the plumbed joint. The armour clamp shall sandwich a copper braid between the clamp and the armouring to ensure a bedded connection.

Compression gland shall be to an approved pattern provide adequate bonding and armour clamping facilities.

Cable cores shall be fitted with suitable termination lugs and be phase coloured as appropriate and marked with an approved label to correspond with the diagram of connections.

Glands exposed to weathering shall be totally wrapped in impregnated tape to exclude all moisture from the gland connection and have an outer wrapping of PVC tape.

1103.114 Jointing

Personnel employed for jointing power cables including all types of terminations for aluminum conductors shall have received specialised training. Joints on all buried or stranded cables shall be sweated, but compression joints will be permitted for stranded copper or solid aluminum conductors at terminations only.

Joints shall be completed without pause of unnecessary delay. Reduction in the number of strand is not approved but limited reduction in the cross sectional area of solid conductors by an approved method is permitted. Cable cores shall be cut with due regard to fanned out terminations, leaving a neatly arranged minimum of slack core between cable and terminal. As far as practicable all HV joints shall be made to avoid crossed or twisted cores, final phasing out being arranged it he cable box termination.

Where crossed joint is approved, a sleeve at least 30% longer than standard shall be used to minimize the distortion of cores. The engineer shall witness the final termination in order that the Contractor may prove the phasing before the last joint in a cable run is made.

Cables shall be jointed colour to colour or number to number. Where numbered cores are to be jointed to existing coloured cores etc. the Engineer will direct the system to be used.

A reliable continuity path shall be provided for fault currents flowing via the lead sheath and/or armouring by means of an efficient earth bond between the cable armouring and sheath on each side of the joint.

Any semi-conducting screens incorporated in HV cables (e.g. XLPE rated at 6350/11,000V) are to be thoroughly removed before application of any stress control components supplied with the necessary cable jointing kits.

1103.115 Sealing Compounds

The outer protection boxes for joints or termination shall be filled with compound of the hot or cold pouring variety of a type compatible with the cable materials to be agreed by the Engineer.

Compound which require heating shall be evenly heated, well stirred and the temperature maintained within the recommended pouring ranges. Cable accessories shall be thoroughly dried before filling and pre-warmed where possible.

Where cable sealing boxes are fitted beneath oil-filled compartments or where inverted cable sealing boxes are used due to cables entering from overhead, the compound shall be of the oil resisting type to prevent any risk of softening due to contamination from the insulating oil.

Cold pouring resin encapsulation materials shall be carefully mixed to avoid entrapped or uncured filler materials.

1103.116 Single Core Cables

Circuits utilizing single core cables shall be installed under IEE ‘Defined Conditions’ but to minimize mutually induced voltages, three phase circuits shall be run for as long as possible throughout the route in close trefoil formation. Where a circuit employs more than one cable per phase, each trefoil group shall contain one cable of each phase, allowing at least 50mm clearance between adjacent groups. Cleat spacing shall not exceed 1.2 metres.

Ferrous screens or armour shall not be used on such cables and associated termination or enclosure must avoid the use of magnetic material which would provide a flux path in service.

To control induced voltages, single core cables shall have their metallic sheathing and/or aluminum armouring bonded together at both ends of the run, the bonding being connected directly to the system earth bar or other approved points. Cables having no insulating oversheath shall have their metallic sheaths or armouring bonded together by the use of normally spaced, well fitting, non-magnetic metallic trefoil cleats.

In all cases the bond shall be sized to carry the prospective fault current and have a conductivity not less than that of the cable sheath and/or armouring. Bonds for cables laid in a flat formation shall also allow for the unequal sheath currents.

To prevent circulating currents, bonding and earthing at the supply end only of short runs of single core cables will be permitted where it can be shown to the satisfaction of the Engineer that the induced voltages are safe under fault conditions.

1103.117 Busducts

Connections between major electrical items shall (where specified) employ a fully integrated, totally enclosed, busduct system to BS 5486 (IEC 439-2), comprising HDHC copper conductors embedded in a non-flammable, self-extinguishing, case epoxy resin insulation.

The complete assembly including junctions shall be completely free of condensation and watertight to IP68. Fire resistance shall be Class M1 (F) and Class B1 (D) to IEC 332.

All parts of the system shall be from the same manufacturer and comprise factory made lengths, bends, tees and terminating pieces to suit the physical application and layout of the installation.

The voltage and prospective fault ratings of the system shall be suitable for the application and the current rating shall be based on the most onerous method of installation for the circuit. The cross sectional area of the conductors shall not be reduced throughout a given circuit.

The installation shall allow foe any necessary expansion, be properly supported and connected in accordance wit the manufacturer’s instructions. Fire and damp-proof barriers shall be provided when passing through walls, floors/ceilings etc.

Conductors shall be jointed by means of double junction plates, one on each side to ensure low joint resistance. The junction shall be compressed by means of high tensile steel nuts and bolts. After assembly, all junctions shall be overcast with the same materials mixed under vacuum, as used for the busduct elements, thus maintaining a homogenous and weatherproof enclosure throughout.

Provision for conductor shifting, transfers and paralleling, shall be made within the terminal elements.

1103.118 Earthing and Bonding

All non-current-carrying metal parts of the electrical installation and other services shall be properly bonded together and connected by means of a protective conductor to an efficient earth in accordance with IEE Wiring Regulations.

All connections shall be by means of an approved mechanical joint or adjustable clamp which shall be accessible and made secure with brass nuts and bolts. On no account shall plain or spring washers of ferrous metal be used.

Protective conductors shall provide earth continuity either through the conduit, armouring, lead sheathing, steel trunking or by independent earth tapes or PVC sheathed wires, according to the system of wiring employed.

Where PVC conduits or trunking systems are employed the protective conductor shall be routed within the conduit or trunking.

Wherever cable armouring is used as a protective conductor, care must be taken to ensure an adequate earth bond and additional bonds to the metalwork shall be provided as required.

1103.119 Main Earth Connections

Where a main earth bar is to be installed it shall be connected in a ring with the earth bar provided on the switchgear and any existing main earth ring in the building. The glands and wire armour of cables shall be connected to the switchgear earth bar or directly to the earth ring.

The main earth bar shall be formed from high conductivity, hard drawn copper bar Grade C101 to BS 1433 of not less than 31.5mm x 6.3mm cross-section. Any joints in the earth bar are to be brazed together using brazing alloy type CP1 to BS 1845 or pan head riveted and sweated. The bar overlap/thickness ratio shall be not less than 5.

The earth bar shall be secured to an inside wall in an accessible position. Connections to the metal work of electrical plant shall be made in soft drawn copper tape or equivalent sized cables. Where plant is subject to vibration, connections shall be made sing flexible conductors. All earthing conductors and equipotential bonding cables shall

have a green and yellow PVC sheath, and earth bars shall have a green/yellow marker tape or sheathing applied.

Reinforced concrete or sheet steel piling shall be connected to the earthing system as directed by the Engineer. Structures of steel framed buildings shall be bonded to the main earth bars.

Earth rods are to be 16mm (5/8”) diameter driven by an automatic hammer to a depth of approximately 4 metres. Spacing between rods is not to be less that the depth of the rod. Inspection pits shall be provided for each electrode to allow subsequent access for testing.

Where copper earth tape is buried below ground level it is to be served with PVC or double half lap wrapped with an approved grease-impregnated tape for a distance of at least 300mm above and below ground level.

The routing, dimensioning and arrangement of all main earth bars and connections shall be detailed on the schedules and drawings forming part of this Specification as called for in the specific requirements. Disconnecting links for testing purposes shall be provided as shown therein.

g) Civil Works for Cable Installations

1103.120 General

The works involved are associated with the cable installation and comprise trenching, excavation, supply, laying and jointing if cable ducts; building of jointing and draw-in pits; application of bedding sand and soil; temporary reinstatement of ground. The installation of cables, supply and laying of cable covers and preparation of route record drawings will be carried our by the Contractor appointed to undertake the cable installation. Excavation, duct and cable laying and backfilling shall proceed in accordance with an agreed programme ensuring that all cables and ducts are satisfactorily covered immediately following laying and after approval from the Engineer.

1103.121 Trenching Measurements

The depths and widths of individual trenches for cables or ducts and the clearances from other services shall be determined by reference to the clauses in this part. For contracts let with scheduled rates it will be assumed upon re-measuring that excavations have been in accordance with this specification unless the engineer has been sent an advice to the contrary.

1103.122 Coverage for Buried Cables or Ducts

Trenches shall be excavated or ducts laid at such a depth that the minimum coverage to the top of the duct of the cable shall comply with the following:

Type of Services	Vehicular Roadways	Open Ground or Foothpaths
HV	1000mm	750mm
Others	750mm	500mm

1103.123 Clearance between other Services

Where possible electric cables and their ducts shall be routed such that subsequent excavation to expose another service will not disturb cables and electrical ducts.

Where separate routes are not practicable then the following clearances shall be ensured:

Type of Cable	To HV Cable	To LV Cable	To Other Cable	To Gas/Water etc. Pipes
HV	150mm	300mm	300mm	300mm
LV	300mm	150mm	250mm	300mm
Others	300mm	250mm	150mm	300mm

Where such spacings are not possible then 50mm thick concrete or stone slabs may be used as separators with the Engineer’s approval. Each cable shall be at least 50mm clear of the side of the trench excavation.

1103.124 Excavations and Precautions

Turf and topsoil shall be carefully removed and positioned where indicated on the drawings or as directed by the Engineer for subsequent reinstatement in their original position.

Broken land drains and damage to other services shall be reported to the Engineer and marked on site.

Excavations shall be kept free of water and properly shored up. Other services uncovered shall be adequately supported by slings or other means and protected.

1103.125 Bedding for Cables

Prior to laying the bedding for the cable, the bottom of the trench shall be cleared of loose and projecting rubble etc. and evenly graded.

A sand bedding shall be applied below and around the cables and shall be thoroughly compacted. Thickness of bedding around the cable shall be 60mm except where soil contains coke, ash or other corrosive matter where the thickness shall be 200mm. Bedding shall be well graded sand, free of clay with minimum particle size of approximately 0.08mm (BS sieve No. 200) and maximum particle size of approximately 2 mm (BS sieve No.7). 60% of the material shall pass through BS sieve No. 72. Where the engineer directs, local soil may be used for bedding after passing through a 10mm mesh sieve provided the material is evenly graded.

1103.126 Ducts and Couplings

Buried cable ducting shall be smooth bore uPVC pipe to BS 4660 (or medium density polyethylene, where greater flexibility is required) jointed by spigotted ends or couplings of compatible, non-deteriorating material. These couplings shall be a self-aligning, push fit and incorporate seals to prevent the ingress of water and other fluids as far as possible and the joint so formed shall be equal in internal diameter to the duct itself.

Ducts entering below ground level into a building or structure shall emerge inside the building either directly into and accessible trench or void, or the duct shall have an upturned bend to emerge adjacent to an inside wall face, or as otherwise specified. All exposed upturned duct ends shall project at least 75mm clear of the finished floor or ground level to prevent unwanted collection of water or debris and protect the cable exit.

1103.127 Bedding of Ducts

Prior to laying ducts in trenches, the trench bottom shall be evenly graded, cleaned of loose rubble etc. and compacted to form a solid foundation. In rocky soil a layer of loose, rock free earth shall be used for this foundation.

Where ducts are laid beneath vehicular access roads, the ducts shall be haunched in C20 concrete for the full width of the road and extend each side beyond the curbside by at least 300mm.

1103.128 Duct Alignment and Cleaning

Ducts shall be laid in a straight line as far as possible with minimum deviation. Where bends are required, these may be manufactured, pre-formed bends with a radius of not less than 10 times the bore diameter. No continuous duct run shall incorporate more than two bends nor turn through a total of more than 135º in any plane. No single bend shall exceed 90º.

Where greater changes of direction are necessary, cable draw pits shall be incorporated in the run as required or defined by the Engineer.

A non-corrodible draw wire or rope shall be left in each duct and plugs shall be inserted at the ends of each section of duct to prevent entry of soil or stones. On completion of the ducts and prior to drawing in cables, a circular wire brush 6mm greater in diameter than the duct shall be pulled through each duct.

1103.129 Cable Draw Pits

Cable draw pits shall be of brick enclosed construction fitted with suitable removable access covers and have bellmouthed duct entries into the pit interior. The interior dimensions shall be determined by the Engineer but shall be not less than 750 x 600mm in plan and the depth shall be determined by the invert of the lowest duct with a minimum of 50mm clearance to the base of the pit.

Where specified, a pulling eye for the use of 2000kg pulley block shall be provided opposite each group of ducts in the wall of the pits, and positioned to facilitate as straight

a pull as possible in the cables with the use of a pulley block. The base of the pit shall be formed with a fall towards a sump, suitably placed for pumping dry.

1103.130 Backfilling and Reinstatement

Reinstatement of soil following laying of cable shall be effected by backfilling in 100mm layers. Hand ramming shall be employed fir the first two layers and power ramming for subsequent layers. Backfilling shall only proceed in the presence of the Contractor responsible for laying cables.

After hand ramming to a depth of 200mm, a yellow coloured plastic tape approximately 150mm wide with the words ‘CAUTION ELECTRIC CABLE BELOW’ shall be provided and run over the centre of the route of each cable run.

Top soil is to be replaced and the level of the finished reinstatement shall not protrude more than 500mm above ground level. All surplus spoil is to be removed from the site, and areas surrounding the excavation shall be restored to their original condition. Where tarmac surfaces have been excavated, the final 200 mm backfilling after allowing the settlement shall consist of 120mm of compacted graded hardcore, followed by 60mm concrete screed and a20mm top dressing of tarmacam.

1103.131 Cable Trenches

Trenches cast in floors of ground shall be of specified internal dimensions to suit the specific installation. They shall have smooth vertical sides and bottom with provision for cover plates to finish flush with the finished floor surface.

Inside bends shall be either radiussed (150mm min) or chamfered at least 100mm back, equally angled from each direction. Such radiussing or chamfers shall extend the full height of the trench, however the top 100mm may be corbelled out to simplify the cover plate arrangement.

Trench covers shall be of aluminum or galvanized mild steel chequer plate (min 8mm thick) supported to prevent undue flexing and having suitable holes to allow removal be standard lifting keys. Support shall be by means of steel curbing rebates cast into the trench top edges, providing a landing width of at least 300mm.

Additional or alternative support for switchboards etc. shall be from at least a 75 x 35 mm channel section cross bearers and transverse trimmers, fixed or cast into the floor and located to suit equipment fixings, access requirements and floor cover spans.

To prevent differential deflection, butt straps shall be fitted to the underside of floor plates which have no other support.

Edging curbs suitable for mild steel chequer plate shall be painted in red oxide primer, the curbing may be tapped to accept cover securing screws. Where aluminum plates are used in contact with any mild steel supports, a bitumen coating on the points of contact shall be used.

1103.132 Cable Troughs

Pre-cast concrete trough sections shall be laid either flush or upon the finished ground level as specified.

The sections shall be sized and provided with rebated covers to suit the span and any imposed load conditions specified, e.g. at road crossings. Provision shall be allowed for handling/removal of such covers. Pre-formed junctions and turn-outs shall be provided with suitable chamfers inside bends.

1103.133 Transformer Bays

The dimensions and weight of the transformers are specified herein in order that access clearances and loadings may be determined. The transformer bases shall be located at ground level, accessible form a made up road or hard standing to the bays.

Each transformer bay shall be separately enclosed to prevent unauthorized access and be portioned by plain brick blast walls up to a height of 2.2m, with one side being fitted with full width, lockable open-mesh gats or louvred doors for access and ventilation. Where roof covering is necessary, it shall be of non-flammable construction and allow 800mm clearance at least for natural ventilation of the transformer.

The bay shall be sized at least 1.5m greater than the transformer width (across terminal boxes) and at least 1.0m greater than the transformer depth. A level concrete mounting ramp shall be located within the bay area suitable for rolling the transformer into position, and a pulling eye shall be fitted centrally in the rear wall at the ground level.

Provision shall be made for the oil to be conducted to underground drainage tanks having access for pumping out, separate tanks being provided for each transformer.

Cable ducts shall be arranged to suit the cable routes and have up-turned spouts projecting clear of the designed oil/pebble level for the bund.

Alternatively, the area surrounding the plinth within the bay, and enclosed after the transformer installation by a low bund wall if required, shall be excavated sufficient to accommodate 10% in excess of the transformer oil capacity when filled with fire quenching 50mm graded pebbles having 30% voids. Provision shall be made for drainage if accumulated rainwater.

For silicon cooled transformers of sealed construction, quenching pebbles will not be required, but an oil catchment area shall be provid3d where specified.

1103.134 Earthing Connections

Two earthing connection tab shall be welded to the concrete reinforcing bars in the positions shown on the specification drawings and be incorporated in the concrete encased, reinforcing steel network of the building foundations. The network shall be not less than 30m in length, buried at least 1m below ground

level. The total length may comprise more than one bar, welded together to form the required minimum length.

Each earthing tab shall be of hot dip galvanized flat bar steel 50mm wide x 6mm thick, attached by welding to at least two parallel reinforcing bars (9mm diameter minimum) and of sufficient length to project beyond the finished concrete surface by at least 100mm in an accessible position.

The welding shall be of good mechanical strength over the full 50mm tab width and shall be located within an area of the rebar not required to provide structural strength, such as a trimmer or surplus length of the bar.

The reinforcing steel of existing buildings may be used to provide the electrode for a new installation or to replace a damaged or deficient conventional earthing system. A substantial rebar of a main beam or column shall be exposed by chipping away its concrete cover. The earthing terminal plate shall be welded to the rebar and the removed concrete replaced by mortar.

h) Electric Actuators

1103.135 General

Electric actuators shall be suitable for outside installation and all components shall be housed in waterproof enclosures to IP67 or better, which shall incorporate an anti-condensation heater.

The whole actuator shall be of easily maintained, robust construction and shall be sized to guarantee the penstock or valve opening or closing at the maximum differential pressure specified herein. The operating speed shall be approximately 300mm/minute unless otherwise specified.

All actuator component items shall be coupled via flanged mating faces secured by stainless steel bolts, except valve mounting fixings subject to thrust forces which shall be by means of suitably sized, high tensile steel bolts.

The gearbox shall be of the wormgear totally enclosed, oil bath lubricated type, having a cast iron enclosure suitable for operating at any angle and provided with the appropriate filling and drain plugs. The actuator drive bushing shall be easily detachable for machining to suit the valve stem or gearbox input shaft and the length of the drive nut shall be less than 1.25 x the spindle diameter.

The drive shall incorporate a lost motion feature to provide the additional torgue required to unseat he valve from the ‘Open’ or ‘Closed’ position in the event of the valve being in either position for an extended period. This movement shall give a hammer blow of sufficient force to free the valve.

The output shaft shall be hollow to accept a rising spindle where appropriate, and incorporate thrust bearings of the ball or roller type. The design shall preferably permit the gear case to be opened for inspection without releasing the spindle thrust or taking the penstock/valve out of service.

1103.136 Motors

All motors fitted to actuators shall be specially designed for the application and of the squirrel cage induction type for operation from the supply system specified.

The rated output of the motors shall be determined by the tenderer in relation to the requirement of the mechanical plant described elsewhere in this specification, and starting torgue shall be at least 10% in excess of maximum service requirements.

The motors shall preferably be 4 pole 1440 revs/minute machines designed with adequate thermal capacity to ensure that the actuator and starter can adequately perform, without overheating, the number of successive opening and closing operations called for in the specific requirements, and in no case shall this number be less than three.

Each motor shall be fitted with a thermostat or thermistor arranged to stop the motor in the event of dangerously high temperature in the motor windings due to overcurrent or an abnormally high number of starts per hour.

1103.137 Manual Operation Interlock

The actuator shall have a handwheel for manual operation which will be at standstill during motor operation. A lever shall be provided for engaging the handwheel drive, and this shall be interlocked so that when starting the motor the handwheel is automatically uncoupled without danger to the operator. Provision shall be made for the lever to be padlocked in either position to prevent hand or motor operation as required.

1103.138 Position Monitoring

A mechanical position indicator, showing the open, closed or intermediate positions of the valve on a visible dial, shall be incorporated in the actuator housing. Alternatively, where specified, a continuous position indicator shall be provided.

Remote position indicators, where specified, shall be controlled from a suitable potentiometric drive arranged to provide a continuous proportional signal from ‘Open’ to ‘Closed’ positions.

1103.139 Position Control

Where specified for control purposes, a current position transmitter shall be provided to give a positive 4-20mA signal proportional to the valve position, and shall incorporate zero and span adjustments to suit the actual valve travel.

1103.140 Torque and Limit Switches

All switches shall be accommodated within the actuator housing and all contacts and mechanism shall be of sealed, rustproof and robust construction and have a self-cleaning wiping action.

Adjustable torque limiting devices and switches shall be provided to trip the starter in the event of mechanism overload due to obstructions or jamming etc. They shall be mechanically latched to prevent torque tripping during unseating.

Limit switches shall be arranged to trip the starters when the ‘fully open’ or ‘fully closed’ positions are reached. Should the manufacturer consider it desirable (to ensure proper seating) the travel may be stopped in the ‘fully closed’ position by the torque limit switches, but in this case the ‘fully closed’ limit switches shall still be provided, although they will be adjusted to be inoperative.

1103.141 Auxiliary Switches

Auxiliary changeover switches shall be provided to operate at each end of the travel, in order that they may be used for remote controls or indications monitoring the 'Open' and 'Closed' positions.

1103.142 Terminal Facilities

All electrical components shall be wired out to terminal blocks in a common terminal chamber incorporated in the actuator housing but separated form all actuator components by means of a watertight seal.

Each terminal shall be labeled to correspond with the diagram of connections and shall be capable of accommodating not less than 2.5mm^2 copper conductors. AC and DC terminals shall be clearly segregated.

Terminal blocks shall comprise shrouded anti-tracking mouldings of melamine phenolic or comparable material with provision for securing conductors by screw clamp connectors or other vibration-proof devices.

The terminal chamber shall be provided with three tapped conduit entries, 1 x 32mm and 2 x 25mm ET or as otherwise specified. These holes shall be plugged with suitable plugs during transit and storage to prevent ingress of moisture or foreign matter.

Any conduit entries not used after cabling is completed shall be plugged with threaded aluminum blanks and the threaded joints made watertight by using suitable tape or jointing compound.

1103.143 Starters and Control Gear

The actuator motor shall be controlled through integrally mounted electrically and mechanically interlocked contactors, rated for switching the motor direct on-line, adequate for the duty requirements and complete with all necessary auxiliary contacts for the functions specified herein.

The control circuit shall operate at 24V DC derived from a suitably rated transformer/rectifier with one side of the secondary winding connected to earth or as otherwise specified. Primary and secondary windings shall be protected by cartridge type fuses.

The method of control and operation shall be as called for under the specific requirements and the actuator shall be provided with any facilities called for therein to suit the method of control, whether this be automatic or by hand. Local controls integrally mounted on the actuator shall consist of push buttons for 'Open', 'Close' and "Stop' functions, together with a Remote/Off/Local selector, lockable in all positions. The "Stop" button shall be effective in both local and remote settings and operate directly on the contactor control circuit.

Facilities by means of volt-free contacts shall be provided for remotely monitoring:

- motor running
- actuator is available for remote operation
- actuator is opened and actuator closed.

1103.144 Paint Finish

The finish colour shall be gloss, Crimson, Colour No 540 to BS 381C (or 04 D 45 to BS 4800).

1103.145 Actuator Isolators

The switch shall have a slow make and break mechanism of the two position rotary pattern arranged to isolate the 3 phase supply and all other control circuit supplies to the actuator. The ratings and number of poles required for each duty shall be as detailed in the specific requirements, the isolator rating being based on the actuator average load current being switched normally off-load, but emergency on-load.

Each switch shall be incorporated in a heavy duty, hoseproof, cast aluminum enclosure to IP65, having external fixing lugs and adequate seals and drip shields on the operating shaft and cover. Austinlite rotary type EXO 190 or equal.

Switch positions shall be 90 apart, clearly and permanently inscribed or embossed as 'OFF' and 'ON' on the cover, and the switch handle shall incorporate provision for the switch to be padlocked in both the 'OFF' and 'ON' position. The 'OFF position to be to the left of centre or vertical, the 'ON' position to the right or horizontal.

It shall be possible to remove the switch cover for access to the terminal without disturbing the switch or its mounting base. The enclosure shall be suitable for mounting on, or adjacent to, the penstock pedestal. If mounted on the penstock pedestal, cabling between the isolator and the actuator above may be arranged through conduit connections, suitable for disconnection should it be necessary to remove the actuator assembly complete.

(This item preferably to be provided by the contractor who is responsible for the cabling).

i) Miscellaneous Equipment

1103.146 Warning Signs

'Automatic Plant' warning signs shall be provided and erected by the Contractor in the building or on the plant in a prominent position to be agreed.

The 500mm x 300mm x 0.7mm (22SWG) signs shall be located approximately 1.6m above the adjacent floor level to the sign centre.

The sign shall be off 22swg, vitreous enameled aluminum sheet or plastic, having black letters on a yellow background, (see Appendix 5) inscribed as follows:

CAUTION

PLANT UNDER AUTOMATIC CONTROL

AND LAIBLE TO START WITHOUT WARNING

ISOLATE AT SOURCE BEFORE ATTEMPTING ANY

MAINTENANCE OF MECHANICAL AND ELECTRICAL PLANT

1103.147 Equipment for Potentially Explosive Atmospheres

Equipment for use in potentially explosive atmospheres shall be selected and installed in accordance with BS 5345, subject to the temperature classification of the specified gas, vapour or liquid. Ex(d) and Ex(i) classified equipment shall be certified for Apparatus Groups IIA and IIB.

In such areas, aluminum and other light metal alloys shall only be used for enclosure of electrical apparatus and fittings where such enclosures conform to the material requirements of BS 5501 Part 1.

Aluminum and light metal alloy fans on motors may be used if adequately protected, or if plastic fans or cowls are used they shall be of anti-static material.

Where no British Standard is applicable, equipment to an equivalent European standard may be submitted, subject to the approval of the Engineer.

1103.148 Field Mounted Equipment

Individual starters, fuse-switches, distribution boards and other equipment shall be housed in robust, heavy gauge, rustproofed, metal-clad enclosures having external fixing lugs except where otherwise specified.

Components, fittings and housings shall be as specified elsewhere in this specification.

Equipment housings shall be mounted such that the terminal and covers are readily and safely accessible and are not obstructed or affected by the adjustment or mounting arrangement.

Push button stations shall be single or composite units suitable for accommodating the required buttons in the above enclosures. Each button top shall be fitted with a durable protective flexible boot.

Junction boxes shall be equipped with rail-mounted, deed-through terminals adequately sized to accommodate the cables to be terminated. An earth connection facility shall be provided for each box.

Auxiliary switches shall be mechanically and electrically suitable for the duty and circuit operations specified herein and intended by the switch manufacturer. Roller-lever operated switched shall be of the snap action type.

Where employed for crane or gantry duty, spring failure within a limit switch shall not render it inoperative.

Handgear interlocks shall be fitted to any driven equipment which has provision for manual operation to ensure that it is not possible for drives to start with the handgear in position.

1103.149 Heavy Duty Electrodes

Each electrode shall comprise a single element mounted in an insulating high impact phenolic moulding, impervious to corrosion and having separate fixings for the flange mounting base and for the cover.

The base shall have a 20mm screwed conduit entry and be suitable for accommodating the electrode length by means of a substantial clamping collar which shall also have a provision for terminating the cable conductor.

A sealing gasket shall be fitted between the base and cap and the whole head shall be sealed to prevent ingress of water after installation is completed.

The electrodes shall be formed of ¾" BSP galvanized steel tubes (approximately 27mm diameter) sealed at one end and cut to suit the specified length, cut ends being dipped or coated with galvanizing paint or similar. Where intermediate steady brackets are required or when otherwise specified, the electrodes shall be sheathed with an insulating material to within 150mm of the electrode tip.

Spacing between electrodes and to the adjacent wall shall be not less than 150mm.

1103.150 Light Duty Electrodes

Each electrode shall be mounted in an insulating moulded body having a 20mm screwed conduit entry and a screwed cover such that the whole head may be sealed to prevent the ingress of water after installation is completed.

The electrodes shall be formed from not less than 6mm diameter stainless steel rod and should not exceed 1.5m in length for light duty applications. Spacing between electrodes and to the adjacent walls shall be not less than 100mm.

1103.151 Electrode Circuits

All electrode circuits and components shall comply with BS 5345 and the BAASEEFA requirements for intrinsically safe system for Apparatus Groups IIA and IIB.

The system shall operate by the circulation of an AC current when the circuit is completed by the liquid coming into contact with the electrode, this current operating a

relay to initiate the events specified herein. The relay operation shall incorporate a five second time delay 'On' and 'Off' to allow for spurious initiation.

Intrinsically safe electrode circuits shall be completed by a separate return electrode for each circuit.

1103.152 Electrode Mounting

The electrode heads shall be mounted on a suitable support bracket at a height well above the expected maximum water level as shown on the specification drawings.

Intermediate steady brackets shall be provided and fitted for every 2m of electrode length, insulated lengths of electrode being fitted where these are used.

Support Brackets and steady brackets shall be hot dipped galvanized to BS 729 or otherwise protected to prevent corrosion.

1103.153 Emergency Lighting

Emergency lighting shall be provided to maintain sufficient illumination in accordance with BS 5266 for escape routes within the building during mains supply failures.

The luminaries shall comprise at lest a single 8w fluorescent tube with a solid state changeover circuit and high efficiency, high frequency, inverter all contained within a die-cast aluminum bulkhead body, having a corrosion resistant, stove enamel finish. The diffuser shall be f unbreakable, opal polycarbonate material, secured by an oil and water proof sealing gasket to result in a laminate rated to IP65.

The luminaries shall be self-contained and shall incorporate a maintenance free, nickel cadium battery, capable of preserving the light output for a period of at lest 3 hours without mains supply, together with an automatic recharging circuit to restore the charge within 24 hours of total discharge. Each luminaire shall incorporate an indicator to show that the charger circuit is healthy and have a hinged gear tray and fused terminal blocks.

The luminaries shall be either of the following forms, as detailed in the Specific Requirements:

- maintained from, normally lit from the mains and automatically switched from
- mains to battery during mains failure;
- non-maintained form, energized automatically from the battery supply only when
- the mains fails and the associated local lighting circuit is switched on;
- sustained form, having tow lamps, one of which is mains fed only, the other
- operating form the battery supply during mains failure.

1103.154 LV Outlet Transformer

Isolating transformers shall be of air cooled, double wound construction in accordance with BS 3535, fitted with an earthed metallic screen between primary and secondary windings and suitable for operation form a 220V 50HZ single phase supply.

The secondary winding shall have a rated output of 100VA continuous (1500VA intermittent tool rating) at 110V and have a centre tapping connected to earth.

The transformer shall be enclosed in a wall mounted sheet steel or moulded casing with external fixings lugs and separate cabling connections. The secondary output shall be via fuses incorporated in the enclosures.

1103.155 Water Heater

Single point water heaters shall be thermostatically controlled free outlet ‘single point’ heater suitable for wall mounting. The water inlet shall be 0.5” BSP fitted with a control tap and the outlet swivel spout shall have a reach of approximately 300mm. The heater shall have a capacity of approximately 1.5 gallons (7.0 litres) and an electrical loading of approximately 3kW.

1103.156 Space Heater

Wall mounted single tier tubular heaters rated at 250 watts/metre and suitable for 220V operation shall be provided.

The heaters shall be mounted approximately 300mm above floor level in the positions indicated on the drawings. They shall be directly connected to heater circuits controlled by the room thermostat, the final connection to the heaters being made by means of flexible conduit and a protective conductor. The flexible conduit shall enter from below the heater.

1103.157 Space Heater Thermostat

The thermostat shall be a surface mounting 14 Amp bi-metallic strip type, adjustable over the range 0-30ºC and lockable to prevent unauthorized adjustment of the setting.

The room thermostat shall be mounted approximately 2.0m above floor level in the position indicated.

1103.158 Electric Trace Heating

Heating cables shall comprise a self-regulating, conductive polymer core or double heating elements within a waterproof outer PVC sheath having sealed ends with a cold lead at one end. The cable shall have a flat section to provide efficient heat transfer.

The cable shall be straight laced along the underside of pipes and secured with cable ties at 300mm spacing or be spiraled around the pipe and secured at each end.

All heating cable must be in intimate contact with the pipe and must not be overlapped on itself, additional ties being positioned on either side and close to all flange joints. To avoid mechanical or leakage damage, the cable shall be run over the sides of flanges at 90º to the invert on horizontal pipe runs.

After any thermal insulation has been fitted, wiring labels shall be fitted in prominent positions in the pipework to indicate the presence of trace heating.

1103.159 Trace Heating Thermostat

A wall mounting, air sensing thermostat set at 5ºC shall be provided and arranged to switch on the heater for frost protection. If non-self-regulating heating tapes are used and where lagging is applied, or on PVC pipework, a thermostat shall be located on the pipework and arranged to switch off the heater if the temperature exceeds 60ºC.

Liquid filled sensing bulbs and capillary tube connections to the thermostat shall be of stainless steel with a stainless steel flexible sleeve fitted over the capillary tube for mechanical protection.

The air measuring thermostat shall be mounted on the outside wall, 600mm above ground level and adjacent to but not above the protected pipework.

Enclosure and terminal arrangements to be as specified for field mounted equipment.

1103.160 Lightning Protection

The building shall be protected against lightning strikes by a system consisting of an air termination network, down conductors and a ground termination network. Ground Termination shall be achieved by installation of electrode rods (in pits) connected via tape tails to the bottom of the down-conductor.

The installation shall be complete with a binding connection taken from a down-conductor position to the building main earth terminal bar.

The protection system shall be designed and installed in accordance with BS 6551 by a specialist contractor; with horizontal conductors on the outside walls of the structure.

All metalwork on or around the structure shall be bonded to the lightning protection system. Where connection between dissimilar metals are made, precautions shall be taken to prevent corrosion.

The horizontal and down conductors shall be of 25mm x 3mm copper strip, fixed with leaded gunmetal clamps, secured by phosphor bronze screws or bolts. Each down conductor shall take the most direct route from the air termination network to the earth termination and be provided with a bolted test joint in a position accessible from the ground level.

Earth electrodes of 16mm2 copper bonded, steel cored rods shall be driven into the ground as close as practicable to the structure at the end of each down conductor. The rods shall be installed in sections connected by screwed couplers and driven to a depth sufficient to achieve a resistance to earth such that the whole of the lightning protection system shall have a combined resistance to earth not greater than 3 Ω ohms. The screwed couplers shall be long length aluminum bronze material, counterbored to protect the threaded ends form damage and corrosion.

1104.1 Pump Duty

Pumps shall be of the type specified and arranged as indicated in the Specification Drawings and shown on schedule of pumps. They shall be designed to give specified output against all losses including those relating to the pump.

The Contractor shall match his pump characteristics to the pipe system network to achieve high pump efficiency and reliability.

Each set must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system characteristics given.

The pump section and arrangement shall be such as to ensure that the head available exceeds the N.P.S.H. requirements of the pump under all operating condition.

Where the system and pump characteristics are such as to give rise to the possibility of surge in the pipeline with consequential damage, a surge investigation shall be undertaken if the results of the investigation show that there is a problem. Measures shall be proposed by the Contractor to alleviate the problem. These measures shall be agreed with the Engineer.

Centrifugal pumps shall 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.

For submersible pumps the ability to operate with the maximum reliability is of prime importance, with efficiency being a paramount consideration. The pump shall therefore operate without clogging, being designed to pass a sphere of 125 mm diameter where the size of the delivery mains permits. Whilst the

pumps shall be designed to meet a specific duty they shall also be capable of operating over the duty range specified for prolonged period and for standing idle for long periods without attention as in the case of storm pumping.

1104.2 Centrifugal Pump Casings

Pump casings shall be of the volute type and shall be capable of withstanding all pressures which may be produced due to operating pressure surges.

Particular attention shall be paid to the wear characteristics of the pumps. In the case of submersible pumps, due to the presence of grit in the water, could be appreciable.

The pump design shall ensure that alignment is maintained between the various assemblies by recesses, spigots and dowels and shall be such that all components liable to wear can be replaced.

Components shall be permanently marked with the manufacturer's number and where dowels are not used, permanently marked for correct assembly. The pump casing and the pump impeller should normally have detachable wear rings.

The casings of the pumps shall be of a suitable grade of close-grained grey cast iron 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.

Sewage pump casings shall be of substantial construction to give long life under abrasive conditions and suitably stiffened to withstand shock due to solids in suspension. Inspection holes shall be provided in any section bend and in the pump casing above the impeller for access to facilitate the clearance of obstructions. The inspection hole covers shall be shaped to conform to the interior profile of the waterway when in place and shall be fitted with starting screws where necessary.

1104.3 Impellers

Impellers shall be securely fitted to pump shafts in such a manner to prevent them becoming loose or detached when the pump is in operation, or when rotating in the reverse direction, either by liquid flow or motor rotation.

The impellers and guide vanes (if any) shall be manufactured from a suitable material, accurately machined and smoothly finished to minimize hydraulic losses.

The rotating elements shall be statistically and dynamically balanced before final assembly. The impeller shall be readily withdrawable from the pump casing without the need to disconnect pipework.

For submersible pumps, the impeller shall be of the open type with the inlet ends of the vanes being of bulbous design and the impeller passages being as large as possible consistent with good performance.

The inlet ends and surfaces of the vanes shall be dressed to give a smooth finish to prevent fouling by rages and fibrous matter within the pumps.

Impellers for both submersible and storm water pumps shall be of the non-shrouded type, constructed normally of close-grained grey cast/nickel-iron, and designed to exclude gritty matter from the shaft and gland.

Clearance at the eye rings and wear plates shall be kept to a minimum, and where it is found necessary to cut back the impeller this it be done on the vanes only.

1104.4 Pump Shaft

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 steel protecting sleeves at glands and bearings.

1104.5 Shaft Seals

Pump shaft sealing arrangements shall be suitable for the water pressures and shaft speeds involved.

Pumps fitted with soft re-packable or packed gland type, seals shall have stuffing boxes designed to facilitate adjustment of the packing materials.

Pumps shall be fitted with a split type mechanical shaft seal arranged such that replacement of wearing components can be carried out without the need to dismantle the pump.

Special care in the selection of materials shall be taken in order to avoid binding and electrolytic action between the shaft sleeve and he mechanical seal components, particularly where long periods of idleness are inherent in the duty cycle as in the case of standby and storm pumping.

1104.6 Bearings

All pumps shall incorporate bearing arrangements which prevent the escape of lubricant into the liquid being pumped. The bearings shall be located in dust/moist-proof housings.

All bearings shall be liberally rated to ensure cool running and meet the load factors specified.

For vertically mounted pumps, the top bearing shall be s a combined thrust and journal type, designed to prevent any thrust loads being transmitted to the drive motor. The pump bottom bearing shall be lubricated by an enclosed water lubricated sleeve bearing for potable water applications by grease or other approved means for sewage use. Storm pump bearings shall also be suitable for standing idle for periods of up to 2 months without attention or movement.

Where grease points are necessary they shall be fitted with removable screwed plugs which shall be accessible without removing guards. All bearings having automatic lubrication shall also have provision for hand lubrication.

1104.7 Baseplates and Stools

For vertical pump units, heavy cast iron or fabricated steel floor plates and motor stools shall be provided for direct mounting in concrete floors or supporting steelwork. Suitable journal and thrust bearings shall be provided in the baseplates to carry out the vertical drive shaft.

Where necessary the motor stools shall be designed to accommodate flywheels and bearing housings.

Floor plates shall be recessed and so arranged that the tops and fixing bolts are level with the finished floor.

The pump units shall be accurately aligned and located on baseplates by set screws and parallel dowels

1104.8 Lubrication/Cooling Monitoring

A lubrication system shall be arranged for the lubrication of all grease points on the pumps and shafting from motor room level. Individual bearings within the support tunnel tubes and on the pump sets themselves shall receive separate supplies of grease fed by pressure tubes laid from each bearing to battery plates readily accessible from motor floor level for grease gun operation.

Pressure tubes shall be grouped together where possible and securely attached by brackets, straps, etc. to tunnel tubes, with connectors located near to the motor support plate for easy removal of shafting in the event of maintenance work. In exposed positions pressure tubes are protected from damage. Motor grease points will not be included in this lubrication system but shall receive individual attention.

The battery plates shall have sufficient greasing points for all bearings to be located on or adjacent to each pump motor stool.

A notice is to be supplied and fixed on the wall in a prominent position detailing the manufacturer's recommended greasing schedule. The notice shall include a warning of the dangers to bearings from 'over greasing'.

A grease gun shall be supplied for all greasing purposes.

Bearings which require a continuous supply of lubricant shall incorporate a means of monitoring such a supply, either by flow or temperature rise as appropriate for the type of bearing employed; separate monitors being fitted for each bearing feed or housing.

Such monitors shall include all necessary ancillary power of pulse counting devices to enable the operation of any monitor to initiate a volt free contact rated at 240V 0.5 A AC.

1104.9 Pump Tundish

Where specified, each pump shall be equipped with a cast aluminum or fabricated steel tundish to accommodate the drain lines from mechanical seals, casing vent and other minor drainage points on the pump. A single drain pipe shall be run from the tundish to the common drainage system.

1104.10 Air Release Cock

The higher point on the pump casing shall be fitted with a manual air release cock have a removable handle or an automatic air release valve with a lockable isolation valve as specified. Air release pipework on sewage pumps shall be not less than 30mm bore and shall discharge back into the wet well at high level and have facilities for rodding. The drain from each air release cock shall discharge via pipework as specified.

1104.11 Couplings

All couplings shall be of an approved type and the Contractor shall arranged for the provision and fitting of both coupling halves to each respective shaft and shall include for all necessary modifications to any existing shafts to be coupled.

Where specified, the Contractor shall include any equipment required to prevent damage to any part of the drive in the event of reverse rotation of the pumps..

1104.12 Lubrication

The gear unit shall be grease or oil lubricated, arranged to provide an adequate supply of lubricant for the duty.

Where oil lubrication is employed, the casing shall include an oil breather, level indicator and drain plug.

Units having a rated output greater than 500kW shall have inspection covers and include a forced lubrication system comprising an oil circulating pump, reservoir tank and full flow 'Duplex' type oil filters having re-useable elements together with associated pipework; the oil being circulated by either (a) an internal mechanically driven gear pump and an external electrically driven pump arranged to prime the gears as pre-set timings as recommended by the unit manufacturer, or (b) duplicate external electrically driven pumps, each of which may be selected to prime pre-set intervals and run when the gear unit runs.

Such a lubrication system shall include dial gauges and alarm switches to monitor high oil temperature and low oil pressure.

1104.13 Submersible Pumps

Pumps impellers shall be closed or semi open type made from zinc free bronze or such other materials required for use with particular water to be pumped. Pump bodies shall be of zinc free bronze or such other material as required for the water to be pumped, treated against corrosion, and equipped with detachable wear rings. The bowls shall be joined by flanges or by tie rods.

The shaft main guide bearings located in the suction and delivery end housings of the pump shall utilize a leaded-bronze material, and shall be provided with protection guards to prevent ingress of sand and grit. Pump bowl guide bearings shall utilize either leaded bronze or other approved abrasion resistant material.

All pump bearings shall be lubricated by the water to be pumped. The pump delivery end housing shall incorporate a thrust washer of suitable material at the shaft end housing to absorb upthrusts that occurs during pump starting. The pump shall incorporate a mushroom type delivery check valve to prevent reverse rotation of the shaft from back flow of water through the pump. The pumps shall be provided with a flanged discharge connection suitable for operating against the pump closed valve head or 16 bar whichever is greater. The shaft coupling connecting the pump and driving motor shall be of the stainless steel material accurately machined and keyed to ensure a precise shaft engagement and alignment. A strainer of suitable corrosion and abrasion resistant material, designed to guard against entry of foreign matter but permitting unrestricted flow of water into the pump, shall be provided on the pump suction housing.

Protections against the effect of sand shall be provided by renewable wear rings (made from a hard smooth flexible material such as polymethane) mounted at the seating of the impellers and the passages of the shaft.

The pump shall be designed to pump water having a sand content of up to $80g/m^3$.

A centralizer shall be fitted to every pump to ensure central alignment of the pumping and motor in the borehole casing.

Electro-submersible motors shall be 'wet' squirrel cage rotor induction type designed to operate continuously under submerged conditions and shall, where appropriate, comply with the requirements of IEC publication 34. They shall have operating speeds not in excess of 3000 rpm.

The motors shall be continuously rated at least 20% above the maximum power absorbed by he pump within the specified operating range. Motors shall be designed to allow three consecutive starts from cold and three starts in any on hour when hot.

The motor housing shall be constructed from close grained cast iron, cast steel or fabricated steel as appropriate, and shall be designed for easy dismantling and re-assembly to facilitate replacement of motor guide and thrust bearings.

The motor windings shall be insulated with an approved heat resistant material of high insulation resistance and impervious to water. All connections on the motor winding shall be made watertight. The temperature rise of motor windings shall be limited to 45ºC above ambient temperature.

The motor shall be equipped, in factory with several PTC or Pt100 thermoprobes, 2 minimum, connected to a multifunction protection relay and a pre-selection digital thermometer which cuts off the operation current of the starter when the threshold temperature is reached. The temperature setting of this device shall depend upon the type of the probe determined by the manufacturer according to the insulation class of the motor.

The motor shaft shall be machined from high tensile stainless steel of sufficient diameter to prevent distortion from the dynamic and electro-magnetic stresses imposed on it. Critical shaft speed shall be well above the maximum running speed.

The motor shall be provided with a heavy duty multipad thrust bearing at the base of the motor to absorb the shaft down thrust developed by the pump. The bearing design shall incorporate tilting thrust pads with replaceable segments arranged to self adjust according to the thrust load. The thrust disc shall be of a suitable segment carbon based or similar approved material.

The thrust bearing design shall also be suitable for reverse rotation of the shaft in the event of backflow of water through the pump.

Motor guide bearings shall utilize either leaded bronze, copper impregnated carbon or similar approved material. Rubber, nylon, Tufnell and similar materials will not be accepted for the motor guide bearings.

Motor guide and thrust bearings shall be lubricated by the motor coolant water which shall be effectively isolated from the water to be pumped. A compensating device shall be incorporated in the motor design to allow for expansion of the coolant on rising temperature.

1104.14 Submersible Pumps Headworks

A fabricated steel discharge head piece shall be provided at the top of the tank to support the complete rising column and electro-submersible pumpset assembly, and shall be complete with lifting eye bolts. The discharge head piece shall comprise a heavy duty sealing plate arranged for bolting to the borehole outer casing flange, and a 90º discharge bend arranged for flanged connection to both rising column and horizontal surface pipework. Lifting eyes shall be provided in the sealing plate. A flange shall be provided and welded by the Contractor to the top of the borehole outer casing. The flange shall be suitably drilled to accommodate the discharge head piece sealing plate bolts. Holes shall be provided in the sealing plate

to accommodate an air vent pipe, motor and control cables, water level dip tubing, etc. and shall include adequate sealing arrangements to protect against borehole contamination. A 255mm diameter screwed removable plug shall be provided over the dip tubing for water level measurement with electrical contact tape. A stainless steel air vent pipe shall be fitted to the discharge head sealing plate, terminating in an insect proof screen and arranged to prevent entry of rain or surface water.

Tank power and signal cabling shall be brought to separate robust watertight junction boxes in the top of the well head chamber, with separate cabling from the junction boxes to the Motor Control Centre (MCC).

1104.15 Surge Suppression Equipment

Surge vessels and associated equipment for suppression of surge in pumping systems shall include the following:

Surge pressure vessel designed and constructed to BS 5500, constructed

category 1, 2 or 3, post weld heat treated and with a corrosion allowance of 1mm. The vessel shall be cylindrical, carbon steel, fusion welded with domed ends and mounted either vertically or horizontally on steel supports. The vessel shall be provided complete with including the following fittings:

- McNeil type access manhole with opening not less than 450 mm x 410 mm;
- Water inlet/outlet branch flanged to BS 4504 Table 16 or 25 as necessary;
- 100 mm diameter drain branch with gunmetal valve and handwheel with drain pipework discharging to drainage channel;
- Spring loaded gunmetal safety valve;
- 150 mm diameter pressure gauge complete with isolating cock;
- Water level sight glass with isolating and blowout prevention valves;
- Air inlet fitting incorporating an air release valve and isolating and non-return valves;
- Three stainless steel water level control electrodes of appropriate length, complete with electrode holders, spacers and brackets;
- Access ladder;
- Lifting lugs;
- Nameplate giving vessel details.
- One or more air compressors with standby facilities. Each compressor shall be capable of charging the pressure vessel from full water in approximately 30 minutes. The compressors shall be air cooled, electrically driven and complete with baseplates.

The compressors are required to deliver completely oil-free air but may be of the air lubricated type with two stage carbon air delivery filters providing complete removal moisture and oil vapour. Each compressor shall be provided with the following fittings:

- Outlet pressure gauge;
- Pressure relief valve;

- Suction filter and silencer;
- Automatic unloading valve for a no-load start under all conditions;
- Non-return valve;
- Protective guard between motor and compressor.

Control equipment to provide fully automatic control of the selected duty compressor from the water level electrodes in the surge vessel. A time delay shall be incorporated to prevent operation of the compressor during water level changes under surge conditions and a push button feature shall be provided for manual test of the system. The control equipment shall be housed in a wall mounted panel fabricated from mild steel to form a rigid box construction of neat appearance providing an enclosure to IP54. The enclosure door shall be hinged with a rotating handle and positive closing action. The equipment shall include:

- A three pole isolating switch, with operating handle interlocked with the enclosure door;
- A water level control module;
- A 0 to 30 minutes adjustable timer;
- A non-latching motor test push-button.

Ductile iron flanged inlet/outlet pipework between a flanged tee on the pumping station or wellhead delivery pipework and the surge vessel. The pipeworks shall include an isolating valve with gearing and handwheel and all necessary bends and fittings.

Small diameter GMS pipework between the air compressors and the surge vessel. The pipework shall be suitably coated and wrapped.

For small installations a vessel with a flexible membrane and hand air pump may be used.

j) Valves

1104.16 Types and Operating Conditions

Valves shall be designed to meet the operational and environmental conditions specified for the types indicated in the specific valve schedule.

The closure rates of all valves shall be designed to prevent the effects of surge. Where necessary, valves with a varying closure rate shall be used.

Valve flanges or couplings shall be as specified in the valve schedule and match those specified for the pipework installation.

1104.17 Identification

Each valve shall be identified by a unique reference as approved which shall identify the medium/plant controlled and be numbered in a logical sequence.

The reference shall ither be engraved on a 3mm thick laminated white/black/white traffolyte disc or stamped on a1.0mm (19g) thick brass disc. The disc shall be at least 35mm diameter with reference letters and numerals not less than 4mm and 8mm high respectively.

The discs shall be mounted on the hub of the handwheel or where this is impractical, they shall be attached to the valve stem by means of suitable brass 'S' hooks and/or jack chain through a hole at the top of the disc.

1104.18 Access

All valves, spindles and handwheels shall be position to give good access for operational personnel. It shall be possible either to remove and replace or to recondition seats, gates or gland packings which shall be accessible without removal of the valve from the pipework or, in the case of power operated valves, without removal of the actuator from the valve.

Extension spindles shall be supplied wherever necessary to achieve the specified operating requirements.

1104.19 Hand Operation

All handwheel shall be arranged to turn in a clockwise direction to close the valve or penstock, the direction of rotation for opening and closing being indicated on the handwheels.

The handwheels shall be coated with black plastic and incorporate facilities for padlocking in either the open or closed position.

The operating gear of all valves and penstocks shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum

specified service value and any gearing shall be such as to permit manual operation on a reasonable time and not exceed a required rim pull of 200kg.

Power operated valves shall include equipment for manual operation by means of a handwheel or other suitable device which shall be interlocked with, and fixed to, the power unit.

Headstocks and valves of 50mm nominal bore and above shall be fitted with mechanical position indicators to show the amount which the valve is open or closed in relation to its full travel, i.e. 0.25, 0.50, 0.75, 1 etc.

1104.20 Valve Materials

Valve bodies and other components shall be of corrosion resistant materials, compatible with the medium and of robust industrial design.

For water applications and where specified, valve bodies, discs and wedges shall be of cast iron, with facing rings, wedge nut and other trim of carrions resistant bronze or gun metal.

The valve stem, thrust washers, screws, nuts and other components exposed to the water shall be of a corrosion resistant grade of bronze or stainless steel.

For water works applications, wedge gate, metal seated valve materials shall be in accordance with BS 5163 Table 6A, fitted with a stuffing box and gland seal on the stem. Oil or grease shall not be used on any bearing or seal that may be in contact with the water being controlled.

1104.21 Non-Return Valves

All non-return valves shall be of a type that will operate without stock.

Valve bodies shall be of cast iron and shall be fitted with renewable type seatings.

In the case of swing gate type valves the hinge pin shall be of stainless steel, mounted in zinc free bronze bushes and extended and fitted with external levers and counter balance weights, all protected by a screen guard.

Other types of valves will be considered. In every case the non-return valve shall be selected with full consideration of the system characteristics, and shall avoid valve slam, and have low maintenance requirements.

Where specified, limit switches shall be provided to operate from the external lever. The screen guard being slotted to allow the guard to be removed without disturbing the switch cabling.

1104.22 Butterfly Valves

Butterfly valves shall conform to BS EN 593.

Butterfly valves shall have a high grade cast iron body to BS EN 1561 designed to the specified working and test pressures. The pressure rating valve shall be cast in the valve body.

The disc shall be of high grade cast iron to BS EN 1561 or nodular cast iron to BS 2789 to the defined working and test pressures. It shall have a convex shape designed to achieve low head loss characteristics. The valve shafts shall be of stainless steel operating in self lubricating bushes in the body.

The valve seat shall be of gunmetal to BS 1400. The sealing ring shall be a renewable Ethylene Propylene Diene Monomer (EPDM) rubber attached to the disc edge by a sectional bronze retaining ring to form a resilient and durable seal.

The valves shall be fitted with hand wheel actuators not exceeding 500mm diameter incorporating gearing to allow opening and closing by manual operation at the pressure stated using an effort no greater than 36kg on the hand wheel supplied.

In all cases the gearing shall be designed to close the valve, from fully open to fully closed in a period of not less than ten minutes with this effort. Actuators shall be designed so as to close the valves when the hand wheel is turned in a clockwise direction; the direction of closing shall be clearly cast on the hand wheel. Position indicators shall be fitted to all actuators.

Where required valves shall be electrically actuated with a manual override. Remote actuation shall be provided with a visual indication of valve open, valve closed and percentage opening together with fault indication.

A performance curve, relating percentage valve travel, open area and discharge coefficient shall be submitted to the Engineer. The head loss coefficient with valve fully open shall be defined.

All valves shall be tested in accordance with BS EN 593 and pressure and material test certificates shall be submitted to the Engineer for approval.

1104.23 Plug Valves

Plug valves shall be of the wedge gate type, with cast bodies. The plug surface shall be coated or lubricated to endure low torque operation with bubble tight shut-off and ‘non-sticking’ materials.

1104.24 Isolating Cocks

For isolation of small bore pipework tappings for instrumentation equipment etc. and for individual component isolation, the cocks shall be stainless steel, quarter-turn, ball or plug valves with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or rear surface.

Where corporation cocks are specified, these shall be similar to the above isolating cocks but shall have a detachable key handle for fitting onto a squared operating shaft, the shaft end being marked to indicate the open and closed valve positions.

1104.25 Air Valves

Air valves shall be either:

- Single (small) orifice valves (SAV), for the discharge of air during the normal operation of the pipeline.
- Double orifice valves (DAV), consisting of a large orifice and a small orifice. These shall permit the bulk discharge of air from the main during filling and air inflow when emptying in addition to the discharge of small quantities of air during normal operating conditions.

Air valves shall be supplied with an independent isolating butterfly valve (DAV) or cock (SAV) which permits the complete removal of the air valve from the main, without affecting the flow of water in the main.

Each air valve assembly shall be suitable for connection to a flange on the pipeline.

At the connection between the air valve and its isolating valve a BSP tapping shall be made suitable for fitting of a pressure gauge. All tappings shall be sealed by a brass plug and copper compression ring gasket.

Air valves shall operate automatically and be constructed so that the operating mechanism will not jam in either the open or closed positions.

1104.26 Systems Design

All pipe systems shall be arranged, installed, supported and provided with all necessary means of venting, draining and expansion subject to the approval to the Engineer before erection commences.

The pipework layout shall be designed so that items of equipment and sections of pipework can be removed from the pipelines 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.

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.

Hydraulic pipework. Pipework for pressurized hydraulic fluid shall be sized to maintain fluid velocities below those which specified and provide a safety factor of 4:1 on the design pressure, which shall be taken as 120% working pressure;

Compressed air pipework. Air pipework shall be seamless heavy duty Black Mild Steel class C, sized such that the air flow velocity does not exceed 8m/sec. the complete pipework will receive 2 coats of chlorinated rubber paint, with a final 3rd coat, the final finish color to match existing and as approved by the Engineer. All joints will be flanged; no threaded joint will be approved for the entire compressed air pipework assembly. 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 30m. Drainage points shall be formed by the use of equal tees with a down-pointing leg fitted preferably where changes of direction of flow occur.

Any branch take-off shall be from the top of the main and the bottom of any falling pipe shall be drained.

1104.27 Flanges

Unless otherwise specified flanges shall be faced and drilled to conform to the dimensions specified in BS 4504. Flanges shall be compatible with the pressure rating of the adjacent pipework but not less than 15 bar. Bolts, nuts and washers (two washers per bolt) shall be to BS BS EN 1092-3;2003. No bolt shall project more than two full threads beyond its nut after tightening. In no circumstances shall the shortening of excessively long bolts by cutting be allowed.

Gaskets shall comply with replaced by BS EN 1514 (1997) and replaced by BS EN 681-2 (200) and BS 681-1 (1996) Type W.

Flanges shall be painted with two coats of chlorinated rubber paint.

1104.28 Mechanical Couplings

Unless otherwise specified or shown in the Drawings pipes and fittings shall be supplied with flexible joints.

Mechanical couplings shall be of the Dresser, Viking Johnson type without a centre register.

Joints rings used shall be of the ethylene propylene rubber (EPDM) or other material approved by the Engineer.

All mechanical couplings and flange adapters including nuts, bolts and washers shall be supplied with 'Rilsan' nylon thermoplastic polyamide applied by fluidized bed dipping.

1104.29 Materials for the Assembly of Flexible Joints

Lubricant shall be of a kind not conducive to the growth of bacteria and shall have no deleterious effects on either the joint rings or pipes. Lubricants for water supply shall not impart to water, taste, colour, or any effect known to be injurious to health.

1104.30 Materials

Pipework materials, sizes, pressure rating, fittings, coupling arrangements and median carried shall be as detailed in the Particular Specification, pipework being in standard metric sizes where possible.

General purpose steel pipework with screwed fitting shall be of galvanized mild steel to BS 1387 heavy grade with fittings of galvanized malleable iron to BS 143/1256, having tapered internal and external threads to BS 21.

Flange joints shall be as specified below for the application and all necessary bolts, nuts and washers shall be cadium plated. Welded joints in carbon steel pipe shall be to Class II quality to BS 2640 or BS 2971. Welding shall only be carried out by welders who are approved in accordance with the relevant BS.

Water pressurized system shall use pipe-work of carbon steel in accordance with BS 3601 with pipe sizes to BS 3600. Sizes greater than 80mm shall be selected from the preferred sizes 100, 150, 200, 300, 450, 600 and 800mm.

Flange sizes shall be according to BS 4505 rated NP16 unless otherwise specified.

All flanged joints shall be made with 3mm thick rubber canvas reinforced insertion rings complying with BS 4865 Part 1 table 16A.

Low pressure large bore systems shall use steel pipes and fittings to BS 4622 unless ductile iron pipes and fittings to BS 4772 are specified. Screwed or cast flanges shall have a minimum NP16 rating and be fitted with 3mm thick rubber canvas-reinforced insertion rings.

Hydraulic pipework shall be of stainless steel high pressure tubing grade CFS 316 to BS 3605 or mild steel grade CDS 23/S to BS 3602 as specified.

Flexible hoses shall be of the twin wire braid reinforced type complying with BS 3832.

Pipe fittings not normally visible or accessible after installation shall be of the welded socket type with break joints at suitable positions for maintenance.

All other fittings shall be of the compression type in mild steel with an electroplated corrosion resistant finish.

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1104.31 Joint and Pipe Fastenings

All nuts, bolts, washers, flanges, gaskets, flanged tied adaptors, drain valves, special connection pieces, supporting hangers, brackets or clips and temporary supports for the pipework, together with all terminal point connection material shall be supplied and installed under this Contract.

All flanged joints shall be fitted with suitable insertion ring gaskets which shall be carefully adjusted concentric to the bore of the pipe so that no undue strain is placed on any of the bolts or flanges of the pipe when bolting up.

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.

Flushing and drain connections on pipework below 150mm shall be made using proprietary welded fittings with G series internal parallel threads to BS 2779 which shall be immediately sealed with steel hexagon headed shouldered plugs and seals. Holes thus made in the pipe shall have any burrs removed and be finally pulled through to remove loose particles.

1104.32 Template Pipes

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 on the connected items after installation.

1104.33 By-passes

Where pipeline flow meters are used, particularly electromagnetic meters, by-pass pipework and valves shall be installed to allow removal of the meter without interrupting the process flow. Draining shall either be via backflow or drain valves.

1104.34 Flanged Adaptors

Flanged adaptors shall be provided as indicated in the Specification drawings. Each adaptors shall be complete with all associated fittings and shall be installed in accordance with the manufacturer's instructions.

1104.35 Branch Pipe and Bosses

Whenever any small bore pipework makes a connection into the pipeline system, a boss of 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 38mm (1.5") BSP and have reasonable access for sampling. Bosses provided for instrumentation equipment shall be tapped 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.

1104.36 Small Bore Pipework

Small bore pipework up to 15mm OD shall be manufactured from stainless steel tubing with suitable compression type fittings. All smart bore pipework and capillary tubes shall be adequately and securely clipped or clamped. Compression fittings bends shall be kept to a minimum, as pipeline bends of generous radii are preferred. Compression couplings shall be heavy series to BS 4386 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.

1104.37 Duct Seals

After the pipework is installed, the Contractor shall seal the ends of all ducts, pipes or trenches leading into buildings, whether occupied or not, for pipework associated with this Contract.

The seals shall be approved water, gas and fire sealing transit units with appropriate fillers, and insert blocks shall be fitted to duct trench entries. All steelwork on such transit assemblies and frames shall be hot dip galvanised. Where shown on the Engineer's drawings, transit frames will be incorporated in the construction by the Civil works contractor.

1104.38 Reference Marking

Prior to dispatch from the manufacturer's works each pipe section shall be marked with an appropriate reference number for future identification.

1104.39 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 type otherwise protected and all flanges shall be fitted with blank discs bolted to each face.

1105 CONTROL PANEL PARTICULAR SPECIFICATIONS

1105.1 Location

The works will be located in Machakos.

1105.2 Scope of Works

The contractor shall supply and install the complete Electrical Services installation systems comprising but not limited to the following:

- Pump Control Panels

1105.3 4.2.1 Control Panel

The contractor shall supply, install, test and commission. Control panels to monitor and control all the electromechanical installations.

The Panel's controllers shall be capable of control and monitoring all the speed controlled pumps. The control panels shall also comprise of external frequency converters for each pump. The starting method for all the pumps shall be done electronically via variable speed drives for each of the pumps.

It shall also allow for fitting of a transducer to provide low water pump shut down protection to the pump set, with alarm signal. The control panel will also incorporate run and fault indicator lights for each pump and as well as speed indication lights.

The Panel shall incorporate the following features:

- LCD panel with backlit dynamic buttons to enable the user to interrogate the panel.
- Automatic fans to cool down the cabinet if required according to EN60439-1
- Lockable mains breaker
- Individually breakers for each pump

Control panels functionality

The control panels shall operate the pumps to keep a required pressure at the discharge manifold. The system shall automatically start the required number of pumps to keep the required Pressure.

The system must ensure a minimum of pressure surges when starting and stopping pumps by ramping the pumps in according to a defined ramp.

On the control unit it must be possible to read out:

Speed of individual pumps.

State of individual pumps.

Power consumption

Energy consumption

A measured or estimated flow rate.

Process value and set point.

The Controller must incorporate a log that graphically shows the trend of:

- The Estimated/measured flow
- Speed of the pumps
- Set point
- Process value

It must be possible to retrieve the data and open it in a spreadsheet.

The control shall store at least the last twenty fault conditions experienced by the pump set, for subsequent display when the panel is interrogated.

The alarms must be presented in plain text indicating the source of the alarm.

The control system shall incorporate password protection and shall fully segregate access to interrogate the pump operating history from the access level at which pump operating settings can be changed.

The control system shall incorporate automatic test run of each pump every 24 hours. The system must automatically ensure equal running hours of the pumps. It must be able to, once a day, evaluate the

running hours of the pumps and alternate between them if an idle pump has less running hours than a running pump.

Standby pump

- It shall be possible from the controller to define a number of standby pumps.

- Where a pump is designated as standby it shall still be included in the duty change cycle.

1105.4 4.2.2 High Pressure protection

It shall be possible to program a “high-pressure” safety cut-out, set 1.5 bar above the duty pressure. The pumps set shall automatically shut down in the event of the above pressure being identified. Following a shut-down the controller shall (a) re-start the pump set automatically once the high condition has disappeared, or (b) will remain shut down until manually re-started by an authorised person. (The preferred option shall be agreed with the end user prior to hand over and the controller programmed accordingly).

1105.5 4.2.3 Low Pressure/pipe burst protection

It shall be possible to program a “Low-pressure” safety cut-out, set 1 bar below the duty pressure. The pumps set shall automatically shut down in the event of the above pressure being identified. Following a shut-down the controller shall (a) re-start the pump set automatically once the high condition has disappeared, or (b) will remain shut down until manually re-started by an authorised person. (The preferred option shall be agreed with the end user prior to hand over and the controller programmed accordingly).

1105.6 4.2.4 Soft pressure build up.

The panel shall incorporate a slow-speed/one-pump-only start up, following a power outage or maintenance shutdown to gradually fill up the pipeline and reduce risk of airlocks and water hammer.

1105.7 4.2.5 Redundant sensor

The controller shall have a feature that gives an alarm if there is incoherency between the two discharge sensor signals.

1105.8 4.2.6 Testing and Commissioning:

Once installed on site, with all necessary permanent water services, power supplies, control and alarm systems completed and tested. The panel manufacturer shall be invited to site to commission, test and demonstrate the operation of the panel to the full satisfaction of the Engineer and End User.

1105.9 Working Drawings /Fabrication Drawings

Upon award of the subcontract the subcontractor shall produce three sets of the working drawings to Engineer prior to commencement of the work. The Engineer has to approve the drawings for the subcontractor to proceed with the works. The drawings shall be in A2 hard copies.

Fabrication drawings of the pumps control panel shall be submitted to the engineers for approval before fabrication commences.

1105.10 As Built Drawings

The subcontractor shall prepare the as installed drawings at the completion for the subcontract. The drawings shall be in AUTOCAD and 3No. Sets of A3 hard copies.

Abbreviations

The following abbreviations are used in these documents:

FIDIC	Federation International des Ingenieurs – Conseils
BS	British Standards
CP	Code of Practice
GRP	Glass Reinforced Plastic
AC	Asbestos Cement
DI	Ductile Iron
Ch	Chainage
PVC	Polyvinyl Chloride
kPa	kilo Pascal
g	acceleration due to gravity - ($9.807 m/s^2$)
gpm	gallons per minute
mgd	million gallons per day
mm	millimeters
m	metres
mhd	metres head
m^3	cubic metres
m^3/day	cubic metes per day
m/s^2	metres per second head
1/head/day	litres per head per day
kW	kilowatts
kVa	kilovolt-ampere
kWh	kilowatt hour
ISO	International Standards Organisation
CFM	cubic feet per minute
AOD	Above ordnance datum

SWL	Static water level
PWL	Pumping water level
GL	Ground level
EOH	End of hole