REPUBLIC OF KENYA

Ministry of Water Sanitation and Irrigation

Project Name: Improvement of Drinking Water and Sanitation Systems in Mombasa – Mwache Project

Credit No.: CKE 1103

Volume 2 of 3 **Bidding Documents: Works Specifications**

- Works Specification
- Employer Requirements

Contract Name: **Emergency Works for Increasing Water Availability in Likoni**

IFB No.: **CWSB/AFD/W1/2019-2020**

Employer: **Coast Water Works Development Agency**

P.O. Box 90417, 80100 Mombasa, Kenya

Funding: AFD

Issued on: **19 January 2021**

Section VII. - Works Specifications and Employer Requirements

Table of Contents

1. GENERAL REQUIREMENTS

1.1 GENERAL PROVISIONS

The General Specifications presented herein define the location of the Site and the Works, specify the purpose of the Works and particular requirements for the completed Works, including functional requirements, quality, performance and scope, requirements for the supply of certain items (such as consumables), special obligations and other details generally in accordance with the Conditions of Contract for Construction for Building and Engineering Works Designed by the Employer, Multilateral Development Bank Harmonized Edition, First Edition June 2010, published by FIDIC.

The General Specifications are deemed to form and shall be construed as an integral part of the Specifications.

1.2 Background

The Contract is part of a package of investments identified by the Coast Water Works Development Agency (formally Coast Water Services Board) to be financed by the International Development Association (IDA) of The World Bank Group and Agence Française de Développement (AFD) through the "***Improvement of Drinking Water and Sanitation Systems in Mombasa – Mwache Project".***

The Agence Française de Développement (AFD) approved in October 2016 a EUR 120M project aiming at improving the water and sanitation services to the population of Mombasa County, with particular focus on Likoni area.

The present contract concerns emergency works for improvement of water supply to Likoni area. This includes improvement of production from the Tiwi Aquifer through rehabilitation of existing well as well as drilling others as replacement boreholes. It also includes improvements in the Marere pipeline system to deliver more water to Kaya Bombo reservoirs which serve Likoni.

Coast Water Works Development Agency (CWWDA), a parastatal under the Ministry of Water and Sanitation of Kenya, is the Employer of the Contract. CWWDA has appointed the Engineer as specified in the Particular Conditions of Contract to be responsible for administering the Contract and supervising execution of the Works as specified in these Employer's Requirements.

1.3 Topographical Site Conditions

Topographical surveys are existing and are attached in Part IV – Supplementary Information

1.4 Geological and Geotechnical Site Conditions

The survey documents are attached under Part IV – Supplementary Information.

The geology in the area consists of:

Permo-Triassic sandstones are the oldest strata within the Tiwi area. The thickness of these rocks may exceed 500 meters. In the North (including the area of Tiwi well field) these sandstones are separated from the unconsolidated sediments of the Pliocene, Pleistocene and recent deposits (hydraulic system 'Unit 1') by Jurassic

shale a rather thick sequence of slightly metamorphic rocks (approximately several hundred meters). Thus, the Tiwi aquifer is not connected to the system Permo-Triassic sandstones. Any groundwater produced is taken from the younger, unconsolidated sediments on top of the Jurassic shale.

Essential results on Aquifer Properties:

The electrical properties of the intersected sedimentary layers are interpreted. The different layers comprise a sequence of (from top to bottom):

- sands (sandy facies);
- sands (loamy facies);
- coral limestone (partly weathered);
- clay, clay stone, shale.

Those sedimentary layers are not evenly distributed. The layers may vary actually over short distances laterally as well as vertically. There are lenses intercalated. Also, the thickness of the layers differs from place to place.

Permo-Triassic Sandstones

The voids and pores of the original sands are closed by minerals like quartz, iron or lime. Nevertheless, the sandstone might contain groundwater. The water circulates through fissures and joints which came into existence as one result of tectonic pressures. Sandstones react on tectonic stress by breaking up rather than by bending the layers. Thus, sandstones are classified as aquifers.

The aquifer properties of the Permo-Triassic sandstones in the project area are not known. There is the possibility that these rocks may store and provide large quantities of groundwater. Exploratory drilling and tests pumping are required in order to get relevant data.

Jurassic Shale

Shale is like clay a so called ‘aquiclude’ which means that any groundwater circulation is interrupted and/or dammed. In the project area the Jurassic shale divides the Permo-Triassic sandstone from the younger aquifers (hydraulic aquifer system ‘Unit 1’)

The Jurassic Shale is missing south of Tiwi meaning that the aquifer system ‘Unit 1’ is in direct contact to the Permo-Triassic sandstones.

1.5 Climatic Conditions

The major influence on East African weather and climate is the Inter-tropical Convergence Zone (ITCZ). This is an area of the atmosphere above the earth’s surface where two airstreams (the North East and South East Trade Winds) converge.

The zone is characterized by warm rising air and the formation of clouds and is clearly visible as an equatorial band oscillating north and south across the equator

as the earth revolves around the sun on it is annual orbit along the plane of the ecliptic.

The ITCZ's effect over the climate of East Africa is to intensify the general weather patterns for the area - for example if an area expects rainfall - when the ITCZ is overhead - the rainfall will be greater and more intense than a time of year when the ITCZ was not passing over.

As the Kenya Coast Area lies at equatorial latitudes, the region experiences two distinct rainy seasons which coincide with the periods of the year when the ITCZ is moving over; when the ITCZ is heading south, passing over the coast region in September, and again moving north passing over in March. The Kenyan rainy seasons are known as the Long Rains in April and May, and the Short Rains in October and November.

To explain this phenomenon in further detail; the sun is closest to the earth (the subsolar point) over the Kenya Coast around the end of March, and again around the end of September - these are the equinoxes. The ITCZ follows the subsolar point with a delay of about a month,when it has it the most intense effect on the climate. So, in both April/May and October/November (both about a month after the subsolar point has passed over the Kenya Coast) is when the ITCZ bears most influence and is when the Kenya Coast experiences the rainy seasons.

The driest months of the year in Kenyan coastal areas are January and February.

The total annual rainfall varies between 1,015 – 1,270 mm with a mean rainfall of 1,040 mm. The rainfall pattern is characterized by two distinct long and short seasons corresponding to changes in the monsoon winds. The long rains occur between March and July with average of 655 mm with a peak of 330 mm in May and correspond to the south easterly monsoon winds.

The average total annual rainfall has reliability of 60 %. The short rains start towards the end of October until December and correspond to the North Easterly monsoon winds which are comparatively dry. The short rains average is 240 mm with a peak of about 100 mm in November.

This rainfall is important in recharging of groundwater aquifers hence maintaining the water table. Availability of rainfall data is important for quantification of the recharge rate to groundwater aquifers for efficient groundwater resource management.

1.6 Description of the Scope of Works

1.6.1 General

The water supply system to Likoni comprises the following sub-systems:

- Tiwi Borehole System
- Marere System

This contract comprises the following works:

Rehabilitation and Improvement of Tiwi Borehole System as well as construction of a parallel pipeline of approximately 6.4km from Marere Headworks to Kibaoni reservoir to supply Kwale Town (through Madabarra pump house) and Kinango Sub-county (through Kibaoni pump house).

1.6.2 Tiwi System

The production wells of the Tiwi Well Field are located some 20 km south of Mombasa along the road Mombasa-Tanzania Wells are located approximately 1 - 3 km west of the named Likoni - Ukunda Road section to Tanzania.

The Tiwi well field has two parts: north well field and south well field. The south well field consists of seven boreholes from where the water is pumped to Magodzoni Reservoir (2,270 m^3), from where water is then supplied through the distribution system by gravity flow.

The north well field consists of six boreholes. The water from the north well field is pumped to the Kaya Bombo Reservoir (1,400 m^3), from where water is then supplied through the distribution system by gravity flow.

The Tiwi System consists of two well fields from where the water is pumped to Magodzoni Reservoir (1 Nr. of 2,270 m^3) and Kaya Bombo Reservoir (2 Nr. of 1250 m^3 and 1,140 m^3respectively). The Kaya Bombo reservoirs supply the Likoni area.

a) Rehabilitation of Tiwi Borehole System

The works comprise:

- Borehole rehabilitation works at 13 boreholes
- Rehabilitation of Electromechanical Installations at 13 boreholes
- Instrumentation and monitoring works at 13 boreholes

b) Drilling and Equipping of 2 No. Tiwi Replacement Boreholes

The works comprise:

- Investigating, drilling, testing and development of replacement boreholes at sites A and 9
- Installation of electromechanical equipment of above boreholes
- Instrumentation and Monitoring works for the boreholes
- Pipelines to connect the replacement boreholes to the Tiwi supply system
- 3 new boreholes as provisional sum

c) Connecting Pipework

The works comprise:

- New DN150 HDPE pipeline to connect the well site of BH A to the transmission main towards Kaya Bombo, length 792 m
- New DN 150 HDPE pipeline to connect the boreholes 4 and 7 to the transmission main towards Kaya Bombo, length 871m

1.6.3 Marere System

The Marere System supplies water to the Coast Area. Water is withdrawn from the Marere, Votia and Mwalunganje Springs in the Shimba Hills, about 40 km to the south-west of Mombasa. The water is conveyed to the Marere Headworks, from where water is supplied through the transmission system by gravity flow, including

pipelines which convey water to Changamwe Reservoirs and to Kaya Bombo Reservoir.

There are several off-takes along the way. The key ones are the Madabarra off-take, Kibaoni off-take and Kaya Bombo off-take.

The Drawings and Supplemental Information which form part of the Contract provide additional information of the existing water supply systems.

a) Construction of parallel Marere Pipeline

The works comprise:

- Construction of flow division chamber at Marere Headworks
- Construction of parallel pipe of length 6368 m (DN 250 HDPE PN25 length 2844 m and DN200 HDPE PN25: length 3,524m) including related chambers and connections.
- Removal of Madabarra off-take from existing DN500 steel main and connection to new DN250 HDPE parallel main and removal of Kibaoni off-take from existing DN500 steel main and connection to DN200 HDPE main.
- Constant flow control valve at Kaya Bombo off-take to regulate flow to Mombasa.
- Removal of existing air valves and installation of 2Nr. new non-slam air valves(PN25) at Mwache Creek
- Installation of Bulk Meters on the Madabarra and Kibaoni off-takes.

1.6.4 Minor works

a) Ancillary Site Works

The works comprise:

- Investigations and repair of existing 1140 m^3 capacity Kaya Bombo concrete reservoir to stop leakages from the bottom
- Construction of 2 No of Chlorine Units, one each at Kaya Bombo and Magodzoni reservoirs
- Repair of existing staff house at Tiwi wellfield Boreholes 4 and 7 (repairs include paintwork, windows panes replacement, fascia board repairs and general fittings)
- New fencing works at 10No. borehole sites
- Installation of sanitation facilities (VIP latrines) at selected 9 borehole sites
- Installation of pilot Solar PV system at 4 borehole sites(BH A, BH 4, BH 7 and BH9).

1.7 Contractor's General Obligations

The Contractor shall design, execute and complete the Works in accordance with the Contract and shall remedy any defects in the Works. When completed, the Works shall be fit for the purposes for which the Works are intended as defined in the Contract.

The Contractor shall be deemed to have obtained all necessary information as to risks, contingencies and other circumstances which may influence or affect the Works when submitting his Bid. The Contractor shall also be deemed to have inspected and examined the sites and their surroundings, and to have been satisfied before submitting his Bid as to all relevant matters, including (without limitation):

- The hydrological and climatic conditions of the work sites,
- The form and nature of the work sites, including sub-surface conditions,
- The extent and nature of the works, goods and installations necessary for the execution and completion of the Works and the remedying of any defects,
- The Laws, procedures and labor practices of the Country of the Employer,
- The requirements for access, accommodation, facilities, personnel, power, transport, water and other services of the Contractor.

The Contractor shall provide all plant, equipment and materials and documents as required in the Contract, and all personnel, goods, consumables and other things and services, whether of a temporary or permanent nature, required in and for the execution, completion and remedying of defects. The Works shall include any work which is necessary to satisfy requirements of the Contract, including any work as included in the Bid of the Contractor, or is implied by the Contract, and all work which (although not mentioned in the Contract) are necessary for stability or for the completion, or safe and proper operation, of the Works.

The Contractor shall be responsible for the adequacy, stability and safety of all site operations, of all methods of construction and of all the Works.

The Contractor shall, whenever required by the Engineer, submit details of the arrangements and methods which the Contractor proposes to adopt for the execution of the Works. No significant alteration to these arrangements and methods shall be made without this having previously been notified to and been approved by the Engineer.

1.7.1 Responsibilities of the Contractor

The Contractor shall comply with the environmental requirements contained in the Contract. In particular, the Contractor shall:

- Ensure environmental awareness among his employees and sub-contractors so that they are fully aware of, and understand, the environmental requirements and the need for them.
- Notify the Engineer immediately in the event of any accidental infringements of the environmental requirements to enable appropriate remedial action to be taken immediately.
- Notify the Engineer, at least ten working days in advance, of any activity he has reason to believe may have significant negative impacts, so that mitigatory measures may be implemented in a timely manner.
- Undertake rehabilitation of all areas affected by his works and to restore them to their original states, as determined by the Engineer
- Undertake the required works within the designed working areas

1.7.2 Accuracy of Employer’s Requirements Not Guaranteed

The accuracy of any general or particular information, specified or presented by the Employer in the Contract, is not in any way guaranteed. The Contractor shall be deemed to have examined all information obtainable in connection with the Works, and to have taken into account any disparity accordingly, all of which shall be deemed covered by the Contractor within the rates and prices of the Contract.

If any deviation or departure from the Contract is deemed necessary by the Contractor for the proper and safe execution of his services, details of such departures or deviations and the reasons thereof, shall be submitted, as soon as practicable, to the Engineer in order to obtain the Employer's written approval. No such departures or deviations shall be made without the prior written approval of the Employer.

1.8 Contractor's Submittals

1.8.1 Insurances

The Contractor shall provide insurances, as shown below, by an insurance company registered in Kenya.

1.8.2 Insurance for works and Contractor's equipment

Covering works, plant, materials and Contractor's documents for not less than the full reinstatement cost including the costs of demolition, removal of debris and professional fees and profit.

1.8.3 Insurance against Injury to Persons and damages to property

Covering each Party's liability for any loss, damage, death or bodily injury which may occur to any physical property or to any person which may arise out of the Contractor's performance of the Contract, for a limit per occurrence of not less than the amount stated in the Contract Data, with no limit on the number of occurrences.

1.8.4 Insurance for Contractor's Personnel

Cover against liability for claims, damages, losses and expenses arising from injury, sickness, disease or death of any person employed by the Contractor or any other of the Contractor's Personnel.

1.9 Health and safety

The Contractor shall always comply with all relevant H&S legislation of Kenya and the ESHS Specification, during the period of the Contract.

The Contractor shall be responsible for the safe conduct of the Works. He shall ensure that all operations are carried out safely and that any person made responsible for the safe conduct of any part of the operations carries out his duties in a proper manner.

The Contractor shall submit to the Engineer the ESMP, including a H&S section, within 28 days after Commencement date. This HS Plan section shall comply with international good practice, local safety codes, laws and regulations.

Where any part of the Works is not covered by the Contractor's Safety Policy, or is a high-risk activity, the Contractor shall, before commencing work on that part of the Works or activity, submit to the Engineer a work-safety Method Statement for approval. No related work shall be commenced unless the Engineer has approved the proposed methods.

The Contractor shall nominate a responsible person for the organization and supervision of first-aid measures and facilities, throughout the contract period. The

Contractor shall conduct H&S-training for all his personnel on a regular basis, familiarizing them with H&S measures.

The Contractor shall introduce an “Operator Permit to Work” system after adequate operator training to ensure that the operator is adequately trained to carry out the required work on any equipment.

On site a first-aid facility, in accordance with the ESHS Specifications shall be provided. Medical supplies for first-aid provision shall be clearly marked and labeled, easy to identify and easily accessible.

The Contractor shall provide for emergency arrangements, in order to mobilize quickly labor-force outside the normal working hours to carry out any work needed for an emergency associated with the works. The Engineer shall always be provided with a list of addresses and telephone numbers of the Contractor's staff who are currently responsible for organizing emergency works. The Contractor shall familiarize himself and his employees with any relevant, existing, local arrangements, dealing with emergencies

1.10 HIV-AIDS/COVID-19 Prevention

With reference to the Conditions of Contract HIV-AIDS Prevention, the Contractor shall conduct an HIV-AIDS awareness program via an approved service provider and shall undertake such other measures to reduce the risk of the transfer of the HIV virus between and among the Contractor’s Personnel and the local community to promote early diagnosis and to assist affected individuals.

The Contractor shall throughout the contract (including the Defects Liability Period):

- Conduct information, Education and Consultation Communication(IEC) campaigns at least every month, addressed to all the Site staff and labor(including all the contractor’s employees, all Sub-contractors and Consultant’s staff and all truck drivers and crew making deliveries to site for construction activities) and to the immediate local communities, concerning the risks, dangers and impact, and appropriate avoidance behavior with respect to Sexually Transmitted Diseases(STD) – or Sexually Transmitted Infections(STIs) in general and HIV/AIDS in particular,
- Provide male or female condoms for all Site staff and labor as appropriate and,
- Provide for STI and HIV/AIDS screening, diagnosis, counseling and referral to a dedicated national STI and HIV/AIDS program (unless otherwise agreed) of all Site staff and labor

The Contractor shall include in the program to be submitted for the execution of the Works under the relevant Sub-Clauses of the conditions of Contract an alleviation program for Site staff and labor and their families in respect of STIs and HIV/AIDS alleviation program shall indicate when, how and at what cost the Contractor plans to satisfy the requirement of this Sub-Clause and the related specifications. For each component, the program shall detail the resources to be provided or utilized and any related sub-contracting proposed. The program shall also include provision of a detailed cost estimate with supporting documentation.

The Contractor shall further conduct a COVID-19 awareness program via an approved service provider and shall undertake such other measures to reduce the risk of the transfer of the virus between and among the Contractor’s Personnel and the local community to promote early diagnosis and to assist affected individuals.

The Contractor shall throughout the contract (including the Defects Liability Period):

- Conduct information, Education and Consultation Communication(IEC) campaigns at least every month, addressed to all the Site staff and labor (including all the contractor's employees, all sub-contractors and Consultant's staff and all truck drivers and crew making deliveries to site for construction activities) and to the immediate local communities, concerning the risks, dangers and impact, and appropriate avoidance behavior with respect to COVID-19,
- Provide masks and protective equipment, cover costs for screening and testing as requested by the national and regional authorities.

The Contractor shall include in the program to be submitted for the execution of the Works under the relevant Sub-Clauses of the conditions of Contract an alleviation program for Site staff and labor and their families in respect of COVID-19, the alleviation program shall indicate when, how and at what cost the Contractor plans to satisfy the requirement of this Sub-Clause and the related specifications. For each component, the program shall detail the resources to be provided or utilized and any related sub-contracting proposed. The program shall also include provision of a detailed cost estimate with supporting documentation.

Payment to the contractor for preparation and implementation of the above programs shall not exceed the Provisional Sum dedicated for this purpose.

1.11 Material and Equipment Supply Requirements

1.11.1 Contractor's Technical Proposal

The Technical Proposal submitted by the Contractor in his Bid shall form part of the Contract according to the Contract Agreement. The Employer may terminate the Contract if the Contractor, in the judgment of the Employer, has engaged in fraudulent practices when submitting his Technical Proposal as part of his Bid.

1.11.2 General Provisions

The Contractor shall take the entire responsibility for the goods to be supplied during purchase, handling, transport and storage at the Project Area. Any losses, damage or whatsoever prior to Completion of the works are the responsibility of the Contractor.

The Contractor shall obtain and provide to the Engineer the entire manufacturer's literature in English language relating to the proper handling, storage and testing of their products, and shall make them or copies thereof available to the Engineer.

All additional costs for purchase, handling, transport, and storage (e.g. costs for insurance, freight, VAT, import / export taxes, etc.) shall be the responsibility of the Contractor, who shall incorporate these costs into the rates and prices of the Contract accordingly. No additional costs other than the rates and prices of the Contract will be accepted.

The Contractor shall take full responsibility for theft, robbery or any losses, damages, or any other attenuation in quality or quantity of the goods to be supplied.

The Contractor shall replace any item of the goods that are found to be defective from faulty manufacture, workmanship and damage during transportation, or

subsequently found defective during any inspection by the Engineer, prior to installation.

1.11.3 Warranty of Goods

The Contractor warrants that all goods to be supplied and installed under the Contract are new, unused, and of the most recent or current models, and that they incorporate all recent improvements in design and materials, unless provided otherwise in the Contract.

The Contractor further warrants that the goods shall be free from defects arising from any act or omission of the Contractor or arising from design, materials, and workmanship, under normal use in the conditions prevailing in the country of final destination.

The Contractor shall be entitled to disclaim responsibility for any design, data, drawing, specification or other document, or any modification thereof provided or designed by or on behalf of the Employer, for any goods to be supplied and installed under the Contract, by giving a written notice of such disclaimer to the Employer.

This warranty shall be administered according to the Conditions of Contract and shall remain valid for the duration of the Defects Liability Period of each Section of the Contract. During this warranty period, the Contractor shall not assign this warranty to the manufacturer or producer of the goods supplied and installed under the Contract.

1.11.4 Patent Indemnity

The Contractor shall indemnify and hold harmless the Employer and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Employer may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract.

Such indemnity shall not cover any use of the goods or any part thereof other than for the purpose indicated by or to be reasonably inferred from the Contract, any infringement resulting from the use of the goods or any part thereof, or any products produced thereby in association or combination with any other equipment, plant or materials not supplied by the Contractor, pursuant to the Contract Agreement.

If any proceedings are brought or any claim is made against the Employer arising out of the matters referred above, the Employer shall promptly give the Contractor a notice thereof. Unless the Contractor fails to notify the Employer within 28 days after receipt of such notice that the Contractor intends to conduct negotiations for the settlement of any such proceedings or claim, then the Employer shall make no admission that may be prejudicial to the defense of any such proceedings or claim.

The Contractor shall be entitled to disclaim responsibility for any design, data, drawing, specification or other document, or any modification thereof provided or designed by or on behalf of the Employer, which the Contractor considers to be an infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract, by giving a written notice of such disclaimer to the Employer.

1.11.5 Manufacturer's Authorization/ Certificates

If the Contractor does not manufacture or otherwise produce the goods to be supplied and installed under the Contract, then the Contractor shall give details of the name and nationality of the manufacturer of such goods. The Contractor shall also provide the Manufacturer's Authorization, showing that the Contractor has been duly authorized by the manufacturer or producer of the goods to supply and install the goods in the Employer's country, and that the manufacturer or producer of the goods has extended his full guarantee and warranty to the Contractor for the goods to be supplied and installed under the Contract.

The Contractor is responsible for ensuring that the manufacturer complies with eligibility requirements of the Contract, and that any goods to be provided by the manufacturer also comply with eligibility requirements of the Contract. At the Employer's request, the Contractor may be required to provide evidence of the origin of any materials, equipment and services which he intends to use for executing the Contract.

The Contractor shall supply to the Engineer an original signed certificate from the manufacturer stating that the goods comply in all respects with the provisions of the Contract and the relevant National or International Standards, and shall also submit a copy of the manufacturer's certified specifications.

1.11.6 Packaging Identification and Marking

All goods shall be packaged and clearly marked before shipping and delivery. All packaging materials shall be marked on two sides with indelible paint with the name of the Project, the Employer, and the Contract number, and shall also have marks indicating the contents.

1.11.7 Handling and Storage

All goods to be supplied shall be handled and stored with protective measures in accordance with the manufacturer's requirements or guidelines. Such protective measures shall be subject to the approval of the Engineer. All goods to be supplied shall then be handled and stored accordingly. The costs for these handling measures shall be deemed to be covered in the rates and prices of the Contract.

Loading, unloading and handling shall be carried out by the Contractor with the least possible impact using such handling equipment so as to prevent damage to the goods. The Contractor shall make arrangements to ensure that such equipment is used throughout transit, including loading and unloading from ships.

During transport, all goods shall be securely fastened in position to prevent movement. Securing chains shall be prevented from coming into contact with the exterior of the goods by inserting pillows or equivalents between the securing chains and the goods. It shall be the Contractor's responsibility to ensure that line cables, chains, hooks, metal bars and the like shall not be permitted to come into contact with the goods supplied.

For shipment of goods to be supplied from abroad, containerized transportation is acceptable, and if arranged by the Contractor, shall be informed to the Engineer prior to shipment. Notwithstanding any intention to utilise containers, all the goods shall be protected against the elements as appropriate and to the satisfaction of Employer.

1.11.8 Inspections and Acceptance

The manufacture and delivery of the goods shall be subject to inspections as required by the Engineer. Such inspections shall ensure that all goods to be supplied are complete and according to the requirements of the Contract.

The Contractor shall allow the Engineer free access to the place of inspection and shall provide all necessary services for a complete inspection by the Engineer.

The Engineer will perform final inspections to check and accept: that all goods have been delivered in good, clean condition, with no signs of physical damage; that handling and storage has been done in accordance with the manufacturer's requirements or guidelines; and that the delivery of goods are according to the requirements of the Contract and the Technical Particulars approved by the Engineer.

1.12 Inspections of Works and Installations

All works and installations executed by the Contractor shall be subject to inspections by the Engineer, who will determine if the works and installations are fit for the purposes for which the works and installations are intended.

No part of any works or installations shall be covered-up on site without prior inspection by the Engineer. If any part of any works or installations are covered-up on site by the Contractor before inspection by the Engineer, then the Contractor shall uncover any part of the works or installations, or shall make openings in or through the same, as required by the Engineer, and shall reinstate and make good such part or parts, all at the cost of the Contractor. In such cases, the Time for Completion shall not be adjusted to the extent that the Contractor has thereby been delayed or impeded in the performance of any of its obligations under the Contract.

1.13 Daywork – Work to be executed as Dayworks

The Contract includes priced Dayworks Schedules to allow such work as specified for works under the Contract to be valued and executed as Dayworks, which will be administered separately according to the Conditions of Contract.

1.14 Provisional Positions in Bill of Quantity

The scope of the works might be extended during project implementation. Upon project development, the Employer might take the decision to drill additional new wells, or it might be identified that the condition of some of the E&M installations is poor and requires replacement. Depending on availability of funds, additional measures might be implemented.

To reflect this possibility, additional positions are included in the Bill of Quantities and referred to as "Provisional Sums". This provisional sums positions should essentially be differentiated from the normal provisional sums including dayworks and contingiencies.

2. PERFORMANCE REQUIREMENTS

2.1 Contractor's Responsibilities

The Contractor shall be fully responsible for all areas of the work sites in the execution of the Contract. The Contractor shall exert full control over the actions of all his employees and other persons with respect to the use and preservation of

property and existing facilities, except such controls as may be specifically reserved to the Engineer or others.

The Contractor shall be responsible for full compliance with the requirements of all duly constituted and authorized Agencies concerned with any or all of the work under the Contract. The Contractor shall give to the Engineer copies of all written notices required by the Agency and the responses given.

2.2 Program

The Contractor shall submit a Program as required by the Contract in five copies.

The work program shall show the logical sequence and correlation between the categories of activities (works). The Contractor's Program shall be in the form of a bar-chart (Gantt Chart). The Work Program shall be produced using common scheduling software, compatible with MS project, and in such a detail that the critical path can be calculated.

The work program shall be able to calculate the critical path and to generate the rate of progress and the cumulative quantity or percentage of work expected to be achieved on each activity by the end of each month.

The horizontal axis of the bar-chart shall be a time scale, expressed either in absolute time or in relative time referenced to the beginning of the Contract, and expressed in months or weeks. Rows of bars shall show the beginning and ending dates of the individual tasks of the Program.

The Contractor shall allocate resources and related cost to each activity in the work Program and calculate the cash flow.

The Program shall include all major activities and work items for each Section of the Contract, including submission of any documents, tests and training. The Contractor is expected to use several teams working on different Sections of the Contract.

The work programme shall show as a minimum for each site:

- Mobilization
- Civil works construction
    - Preparation of structural design, design approval
    - Equipment and material proposals and approval
    - Temporary works
    - Earthworks
    - Drilling works – well development phases in accordance with defined sequencing
    - Concrete works, concrete curing period, period for water tightness testing (if applicable)
    - Architectural works
    - Steel works
    - Road works
    - Landscaping works

  - Pipe laying works, construction of pipe bridges and culverts, pipe pressure testing, pipe cleaning and disinfection
- Mechanical works (valves, pumps, and other major mechanical equipment)
  - Submission of proposals for equipment and material and approval / ordering date
  - Manufacturing, delivery to site
  - Installation, testing
- Electrical works (MV switchgear, transformers, LV switch gear and MCCs and other major electrical equipment)
  - Preparation of electrical execution design, design approval
  - Submission of proposals for equipment and material and approval / ordering date
  - Manufacturing, delivery to Site
  - Installation, cabling, testing
- ICA works (instruments, control and automation hardware, and other major ICA equipment)
  - Preparation of ICA execution design, design approval
  - Submission of proposals for equipment and material and approval / ordering date
  - Manufacturing, delivery to site
  - Installation, cabling, programming, testing
- Preparation and approval of as-built documentation, O&M Manuals, and Functional Design Specification
- Preparation / submission / approval of commissioning / testing program of the entire system
- Defects Notification Period

The program shall show important milestones for design, construction, testing, commissioning and contract commencement date and scheduled taking-over date.

The Program shall comply with the Intended Completion Date as specified in the Contract. The Program shall also take into account all factors affecting the Contract, including public holidays, weather, groundwater and geotechnical conditions.

The work program shall consider, when calculating periods for execution:

- The prevailing climatic conditions
- The periods for approval of submittals by the Engineer / Employer
- The periods required to obtain various permits and approvals from other stake holders than the Engineer or Employer
- ESHS requirements
- Periods of work of sub-contractors

The Contractor shall be solely responsible for internal coordination and management of the execution design and construction process. Consent to the Contractor's Program by the Engineer shall not relieve the Contractor of his duties and responsibilities under the Contract.

The Program shall be updated when requested by the Engineer but as a minimum on a monthly basis (as an attachment to the monthly report, in paper and electronic format) to show actual progress and any revisions necessary to achieve completion.

2.3 Management Meetings

Management Meetings shall be organized according to the Contract.

The Contractor shall schedule and hold regular Management Meetings with the Engineer at least every two weeks and at other times as required by the progress of the work. Further regular site meetings shall be conducted as agreed with the Engineer.

The Contractor and the Engineer shall be represented at each Progress Meeting. The Contractor may, at his discretion and cost, request the attendance of representatives of his suppliers and manufacturers.

2.4 Monthly Progress Reports

The Contractor shall submit Monthly Progress Reports to the Engineer in five copies within seven days from the end of the respective month. The actual work done shall be superimposed upon the Contractor's Program. The Contractor shall furnish an explanation of any deviation from his Program and shall state his ways for improving progress in the event of this be lacking in any respect.

The Contractor shall maintain photographic records during execution of the Contract. The Contractor shall submit such records when requested by the Engineer.

The costs for all reports, photographic records, and any Program updates of the Contractor shall be deemed covered by the Contractor within the rates and prices of the Contract.

2.5 Preparation of Technical Particulars

As soon as practically possible, the Contractor shall perform site investigations, and thereafter prepare Technical Particulars for all associated goods to be supplied and installed under the Contract for all sites.

Technical Particulars shall be presented using tabular format with both qualitative and quantitative data and shall be complete and shall comprise precise and substantial specifications, to the full satisfaction of the Engineer.

Technical Particulars shall include a Cover Page displaying the following as minimum:

- Name of the Project;
- Name of the Contractor;
- Name and identification of the Contract;
- Name and identification of the installation; and
- Date (day, month, year) of the document.

The size of these documents shall be A4 size (297 by 210 mm) with inserts and appendices of maximum size of A3 size (420 by 297 mm).

The Contractor shall submit Technical Particulars to the Engineer for his approval.

Approval by the Engineer shall not absolve the Contractor of any of his responsibilities and obligations under the Contract. Approval by the Engineer shall only indicate that the Engineer has no objection to the works and installations proceeding in accordance with the Contractor's Technical Particulars.

2.6 Preparation of Working Drawings

As soon as practically possible, the Contractor shall perform site investigations, and thereafter shall prepare Working Drawings for works to be performed under the Contract, or any other works required by the Engineer, prior to performing the work.

Working Drawings shall be comprehensive and present sufficient and substantial details of existing and new pipe works, and associated temporary and permanent works, including but not limited to the following:

- Site data, including geodesic coordinates and levels;
- Existing facilities / structures, pipe works and utilities;
- New pipe works to incorporate or replace existing off-takes; and
- New pipe works to reinstate existing service connections of existing off-takes.

The Contractor shall be responsible for obtaining all necessary field data and information necessary to prepare these Working Drawings.

The Contractor shall submit Working Drawings to the Engineer for his approval.

Approval of the Working Drawings by the Engineer shall not be construed as a complete check but shall only indicate that the general method of construction, installation and detailing is satisfactory. Approval by the Engineer shall not be construed as permitting any departures from the Contract and shall not relieve the Contractor of the responsibility for any error presented on the Working Drawings.

2.7 Preparation of Method Statements

As soon as practically possible, the Contractor shall perform site investigations, and thereafter shall prepare Method Statements for works to be performed under the Contract, or any other works required by the Engineer, prior to performing the work.

Method Statements shall be complete and comprehensive, with precise and substantial information, all to the full satisfaction of the Engineer, and shall include but not be limited to the following:

- Details of the work site;
- Protection of existing structures and utilities;
- Handling of goods and materials;
- Installation methods and equipment;
- Protection of installed goods until completion;
- Operation of existing utility services;
- Salvage of equipment and materials; and

- Work program and time schedule.

Method Statements shall include a Cover Page displaying the following as minimum:

- Name of the Project;
- Name of the Contractor;
- Name and identification of the Contract;
- Name and identification of the installation; and
- Date (day, month, year) of the document.

The size of such documents shall be A4 size (297 by 210 mm) with inserts and appendices of maximum size of A3 size (420 by 297 mm).

The Contractor shall submit Method Statements to the Engineer for his approval.

Approval by the Engineer shall not absolve the Contractor of any of his responsibilities and obligations under the Contract. Approval by the Engineer shall only indicate that the Engineer has no objection to the works and installations proceeding in accordance with the Contractor's Method Statements.

2.8 Daily Construction Records

The Contractor shall keep daily activity records for each borehole / each site. The records shall contain the information as specified in sections 11.3.10 and 11.4.16.

2.9 Supply of As-Built Drawings

The Contractor shall supply As-Built Drawings for all works shall perform this work in parallel with construction progress. As-Built Drawings and associated site records shall be available for inspection by the Engineer at any time.

As-Built Drawings shall include a title block located in the lower right-hand corner of the drawing, which shall display the following as minimum:

- Name of the Project;
- Name of the Contractor;
- Name and identification of the Contract;
- Name and identification of the installation; and
- Date (day, month, year) of the drawing.

As-Built Drawings shall be presented on A3 size (420 mm x 297 mm) sheets, arranged in sequential order for each portion of work. All individual drawings shall be clearly marked "As-Built" and shall accurately and substantially represent as-built conditions including any field modifications.

The Contractor shall submit two draft copies of the As-Built Drawings for all works of the Contract to the Engineer for his approval.

The Engineer will, within 14 days after receipt of the documents, either issue a Notice of Approval, or return a draft copy to the Contractor with noted exceptions.

If the draft copy of the As-Built Drawings is returned to the Contractor with noted exceptions, then the Contractor shall address the noted exceptions at his own cost.

Thereafter, the Contractor shall resubmit the As-Built Drawings at his own cost, and the procedures above shall be repeated.

If the Engineer fails to issue a Notice of Approval or fails to provide the Contractor of the draft copy with noted exceptions within 14 days after receipt of the documents, then the Contractor has the right to notify the Employer in writing that he deems the As-Built Drawings to be approved, by Notice of Deemed Approval, as of the date of his notice.

Upon approval, whether by the Engineer or as deemed by the Contractor, the As-Built Drawings for all works of the Contract shall be submitted as five hard copies and one soft copy on CD-ROM/Flash Disk to the Engineer as final version. All individual drawings shall be clearly marked "Final" and hard copies shall be signed by the Contractor.

2.10 Project Sign Boards

The Contractor shall fabricate project sign boards according to the requirements of the Contract or the written instructions of the Engineer and shall erect these sign boards at locations indicated by the Engineer. The sign boards shall be properly lettered and constructed using substantial design and durable materials, all of which shall be subject to the written approval of the Engineer, before fabrication begins.

2.11 Surveying and Setting Out

All works and installations shall be done to the lines, grades and elevations established using suitable surveying equipment as approved by the Engineer. Basic horizontal and vertical control points shall be established by the Contractor prior to executing the works and installations, including any temporary points to be used as datum, but only after checking by the Engineer.

2.12 Survey Data

All field books, notes and other data developed by the Contractor in performing surveys required as part of the works and installations shall be made available to the Engineer for examination throughout the Contract period. All such data shall be submitted to the Engineer with the other documentation required for final acceptance of the work. Surveys for the measurement and preparation of interim payments shall be done in the presence of the Engineer.

2.13 Layout Data

The Contractor shall keep neat and legible notes of measurements and calculations made by him in connection with the layout of the works and installations. Copies of such data shall be provided to the Engineer upon his request for use in checking the layout.

2.14 Protection of Existing Structures and Utilities

The Contractor shall assume full responsibility, at no additional cost to the Employer, for providing adequate protection of all buildings, structures, and utility services, either public or private, which may be damaged by his activities, whether or not they are presented in any document of the Contract, or any document approved by the Engineer. The Contractor is responsible for contacting and informing any Third Party as part of this provision, whether the relevant Third Party is a public agency or a

private organization and maintaining close liaison with them throughout the Contract period.

The Employer accepts no responsibility whatsoever for any omissions or for the correct representation in any document of the Contract of any existing building or service.

Prior to commencement of any work or installation, the Contractor shall excavate trial pits, and shall inform the relevant Third Party as necessary, to determine the exact location of any buried structure or service which may be in conflict with the execution of the works and installations. The Contractor shall also search for any buried structure or service not shown on any document, but which he or the Engineer may believe to exist.

The Contractor shall provide adequate temporary support to all existing structures and services which are exposed or partially exposed or otherwise weakened by any excavation. The Contractor shall immediately notify the Engineer and any relevant Third Party if any damage occurs and shall immediately provide for quick and complete repair. No separate payment shall be made to the Contractor for such repairs.

Whenever structures or services are encountered which may conflict with the execution of the works and installations, the Contractor shall advise the Engineer who will determine the extent of the conflict. Early scrutiny by the Contractor is required to identify such conflicts, and to enable any relocation works of the affected structures or services to be prepared, in advance of the Contractor's activities.

If any existing structure or service conflicts with any work or installation to be executed under the Contract, then the Engineer may instruct the Contractor to perform works for permanently relocating the structure or service. If the structure or service is the responsibility of a Third Party, then the relevant Third Party must provide detailed instructions in writing before the Contractor would perform the work. The relevant Third Party may also perform part of the work, unless prior agreement is obtained in writing from the relevant Third Party that the work would be done by the Contractor instead.

In addition to the precautions to be taken with buried structures and services, the Contractor shall ensure that his plant and equipment do not damage pipelines or pipe supports above ground level, or any electricity or telephone overhead cables.

The costs for searching and locating buried structures and services, including the excavation of trial pits, and the protection of any existing building or service, shall all be deemed fully covered by the Contractor within the rates and prices of the Contract.

2.15 Operation of Existing Utility Services

The Contractor shall obtain the written approval of the Engineer before operating any valve, switch, or other control for any existing utility service.

Early scrutiny by the Contractor is required to identify such operations, and to enable written approvals to be also obtained from the Employer or the relevant Third Party, in advance of the Contractor's activities.

2.16 Mobilization, Site Setup, Demobilization

The Contractor shall deliver to and remove from the site all workmen, materials and equipment required to successfully complete the project. The Contractor shall also prepare the site for performance of the project work. Site preparations may include, but are not necessarily limited to, addition of work area fencing, removal and replacement of building roofs, protection of existing facilities and equipment, construction of wastewater discharge piping, and placement of equipment. The Contractor is responsible for site security and safety from the project start date until site clean-up and restoration is completed. A portable toilet and sanitary facilities for project workers shall be provided by the Contractor. This task includes per diem and other costs that may not be shown as line items on the bid schedule.

All solid waste generated, and site alterations performed by the Contractor during the project shall be addressed by the Contractor so that the site is returned to its pre-project state. Wastes, including trash, unused chemicals and solids removed from the well, shall be disposed of properly. Documentation of proper waste disposal must be provided to the Engineer and the Employer before this task is considered complete.

2.17 Salvage of Equipment and Materials

Existing materials and equipment removed by the Contractor shall not be reused in the works and installations to be executed under the Contract, except where otherwise specified or indicated in the Contract, or as instructed or approved in writing by the Engineer.

Any existing materials or equipment that are removed by the Contractor and are not reused as a part of the works and installations to be executed under the Contract, shall remain the property of the Employer or the relevant Third Party. Such materials or equipment shall be transported and delivered by the Contractor in good condition to the designated location of the Employer or the relevant Third Party, as instructed by the Engineer.

Any materials or equipment damaged during removal, storage, handling or transportation through carelessness or improper procedures by the Contractor shall be replaced by the Contractor in kind with new items at his own cost.

2.18 Clean-Up Work

The Contractor shall be responsible for the clean-up of all working areas, whether public or private, which are affected by his operations. Clean-up means that the working areas are restored to their original form and conditions upon completion of the works and installations of the Contract.

3. FACILITIES AND SERVICES FOR THE ENGINEER

3.1 General Provisions

The Contractor shall provide in the rates and prices of the Contract for his attendance on the Engineer, including provision of office accommodation, equipment, labor and materials necessary to enable the Engineer and his staff to perform checks on the execution of the works and installations of the Contract in the Project Area.

3.2 Site Offices

The Contractor shall arrange and maintain Site Office accommodation for the sole use of the Engineer and his staff for the time period specified in the Contract or as required by the Employer. It is proposed to accommodate the Engineer in a part of the existing water office at Tiwi which is the property of the Employer

The Contractor will ensure payment of electrical power and water supply as well as daily cleaning. The Contractor shall provide clean towels daily and an adequate supply of soap and toilet paper.

The costs of water supply, electricity and security services and supply of consumables for the contract period shall be deemed covered by the rates and prices in the Contract.

3.3 Office Furniture and Equipment

The Contractor shall provide the Engineer with the Office Furniture and Equipment as described in the table below. The Contractor shall ensure that this Office Furniture and Equipment are available for the use of the Engineer for the time period specified in the Contract or as required by the Employer.

The Contractor shall provide the Engineer with the specifications for all of the Office Furniture and Equipment, which shall be subject to the Engineer's written approval, before placing an order and supplying the goods.

Description	**Amount**
(i) Personal Computer with latest configuration available. (approved Make)- 2 No. with following features, plus UPS: **Laptop Dell Inspiran 15 7000 Gaining-7577 (Ï7-7700HQ 3.8 GHz/128 SSD +1TB/16GB/W10H/ 15.6")** Processor: Intel Core i7-7700HQ 3.8 GHz (7 th Gen) Storage Unit: 128 SSD + 1TB SATA5400 rpm RAM: 16GB (2x8GB) DDR4 2400Mhz Graphic: NVIDIA GeForce GTX 1050 Ti 4GB GDDR5 Display: 15.6" FHD (1920 x 1080) Connections: 10/100/1000 Mbps Ethernet LAN Wi-Fi 802.11 b/g/n, Bluetooth v4.2	02

Description	Amount
Optical: N/A I/O: USB-C, USB 3.0,HDMI 2.0,RJ45,Thunderbolt 3,Camera Web HD, Car Reader Keyboard: Ingles, Backlit keyboard with numeric keypad Peso: 2,65 kg	
(ii) Desktop: Intel Pentium 640GB 2.66 Ghz, core duo, DVD WR, 4GB RAM, 17'' Screen, Windows 7 Professional, MS Office 2010 Professional, 650 AV UP and antivirus. (iii) Colour Laserjet Printer (suitable for A4/A3 size paper) or equivalent	01 01
Desk (1 m x 1.5 m) with six lockable draws	03
High back chairs	03
Lockable steel filing cabinet (with minimum four drawers)	02
Bookshelves (with minimum four shelves)	02
Power type fire extinguishers	01
Safety helmets (BS 5240)	04
Rubber boots (pair)	04
Weatherproof protective clothing (set)	04
Tea set complete with 6 cups and saucers	01
Gas cylinders with double ring cookers	02

The Contractor shall also supply all office stationery for the use of the Engineer and his staff whenever requested in writing by the Engineer.

The Contractor shall promptly provide suitable replacements should any of the above Office Furniture and Equipment need to be sent away for repair. The Contractor shall also fill and maintain the gas cylinders of the double ring cookers for the contract period specified in the Contract or as required by the Employer.

The Office Furniture and Equipment shall revert to the Employer at the end of the Contract.

3.4 Surveying Equipment

The Contractor shall provide the Engineer with the Surveying Equipment as described in the table below and maintain until the end of the Contract.

Description	Amount
Total station surveying instrument	01
Heavy duty tripod	01
Telescopic metal leveling staff with bubble	01
100 m steel tape	01
30 m fiber reinforced tape	01
5 m steel tape	01
Ranging rods	02
Collapsible stands for ranging rods	02
Steel arrows	02
Plumb bob	01
Club hammer	01
900 mm spirit level	01

The total station surveying instrument shall be an electronic theodolite integrated with an electronic distance meter to read slope distances from the instrument to a particular point. The instrument shall be supplied complete, including computer software for data processing.

The Contractor shall provide the Engineer with the specifications for all the Surveying Equipment, which shall be subject to the Engineer's written approval, before placing an order and supplying goods.

The Contractor shall also provide a sufficient supply of pegs, nails, chalk, paint and other small tools required for checking the setting out the works and installations.

The Contractor shall be responsible for the maintenance and security for all the Surveying Equipment and shall promptly provide suitable replacements should any equipment need to be sent away for repair or becomes lost or stolen. The equipment shall revert to the Employer at end of contract.

3.5 Labor

The Contractor shall supply the following staff for the sole use of the Engineer and his staff for the time period specified in the Contract or as required by the Employer.

Description	Amount
Chainmen	03
Clerk / messenger	01
Drivers	02

The drivers shall have minimum 10 years' experience. The Contractor shall be responsible for payment of all overtime, accommodation, and other associated costs of the drivers, as required to enable the Engineer and his staff to perform checks on the execution of the Contract in the Project Area.

3.6 Vehicles

The Contractor shall provide the Engineer with the Vehicles as described in the table below and maintain until the end of the Contract.

Vehicle Type	Amount	Minimum Requirements
Double cabin 4WD pick-up truck	02	Double Cab 4WD GLS High Grade, Diesel, 2.5 liter displacement, 5-speed manual, with air conditioning Front and Rear :265/70R16 Tyres, Alloy Wheels, Airbag (Driver & Passenger), ABS with EBD, USB Port, Audio switch on steering wheel, Hands free, Wide 2DIN AM/FM CD display audio, Step bumper-stylish type, Rearview camera, FR skid plate and Floor under cover, Heavy Duty type, Side step(pipe type), Front fog lamp

The vehicles shall be provided to the Engineer new from the supplier and shall be comprehensively insured for all drivers and passengers.

The Contractor shall provide the Engineer with the specifications for the Vehicles, which shall be subject to the Engineer's written approval, before placing an order and supplying or leasing the Vehicles.

New vehicles shall be provided within 30 days after the commencement date. The Contractor shall provide similar rented vehicles to the approval of the Engineer, at no extra cost, within two weeks after the date of the Letter of Acceptance, and until such time as the Engineer takes delivery of the vehicles supplied or leased under the Contract.

The vehicles shall be maintained at the expense of the Contractor on a regular basis. The Contractor shall provide a replacement vehicle of similar standard, wherever a vehicle provided under the Contract is not available for use because of un-serviceability or because of regular maintenance taking more than four hours a week.

New vehicles shall revert to the Employer at the end of the Contract.

3.7 Other Items

The Contractor shall be responsible for the costs of field allowances of the Employer's staff for supervision, commissioning and training, when working outside the normal workstation.

The Contractor shall be responsible for the costs of any diversion of utility services, including any modifications or relocations of existing electrical and/or optic fiber and telephone installations.

The Contractor shall be responsible for the costs of accommodation including the furniture, water supply and electricity of the Engineer and his staff, for the Contract

period. The type and duration of accommodation shall be subject to the Engineer's approval before renting the accommodation.

The Contractor shall supply and maintain: digital cameras of 8 Mega-Pixels specification with 512 MB memory cards; and mobile telephones, including payment of all monthly telephone bills; for the Contract period. The Contractor shall provide the Engineer with the specifications of the cameras and mobile telephones, which shall be subject to the Engineer’s written approval, before placing an order and supplying the goods. The goods shall revert to the Employer at the end of the Contract.

The Contractor shall insure all office furniture and equipment, and surveying equipment provided to the Engineer against fire and theft. The Contractor shall also insure all vehicles provided for the Engineer, which covers the insured vehicle and party, and also covers third parties, and also covers fire and theft, all on No-Fault basis.

4. ENVIRONMENTAL REQUIREMENTS

4.1 Contractor's Responsibilities

The Contractor shall fully comply with the environmental requirements of the Contract. In particular, the Contractor shall:

- Ensure environmental awareness among his staff and sub-contractors so that they are fully aware of, and understand, these environmental requirements;
- Notify the Engineer immediately in the event of any accidental infringements of these environmental requirements to enable appropriate remedial action to be taken immediately by the Contractor;
- Notify the Engineer, at least 14 days in advance, of any activity the Contractor has reason to believe may have significant negative impacts, so that mitigative measures may be implemented in a timely manner;
- Undertake rehabilitation of all areas affected by his activities and to restore them to their original states, as determined by the Engineer; and
- Undertake the required works and installations within the designated working areas.

4.2 Engineers' Responsibilities

The Engineer will designate all working areas and monitor and enforce compliance of the Contractor with the environmental requirements of the Contract on a continuous basis. In particular, the Engineer will:

- Communicate to the Employer and Contractor, at least 14 days in advance, any proposed actions which may have negative impacts on the environment;
- Maintain a record of complaints from the public, and communicate these complaints to the Employer and Contractor; and
- Facilitate communication between the Contractor and Employer, and any relevant Third Party, in the interest of effective environmental management.

4.3 Working Areas

The Contractor shall only perform activities in designated working areas. Working areas are those areas required by the Contractor to execute the works and installations, and those areas as approved by the Engineer. These areas include the sites of permanent works, burrow areas and haul roads between the work site and burrow areas. If necessary, working areas will be demarcated during the period of the Contractor's activities. The Contractor shall not be permitted beyond the designated working areas.

4.4 Protection of Flora, Fauna and Natural Features

The Contractor shall protect natural features, flora and fauna in the vicinity of the work sites and prevent or minimize damage or disturbance, particularly:

- No plant species may be removed unless approved by the Engineer or unless they are listed as invasive or alien species;

- All fauna (including domestic livestock) within and surrounding the site shall be protected, and they shall not be caught or killed; and
- Natural features shall not be defaced or painted or otherwise tampered with, even for survey purposes, and any features defaced by the Contractor shall be reinstated by the Contractor to the full satisfaction of the Engineer.

The Contractor shall restrict its activities to ensure minimal vegetation disturbance.

4.5 Conservation and Stockpiling of Topsoil

Topsoil shall be excavated no later than five days before the start of work, such as:

- Areas to be excavated for the permanent works;
- Areas to be occupied by roads, including temporary roads;
- Areas for the storage of fuels and oils;
- Areas to be used for batching/mixing of concrete;
- Areas for stockpiling of materials; and
- Areas for the Contractor's site camps.

Topsoil shall be stored in stockpiles less than one meter in height. This stockpiled soil shall be used for rehabilitation purposes. Grass shall not be separately removed prior to stripping of topsoil. Topsoil shall not be mixed with any other material, and erosion of topsoil stockpiles shall be prevented by the Contractor.

4.6 Stockpiling and Disposal of Materials

All stockpiling sites shall be subject to the approval of the Engineer. The stockpiles shall be located in designated sites, or areas such as exhausted borrow pits or quarries. Material shall be stockpiled in such a way as to minimize the spread of materials and the impact on the natural vegetation. The Contractor shall provide permanent reinstatement of areas used for stockpiling upon completion of the works and installations.

The Contractor shall be responsible for making all arrangements for the disposal of all surplus material from any excavation or stockpile. Costs for such disposal shall be deemed covered by the Contractor within the rates and prices of the Contract.

4.7 Erosion Control

The Contractor shall take all reasonable measures to prevent soil erosion resulting from a diversion, restriction or increase in the flow of storm water or stream flow caused by the Contractor's activities. Erosion prevention measures shall be implemented by the Contractor to the full satisfaction of the Engineer.

All storm water shall be adequately controlled and disposed. No erosion will be tolerated at the work sites. Areas affected by the Contractor's related activities shall be monitored regularly by the Contractor for evidence of erosion. Areas particularly susceptible to erosion are areas stripped of topsoil, soil stockpiles and slopes of steep gradient.

Where soil erosion does occur, the Contractor shall reinstate such areas and any other areas damaged by the erosion, all to the full satisfaction of the Engineer.

4.8 Prevention of Pollution

The Contractor shall prevent pollution of drains and watercourses by sanitary wastes, sediment, debris and other substances resulting from his activities. No wastes shall be permitted to enter any drain or watercourse or any sanitary sewer, unless satisfactorily treated to the approval of the Engineer.

4.9 Dust Control

The Contractor shall be responsible for the control of dust arising from his activities. Control measures may include regular spraying of working/bare areas with water, at an application rate that will not result in soil erosion, to the full satisfaction of the Engineer. Dusty materials in piles or transit shall be covered as practicable as possible to prevent blowing.

The Contractor shall also establish communication platforms for complaints and compliments measures as part of his dust control activities.

4.10 Odour Control

The Contractor shall take reasonable measures to control nuisance odor whenever such odors arise. The Contractor shall maintain the work sites free of trash, garbage, and debris as part of his activities to control nuisance odor, and shall fully cover and secure haul truck cargos during material transport on public roadways.

The Contractor shall clean-up and properly dispose of excavated material that is deemed odorous. If odorous material is located on public roadways or walkways, clean-up methods shall consist of wet spray sweeping or vacuuming.

Other control measures may include reducing the amount of time that excavated material is exposed to the open atmosphere, or covering such stockpiles of excavated material with polyethylene sheeting and securing with sandbags or an equivalent method to prevent the cover from being dislodged by the wind. The Contractor shall obtain the approval of the Engineer prior to the use of any chemical application for controlling odor. This method shall be used only when other methods are impractical.

The Contractor shall locate combustion engines away from sensitive receptors such as fresh air intakes, air conditioners, and windows. The Contractor shall establish a staging zone for trucks that are waiting to load or unload material at the work site, in a location where the diesel emissions from the trucks will not be noticeable to the public.

The Contractor shall control nuisance odors associated with diesel emissions by turning off diesel combustion engines of his equipment not in active use and dump trucks that are idling while waiting to load or unload material for five minutes or more.

The Contractor shall also establish communication platforms for complaints and compliments measures as part of his odor control activities.

4.11 Noise Control

The Contractor shall take reasonable measures to avoid unnecessary noise. Such measures shall be appropriate to maintain the legal noise levels applicable to each area.

All of the Contractor's machinery and vehicles shall be equipped with practical sound muffling devices and shall be operated in a manner to cause the least noise consistent with scheduled execution of the Contract.

During the Contractor's activities on or adjacent to occupied buildings and when appropriate, the Contractor shall erect screens or barriers effective in reducing noise in the building, and shall conduct his operations to avoid unnecessary noise which might interfere with the activities of building occupants.

The Contractor shall also establish communication platforms for complaints and compliments measures as part of his noise control activities.

4.12 Fire Prevention and Control

The Contractor shall take all the necessary precautions to ensure that uncontrolled fires are not started as a consequence of his activities on site. The Contractor, his subcontractors and all of his staff are expected to be fully aware and conscious of fire risks. The Contractor shall hold fire prevention talks with his staff to create an awareness of the risks of fire. Regular reminders to his staff on this issue are required.

The Contractor shall ensure that there is adequate fire-fighting equipment on site.

The Contractor shall be liable for any costs incurred by any organization called to assist with fighting fires and for costs involved in the rehabilitation of burnt areas, property and/or persons, should the fire be the result of the Contractor's activities.

4.13 Traffic Control

The Contractor shall comply with all the applicable Laws of the Employer's Country with regard to road safety and transport. The Contractor shall instruct his drivers and equipment operators that vehicles will be expected to comply with all road ordinances, such as speed limits, road-worthiness, load securing and covering.

4.14 Movement of Vehicles

The Contractor’s vehicles shall be permitted only within the designated working areas or on existing roads, as would be required to complete their specific tasks. Vehicles are not permitted on re-vegetated areas, and site traffic shall be limited to prevent unnecessary damage to the natural environment.

The Contractor shall not enter for any deliveries or occupy for any other purpose with men, tools, equipment, materials, or with materials excavated from any trench or pit in any private property outside the designated way-leaves, without written permission from the owner and/or tenant of the property.

The Contractor shall arrange with property owners to establish and maintain temporary access roads to various parts of his site as required to complete the works and installations at his own cost. Such roads shall be available for the use of all others performing work or furnishing services in connection with the Contract.

4.15 Social Disruption

The Contractor shall prevent inconvenience as far as possible to the owners and occupants of properties adjacent to the designated working areas.

The Contractor shall give at least seven days' notice to the residents in the vicinity of his activities of his intention to begin activities in their area.

The Contractor's staff shall in no way be a nuisance to nearby residents. Any complaints received by the Engineer will be addressed and the relevant persons shall be removed from the work site.

The Contractor shall ensure that access to property is not unreasonably disrupted. When it is necessary to temporarily deny access to owners or tenants to their property or when any utility service connection must be interrupted, the Contractor shall give written notice sufficiently in advance to enable the affected persons to provide for their needs. Notices shall include appropriate information concerning the interruption and instructions on how to limit their inconvenience.

4.16 Protection of Public Health

The Contractor shall be responsible for the protection of the public health, and public and private property, from any dangers associated with his activities, and for the safe and easy passage of pedestrians and traffic in areas affected by his activities.

Any excavations, material dumps, spoil dumps or other obstructions likely to cause injury to any person or thing shall be suitably fenced off and at night marked by red warning lights.

4.17 Protection of Public and Private Property

The Contractor shall protect, shore, brace, support, and maintain all structures, underground pipes, conduits, drains and other underground structures uncovered or otherwise affected by his activities. All pavement, surfacing, driveways, curbs, walks, buildings, utility poles, guy wires, fences and other surface structures affected by the Contractor's activities, together with all sod and shrubs in yards and parking, shall be restored by the Contractor to their original condition, whether within or outside the designated working areas. All replacements shall be made with new materials, without any additional cost to the Employer.

The Contractor shall be responsible for all damage to structures, streets, roads, highways, shoulders, ditches, embankments, culverts, bridges, and any other public or private property, regardless of location or character, which may be caused by transporting equipment, materials, or men to or from the designated working areas, or any part or site thereof, whether by him or his sub-contractors.

The Contractor shall make satisfactory and acceptable arrangements with the owner, or the agency having jurisdiction thereupon, of any damaged property concerning its repair or replacement, or payment of any costs incurred in connection with the damage, without any additional cost to the Employer.

In the event of any claims for damage or alleged damage to property, the Contractor shall be responsible for all costs in connection with the settlement or defense against such claims. As a condition for final payment under the Contract, the Contractor shall furnish satisfactory evidence to the Employer that any claims for damage have been legally settled.

The Contractor shall minimize the cutting and removal of trees and other vegetation. All cutting and removal shall be subject to the approval of the Engineer, and if necessary subject to the approval of the relevant agency.

4.18 Fences

The Contractor shall maintain all existing fences affected by his activities until completion of the works and installations, all at no additional cost to the Employer. Where the Contractor's activities require the removal of fences from around private land, the Contractor shall inform occupants at least three days in advance to obtain their prior permission.

Fences which interfere with the Contractor's activities shall not be relocated or dismantled, until written permission is obtained from the owner of the fence, and the period the fence may be left relocated or dismantled has been agreed upon.

Where fences must be maintained across an easement, adequate gates shall be installed by the Contractor. Gates shall be kept closed and locked at all times when not in use.

On completion of any work across any tract of land, the Contractor shall restore all fences and/or boundary markers to their original or better condition and at their original location, without any additional cost to the Employer.

4.19 Site Camps

Where site camps are to be established, the need for removing topsoil from the site shall be investigated before site establishment. Removed topsoil shall then be stockpiled by the Contractor for use in rehabilitation of the site camp.

The site camp shall not be located in an environmentally sensitive area. Runoff from the site camp shall be prevented from entering any water bodies. All water requiring discharge shall be discharged in a manner approved by the Engineer.

The Contractor shall maintain all site camps and surrounding areas in a clean, tidy and orderly condition at all times.

4.20 Prevention of Oil and Fuel Spills

The Contractor shall take all measures necessary to protect surface and groundwater from contamination by fuels and lubricants. He shall:

- Bund all tanks for fuels, oils etc. to contain any possible spills;
- Provide spill mitigation equipment including absorbents, foam cover spraying equipment and oil skimmers; and
- Take immediate actions according to methods and procedures approved by the Engineer in case of any spills.

4.21 Temporary Drainage Provisions

The Contractor shall provide at his own cost for the drainage of storm water and such water as may be applied or discharged in order to execute the Contract.

Drainage facilities shall be adequate to prevent damage to the works and installations, the work site and adjacent property. Dikes shall be constructed as necessary to divert increased runoff from entering adjacent property (except in natural channels) in order to protect property, and to direct water to drainage channels or conduits. Stilling pools shall be provided as necessary to prevent downstream flooding.

4.22 Refuse and Litter

The Contractor shall keep all work sites clean and litter free. The Contractor shall provide refuse bins at all work sites and shall be responsible for the disposal of all litter generated by all his staff and his sub-contractors in a manner approved by the Engineer.

4.23 Work Stoppage

The Engineer shall have the right to order the Contractor to stop his activities in the event of significant infringements of the environmental requirements of the Contract, until the situation is rectified. In this event, the Contractor shall not be entitled to claim for any delays or incurred costs.

5. SITE CLEARANCE

5.1 Clearing Site

The Contractor shall demolish, break up and remove buildings, walls, gates fences, advertisements and other structures and obstructions, grub up and remove Trees. hedges, bushes and shrubs and clear the site of the works at such time, and: the extent required by the Engineer but not otherwise, subject to the provisions, of Cause 21 of the conditions of Contract: the materials so obtained shall so far as suitable be reserved and stacked for further use; all rubbish and materials not for use shall be destroyed or removed from the site, as directed by the Engineer.

Where top soil has to be excavated this shall be removed and stacked on site. After completion of construction, it shall be spread over the disturbed ground, any surplus being disposed of as directed by the Engineer.

Underground structures and chambers where required to be demolished, shall be demolished to depths shown on the Drawings or as directed. They shall be properly cleaned out and backfilled and compacted with suitable material to the directive and approval of the Engineer.

5.2 Vegetation

No allowance will be made for the cutting and removal of the crops, grass, weeds and similar vegetation. The cost of all such work will be held to be included in the rates entered in the Bills of Quantities for excavation.

5.2.1 Bushes and Small Trees

All bushes and small trees, the main stem of which is less than 500 mm girth at 1 meter above ground level shall be uprooted (unless otherwise directed by the Engineer) and burnt or otherwise disposed of as directed by the Engineer.

5.2.2 Hedges

Where directed by the Engineer hedges shall be uprooted and disposed by burning

5.2.3 Felling Trees

Where shown on the Drawings or directed by the Engineer, trees shall be uprooted or cut down as near to the ground level as possible, and the rates entered in the Bills of Quantities shall include for cutting down, removing branches and foliage, cutting useful timber into suitable lengths, loading, transporting no more than 1 Km and stacking or disposing of all as directed by the Engineer.

For the purpose of measurement trees cut down shall be classified according to their girth at 1 meter above ground level, the cost of grubbing roots shall be deemed to be covered by the rate for felling trees.

5.2.4 Grubbing-up Roots

Stumps and tree roots shall, unless otherwise directed, be grubbed up, blasted, burnt or removed and disposed of in approved dumps to be provided by the Contractor Where directed by the Engineer, the holes resulting from grubbing up shall be filled with approved materials, which shall be deposited and compacted in layers not exceeding 225mm loose depth, to the same dry density as that of the

adjoining soil. For the purpose of measurement, trees roots shall be classified according to the mean diameter of the stump measured across the cut.

5.2.5 Weed Control

The Contractor shall take all necessary precaution against the growth on the site of weeds and remove them as necessary throughout the period of works and maintenance. The finished base of all footways and elsewhere as directed shall be sprayed with an approved persistent total herbicide at the rate recommended by the manufacturer. The application shall be by an even spray in a high volume of water at about 0.7 to 0.11 liters per square meter. After this application the footways shall receive at least two further watering before the surface is sealed.

6. EXCAVATIONS AND EARTHWORKS

6.1 General Provisions

This section of the Specifications refers to the technical and workmanship requirements for carrying out earthworks.

The Contractor shall carry out earthworks generally according to BS 6031:2009.

The Contractor shall provide all machinery, equipment, labor, materials, and incidentals required for all earthworks to be carried out.

The entire area within the limits of earthworks shall be executed to the lines, grades, elevations, slopes and cross sections as approved by the Engineer with added allowance for the thickness of any gravel base and paving where required. Slopes and drainage features shall present a neat uniform appearance upon completion of the work, subject to the full satisfaction of the Engineer.

The Contractor shall give the Engineer at least 10 days written notice of his intention to commence earthworks at any site and submit his Method Statements for work at each respective site as required by the Engineer, including details of the location, program of work and handling of material, and necessary supports, together with all ground levels and other particulars the Engineer may require.

The Contractor shall take and record levels of any designated area at any site in the manner specified or as agreed with the Engineer prior to the surface of that part of the site is disturbed or the work thereon is commenced. The Engineer shall be given at least three working days' notice to facilitate recording of ground levels by the Contractor in the presence of the Engineer.

Earthworks shall not be commenced on any portion of the Contract until, in the opinion of the Engineer, sufficient materials and equipment are on site, including dewatering pumps, to ensure the uninterrupted progress of the work after commencement of the work.

6.2 Borrow Pits

No borrow pits will be allowed to be opened on the site unless permission in writing has been obtained from the Engineer.

Before the excavation of an approved borrow area is commenced, the Contractor shall clear the surface and strip the topsoil in accordance with Clauses 3.4.1 and 3.4.2.

Borrow excavations shall be regular in width and shape and shall be properly graded and drained and finished with neatly trimmed slopes, and if so directed soiled and grassed.

The Contractor shall not be entitled to any additional allowance above the unit prices on account of any changes ordered by the Engineer in the amounts of materials to be secured from any borrow area, or on account of the designation by the Engineer of the various portions of the borrow areas from which materials are to be obtained, or on account of the depths of cut which are required to be made.

Measurement for payment of excavation in borrows areas will only include for the quantities of materials utilized for construction of embankments etc. Any costs of

excess excavated material, except if directed by the Engineer shall be borne fully by the Contractor.

6.3 Excavation for Fill

Where excavation reveals a combination of suitable and unsuitable materials, the Contractor shall, wherever the Engineer consider it practicable, carry out excavation in such a manner that the suitable materials are placed separately for use in the works without contamination by the unsuitable materials. If any suitable material excavated from within the site is, with the agreement of the Engineer, taken by the Contractor for his use, sufficient suitable material to occupy specified compaction, a volume corresponding to that which the excavated material occupied, shall, unless otherwise directed by the Engineer be provided by the Contractor from his own sources.

6.4 Compaction of Fill

All materials used in fill shall be compacted to specification by plant approved by the Engineer for that purpose. Maximum compacted thickness of such layer shall not be more than 200mm.

6.4.1 Standard Earthwork Compaction Test Procedure

The dry density of all compacted earth fill shall equal or exceed the percentage as determined by the Modified Proctor Compaction Test (ASTM D1557 − Method C, or BS 1377:1990). This method shall be applicable to determine the maximum dry density of each type of soil used in compacted fills, backfills, and embankments and to measure the relative compaction at optimum moisture content of compacted backfills.

6.4.2 Compaction Testing

Compaction tests on completed works shall be performed by the Contractor directly or using an approved testing laboratory selected by him, as required by the Engineer. The Contractor shall adjust his mode of operations in order to permit time to make tests and shall excavate and fill such holes as may be required for sampling and testing.

The costs of any compaction tests associated with any of the earthworks shall be deemed covered by the Contractor within the rates and prices of the Contract.

6.5 Excavated Materials

Excavated materials meeting the characteristics of the requirement of fill materials may be conserved for subsequent use or placed as earth fill immediately after excavation upon approval of the Engineer. The suitability of all excavated materials for specific purposes shall be determined by the Engineer. The Contractor shall not waste or otherwise dispose of any excavated materials suitable for filling.

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

Topsoil shall be stored separately from the main excavated material and shall not be disposed without the approval of the Engineer.

The Contractor shall remove to designated areas all surplus excavated material, rubbish and waste matter, and provide dumps and leaving them with an acceptable appearance, all to the full satisfaction of the Engineer.

6.6 Supporting and Dewatering of Excavations

Unstable and unsafe deep excavations shall be supported as necessary to prevent sliding or settling of the adjacent ground in order to avoid damage to existing features and to safeguard the work and workmen. The width of the excavation shall be increased as necessary, but only to provide space for sheeting, bracing, shoring, and other supporting installations. The Contractor shall furnish, place and subsequently remove such supporting installations upon completion of the work.

The design of the supporting of the excavations shall be made by the Contractor on Working Drawings, including any supporting calculations required, all of which shall be submitted as required by the Engineer for his approval. The Contractor shall be fully responsible for the supporting of the excavations, and for the prevention of slips and falls.

The Contractor shall not remove any temporary supports from the excavations until in the opinion of the Engineer the permanent work is sufficiently advanced to permit removal. As shoring is removed, any voids left by its removal shall be filled and compacted by the Contractor as specified.

Where the removal of excavation support is considered by the Engineer to endanger existing structures, thus making them liable to subsidence damage, the Contractor shall leave such supports permanently in place, only removing part as necessary in order to reinstate surfaces. Supporting materials shall not be left in the excavations as they are being filled up unless approved by the Engineer.

Every precaution shall be taken by the Contractor against slips and falls in the excavations, but if any slips or falls occur the Contractor shall at once make good including all surface restoration and reinstatement. If any such fall or slip disturbs or weakens any foundation or support to adjacent buildings or existing services, or causes a space to exist outside the new work itself, the Contractor shall execute such additional works as the Engineer may require and fill up the space so caused, with concrete if necessary, as the Engineer may require.

All excavation shall be kept free from water until the work is complete and for such time as the Engineer considers necessary to safeguard the permanent works.

The Contractor shall furnish, install and operate all necessary machinery, appliances and equipment to keep excavations free from water during construction and shall dispose of water to avoid damage to private property or to cause a nuisance or menace to the public. If any damage is caused by prolonged or excessive pumping, making good of such damage shall be carried out by the Contractor to the Engineer's full satisfaction.

Side berms shall be provided to prevent surface water from draining into excavations. Earth embankments shall be suitably protected from damage by erosion during construction. Any damage occurring shall be repaired by the Contractor at no extra cost to the Employer.

All extra costs associated with supporting and dewatering of excavations shall be deemed covered by the Contractor within the rates and prices of the Contract.

6.7 Trench Excavations for Water Pipe laying

All surface material including top soil which differs in any nature whatsoever from the sub-strata shall in every case be carefully set aside and stored separately from other excavated material. No extra claim will be allowed for setting aside surface matter or topsoil for later use.

Trench excavation shall be carried out with great care, true to line and gradient and as near as practicable to the size required for construction of the permanent work. Nowhere shall the external dimensions of the excavations be less than the dimensions of the permanent work shown on the Drawings or directed by the Engineer.

If the bottom of the excavation becomes weathered prior to pipe laying, due to fault of the contractor, the weathered soil shall be replaced with suitable compacted material to the original formation level at the contractor's expense. The pipe trench shall be excavated to a depth of 150 mm below the invert level of the pipe and refilled with sand, gravel or other selected materials free from stones and well rammed in order to provide a smooth bed for the pipes.

Where concrete pipes are laid in concrete, the pipe trench shall be excavated to a depth of 150 mm below the invert level or the pipe and the width shall be equal to the breadth of concrete bedding for the pipes plus 150 mm on either side.

Excavation for pipe trenches shall be of sufficient depth to give a minimum cover of 0.9 m over the top of the pipe. Where pipes/sewers cross under roads, minimum cover shall be 1.2 m, or such cover as may be directed by the Road Authority.

Where the pipeline is required to be laid at depth, which does not satisfy the minimum cover conditions set out above, the ground surface shall be brought up to the required level by banking the backfill or as directed by the Engineer.

No pipes shall be laid and no excavation filled in or covered with concrete until the formation has been inspected and permission to proceed with the work obtained.

Where UPVC or HDPE pipes are being laid, the bottom of the trench must be completely free from stones, and a smooth bed of fine material must be provided. Where the bed of the trench for UPVC or HDPE pipes is excavated in rock, this must be to a depth of not less than 100 mm below the bottom of the pipe, and refilled with selected fine granular material to make a smooth bed for the pipe.

The width of the trench to be excavated will depend on the size and type of pipe being laid as specified on the drawings. Sufficient width must be excavated to allow the pipe to be correctly bedded and aligned, and to allow for the joints to be correctly made. Generally, the grade of the pipe will conform to the grade of the ground, but the excavation must be deepened where necessary to avoid backfills in any section. Minimum gradients for sewer lines are shown on the drawings.

Any excavated material stored on site for backfilling or other purposes shall be deposited alongside the excavation at a minimum distance of 0.5 m in such a manner that it will cause no damage and as little inconvenience as possible.

6.8 Timbering of Excavations

The Contractor shall supply and fix outside the limits of the permanent Works all the timber necessary for support of sides and bottoms of the excavations, for the security of adjacent structures and properties and for every other purpose for which it

may be required, all to the satisfaction of the Engineer. The Contractor shall maintain such supports until in the opinion of the Engineer, the works is sufficiently advanced to permit the withdrawal of the support. Such withdrawal shall be executed only under the personal supervision of a competent foreman.

The Engineer may order excavations to be timbered or to be close timbered or may order timbering to be driven ahead of the excavation, or may order the adoption of any other method of supporting the sides and bottoms of the excavations as may appear to be necessary, and the Contractor shall adopt and shall make no charge for executing the adopted method.

The Contractor shall be responsible for any injury to the work and any consequential damage caused by or arising out of the insufficiency of the support he provides for his excavations or caused by or arising out of the removal of that support, and any advice, permission, approval or instruction given by the Engineer relative to that support or removal thereof shall not relieve the Contractor of his responsibility.

Any instruction given by the Engineer will be directed to the provision of stronger support than that proposed by the Contractor, and will be given only when, in the opinion of the Engineer, the support proposed by the Contractor is insufficient.

Where timber has been used in excavations any such timber left in position shall be at the expense of the contractor except where the Engineer has ordered the timber to be left in place or if any timber should be left in place with the prior approval of the Engineer. The timber approved or ordered to be left in place will be paid for at the rates entered in the Bills of Quantities.

For the purpose of this clause the words "timber" and timbering" shall be construed to include trench sheeting and steel or concrete sheet pilling or any other means adopted by the Contractor for supporting excavations.

6.9 Water in Excavations

All excavations shall be kept free from water at all times during construction of works until in the opinion of the Engineer, any concrete or other works therein are sufficiently set.

The Contractor shall construct any sumps, cofferdams, caissons or temporary drams that the Engineer may deem necessary and 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 Engineer so as to ensure that excavations are kept dry.

The Contractor shall provide all plant, labor and materials required for such work and all costs incurred shall be deemed to be included in his rates for excavation.

6.10 Blinding of Foundations

The Contractor shall give due notice to the Engineer whenever any foundation work is ready for preparation and inspection, and no further work shall proceed thereon until the Engineer's approval is given.

Where concrete is to be cast against the existing ground, the excavation shall be neatly excavated to the shape required. The Contractor shall stop excavation at a minimum depth of 150 mm above any final surface to be blinded. The final 150 mm of excavation shall not be carried out until the Contractor is ready to protect the final surface with blinding.

The faces of excavations shall be clean and trimmed to the required lines and levels. Any parts of the formation inconsistent with the nature and texture of the main formation shall be removed if required by the Engineer, and the voids so formed filled with a material and a manner approved by the Engineer.

The Contractor shall not excavate below the formation level or beyond any exposed faces. Where the foundation is inadvertently over-excavated, the space between the foundation and the soil face shall be backfilled with concrete.

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

6.11 Measurement of excavation work

Excavated material will be measure, in cubic metres in excavation to the lines shown on the drawings or described in these specifications and will include only material that is actually removed at the direction of the Engineer.

Where excavation lines are not shown on the drawings, the excavation will be measured to the most practicable lines, grades, and dimensions as directed by the Engineer.

In the case of bulk excavations, the Contractor shall unless otherwise directed by the Engineer prior to the commencement of any excavation prepare grid plans of the various sites showing the existing ground levels at intervals of not more than 10 m. For any particular part of excavation the mean ground level shall be determined from the aforesaid grid plan and the depth shall be calculated from the above mean ground level.

Pipe trenches are measured in linear metres as one item for each pipe size with a minimum width and depth as indicated on the drawings. Extra excavation for deeper trenches will be measured on cubic metres and paid for where ordered by the Engineer.

Rates for excavation shall include for all labor, equipment; preparation of bottoms for receiving concrete or granular soil beds; for forming joint holes where applicable, for preserving surfaces of excavation; for returning excavated material as rammed backfill and for carting away surplus to dump.

Rates for excavation shall also include for working in a manner that causes no interference with the stability of adjacent structures and properties; for the cost of all timber or other support left in place unless ordered or approved to be left in place by the Engineer: for ground stabilization by means of de-watering, chemical processes or other approved method whether affected by floods, storms or otherwise; for the provision and sealing of temporary channels, drains and dumps; for temporarily storing excavated materials required for backfill or other purposes; for temporarily supporting, protecting, diverting, maintaining utility services; for maintaining flows in sewers and water found necessary for the proper execution and safety of the works.

Further, the rates in the Bills of Quantities for excavation in open cut shall include the entire cost of:

a) Transportation of materials from the excavation to points of final use, to disposal areas, to temporary stockpiles, and from temporarily stockpiles to points of final use.

b) Re-handling the excavated materials which have been deposited temporarily in stockpiles.

c) Removal of oversize materials from otherwise suitable materials and disposal of the same.

No extra payment shall be made to the Contractor for working in confined space or if the position of the Works as set out or ordered will not allow the use of mechanical excavators.

50% of the rate for excavation, backfilling and disposal of surplus materials will become due for payment when trenches have been backfilled to a depth of 150 mm over the pipe barrel. Excavation for structure foundations will be authorized for payment of 50 % of the rate, when the excavation has been approved and the surface blinded.

6.12 Gabion protection works

6.12.1 Gabions

Where shown on the Drawings or directed by the Engineer, the Contractor shall excavate for, trim to line and level, provide and erect gabions including providing selected rock, crushed if necessary, packed and compacted inside the gabions.

Gabions shall include gabion mattresses and gabion boxes and for the purpose construction and method measurement and payment no distinction shall be made between them.

Gabions shall be “Maccaferri” boxes and /or “Reno” mattresses both with diaphragms at 1 metre centres, or similar approved. Gabions shall be of the hexagonal wire mesh type. The maximum mesh size shall be 100 mm x 120 mm for boxes and 60 mm x 80 mm for mattresses. The wire used for the construction of gabions shall unless otherwise instructed by the Engineer comply with the requirements set out in the table below.

	Diameter (m	Galvanising (g/m)
Mesh		
Box	3.4	275
Mattress	2.7	260
Binder		
Box	2.2	240
Mattress	2.2	240
Selvedge		
Box	3.9	290
Mattress	3.4	275

All wire shall be to B.S 1052 having a tensile strength of not less than 40 kg/mm2.

Gabions shall be constructed to the shapes and dimensions as show on the drawings given in the Special Specifications or as directed by the Engineer. Galvanising shall comply with the requirements of B.S 443. Gabions, as constructed shall be within a tolerance of ± 3% on the length instructed.

All wire used in the fabrication of gabions and in the wiring operations during construction shall after galvanising, have extruded onto it a coating of polyvinyl chloride compound referred to as PVC. The coating shall be black in colour, not less than 0.4 mm thickness and shall be capable of resisting deleterious effects of exposure.

The alignment of the gabion shall be correct within a tolerance of 100 mm of the instructed alignment and level of any course of gabion shall be correct to within 50 mm of instructed level. In addition adjacent gabions shall not vary by more than 25 mm in line and /or level from each other.

The surface upon which gabions are to be laid shall be compacted to a minimum dry density of 95% MDD (AASHTO T99) and trimmed to the specified level or shape.

Joints in gabions shall be stitched together with 600 mm minimum lengths of binder wire, with at least one stitch per 50 mm, and each end of the wire shall be fixed with at least two turns upon itself.

Adjacent gabions shall be touching edges.

Gabion boxes shall be laid with broken bond throughout to avoid continuous joints both horizontally and vertically. Pre-tensioning of gabions shall be subject to the approval of the Engineer.

Gabions shall be handpacked with broken rock of 150 m minimum dimension and 300 mm maximum dimension. The sides shall be packed first in the form of a wall, using the largest pieces, with the majority placed as headers with broken joints to present a neat outside face. The interior of the gabion shall be handpacked with smaller pieces and the top layers shall be finished off with larger pieces. The whole interior and top layers shall be handpacked tight and hammered into place.

Where instructed by the Engineer the Contractor shall place filter fabric (“Terram” or similar approved) behind gabion faces in contact with existing or backfilled ground. The Contractor shall ensure that the filter fabric is not damaged during the construction or backfilling around the gabion works and any damaged or torn fabric shall be replaced at the contractor’s expense. The filter fabric shall be installed in accordance with the manufacturer’s instructions and the filter fabric shall not be left exposed to sunlight for than 3 weeks.

At the back face and ends of the completed gabion works or where on the Drawings or instructed by the Engineer the existing soil shall be backfilled, thoroughly compacted against the sides of the gabions and finished flush with the top of the gabion.

On completion of the gabion construction the exposed joints shall be painted with thick bitumen to the approval of the Engineer to discourage vandalism.

7. CONCRETE WORKS

7.1 General Provisions for Concrete

This section of the Specifications refers to the technical and workmanship requirements for carrying out concrete works for Section 2 of the Contract.

The Contractor shall carry out concrete works generally according to BS EN 1992:2004, BS EN 206:2000, and BS 6073:2008.

The Contractor shall provide all labor, equipment, materials and incidentals required to supply, test, mix, transport, and place all in-situ and ready-mixed concrete, and install miscellaneous related items including forms, sleeves, anchor bolts, inserts and embedded items as required to complete the works.

The Contractor shall submit a Method Statement for concrete preparation, and discuss with the Engineer the sources of materials and concrete mix design which he proposes to use at least 30 days prior to placing of the first batch of concrete.

The Contractor shall obtain samples of materials intended for use as concrete aggregate in the works, together with test results of the properties of these aggregate materials for the approval of the Engineer. Tests of aggregate properties shall be made in a laboratory approved by the Engineer. All materials incorporated in the works shall conform to the approved samples. All costs involved in these procedures shall be deemed covered by the Contractor within the rates and prices of the Contract.

The Contractor shall submit his concrete mix design together with test results of the strength of this concrete mix design for the approval of the Engineer. Concrete strength tests shall be made in a laboratory approved by the Engineer. All concrete incorporated in the permanent works shall conform to the approved concrete mix design. All costs involved in these procedures shall be deemed covered by the Contractor within the rates and prices of the Contract.

None of these requirements shall relieve the Contractor of his responsibility to produce in the permanent works only sound and well-compacted concrete free from voids and cracks.

7.2 General Provisions for Reinforcement of Concrete

The Contractor shall provide all labor, materials, equipment and incidentals required for furnishing, fabricating and installing all steel bars, steel wire, and steel supports required for the reinforcement of concrete.

The Contractor shall prepare Working Drawings and Bar Bending Schedules for concrete reinforcement according to BS EN ISO 3766:2003 and BS 8666:2005 to be submitted to the Engineer for his approval.

Approval by the Engineer of the Contractor’s Working Drawings shall apply to sizes, locations, type of bars and dimensions of bar lap splices only. Dimensions shown on the Contractor’s Working Drawings are the responsibility of the Contractor and the Engineer’s approval of the Contractor’s Working Drawings shall not constitute approval of the dimensions therein.

Reinforcement shall be accurately fabricated to the dimensions approved by the Engineer. Particular care shall be exercised not to have stirrups over-sized in order

to maintain proper coverage of concrete. Stirrups and tie bars shall be bent around a revolving collar having a diameter not less than two and one-half times respectively of the minimum diameter of the bar. Bends for other bars shall be made around a pin having a diameter not less than six times the minimum diameter except for bars larger than 25 mm diameter, in which case the bends shall be made around a pin of eight times bar diameter. All bars shall be bent cold. Bars reduced in section or with kinks or bends not approved by the Engineer shall not be accepted.

7.3 Approval of Concrete Materials

Concrete shall be composed of ordinary Portland cement, fine aggregate, coarse aggregate, water and admixtures as approved by the Engineer. Ready-mix concrete is permitted, provided the concrete can be placed within the specified time requirements and complies with the requirements of the Contract.

No concrete shall be placed in the permanent works until the Engineer has approved the constituent materials. Approved materials shall not thereafter be altered or replaced by other materials without the approval of the Engineer.

7.4 Quality of Concrete and Workmanship

Concrete shall be of such consistency and mix composition that it can be readily worked into the corners and angles of the forms and around the reinforcement, inserts, embedded items and wall castings without permitting materials to segregate or free water to collect on the surfaces. Due consideration shall be given to the methods of placing and compacting.

No excessively wet concrete shall be permitted for the works. If at any time concrete of poor consistency is delivered to the work site, the Engineer may reject the concrete. No additional water shall be added at any time (e.g. while in transit) except that established for the mix design. Failure to comply with this requirement shall be a justification for rejecting the concrete by the Engineer.

In the event the Contractor desires to use materials other than those approved originally by the Engineer, or materials from the sources originally approved change in characteristics during the progress of works, the Contractor shall carry out new acceptance tests of these materials to establish new basic concrete mixes and obtain the approval of the Engineer prior to use at no extra cost to the Employer.

7.5 Inspection and Control

The preparation of forms, placing of reinforcing steel, embodiment items, conduits, pipes, and sleeves, batch mixing, transportation, placing and curing of concrete shall be subject to the inspection of the Engineer, including testing in the laboratory.

The Contractor shall inform the Engineer of his readiness to proceed with placement of concrete at least 24 hours prior to such operation. The Engineer shall inspect the preparatory works for concreting, including the surface preparation of previously placed concrete, the reinforcement, the alignment and tightness of the formwork. All sub-grades below slabs and footings shall be approved by the Engineer before placing concrete.

No placement of concrete shall be made without the approval of the Engineer. Placing of concrete shall not be permitted if, in the opinion of the Engineer, the Contractor does not have proper facilities available for placing, curing and finishing.

The Contractor shall place no concrete until reinforcement steel, pipes, conduits, sleeves, hangers, anchors, and other works required to be built into the concrete have been inspected and approved. Water and foreign matters shall be removed from the forms and excavation.

7.6 Concrete Mixes

Concrete shall be "Designed mixes" for reinforced concrete and "Nominal Mixes for Mass Concrete" to BS 8110 and used as shown on the drawings and in the Bills of Quantities. The concrete mixes, maximum aggregate sizes, maximum water/cement ratio and minimum cement content shall be in accordance with the following table.

Class/Grade of concrete	Nominal Mix Proportions by Weight	Max. size of Coarse Agg.	Sum of the Volumes of each size of Aggregate per 50 kg. concrete in m3	Minimum Cement Content	Minimum compressive strength 20 days after mixing. Preliminary test in Kg/mm2	Works Test in Kg/mm2
A(30)	1:1:2	14	0.105	460 kg/m3	4.2	3.2
B(25)	1:1½ :3	14	0.16	390 kg/m3	3.5	2.6
C(20)	1:2:4	20	0.21	320 kg/m3	2.3	2.1
D(15)	1:3:6	40	0.29	250 kg/m3	2.1	1.4
E(10)	1:4:8	40	0.42	210 kg/m3	0.4	0.3

Table 4-1: Concrete grades

7.6.1 Trial Mixes.

The actual concrete mixes shall be determined prior to starting of concrete works according to BS 8110.

For each grade of concrete three separate batches shall be made using the actual aggregates.

The workability of each of the trial batches should be determined and two times three cubes made from each batch for test at 7 days and 28 days.

The average strength of the nine cubes shall exceed the following values:

Concrete grade	Minimum average strength of 9 cubes	
	At 7 days	At 28 days
20	21 N/mm^2	31.5 N/mm^2
25	24.5 N/mm^2	36.5 N/mm^2
30	27.5 N/mm^2	36.5 N/mm^2

Table 4-2: Average strength at 28 days

For the trial mixes the mix proportions shall be as specified under clause 6.3 of BS 8110 or equivalent Eurocode

7.7 Testing of Concrete

7.7.1 General

Testing of concrete shall comply with BS 8110 of equivalent Eurocode. All test cubes shall be manufactured, cured and tested as detailed in BS 1881 of equivalent Eurocode.

The Contractor shall provide at his own expense all the necessary labor, equipment, moulds, transport, etc., required for manufacture of the test cubes. All test cubes requested by the Engineer shall be tested by Ministry of Works, Materials Branch, and the Contractor shall allow in his rates for concrete for all costs in relation with test cubes.

Should the Contractor require independent tests, he shall make them at his own expense, and the results of such tests shall not be valid unless test cubes are manufactured in the presence of the Engineer and tested by an approved agency and to the requirements in all details of the BS mentioned above.

Sufficient moulds and equipment shall be provided to enable a minimum of six test cubes to be prepared on each day when concrete is being mixed or such other number as the Engineer may direct. The Contractor shall be responsible for delivery of the test cubes to the Ministry of Works and Communication, or other approved testing laboratory.

The precise location of the concrete, which the test cubes represent and the time of Placing, shall be noted on the drawings or elsewhere.

Where the concrete in the work is compacted by mechanical vibration, the test cubes shall be compacted by mechanical vibration, and where the concrete in the work is compacted by hand, the test cubes shall also be compacted by hand as specified in BS 1881.

The Engineer may in the Laboratory make test cubes for any purpose from site materials, and the Contractor shall supply such materials as required free of charge.

The test cubes shall be stored at the site of construction at a place free from vibration under damp sacks for 24 hours after which time they shall be removed from their moulds, marked and buried in damp sand or under water until the time for delivery to the testing laboratory.

The cubes shall then be paced in damp sand or other suitable damp material and sent to the testing laboratory, where they shall be similarly stored until the date of test. Test cubes shall be kept on the Site for as long as practicable but for at least three-fourths of the period before testing, except for tests at ages less than seven days.

7.7.2 Standards for Acceptance of Cube Tests

The result of all cube tests shall be accepted by the Contractor and Engineer as true results of the crushing strength of the cubes. The cube strength shall be calculated from the maximum load sustained by the cube at failure.

The appropriate strength required may be considered to be satisfied if the requirements in BS 5328: Part 4, clause 3.16(or equivalent Eurocode), is fulfilled.

If the tests fail to give the required strength, further testing of the Concrete shall be carried out. If these tests fail to prove the strength of the concrete used, the Contractor shall at his own expense remove and replace all such concrete as directed by the Engineer.

7.7.3 Slump Tests

Concrete consistency shall be determined by a slump test carried out in accordance with BS 1881 and at the Contractor's expense.

Unless otherwise specified by the Engineer, the following are the slumps for the particular class of work.

	Compaction by vibrator	Compaction by hand
Reinforced Concrete	30 to 60 mm	-
Mass Concrete	0 to 30 mm	30 to 80 mm

Concrete having a slump test value exceeding the values here-in specified may be rejected by the Engineer

7.8 Measurement of Materials

Materials shall be measured by weighing except when otherwise approved by the Engineer. The apparatus for weighing aggregates and cement shall be designed and constructed for this purpose and shall be regularly calibrated. Each quantity of aggregate and cement shall be weighed separately. The accuracy of all weighing devices shall be such that the successive quantities can be measured to within 1% of accuracy. Cement in standard packages (sacks) need not be weighed, but bulk cement shall be weighed in all cases.

The water for concrete shall be measured by volume or by weight. The water measuring device shall control the volume or weight accurately to half a percent. All measuring devices shall be subject to approval by the Engineer. Admixtures shall be dispensed either manually with the use of calibrated containers or by an approved automatic dispenser designed by the manufacturer of the specific admixture.

7.9 Mixing of Concrete

Concrete shall be produced using equipment acceptable to the Engineer. Adding water in controlled amounts during the mixing cycle shall be done after prior approval of the Engineer. Concrete shall be mixed until there is a uniform distribution of constituent materials and shall be discharged completely from the mixer before the mixer is recharged.

Site concrete mixers shall be equipped with suitable charging hoppers, a water storage tank and water-measuring device, and constructed in such a manner that some water will enter in advance of the cement and aggregate when the mixer is being charged with a batch. The loss of materials during charging shall not be permitted.

At regular intervals the concrete mixers shall be cleaned of any hardened concrete that may have incrusted on the inside of the drum.

7.10 Form Works

Forms shall be used for all concrete work including footings. Forms shall be so constructed and placed that the resulting concrete will be of the shape, lines, dimensions, appearance, and to the elevations approved by the Engineer and conforming to ACI 347-04.

The Contractor shall submit Working Drawings together with calculations for formwork and temporary works for approval by the Engineer at no additional cost to the Employer.

Forms of all cast-in-place concrete shall be made of wood, metal or other approved material. All exposed concrete surfaces shall be formed with metal or plywood forms.

Forms shall generally be constructed such that the finished concrete conforms to ACI 117-10.

Forms shall be sufficiently rigid to prevent displacement or sagging between supports under all conditions and shall be so constructed that the concrete shall not be damaged by their removal. The Contractor shall be entirely responsible for their adequacy. Forms shall be oiled before reinforcement is placed with an approved non-staining oil or liquid form coating not having a paraffin base.

Edges of all form panels in contact with concrete shall be flushed within 0.8 mm and forms for plane surfaces shall be such that the concrete shall be plane within two millimeters each four meters. Forms shall be tight to prevent the passage of mortar, water or grout.

Moulding or bevels shall be placed to produce a 20 mm chamfer on all exposed projecting corners. Chamfer strips shall be provided at horizontal and vertical extremities of all wall placements to produce clean separations between successive placements.

All surfaces that have been in contact with concrete shall be thoroughly cleaned, damaged places repaired, projecting nails withdrawn, and intrusions or protrusions smoothen before reusing the form materials. Form ties encased in concrete shall be designed carefully to ensure that after removal of the protecting part, no metal shall be within 25 mm of the face of the concrete. That part of the tie to be removed shall be at least 12 mm in diameter or be provided with a wood or metal cone at least 12 mm in diameter and 25 mm long. Form ties in concrete exposed to view shall be of the cone-washer type. Through-bolts or common wire shall not be used for form ties.

Formwork shall be designed to allow placing of the concrete, mortar or grout so as to fill the voids completely, and to enable air to escape from any cavities during filling. The formwork shall be sealed against pipe work to prevent leakage of grout. Formwork shall be supported independently of all pipe work.

Before placing concrete, the Engineer may inspect the forms, as to condition, cleanliness, joint preparation and ascertain that all reinforcement and embedded items are adequately supported in the proper location. This inspection shall not relieve the Contractor of his responsibility for the adequacy of the forms or for the completeness and accuracy of embedded items.

Holes and seams in the forms shall be such that water and mortar shall not escape. Forms in the vicinity of joints shall be re-tightened just prior to placing the next lift of concrete. The Contractor shall maintain the forms tight and in position during the entire concreting process. Any necessary adjustment shall be made immediately.

7.11 Placing of Concrete

Transport of concrete from mixer to place of final deposition shall be done as rapidly as practical by methods which prevent the separation of ingredients and displacement of reinforcement and thereby avoid re-handling. No partially hardened concrete shall be deposited. All equipment used to transport concrete shall be clean and free of debris and contaminants. In selecting the method or methods used for transport, consideration shall be given to the effects of the method on the properties of the concrete so as not to result in inferior concrete caused by segregation produced during transport.

Concrete shall be placed so as to maintain a plastic surface approximately horizontal until the completion of the work. At construction joints the surfaces of the concrete already placed shall be thoroughly cleaned of foreign materials and laitance, and weak concrete shall be roughened with suitable tools to expose a fresh face.

At least two hours before and again shortly before the new concrete is deposited, the joints shall be saturated with water. After glistening water disappears, the joints shall be given a thorough coating of cement grout mixed to the consistency of a very heavy paste. The surfaces shall receive a coating at least five millimeters thick, well-scrubbed in by means of stiff bristle brushes wherever possible. New concrete shall be deposited before the cement grout dries.

Where the placement consists of several layers, each layer shall be placed while the preceding layer is still plastic in order to avoid cold joints. If the under-laying layer has stiffened just beyond the point where it can be penetrated by a vibrator, bond can still be obtained by thoroughly and systematically vibrating the new concrete into contact with the old. In thin sections, concrete shall be placed using suitable hoppers, spouts with restricted outlets, or otherwise as approved by the Engineer.

7.12 Compacting of Concrete

Concrete shall be thoroughly compacted during and immediately after depositing by means of suitable tools and methods. Concrete slabs on the ground shall be well tamped into place. Foundation material shall be wetted, tamped, vibrated, and rolled until thoroughly compacted prior to placing concrete. Concrete shall be deposited continuously in layers of such thickness that no concrete will be deposited on surface that has hardened sufficiently to cause the formation of seams and planes of weakness within the section.

7.13 Curing of Concrete

The Contractor shall protect all concrete work against damage from outside elements and defacement of any nature during construction operations. All concrete, particularly exposed surfaces shall be treated immediately after concreting or cement

finishing is completed, and shall be provided with continuous moist curing for at least seven days regardless of the ambient air temperature. Walls and vertical surfaces may be covered with continuously saturated burlap or by other approved means. Horizontal surfaces, slabs, and other items shall be inundated with pool of water to a depth of 12 mm and kept continuously wet.

7.14 Placing of Concrete during Rain

Concreting shall not start during times of heavy rainfall. When directed by the Engineer to continue placing concrete during times of rainfall, the Contractor shall protect the work by covering to prevent water collecting in pools or washing the concrete surface.

7.15 Removal of Forms

The period of time elapsing between the placing of concrete and the striking of form work shall be subject to the approval of the Engineer.

Approval of the Engineer for stripping of formwork does not relieve the Contractor from his responsibility for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

7.16 Patching and Repairs

As soon as the forms have been stripped-off from the concrete surfaces, exposed fins and other projections shall be removed; recesses left by the removal of form ties shall be filled; and surface defects that do not impair structural strength shall be repaired. All exposed concrete surfaces and adjoining work stained by leakage of concrete shall be cleaned to the full satisfaction of the Engineer.

Immediately after removal of forms, the Contractor shall remove plugs and break off metal ties as required. Holes shall be promptly filled by moistening with water and followed with a 1.5 mm brush coat of neat cement slurry mixed to the consistency of a heavy paste. The hole shall immediately be plugged with a 1:1.5 mixture of cement and fine aggregate slightly damp to the touch. The surface shall be trawled smooth with heavy pressure. Form tie holes in the exposed exterior walls and interior walls shall likewise be immediately filled.

7.17 Finishing of Concrete Surfaces

Concrete for every part of the permanent works shall be a homogeneous structure that when hardened will have the required strength, durability and appearance. Formwork, mixtures and workmanship shall be such that concrete surfaces, when exposed, shall require no finishing.

If concrete surfaces are not acceptable in appearance, then the Contractor shall furnish all labor, equipment and incidentals necessary to finish cast-in-situ concrete surfaces to an acceptable appearance. All concrete surfaces shall have all fins burrs and projections removed. Holes and honeycomb areas shall be filled and patched. Care shall be exercised to prevent rounding of chamfered edges or obliterating the bevel line when removing the forms or finishing the surface or doing any other work adjacent thereto.

7.18 Storage and Handling of Reinforcement Materials

Reinforcement steel shall be stored on site either in racks or on a hard impermeable base so that it remains straight and free from contamination. Any reinforcement that is likely to remain in storage for a long period shall be protected from the weather in

order to avoid corrosion and pitting. If required by the Engineer, any corroded reinforcement shall be removed from site.

Reinforcement shall be stockpiled at work sites with bars of the same size and shape fastened in bundles with metal identification tags, giving size and mark, and securely wired on.

The metal identification tags shall be labeled with the same designations as shown on the Working Drawings and Bar Bending Schedules submitted by the Contractor and approved by the Engineer.

All bars shall be stored off the ground and shall be protected from moisture and be kept free from dirt, oil, or injurious contaminants.

7.19 Reinforcement

Reinforcing bars shall not be welded either during fabrication or erection without prior approval of the Engineer. If the Engineer approves the welding of reinforcing bars, the Contractor shall submit a sample of a welded piece together with test results of its strength which shall not be less than such reinforcing bar. Any bars that have been welded, including tack welds, without such approval shall be immediately removed as required by the Engineer.

The reinforcement bars shall be thoroughly cleaned of loose mill scale, dirt, and other coatings that reduce or destroy bonding, by using sand blasting before being placed in position. The reinforcement bars shall be re-inspected and cleaned when there is a substantial delay in depositing the concrete after reinforcement is in place.

Reinforcement shall be accurately positioned as approved by the Engineer and secured against displacement by using iron wire ties or suitable clips at intersections. Splices and laps in columns, piers and struts shall be sufficient to transfer full stress by bond. Splices in adjacent bars shall be staggered if required by the Engineer. All accessories shall be furnished and installed in sufficient quantity to satisfactorily position all steel and shall conform to ACI 315-99.

In no case shall any reinforcing steel be covered with concrete until the amount and the position of the reinforcement have been checked by the Engineer and his approval given to proceed with the concreting. The Engineer shall be given at least three days notice of the availability of the set reinforcement for checking.

7.20 Reinforcement Accessories

The Contractor shall supply all accessories such as reinforcing steel supports, hold-downs, spreaders, hangers, tie wire and all other incidentals necessary to complete an acceptable installation of all concrete reinforcement. All accessories shall be of steel with the exception of spacers to maintain concrete cover to reinforcement against formed or blinded surfaces.

Concrete spacers shall be in the form of a truncated cone or pyramid and shall be used with the larger face towards the reinforcing steel. The smaller face of a truncated cone or pyramid shall have minimum dimension of 50 mm.

Dowels shall be of the same size and spacing as bars with which they are lapped. Dowels shall be wired or otherwise held in position. Dowels shall be installed prior to placing concrete. They shall not be placed into freshly placed concrete.

7.21 Repair of Existing Concrete Works

Existing concrete works shall be repaired for deteriorated and spalling concrete, as specified in the Contract, or as required by the Engineer, according to the Contract.

Concrete repairs shall be performed by cutting and removing unsound concrete, followed by hand troweling methods using repair materials based on portland cement.

Any loose, delaminated concrete shall be first removed until the substrate consists of sound concrete. Where corrosion of the reinforcement exists, bulk concrete shall be removed along the reinforcement steel as well as adjacent areas where there is evidence of corrosion-induced damage. Bulk concrete removal may also include undercutting the corroded reinforcement steel. The shape of the prepared cavity shall be square or rectangular in shape and shall be kept as simple as possible. Feathered edges will not be acceptable, and the Contractor shall be required to saw cut the outer perimeter of the repair area.

Prior to any concrete repairs, the Contractor shall remove all dust, dirt, water and debris from the surface of the concrete. The concrete surface shall then be prepared to provide a saturated surface dry condition, including abrasive cleaning, hammer chipping, cleaning of existing reinforcement, and the removal of contaminants or carbonated concrete.

The concrete repair mortar shall be handled, stored, mixed and applied according to the manufacturer's instructions or guidelines. The Contractor shall scrub a thin bond coat of the repair mortar into the saturated surface dry substrate, filling pores to ensure intimate contact and to prevent sloughing. Then the Contractor shall apply the concrete repair mortar with adequate pressure until the bond coat dries, and thereafter shall consolidate the repair material into the corners of the patch and around any exposed existing reinforcement in the repair zone until the reinforcement is fully encapsulated.

If two lifts are required, the surface of the first lift shall be thoroughly roughened by scoring the soft mortar to achieve a rough finish, similar in profile to the prepared concrete substrate. If the second lift is not immediately applied, the first lift shall be maintained moist until the second lift is applied. After the first lift has reached final set, the surface shall then be moistened and a thin layer of fresh mortar scrubbed into the surface, followed by the application of the second lift. Once the desired thickness has been achieved, the surface shall be leveled with the adjacent concrete, followed by final curing of the repair mortar.

7.22 Water-Proofing of Concrete Works

Water-proofing of concrete works shall be provided using a surface applied capillary water-proofing material suitable for concrete and mortar, and shall consist of a blend of moisture-activated chemicals, high-grade silica aggregates and selected cements.

Water-proofing material shall provide water-proof protection through the formation and development of crystals in water bearing capillaries and interstices of the concrete surface to be applied. The material shall be effective against both positive and negative water pressure, and shall be vapour permeable to allow the coated surface to breathe.

Water-proofing of new structures shall be performed immediately after the formwork has been removed, to ensure full hydration of the concrete. Water-proofing to refurbish existing structures shall be performed after first pre-wetting the surface.

Surfaces shall be first cleaned of dust, oil, grease, paint, residual curing compound, mould oil or any previous surface treatment. Areas of weak or honeycombed concrete shall be first repaired. Hollow de-bonded renders shall also be removed and made good. Surfaces that are not damp shall be pre-wetted and still be damp at the time of application.

Water-proofing material in powder form shall be mixed using clean water in the correct proportions, and according to the manufacturer's requirements or instructions. Additional water shall not be added to the ready material after initial mixing.

Ready material shall be applied by brush or trowel in two coats, with the coats at right angles, with the second coat applied after the first coat is firm. Each coat shall be protected against rapid drying by mist spraying to ensure homogenous curing. Each coat shall be applied for coverage of minimum 2 kg/m^2.

7.23 Composite Chamber Covers

Inspection covers of composite material shall be manufactured of engineered composite material, such as polymer-based fiber reinforced plastic. The covers shall comply with BS EN 124 1994 for a minimum A15 load rating. The covers shall have monolithic construction, and shall be designed and manufactured not to crack and not to delaminate. The cover surface shall have anti-slip, wear-resistant, deep-tread pattern.

Each cover shall be supplied and installed complete with frame, and shall be installed to comply with the Manufacturer's instructions or guidelines. Each cover shall be locked using Allen key type. The lock hole shall be made with a self-locking flange.

8. BUILDINGS AND ASSOCIATED WORKS

8.1 Concrete block walling

8.1.1 Precast concrete blocks

Concrete blocks shall comply with BS 6073. The blocks shall be solid or hollow, as specified on drawings, with a minimum compressive strength of 3.5 N/mm^2, tested as described in BS 6073.

All blocks must be left with good sharp edges. The standard face size of blocks for use in the works shall be 440 mm x 190 mm x 190 mm and this size of blocks shall be used wherever practicable.

No work with concrete blocks shall commence prior to a test report being presented to and accepted by the Engineer.

The contractor shall be responsible for making test blocks and experimenting with available materials to ascertain what mix will be necessary to attain the required strengths. If suitable materials are not available locally, the Contractor shall obtain them from other approved sources.

Manufacture shall be carried out under shelter and after casting, the blocks shall be stacked under shelter to protect them from sun and weather, and properly cured by covering with sand or sacks and sprayed daily for not less than 14 days.

8.1.2 Wall reinforcement

Reinforcement in walls made of solid blocks shall, where so specified, consist of a 25 mm wide strip of "Exmet" or similar brick reinforcement centrally placed in joints at approximately 450 mm centres (vertically) for the full length of the walls, lapped and crimped 300 mm at running joints and full width of walls at angles and intersections.

8.1.3 Cement

The cement shall be as described in "Concrete Work".

8.1.4 Sand

The sand for mortars shall be as described in "Concrete work", except that it shall be fine sand.

8.1.5 Mortar

The cement mortar shall consist of one part of Portland Cement to three parts of sand by volume.

The ingredients of mortar shall be measured in proper gauge boxes on a boarded platform, the ingredients being thoroughly mixed dry, and again whilst adding water. In the case of cement/lime mortar the sand and lime shall be mixed first, and then the cement added.

All mortar is to be thoroughly mixed to a uniform consistency with only sufficient water to obtain a plastic condition suitable for trowelling. No mortar, that has commenced to set, is to be used or remixed for use.

8.1.6 Damp-proof course

All damp-proof courses shall be of bituminous felt to BS 743 weighing not less than 3 Kg per m2, free from tears and holes, lapped 150 mm at running joints and for full width of wall at angles and intersections and bedded on an including a 12 mm levelled screed of cement mortar.

8.1.7 Workmanship

Blocks shall be laid in regular even courses and shall be bedded in cement mortar consisting of one part of cement to three parts of sand. Before being laid all blocks shall be immersed in water for at least 12 hours. All beds and vertical joints shall be filled completely with mortar when the blocks are laid, and no flushing up will be permitted. No vertical joint in any one course shall be within 100 mm of a similar joint in adjacent courses. Beds and joints shall be not less than 10 mm or more than 15 mm thick. (Blockwork Tanks excepted, see Clause 5.1.8).

The courses shall be laid parallel and all perpendiculars shall be truly kept. Reveals and internal and external angles shall be perfectly square and true.

All walls throughout the work shall be carried up evenly, no part being carried up more than 1 m higher than any other part.

The Contractor shall provide proper setting out rods and set out on the same all work showing openings, heights, sills and lintels and shall build the various walls and piers to the thicknesses, widths and heights shown upon the drawings.

All exposed faces of walls for plastering are to be left rough and the joints raked out while mortar is green to form adequate key. All other faces shall be cleaned down on completion with a wire brush or as necessary and mortar droppings, smear marks, etc., removed and rates must include for this.

Where blockwork faces are to be left exposed, blocks shall be chosen for their uniformity, unmarked faces and unbroken arises and shall be finished with a fair face and pointed with a neat joint recessed from the face of the blocks.

Where shown on the Drawings, walls are to be carried up to the underside of the roof sheets and are to be cut on top edge to suit roof slope and flushed up in cement mortar.

All putlog holes shall not be less than one course deep and carefully filled with a block cut to fit size of opening with beds and joints filled with mortar well tamped in after scaffolding is removed. In the case of walls receiving plaster, or other in-situ facings, putlog holes must be filled before any facing is applied and prices must include for additional cost of free-standing scaffolding.

Tolerances as for concrete works (Clause 4.4.11).

8.1.8 Blockwork tanks

The concrete blocks shall be solid, type A with a minimum compressive strength of 7 N/mm2, tested as described in BS 2028.

For circular blockwork tanks the blocks shall be manufactured in the required shape to fit the curvature of the tank, and all blocks shall be immersed in water for 24 hours before being laid.

Care must be taken to ensure that all joints are filled up completely. The horizontal joints to be reinforced as shown on the Drawings, with the reinforcement covered on all sides at least 6 mm of mortar, thus giving a thickness of horizontal joints of approximately 20 mm.

No parts of the wall shall be carried up more than one course above any other part of the wall. Reinforcement and holes for pipes passing through walls and floors shall meet the requirements as specified in Section 4.

Internal plaster shall be of mix 1:2, made waterproof by use of approved additive.

8.1.9 Measurement

Walls are measured in square metres for each thickness of walls.

The prices shall include for all straight cutting, bonding plumbing angles, forming reveals, pinning up to underside of concrete soffit and cutting up to sides of columns and cutting and pinning ends of lintels and sills.

8.2 Plasterwork and other floor, wall and ceiling finishes

8.2.1 Cement

The cement shall be as previously described in "Concrete works".

8.2.2 Sand

The sand shall be as described for fine aggregate, but that for plastering shall be light in colour and well graded to a suitable fineness in accordance with the nature of the work in order to obtain the finish directed.

8.2.3 Lime

The lime for plastering shall comply with BS 890 Clause "A" for non-hydraulic lime and shall be as rich as obtainable and to approval. It must be freshly burnt and shall be slaked at least one month before being used by drenching with water, well broken up and mixed and the wet mixture shall be passed through a sieve of 3 mm meshes.

Lime putty shall consist of freshly slaked lime as described above, saturated with water until semi-fluid and passed through a fine sieve; it shall be allowed to stand until surplus water has evaporated and it has become of the consistency of thick paste, in no case for a shorter period than one month before being used, during which time it must be kept damp and clean and no portion of it allowed to become dry.

Alternatively, hydrated lime with 70% average calcium oxide content may be used and it must be protected from damp until required for use. It shall be soaked to in putty at least 24 hours before use.

8.2.4 Composition of plasters etc

A mix referred as 1:4 shall mean 1 cubic metre of cement to 4 cubic metres of sand. All other mixes shall be construed in a like manner.

8.2.5 Hacking etc

The prices for all screed, paving and plastering, etc. shall include for hacking concrete surfaces and for raking out joints of walls 15 mm deep and for cross scoring undercoats to form a proper key. Plastering on walls shall generally be taken to include faces of lintels, beams, etc. in same.

8.2.6 Surfaces

All surfaces to be paved or plastered must be brushed clean and well wetted before each coat is applied. All cement paving and plaster shall be kept continuously damp in the interval between application of coats and for seven days after the application of the final coat.

8.2.7 Partially or wholly set materials

Partially or wholly set material will not be allowed to be used or remixed. The plaster mixes etc. must be used within one hour of being combined with water.

8.2.8 Samples

The Contractor shall prepare sample areas of the screed, pavings and plastering as directed until the quality, texture and finish required is obtained and approved by the Engineer, after which all work executed, shall conform with the respective approved samples.

8.2.9 Finish generally

All screed and pavings shall be finished smooth, even and truly level unless otherwise specified.

Rendering and plastering shall be finished plumb, square, smooth and even. All surfaces to be plastered shall be thoroughly wetted before any plastering is commenced.

No plastering will be allowed to take place until all chases for services have been cut, services installed and chased surfaces made good. On no account may finished plaster surface be chased and made good. All work shall be to the approval of the Engineer and any work not complying with the above shall be hacked away and replaced at the Contractor's expense.

Arises and angles

All arises and angles shall be clean and sharp or slightly rounded or thumb-coved as directed including neatly forming mitres.

8.2.10 Making good

All making good shall be cut out to a rectangular shape, the edges undercut to form dovetail key and finished flush with the face of surrounding paving or plaster. All

cracks, blisters and other defects shall be cut out and made good and the whole of the works shall be perfect on completion.

8.2.11 Prices to include

In addition to the fore-going, prices are to include for all labor, angles and arises, all fair edges, for making good up to or stopping to a line and the required level at top of skirtings or angles where directed and for making good up to windows, door frames and similar.

The prices for all linear items unless otherwise measured are to include for all short lengths, lengths, angles and arises, mitres and ends of every description.

8.2.12 Cement pavings, screed etc

Cement screed shall consist of cement and sand mix 1:2 laid in panels and finished with a steel trowel if not otherwise specified.

Where specified as waterproof "Pudlo" or similar waterproofing compound shall be added to the cement paving or screed strictly in accordance with the Manufacturer's instructions.

Where practicable, screed is to be laid while the concrete is still green. When this is not practicable, the concrete is to be well washed and brushed perfectly clean with a steel wire brush, to remove laitance and to give a roughened face as a key and then kept wet for at least seven days before the screed is laid.

On the day of laying the screed, the surface is to be only damp with all surplus water removed and the surface has to be painted with cement and sand mix 1:1 grout immediately before commencing laying of the screed. The grout is to be applied continuously in front of the screed, and not in large areas that will dry out before the screed is applied.

Screed shall be protected during the first stage of hardening from eh harmful effects of sunshine, drying winds, rain or water. In exposed positions, the screed shall be covered with a well wetted layer of sawdust, Hessian or other approved material, and this layer shall be damp for at least seven days, during which period no traffic is to be allowed over the screed.

8.2.13 Cement rendering

Cement rendering shall consist of cement and sand mix 1:4 to not less than 15 mm finished thickness and be finished to a true and even surface.

8.2.14 Protection

All work shall be adequately protected against damage, to the satisfaction of the Engineer until the works are handed over to the Engineer.

8.3 Carpentry and joinery

8.3.1 Timber materials

All timber shall be in accordance with the latest approved Grading rules issued by the Ministry of Works or other competent authority. The quality shall be as First (or Prime) Grade.

All timber work to be carried out in accordance with BS 1186 and CP 112.

Any of the following timber may be used:

Standard Common Name	**Botanical Name**
Podocarpus	Podocarpus Spp
Cedar	Juniperus Procera
African mahogany (Munyama)	Khaya anthotheca
Muringa	Pterocarpus Angloensis
Mvule	Chrophora Excelsa

All timber, as it arrives on the Site, shall be inspected by the Engineer, and any timber brought on the Site and not complying with the Specification or not approved must be removed forthwith from the Site, and only timber as approved shall be used in the works.

The Contractor shall upon signing the Contract, purchase sufficient supplies of specified hardwoods to avoid possible shortages at a later date.

All timber shall be free of live borer beetle or other insect attack when bought upon the Site. The Contractor shall be responsible up to the end of the maintenance period for executing at his own cost all work necessary to eradicate insect attack of timber which becomes evident - including the replacement of timber attacked or suspected of being attacked, notwithstanding that the timber concerned may have already been inspected and passed as fit for use.

All timber shall be seasoned to a moisture content of not more than 15%.

8.3.2 Boards and sheets

Fibreboard shall be 12 mm "Celotex" or other approved fibreboard complying with BS 1142, Part 3,

Plywood shall be laminated board faced on in both sides with 4 mm plywood. Exposed edges shall be lipped with 20 mm hardwood and rates shall include for leaping.

Plastic Sheeting shall be "Formica" sheeting, 1.5 mm thick and securely fixed with approved type waterproof adhesive, and in the colours approved by the Engineer.

Flush doors shall be 45 mm thick, and shall be obtained from an approved manufacturer. The doors shall comply with BS 459, Part 2. External doors shall be framed, ledged and braced as shown on the drawings, and they shall comply with BS 459, Part 4.

8.3.3 Workmanship

All timber shall be as long as possible and practicable to eliminate joints. Where joints are unavoidable, surfaces shall be in contact over the whole area of the joint before fastenings are applied.

No nails, screws or bolts are to be fixed in any split end. If splitting is likely, or is encountered in the course of the work, holes for nails must be bent at right angles to the grain.

Lead holes are to be bored for all screws. When the use of bolts is specified, the holes are to be bored from both sides of the timber. Nuts must be brought up tight, but care is to be taken to avoid crushing of the timber under the washers.

All joiner's work shall be accurately set out on boards to full size for the information and guidance of the artisans before commencing the respective works, with all joints, iron work and other works connected therewith fully delineated. Such setting out must be shown to the Engineer and approved before such respective works are commenced.

All joiner's work shall be cut out and framed together as soon after the commencement of the building as is placable, but not to be wedged up or glued until the building is ready for fixing same. Any portions that wrap wind or develop shakes or other defects within twelve months after completion of the Works shall be removed and new ones fixed in their place together with all other work which may be affected thereby, all at the Contractor's own expense.

All work shall be properly mortised, tenoned, housed, shouldered, dovetailed, notched, pinned, braded, etc., as directed and to the satisfaction of the Engineer and all properly glued up with the best quality glue.

Joints in joinery must be as specified or detailed, and so designed and secured as to resist or compensate for any stresses to which they may be subjected. All nails, springs, etc., are to be punched and puttied. Loose joints are to be made where provision must be made for shrinkage, glued joints where shrinkage need not be considered and where sealed joints are required.

Glue for load bearing joints or where conditions may be damp must be of the resin type. For non-load bearing joints, or where dry conditions may be guaranteed, casein or organic glues may be used.

All exposed surfaces of joinery work shall be wrought and all arises "eased off" by planning and sandpapering to an approved finish suitable to the specified treatment.

Round wood plugs shall not be used. All work described as plugged shall be fixed with screws to plugs formed by drilling concrete, walls, etc., with a proper tool of suitable size and filling the holes completely with "Expandet" raw plastic or "Rawplugs" in accordance with the Manufacturer's instructions.

Where intended to be in contact with stone, concrete blocks, cement or plaster, the backs and other faces of all doors, windows and other frames and linings, posts,

architectural skirting, fillets and fascias shall be treated with two coats of wood preservative before fixing.

Bottom edges of doors shall be painted with one coat of approved primer before fixing.

Any fixed joinery which in the opinion of the Engineer is liable to become bruised or damaged in any way shall be completely cased and protected by the Contractor until the completion of the Works.

8.3.4 Inspection and testing

The Engineer shall be given facilities for inspection of all works in progress whether in workshop or on Site. The Contractor is to allow for testing of prototypes of special construction units and the Engineer shall be at liberty to select any samples he may require for the purpose of testing, i.e. for moisture content, identification, species, strength, etc. Such tests will be carried out by the Forestry Department.

8.3.5 Clearing up

The Contractor is to clear out and destroy or remove all cut ends, shavings and other wood waste from all parts of the building and the site as the work progresses and at the conclusion of the work.

This is to prevent accidental borer infestation and to discourage termites and decay.

8.3.6 Prices to include

Prices of items shall include for the foregoing labour, etc. and in addition the prices for linear items are to include all internal and external angles, either mitres or tongued, all fair, fitted, stopped, notched or returned ends, all similar incidental labours and all short lengths.

The Contractors rates must also include for bedding frames, sills, etc., in mortar or dressing surfaces of walls etc.

8.4 Roofing

8.4.1 Galvanised Steel Roof

Galvanized steel corrugated sheeting

Galvanized steel corrugated sheeting shall be in accordance with KS 06-02 and not less than 0.56mm thick.

Before laying it shall be ensured that the sheets are free from twists and buckles and that the galvanizing is free from any defect and firmly bonded to the steel.

All necessary ridges, valleys, flashings and the like of the same profile and quality as the roofing sheets shall be available.

Unless otherwise specified connection to square abutment shall be formed by flattening two corrugations without damaging the galvanization and turning up 150mm against abutment allowing for thermal movement.

8.4.2 Translucent sheeting

Glass fibre reinforced translucent plastics to BS 4154 shall be of approved manufacture and satisfying any requirements specified for fire resistance.

Sizes and profiles shall match those of the roofing sheets in use.

8.5 Doors

All doors will be manufactured from the best quality first grade timber as specified under Clause 5.3.1 in the specifications. The iron monger will be as per the specifications in Clause 5.6. The schedule of the sizes of the required doors are provided on drawing No. ISEP/SD/09.12. Painting will be according to the paint procedures and quality of materials as provided in Clause 5.8

8.6 Windows

Window will be manufactures of high quality steel as provided for in Clause 5.5. The steel surfaces will be cleaned and prepared and finally painted as per Clause 5.8. All iron-mongery will be provided as per Clause 5.6. The schedule of windows sizes is as provided on drawings No. ISEP/SD/09.12.

8.7 Steelwork

8.7.1 Materials

All materials shall be the best of their respective kinds and free from defects. The materials in all stages of transportation handling and stacking shall be kept clean and injury from breaking, bending and distortion prevented.

All steel and steel sections shall comply with BS 4, BS 4360 and BS 4848.

All steel shall be of approved manufacture and the Contractor shall on request deliver to the Engineer a manufacturer’s test certificate for all steel used.

All structural steel shall be of Grade 43A according to BS 4360. Steel for handrails, screens etc. can be of a lower grade, but all steel shall be weldable and the grade shall be approved by the Engineer.

Electrodes shall be according to BS 639 and shall be of a class appropriate to the steel. Bolts and nuts shall be according to BS 4190.

8.7.2 Workmanship

Workmanship for all steelwork shall generally follow the requirements in BS 449 and BS 5135.

The Contractor shall prepare all the necessary workshop drawings, which shall be approved by the Engineer. The Engineer's approval shall not in any way relieve the

Contractor of his responsibility for the Workshop drawings being in accordance with the contract drawings and specifications.

All welding of structural steel shall be carried out in the Contractors workshop and the whole structure or pars thereof shall be test assembled into the workshop before delivery to the site.

Should any doubt arise as to the quality of the steel or the welds, the Engineer may require testing carried out. If the results show insufficient quality of materials or workmanship, the Contractor shall cover all expenses related to the tests and shall replace and rectify all materials and welds found unsatisfactory.

8.7.3 Ladders

All ladders in tanks etc. shall be galvanized steel pipes in accordance with BS 1387 "medium class", and shall be made to the dimensions shown on the drawings.

8.7.4 Measurements

The rates inserted in the Bills of Quantities shall include for preparing workshop drawings, cutting to specified lengths and shapes, drilling of holes, welding, bolts, nuts washers, gusset plates, base plates etc.

8.8 Ironmongery and other fittings

All ironmongery shall be approved by the Engineer. The approve samples shall be regarded as the standard for work.

8.8.1 Locks

All locks and ironmongery shall be with screws, etc. to match. Before the door etc. is painted, handles shall be removed, carefully stored and re-fixed after completion of painting. Locks shall be oiled and left in perfect working order.

25 mm diameter rubber door stops shall be provided at all doors and securely plugged and screwed to floors or walls.

All external doors shall be provided with locks of cylinder type. All internal doors to be provided with approved latch locks and handles. All locks shall have two keys with attached labels with door references before being handed over to the Engineer.

8.8.2 Sanitary fittings

All sanitary fittings shall be approved manufacture and installed in accordance with the manufacturer's recommendations.

8.9 Glazing

8.9.1 Glass

All glass shall comply with BS 952 and be free from flaws, bubbles, specks and other imperfections.

Glass panes shall be cut to sizes to fit the opening with not more than 2 mm play all round and where puttied shall be clipped to the frames.

Clear sheet glass shall be ordinary glazing quality.

8.9.2 Cleaning etc

On completion, remove all broken, scratched or cracked panes and replace with new to the satisfaction of the Engineer. Clean inside and out with approved liquid cleaner. On no account shall windows be cleaned by scraping with glass.

8.10 Painting, decorating and other surface treatment

8.10.1 Approved Specialist

All work under this trade must be executed by an approved specialist unless the Engineer agrees otherwise. The paint shall be of approved manufacture.

8.10.2 General

The Contractor shall so arrange his programme of work that all other trades are completed and the workmen are away from the area to be painted, when painting begins. Before painting, the Contractor must remove all concrete and mortar dropping and the like from all work to be decorated and remove all stains as to obtain uniform colour to work to be oiled and polished.

All plaster, metal, wood and other surfaces which are to receive finishes of paint, stain, and distemper or paint work of any description are to be carefully inspected by the Contractor before he allows any of his painters to commence work. The Contractor will be held solely responsible for all defective work condemned as a result of his painter's failure to insist on receiving from the other trades surfaces in the proper condition to allow first class finishes of the various kinds specified being applied to them.

8.10.3 Painting generally

All materials to be applied externally shall be of exterior quality and/or recommended by the manufacturers for external use, all in accordance with BS 4800 or similar.

All materials shall be delivered on site intact in the original sealed drums of tins and shall be mixed and applied strictly in accordance with the manufacturer's instruction and to the approval of the Engineer. Unless specially instructed or approved by the Engineer, no paints are to be thinned or otherwise adulterated, but are to be used as supplied by the manufacturers and direct from the tins.

The priming, undercoats and finishing coats shall each be of differing tints and the priming and undercoats shall be the correct brands and tints to suit the respective finishing coats in accordance with the manufacturer's instruction. All finishing coats shall be of colours and tints selected by the Engineer. Each coat must be approved by the Engineer before the next coat is applied.

All paints, emulsion paints and distempers shall be applied by means of a brush or spray gun or rollers of an approved type where so agreed by the Engineer.

No painting is to be done in wet weather or on surfaces which are not thoroughly dry.

Each coat shall be properly dry and in the case of oil or enamel paints shall be well rubbed down with fine glass paper before the next coat is applied. The paint work shall be finished smooth and free from brush marks.

The rates for painting shall include for preparation of surfaces, rubbing down between each coat, stopping, knotting, etc. and all other work in connection and as described and as necessary to obtain a first class and proper finish to the Engineer's approval.

8.10.4 Samples

The Contractor shall furnish at the earliest possible opportunity before work commences and at his own cost, samples of painting for the Engineer's approval and any further samples in the case of rejection.

Such samples when approved shall be the minimum standard for the work to which they apply. If required by the Engineer, the Contractor is to provide at his own expense samples of paints, etc., with containers and cases to be forwarded carriage paid by the Contractor for analysis at a laboratory.

Colour cards of all paints, etc. shall be submitted to the Engineer. The Engineer may reject any materials or workmanship not in his opinion up to the approved sample, and these must be removed from the site without delay.

8.10.5 Preparation and priming of plaster surfaces etc

Surfaces shall be perfectly smooth, free from defects and ready for decoration. All such surfaces shall be allowed to dry for a minimum period of six weeks, stopped with approved plaster compound stopping and rubbed down flush, as necessary, and then be thoroughly brushed down and left free from all efflorescence, dirt and dust immediately prior to decorating.

Plaster surfaces, which are to be finished with emulsion, oil or enamel paint, shall be primed with an alkali resisting primer complying with the particular paint Manufacturer's specification and applied in accordance with their instructions.

Fibreboard or similar surfaces shall be lightly brushed down to remove all dirt, dust and loose particles and have all nail holes or other defects stopped with an approved plaster compound stopping rubbed down flush and left with a texture to match surrounding material.

8.10.6 Preparation and priming of metal work

All surfaces shall be thoroughly brushed down with wire brushes and scraped were necessary to remove all scale, rust, etc. immediately prior to decorating. Where severe rust exists and if approved by the Engineer, a Proprietary de-rusting solution may be used in accordance with the manufacturer's instructions.

Shop primed and unprimed surfaces shall be given one coat of metal chromate primer or lead oxide primer.

Galvanized surfaces shall be treated before priming with an approved proprietary mordant or de-greasing solution. The surfaces shall be thoroughly washed down with water, allowed to dry and primed as last.

Coated surfaces already treated with bituminous solution, shall be scraped to remove soft parts and then receive two isolating coats of aluminium primer or other approved anti-tar primer.

8.10.7 Preparation and priming woodwork

All woodwork shall be rubbed down, all knots, covered with a thick coat of good shellac or aluminium knotting; primed with one coat of approved ready-mixed proprietary wood primer and all cracks, nail holes, defects and uneven surfaces, etc., stopped and faced up with hard stopping rubbed down flush.

8.10.8 Wood preservative

All woodwork in contact with walling or plaster shall be treated after cutting and preparation but before assembly or fixing with one coat of approved wood preservative. The solution is to be brushed on all faces of all timbers, unless exposed to view and painted.

8.10.9 Cement paint

Shall be Super Snowcem or equal approved. Two coats shall be applied after preparation as specified above.

8.10.10 Emulsion paint

After preparation as specified above a minimum of three coats shall be applied using a thinning medium or water only if and recommended by the Manufacturer.

An approved plaster primer tinted to match may be substituted for the first coat.

8.10.11 Enamel paint

Apply two undercoats and one finishing coat, after preparation and priming as specified above.

8.10.12 Ironmongery

Where instructed, all ironmongery shall be removed from joinery, steel windows and louvers before painting is commenced, and shall be cleaned and renovated if necessary and re-fixed after completion of painting.

8.10.13 Painting items

As billed here-after shall include for preparing and priming surfaces as above described.

8.10.14 Cover up

Cover all floors, fittings, etc. with dust sheets when executing all painting and decorating work.

8.10.15 Clean and touch up.

Paint splashes, spots and stains shall be removed from floors, wood-work, etc., and any damaged surfaces touched up and the whole of the work left clean and perfect upon completion and during the maintenance period.

8.11 Precast Concrete Invert Blocks

Precast concrete invert blocks for open channel shall be formed to the dimensions shown on the drawings. The concrete used shall be 15N/mm2 concrete as described in Section 3 “Concrete Works”.

The excavation to receive the concrete invert blocks shall be shaped as indicated on the drawings or as directed by the Engineer and thoroughly compacted before the channel is laid. The invert of the trench shall be accurately excavated to line and level.

After the block is laid, soil shall be backfilled, watered if necessary, and compacted against the sides of the block. Where indicated by the Engineer the block shall be jointed by thickly covering the joint face with 1:3 cement: sand motor and driving the next blck hard up against it. The excess mortar squeezed out of the joint shall be neatly trowelled off to a smooth invert.

Where required by the Engineer, the Contractor shall set up sight rails and shall bone in the block with a traveller.

All block ends shall be socked with water for one hour before joining and all joints shall be protected from the wind, sun and rain by a covering approved by the Engineer and shall be kept constantly damp for a period of at least 3 days after forming.

8.12 Precast Concrete Paving Slabs and Open Channels

Precast concrete paving slabs for open channels shall conform to BS 368 and shall be 50mm thick.

The sides of the open channel shall be trimmed and re-compacted as necessary to allow placing of the slabs as slope of 45°. Where directed by the Engineer the slabs shall be jointed to the invert block by thickly covering the joint faces with 1:3 cement and mortar and driving the slab up tight. The excess mortar squeezed out of the joint shall be neatly trowelled off to a smooth invert.

9. PIPEWORKS VALVES AND FITTINGS

9.1 General Provisions

This section of the Specifications refers to the technical and workmanship requirements for carrying out pipe works and associated refurbishment works for Section 2 of the Contract.

The Contractor shall provide all labor, materials, equipment and incidentals required to supply, install, test, and clean, and all other activities required to install new pipe work, and for all refurbishment works as specified in the Contract, or as required by the Engineer, according to the Contract.

Loading, transporting and handling of pipe materials shall be done by the Contractor in conformance with the recommendations of the manufacturer. Any damage to pipe coatings shall be repaired by the Contractor at his own cost.

Each pipe and fitting shall be laid true to alignment, curve and gradient as approved by the Engineer. Precast concrete marker posts shall be set in concrete and fixed near valves, washouts, etc. and at changes in direction of the mains.

Each flanged pipe and fitting shall be supplied and installed complete with bolts of high tensile steel to BS 4882 Grade MB7 or similar, nuts of steel to BS4190:2001 Grade 4, washers of ASI Type 316 stainless steel, and gasket of vulcanized rubber to BS EN 681-1:1996. Nuts and bolts shall be Sheraplex coated to WIS 4-52-03 or equivalent.

All costs involved in supply, construction, installation and commissioning of pipe works shall be deemed covered by the Contractor within the rates and prices of the Contract.

9.2 High Density Polyethylene (HDPE) Pipes and Fittings

9.2.1 Standards of Manufacture

HDPE pipes and fittings where specified in the Contract/drawings shall meet the requirements of ISO 4427 and carry the KEBS standard mark of quality. The pipes and fittings will be manufactured from PE100 raw materials. The pressure de-rating factor for working temperatures above 20 ºC shall be 0.4. The pipes shall be transported, laid, jointed and backfilled in accordance with the manufacturers written instructions.

9.2.2 Jointing

The jointing shall be in either Butt-Fusion or Electro-fusion jointing.

Pipes shall be supplied in lengths not exceeding 12 m. Installation – including butt fusion jointing work on HDPE pipelines – must be directed and supervised by suitably qualified and experienced persons and the Contractor shall have demonstrated his ability to provide this in his Tender. The Contractor shall provide proof of availability of jointing equipment with his tender.

9.2.3 Pipe Dimensions Tolerances

The following table gives the dimensional tolerances of the pipes

Working Pressure	PN10				PN12.5				PN16				PN20				PN25			
Nominal Size(mm)	Wall Thickness(t)		Pipe ID and Wt		Wall Thickness(t)		Pipe ID and Wt		Wall Thickness(t)		Pipe ID and Wt		Wall Thickness(t)		Pipe ID and Wt		Wall Thickness(t)		Pipe ID and Wt	
Mean Outside Diameter	Min	Max	ID	Kg/m	Min	Max	ID	Kg/m	Min	Max	ID	Kg/m	Min	Max	ID	Kg/m	Min	Max	ID	Kg/m
110	6.6	7.4	96	2.15	8.1	9.1	93	2.6	10	11.1	89	3.13	12.3	13.7	84	3.76	15.1	16.8	78	4.48
125	7.4	8.3	109	2.74	9.2	10.3	106	3.35	11.4	12.7	101	4.06	14	15.6	95	4.87	17.1	19	89	5.76
140	8.3	9.3	122	3.45	10.3	11.5	118	4.2	12.7	14.1	113	5.06	15.7	17.9	106	6.18	19.2	21.3	100	7.24
160	9.5	10.6	140	4.5	11.8	13.1	135	5.48	14.6	16.2	129	6.65	17.9	19.8	122	7.94	21.9	24.2	114	9.42
200	11.9	13.2	175	7.02	14.7	16.3	169	8.54	18.2	20.2	162	10.36	22.4	24.8	153	12.42	27.4	30.3	142	14.74
225	13.4	14.9	197	8.9	16.6	18.4	190	10.84	20.5	22.7	182	13.11	25.2	27.9	172	15.72	30.8	34	160	18.62
250	14.8	16.4	219	10.91	18.4	20.4	211	13.35	22.7	25.1	202	16.13	27.9	30.8	191	20.15	34.2	37.8	178	23.05

9.2.4 Physical Properties

The HDPE pipes will be manufactured to the following standards, relative to the temperature as detailed in the sections below.

Property		Value	Unit	Test Method	Test Specimen
Density at 23°C		0.958	g/cm^3	ISO 1183	10 mm x 10 mm x 4 mm
Viscosity Number		380	m/g	1SO 1628-3	0.1% solution of granules in decahydronaphalene
Melt Flow Rate	MFR 190/5	0.23	g/10min	ISO 1133	Granules sample weight 3g to 6g
	MFR 190/216	6.5	g/10min		
Tensile Properties	Yield Stress	26	N/mm^2	1SO 527 Test rate 50mm/min	ISO 3167 4mm thick(test specimen Nr.3, 4mm thick according to DIN53 455)
	Elongation at Yield Stress	10	%	1SO 527 Test rate 50mm/min	
	Tensile Modulus of elatricity(secant between 0.005&0.25% strain)	900	N/mm^2	ISO 527	
	Tensile Creep Modulus (1 hr value)	650	N/mm^2	ISO 899 Test load $2N/mm^2$	
	Tensile Creep Modulus (1000 hr value)	350	N/mm^2		
Flexural Properties	Flexural Creep Modulus (1Min value)	1100	N/mm^2	DIN 54852-Z4 ab=$2N/mm^2$	110 mm x 10 mm x 4mm loaded flat
	Flexural Creep Modulus (3.5% deflection)	20	N/mm^2	ISO 178 Test rate 2mm/min	80 mm x 10 mm x 4mm
Stiffness in Torsion		180	N/mm^2	DIN 53447	60 mm x 6.35 mm x 3 mm
Hardness	Ball indentation Hardness	41	N/mm^2	ISO 2039 Part 1 Test Load 132N	4mm sheet
	Shore Hardness D (3sec value)	61	-	ISO 868	6mm sheet
	Shore Hardness D (15sec value)	59	-		
Notched Impact Strength acN(test specimen from compression moulding sheet)	At 23°C	20	kl/m^2	ISO 179/1ea	80 mm x 10 mm x 4mm
	At 30°C	10	kl/m^2		
Vicat Softening Point VST/B/50		67	°C	ISO 306	4 mm sheet
Oxidation Induction Time	200°C in O_2	>=60	min	ISO TR 10837	granules

9.2.5 Temperature and Working Pressure Consideration

The standard design temperature for HDPE pipes is 20°C and working pressures are usually quoted for this temperature. HDPE pressures pipes function perfectly well below 20 °C right down 0 °C and can, in fact withstand higher pressures than those quoted at 20 °C. The pressures de-rating factors for temperatures above 20 °C are as follows.

Temperature	0-20°C	20-25°C	25-30°C	30-35°C	35-40°C	40-45°C	45-50°C
Multiply Working Pressure by:	1	0.8	0.63	0.5	0.4	0.32	0.25

9.2.6 Hydrostatic Pressure Testing

Hydrostatic pressure leak tests of PE pressure piping systems should be conducted in accordance with ASTM International F 2164, Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure. It is essentially a hydrostatic "pressure rebound method". This standard practice is available for purchase at: www.astm.org. The preferred hydrostatic testing liquid is clean water.

The contractor will be well advised to begin testing early during the pipeline installation to confirm adequacy of the fusion, laying, embedment procedures, and then later to progressively increase the length of test section, as experience is gained. Polyethylene pipe lengths as long as 1000 meters, will be considered for testing.

9.2.6.1 Selection of Test Pressure:

Before commencement of the tests, the Contractor will prepare and seek approval of the Engineer for the type of test, the length of test, and the test parameters. The hydrostatic pressure test is a leak test intended to validate the integrity of the pipeline. The test pressure is never less than the designed operating pressure. The maximum hydrostatic test pressure is based on the pipeline component with the lowest design pressure rating. The hydrostatic test pressure is usually between **1.25 times** the nominal operating pressure and **1.5 times the Design Pressure** Rating of this component. The maximum hydrostatic test pressure must be recorded at the lowest point along the pipeline, and must be compensated for temperatures other than 73ºF.

Typically, for visco-elastic HDPE pipe, the hoop-stress during hydro-test should exceed 30% of the specific minimum yield stress (SMYS) but remain less than 42% of the SMYS. The following test pressure ratios for HDPE pipe may be used, as decided by the Engineer, depending upon the owner's needs and test objectives.

1.0 x Operating or Design Pressure

1.25 x Operating or Design Pressure

1.50 x Operating or Design Pressure

Stress within straight pipe is simple, but stress in fittings is more complex. Within elbows, tees and wyes, the local stress intensifications can raise the local stress to higher stress values, unless the fabricated fittings are sufficiently wall thickened to compensate for geometric effects. The design pressure ratings of installed fittings should be recorded prior to hydro-test, and, the test pressure should be based on a multiplier times the pressure rating of the pipeline component with the lowest pressure rating in the test section at its elevation in the test section at the test temperature.

Three hydro-test parameters are: the hydrostatic test pressure, ratio of hydrostatic test pressure to actual operating pressure, and the pipe's estimated hoop-stress during test. These should be calculated and recorded as follows:

1. Hydro-test Pressure = _____-psi (approved by Authorizing Agent(s)) …… EQ-1
2. R = hydro-test pressure / operating pressure ……EQ-2
3. Estimated pipe hoop-stress = (hydro-test pressure x (DR-1)) / 2 …… EQ-3

9.2.6.2 Selection of Test Length

The pipeline length tested shall be either the whole pipeline, or a section of the entire pipeline capable of being isolated, dependent upon the length and diameter, the availability of water, the disposability of the water, and the spacing between sectioning valves or blind flanged ends. Based upon elevations and distance, the pipeline shall be divided into test sections such that:

- The hydrostatic test pressure at any point in the test section is (i) not less than the design pressure, and, (ii) not more than 25% to 50% above the design pressure rating of any pipeline component; and

- Water is available for the test together with facilities for its disposal, in accordance with regulatory requirements, after test.

When the pipeline is longer than 1000 m, the pipeline may need to be tested in several sections. Where long lengths are tested, radio, cell phone, or other communication means may be required between test operators for safety, to coordinate test activities and keep the test within desired time limits.

Very long test sections may incorporate a large number of mechanical and flanged connections, which must be checked for leakage. The longer the test section becomes, the harder it is to locate a leak or to discriminate between a leak and other effects such as entrapped air being dissolved into solution under pressure. Prior to testing execution, a pre-assessment should be made as to what the recorded pressure versus time curves should look like, and how to read or interpret the actual recorded pressure data, so that acceptance or corrective action can be taken by experienced, trained, and qualified operators.

9.2.6.3 Selection of Fill-Rate:

Slowly fill the test section of the pipeline with water at ambient temperature. Filling is ideally supplied from the lowest point such that the water's entry is submerged and under a "pool" of water inside the pipeline, thus avoiding frothing, air entrainment and air being dissolved into the test water. A slow, submerged, fill velocity will prevent air entrainment and dissolving when the water stream is cascading through downward slopes along the pipeline. Dissolved air can be eruptive leading to a large surge pressure event, and can disguise a possible leak. Obviously the high point air vents should be open and monitored. After filling, allow 3-hours to 24-hours for the system to reach thermal equilibrium, AND, to allow time for any dissolved air to "breathe"

and exit the system vents. The period of stabilization will depend upon the volume of water within the pipeline. The recommended slow fill-rate Q, in gpm, is based on the pipe inside diameter D, in inches, and an axial filling velocity of less than 10-feet per min calculated as follows:

Q gpm = 0.402 D^2inches .

A firm urethane foam pig or swab, pushed by the fill water, may be used to assist in air removal, especially where the pipeline undulates and air pockets may be trapped.

9.2.6.4 Pre-Testing Checklist:

Prior to carrying out any testing activities, the contractor will seek the approval of the Engineer on the type of test and in addition carry out the following pre-test activities:

a) Test Planning

Before commencement of the tests, the contractor will assess the following matters and get approval of the Engineer in preparation of the tests:

- Has all the pipeline section applied for been been completed, inspected and signed off by the Engineer?
- Has it been verified by Engineer that the proper pipe material, diameters, DR's, flange ratings, fittings ratings, are in accordance with the drawings and specifications?
- Has the last fusion joint been allowed to cool sufficiently to ambient temperature?
- Has the pipeline been cleaned of all construction debris and foreign matter?
- Are the facilities available for preparations for testing?
- Are all foreign construction materials removed from the trench in contact with the HDPE pipe?
- Are there any point loads on any fittings? (remove them)
- Are the PE pipelines supported by backfill or otherwise restrained by sandbags to prevent lateral movement or axial contraction under test pressure?
- Where cast concrete has been used, has the concrete cured in excess of 7-days?
- Will the hydro-test be scheduled to occur in dry weather, so that leaks may be detected? (testing in wet weather or in water filled trenches is not recommended)
- Have the proper environmental and regulatory permits been obtained for access to sufficient volumes of fill water, post-test water analysis and treatment, and proper disposal of the test water?
- Has the pipeline elevation profile and filling procedure been analyzed for the fill velocity potential against dynamic surge pressure during filling, which might over-pressure local components, especially in low elevations?
- Has the volumetric rate of fill, fill method, and fill procedure been finalized?

- Has the rate of initial pressurization, prior to full pressure hydro-test, been finalized?
- Has the test plan manual been approved, circulated to inspectors, and understood by all participants in pre-test safety and quality meeting? (sign-in sheet)
- Are some bolted joints going to be left exposed for visual inspection and possible re-torquing during or after testing?
- If desired, is compacted embedment and trench fill going to be placed so that certain specified joints, fittings, service connections, or valves are exposed, in accordance with the owners test plan?
- Have all high elevation points and lateral “dead-legs” been identified with provisions made to properly install adequately sized air vent valves of sufficient volume & pressure capacity? Has it been verified that all vent points are installed in the “open” position, for proper operation during filling? Blind-flanges may be used as high-point vents when they are snuggly bolted and subjected to low filling pressure, such that trapped air is pushed out past the snug gasket, until the fill-water reaches it and sprays out, thus indicating that all air is expelled, followed by the mechanic fully torquing the flange per the approved bolting procedure with just static head against the blind.
- Has an emergency response plan been considered (as appropriate) in the event of a dramatic rupture during hydro-test?
- Has a temporary, foam pipe-pig launcher and receiver been considered so as to make filling the pipeline easy, and to prevent entrapped “pockets” of air?
- Has the Hydro-testing Schedule and Milestone plan been fully developed, reviewed approved, understood and implemented?
- Has the contractor’s list been published of nominated personnel who are to supervise the pressure testing operation, including their qualifications, tasks, and responsibilities, and limits of authority?
- Are supporting documents such as P&ID and isometric drawings available for the hydro-test section, which conform to the as-built configuration?

b) Preparation and Checking of Equipment

- Are all blind-flanged ends (blanks) and valves restrained and supported?
- Are all intermediate valves open and capable of passing or venting entrapped air?
- Has all the equipment been reviewed for capacity to perform its function without fault during the test?
- Have all gauges, dead-weight testers, data recorders, temperature recorders, water volume meters, etc, been calibrated within the last year; are certificates on file? Are the gauges permanently identified with traceability to calibration records?
- Are at least two calibrated pressure gages or instruments placed into the test system to be used as a cross-check for gage accuracy? Typically, one calibrated pressure gage is placed at each end and then monitored, to assure the entire test section was pressurized. When an additional dead-weight tester is used, the pressure readings shall be recorded at a minimum of ½-hour increments. When a calibrated pressure recorder is used, it shall record

continuously during the test. Any pressure gage used shall have sufficient pressure range to 150% of the maximum allowable test pressure.

- Are all temporary tools such as hoses, connection fittings, flanges, blinds, isolation valves, etc, rated higher than the maximum hydrostatic pressure?
- Is an adequately sized and calibrated hydro-test Safety Relief Valve installed and checked for proper operation; and, set for 5 psi higher than the maximum test pressure expected at its point of installation?
- Are properly sized drain ports correctly installed at the lower position along the pipeline, so as to enable emptying of the pipeline as required by contract specifications? Have provisions been made for treatment and disposal of the hydro-test water? Note: when draining is started, have provisions been made to open the upper air vents, to avoid a vacuum internal to the pipeline and to facilitate speed of draining?
- Are the test heads restrained? Blind flanges are fully restrained. Mechanical ends that are not end load resistant shall be temporarily strutted or anchored to withstand the test pressure thrust without movement. Temporary supports shall not be removed until the pipeline is de-pressurized and shall have signs noting the load limits on temporary fittings and supports.
- Does the hydrostatic pressurizing pump have its own calibrated safety relief valve?
- Has the pressurizing equipment been placed in the proper position and checked for proper operation without leakage?
- Is the pressurization pump “right-sized”? Too small of a pump will extend the test duration, and too large of a pump may inhibit adequate control of the test pressure.

c) Safety

- Has there been a safety meeting to review the safety measures and safe practices that are being employed?
- Will test operators be supplied radio or cell phone communications so that the test progress at remote, non-line-of-sight sections can be monitored for venting, or possible leaks or other problems?
- Has a safety perimeter or boundary been established along the pipeline, surrounded or marked by posts supporting yellow safety-tape or safety-line, to assure unnecessary personnel and equipment stay out of the area during pressurized testing?
- Have the on-site hydro-testing personnel filed their OQ (operator qualifications) validating that they have experience and training (contractor licenses, professional degrees, professional certifications, work history) to participate and perform hydro-testing activities, plot pressure-time curves, make calculations, and otherwise work in their assigned role during the hydro-test, in a safe and knowledgeable manner?
- Have all personnel authorized to participate in the hydro-test, been adequately instructed in the test plan, and have they been issued the required personal protective equipment?

- Inclusion Zone: Has the access to the test ROW or test zone been limited to only those trained and qualified persons who are necessary to perform the test?
- Exclusion Zone: Has a safety perimeter or boundary been established along the pipeline, surrounded or marked by posts supporting yellow safety-tape or safety-line, to assure un-necessary personnel and equipment stay out of the area during pressurized testing? (Note: During testing or de-watering, there are possible unrecognized hazards that may not have been completely controlled, such as unexpectedly high pressures from internal malfunctions or equipment failures, rupture of the pipe or fusion joint, un-detected flaws. Such situations may develop forces large than the designed capacities of the anchorages. All non-essential persons should be excluded from the test zone).

d) Testing

- Is testing going to be conducted against a closed valve? Testing should not be conducted against closed valves unless they are mechanically restrained and it is possible to check for leakage past the valve seat. Best practice is to blind-flange before the closed valve.
- Have provisions been made to remove all trapped air at high points? In non-accessible zones, high velocity water flushing can laterally “move” the air from those zones if the water velocity exceeds about 2 to 4 feet per second. This may take large volumes of water and large pumps, but can be effective to move the air bubble to a vent location, when repeated a few times. The methods of removing trapped air are pigging, flushing, venting.
- Has removal or isolation been accomplished on all monitoring pressure-gages, control-valves, relief valves, rupture disks, orifice plates, diaphragm instruments, expansion joints, compressors, lower pressure pumps, etc , which could be damaged during the high pressure test?
- Have the proper drain ports of adequate size been installed correctly in the specified low-elevation points to permit draining of each zone of the hydro-test section?
- Will the fill rate be controlled to at or less than 10-feet per minute axial velocity? This fill velocity avoids air entrainment when the filling water is cascading through downwards gradients along the pipeline (hence preventing the potential eruption of dissolved air like that occurring from a shaken bottle of soda water.)
- Has it been verified that proper tags, tag-outs, signs, and notifications have been implemented/ applied/installed?
- Has it been verified that check-valves (CV) are not being pressurized against the flapper/ seat? When the pipeline has check-valves, assure the CV does not block the flow of the water to other pipe sections included in the test (remove the CV flapper, or block the CV flapper in the “open” position.)

e) Post-Testing

- Have the temporary de-watering lines been secured against movement or de-coupling? Note: During de-watering, significant and sudden pressure variations will occur within the mainline and be transferred into the temporary

de-waterline lines. These variations can be caused by changes in pig velocity thru bends, or, changes in pig and water velocity due to changes in pipeline elevation. Also, air by-passing the pig combining with entrapped air can accumulate stored energy. These sudden changes produce instant over-pressure surges transferred into the temporary de-watering lines which can result in movement, rupture, or de-coupling of those lines. These violent reactions can damage equipment, cause bodily harm, and have killed workers, when the temporary lines were not properly anchored and coupled. The project safety analysis should include safe-guards against lack of anchoring, worn coupling, and excessive and variable system pressures; and for installed anchoring, restraint, and control of de-watering piping, written procedures, and adequate employee training. Pipeline operators are required to protect employees and the public during hydro-testing: 49 CFR 192.515(a) states that: "each operator shall insure that every reasonable precaution is taken to protect its employees and the general public during testing."

- Have the Hydrotest Data, record types, and final Report Forms and format been prepared and approved for use?

f) The Test Report

The pressure test report should include full details of all work associated with the hydro-test, including the planning documentation, safety training, pre-test meeting minutes, the hydro-test-plan, the hydro-test documentation, any leak corrective actions, the certified test results, and the sign-offs for acceptance.

Each Hydrostatic Test shall be documented using the following format:

HYDROSTATIC WATER PIPELINE TEST REPORT

Date_____

Tester_____

Project Name_____

Location_____

Pipe Diameter_____ Pipe Length_____ Pipe Material_____

Meter Number & Size_____

Meter Reading_____ Allowable Leakage (for two hour test period)_____

Test Start Time_____ Test Ending Time_____

Test Pressure Used_____

Leakage Recorded_____ Test Analysis (U-unsatisfactory

S-satisfactory)_____

Sketch of pipe layout being tested (include fittings, caps, and plugs, etc. in the sketch) to be noted below or to be attached.

9.2.7 Chlorination and Swabbing and Commissioning

To safeguard water quality and public health, it is required that supply pipes are chlorinated and tested before a connection is allowed to the water main.

Each chlorination commences with flushing of the system with clean drinking water to remove any debris and providing a clean base for the chlorination to take place.

Following the initial flush through, the system is filled with a chlorinated solution (minimum 50mg/l strength) which will remain for a minimum of 1 hour. After this contact period has been achieved, Contractor's technicians will neutralise the chlorinated solution and dispose of it safely, flushing the system through again with clean water to remove any residual traces of chlorine.

The system is then again filled with clean drinking water, sitting once more for a minimum contact period of 1 hour. This final flushing water will then be sampled for Chemical and Microbiological Analysis, and the samples submitted to one of our certified laboratories to be analysed using approved methods.

Following receipt of the analysis from the laboratory, Contractor provides a Certificate of Chlorination, along with a full Analytical Report for each sample. These results and certificates are usually provided within 7 days of the work taking place providing assurance that the system is safe for use in the supply of wholesome drinking water. This evidence can be provided to Irish Water to enable a connection.

We are available to discuss all your results, their possible meanings and provide guidance on overcoming any failures, like pipe swabbing or Leak Detection.

9.2.8 Handling and Transportation

Before transporting HDPE pressure pipes the loading surface of the vehicle must be cleaned and free from projecting nails, screws or other sharp objects. The bottom layer of all pipes must as far as possible be in contact with the loading surface throughout their entire length and not project beyond it. The pipes must be secured from slipping and shall not be pulled over sharp edges when loading and offloading. Pipes shall not be dragged along the ground.

Pipes, fittings and coils shall be stored in such a way that they are completely protected from direct sunlight. When covered they must be well ventilated to avoid accumulation of heat and resultant deformation. Transparent coverings shall not be used. The storage location shall be flat and shall, for pipes, support the pipes throughout their length. Stones and sharp objects shall not be present. Pipes shall not be stacked to a height exceeding 1 m. The pipes must be secured at the sides to prevent them from rolling. Contact with harmful materials shall be avoided. As far

as possible, coils shall be stored in a horizontal position. The area shall be free of stones and sharp objects. If stored upright they must be secured to avoid tilting.

Prior to laying in trench the bed of the trench must provide support throughout the entire length of the pipe. The pipe shall not be laid directly on cohesive, rocky soil. Such material shall be over excavated to a depth of not less than 0.1 m and shall be removed and replaced by non-cohesive soil or a special pipe support. This shall initially be re-compacted and then the surface loosened on the day of and prior to laying.

9.3 Steel Pipes and Fittings

9.3.1 Standard of Manufacture

Steel pipes and fittings where specified in the contract/drawing will be manufactured to AWWA C200 or equivalent BS EN. Pipes from DN150mm and above will be manufactured with a spiral weld seam or with a spiral seam or longitudinal weld seam. Automatic submerged-arc fusion welding from both sides shall be used.

9.3.2 Design criteria, steel grade, minimum thicknesses and working pressures

1. Design Criteria

Steel grades and wall thicknesses shall meet the following criteria set out in AWWA M11 (Design manual for steel water pipe):

- Internal Working Pressure of 16bars, utilisation factor: 50% of min. yield stress
- 3% max. deflection under Trench and Vehicle Loads for 1-3 m soil cover
- 3% max. deflection under Trench and Vacuum Loads for 1-3m soil cover
- Resistance to Buckling (Factor of Safety 2.5) under above Loads
- Pipe Stiffness of 2000N/m2 for Handling (CIRIA 78 Report)

The supplier shall provide calculations to this effect.

Steels used shall be ASTM A570 Grade 33 (228 MPa yield stress) or equivalent/superior minimum yield stress. The working pressures and test pressures for the minimum wall thickness shall be as follows:

Outside Diameter (mm)	**Min. Wall Thickness (mm)**	**Max. Working Pressure (bars)**	**Works Test Pressure (bars)**
88.9	2.6	67	100
114.3	2.6	52	78

168.3	2.9	39	59
219.1	2.9	30	45
273.0	3.2	27	40
323.9	3.6	25	38
355.6	4.0	26	38
406.4	4.0	22	34
457.2	4.5	22	34
508.0	4.5	20	30
610.0	5.0	19	28

2. Pipe ends

Pipe with socket and spigot push fit joints shall have the socket hot or cold expanded to incorporate an internal groove for fitting of the rubber gasket either is the socket or the spigot. The rubber gasket shall conform to BS EN 2494 Type W. The external weld on the spigot end shall be ground back 203mm from the pipe ends.

3. Lengths, dimensional tolerances and visual inspection.

Pipes shall be delivered with 12 m length from 323.9 mm and above and 6m lengths for below 323.9mm. Tolerance on length will be +/-51mm (AWWA C200 4.12.4)

Tolerance on diameters over a distance L from pipe ends shall be as follows:

Tolerances (mm)	L (mm)	Pipe Outside Diameter (mm)
+1.6/-0.8	100	88.9 - 323.9
+1.6/-1.6	150	355.6 – 1219
+1.6/-3.0	150	1422
+3.0/-3.0	150	1626 - 1829

Circumferential Tolerances of Pipe Body shall not exceed +/-1.00% of the pipe outside circumference but not exceeding a maximum of 19mm (AWWA C200 4.12.2)

Wall thickness tolerances shall not exceed +/-7.5% of the specified wall thickness

Maximum deviation from straightness shall not exceed 3.2mm over a length of 3000mm (AWWA C200 4.12.3).

Weld bead height shall not exceed 3.2mm

Defects in the parent metal of the pipe such as dents, scabs, tears, laps, slivers not greater than 12.5 percent of wall thickness shall be removed by grinding and smoothly dressed to match the pipe contour provided the minimum wall thickness tolerance is not exceeded. Defects greater than 12.5 percent of wall thickness will not be accepted. Cracks, sweats and leaks in welds shall not be acceptable.

Radial Offset of weld seams shall be 1.6mm or 0.1875 wall thickness whichever larger for thicknesses 9.5mm or less and 3.2mm or 0.1875 wall thickness for thicknesses above 9.5mm (AWWA C200 Sec 4.10.1).

9.3.3 Testing

i. Hydrostatic Testing

All pipes shall be hydrostatically tested. Works Test Pressures shall be carried to induce a hoop stress of 75% of the minimum yield stress of the steel

The results of all hydrostatic tests shall be recorded on a pressure-recording chart. All test pressures must be held for a minimum of 10 seconds.

ii. Destructive testing

One set of production weld tests consisting of reduce section tensile tests, bend tests and etching tests shall be carried out on each batch of pipes in accordance with AWWA C200 Section 4.11.5. One batch is defined as 915 meters of pipes having the same diameter, thickness and steel grade

9.3.4 Chemical composition

The steel manufacturer shall furnish a ladle analysis of each heat of steel supplied and the analysis shall conform to the requirements of ASTMA 570

9.3.5 Pipe repairs

Pipes with defects exceeding the 12.5 percent limitation of Clause 1.4.7 shall be disposed of in following way:

Defect removed and cavity cleaned.

Defect repaired by automatic or manual welding according qualified under 4.11.2.1 or 4.11.3.1 of AWWA C200

Hydrostatic testing of the repaired pipe

Cutting off of the section containing the defect provided length limits are met.

All weld repairs shall be carried out in accordance with AWWA C200 4.11.8.

9.3.6 Pipe couplings

Plain ends of pipes and fittings will be joined using bolted, sleeve-type couplings and manufactured in accordance with AWWA C219 (Standard for Bolted, Sleeve Type Couplings) and rated at PIN25. Deflections will be as per Table 3 of AWWA C219.

End rings and centre sleeves will be manufactured from specially shaped hot rolled steel tee sections and hot rolled steel coil respectively. After rolling into circular sections, ends will undergo automatic flash welding and welds will be tested by internal radial expansion.

All couplings will be coated internally and externally in fusion bonded epoxy to AWWA C213 to a thickness of 300-400 microns.

All coatings will be holiday tested and checked for thickness.

Rubber gaskets will be to BS2494 Type W (Nitrile) and suitable for portable water.

Bolts, nuts and washers will be hot dipped galvanised to BS729 with minimum coating weight of 305 gms/m^2.

9.3.7 Fittings, flanges and flange gaskets.

All fittings shall be manufactured from pipes that have been previously successfully tested. All new welds made during the fabrication of the fittings shall be subjected to non-destructive testing using wither radiological, ultrasonic or dye penetrants or a combination of these depending on the geometry of the weld.

Fittings will have dimensions in accordance with BS534 or AWWA C208 depending on the client's preference. If required fittings can be manufactured with dimensions in accordance with Ductile Iron specifications BS4772 or ISO2531. If required fittings will be reinforced in accordance with AWWA M11 and AWWA C208.

Calculation of wall thickness of bends will be carried out in accordance with AWWA C208. Reinforcement of Tees and washout tees shall be carried out with AWWA M11 and AWWA C208 respectively.

Flanges shall be manufactured in accordance with the relevant table of BS4504 for steel flanges.

Flanges gaskets will be manufactured with dimensions to BS4865 Part 1 and shall be of the inside bolt circle diameter type with material to BS2494 Type W for potable water.

Flange Bolts, nuts and washers shall be manufactured to BS4190 and BS4320 respectively and hot dipped galvanised to BS729 with a minimum coating weight of 305 gms/m2.

9.3.8 External and internal coatings to pipes and fittings

Prior to external and internal lining, all Pipes and Fittings will be grit blasted to ISO8501-1 SA2.5 quality with a surface profile of 38-102 microns. All grit blasting machines will be fitted with air-wash systems to remove dust and fines from the surfaces during grit blasting. All surfaces will be cleaned of dust by compressed air prior to coating or lining.

Pipes and fittings will be coated internally and externally in fusion bonded epoxy powder to AWWA C213 to a thickness of 300-400 microns. Pipes will be electro-statically sprayed and fittings will be coated using a combination of electrostatic sprays and fluidised beds.

Prior to startup of coating, the following tests will be done on epoxy powder or on steel plate specimens coated with epoxy powder by the epoxy manufacturer or the coating contractor in accordance with AWWA C213 Clause 5.3.2.

- Specific gravity
- Sieve analysis
- Gel Time
- Appearance
- Impact
- Bendability

- Shear Adhesion
- Penetration
- Abrasion Resistance
- Hot water resistance

During production external epoxy coatings will be tested by the pipe coating contractor according to AWWA C213 Clause 5.3.3 as follows

Electrical continuity, every pipe and fitting

Thickness, every pipe and fitting

Adhesion, every 10 pipes and fittings

9.4 uPVC Pressure Pipes and Fittings

9.4.1 Kebs Specification

Unplasticised Polyvinyl chloride (uPVC) pipes where required in the contract/drawings shall be in accordance with the latest revision of:

Kenya Bureau of Standards: KS 06-149

9.4.2 Pipe Classes and Pressure

Pipes shall be classified by the maximum sustained working pressure as follows

	Working Pressure	Test Pressure
	kN/m2	kN/m2
Class A	600	1200
Class B	900	1800
Class C	1200	2400
Class D	1500	3000

Each pipe shall be clearly marked, using a colour code system to indicate the class.

9.4.3 Fittings

uPVC fittings shall be moulded from material similarly to the pipes and shall comply with the appropriate limits of tolerance in the dimensions as specified for the pipes.

Flanged fittings and other specials not manufactured from uPVC shall be manufactured from ductile iron or steel with materials as specified by the Engineer or form grey iron meeting the requirements of British Standard Specification BS 1452 Grade 12.

The dimensions of flanged fittings and other special shall be as indicated in the preamble to each Schedule in the Bill of Quantities. Where no dimensions are given they shall be at the option of the manufacturer and to the approval of the Engineer. Detailed drawings of all fittings and special shall be submitted to the Contractor to the Engineer for the approval before the commencement of manufacture. The external diameter of flanged fittings and specials shall be the same and to the same tolerances given for the uPVC pipes to which they will be jointed.

Flanged fittings and other specials manufactured from ferrous materials shall be lined internally and coated externally as specified by and to the approval of the Engineer.

9.4.4 Flanges

Flanges shall be suitable for the normal pressures of NP 10 for a nominal hydraulic working pressure of 100 kN/m^2 unless otherwise stated.

Dimensions of all flanges shall be in accordance with BS 4504: 1969 to suit the flange material and type used. Each flange on uPVC pipework shall be supplied with a metal backing ring to the appropriate flange dimension.

All bolts to be supplied with flanges shall be of ductile iron or high tensile steel to the approval of the Engineer.

All gaskets shall be of the 'inside bolt circle' type manufactured from Class 'A' natural rubber in accordance with the requirements of British Standard Specification BS 2494.

9.4.5 Pipe Lengths

The nominal length of pipe in any diameter shall not be less than 6 metres nor greater than 9 metres. The Contractor shall state in the Schedule of the Bill of Quantities the nominal length of pipe he proposes to supply.

9.4.6 Joints

Joints shall be of the sleeves or integral socket type sealed with rubber rings. Details of the joint shall be submitted at the time of tendering for the Engineer's approval. All uPVC material used in forming the socket shall be of a material similar to that of the pipes. The socket shall be fixed truly at right angles to the axis of the pipe.

The rubber jointing rings shall be suitable for the type of joint proposed and they shall be suitable for use with sewerage. The quality of the rubber shall be Class 'A' in accordance with the requirements of British Standard Specifications BS 2494.

The joints shall be flexible and shall be capable of withstanding the work hydrostatic test pressure of the pipes on which they are to be used, without showing any leakage or other defect.

The Contractor shall include in the rates for all lubricants necessary for making joints. The lubricant shall be of a kind not conducive to the growth of bacteria.

Solvent welded joints are not acceptable.

9.4.7 Pipe Ends

Pipe spigot ends for use with rubber ring socket joints shall be cut truly square to the axis of the pipe, with the leading edge of the spigot chamfered to an angle of 15^{o}.

9.4.8 Mechanical Couplings and Flange Adaptors

Couplings for jointing plain-ended pipes may alternatively be of the Dresser Viking Johnson or similar type approved by the Engineer and may be of Steel or ductile iron at the option of the Contractor.

The middle ring (sleeve) and the follower rings (flanges) shall be of such materials and dimensions that they are not stressed beyond half the yield stress of the material when the pipes connected by them are subjected to a hydrostatic test pressure of 1700 kN/m2.

Except where otherwise stated the middle ring (sleeve) of the coupling shall be provided with a suitable pipe stop (Centre register).

The joint rings used shall be of first grade natural rubber and the physical properties of the mix shall meet the requirements of British Standard Specification BS 2494.

Flange adaptors for jointing flanged specials to plain-ended pipes shall conform to the foregoing contents of this clause.

Prior to the commencement of manufacture the Contractor shall submit to the Engineer for approval detailed drawings of all mechanical couplings

All couplings shall be supplied with a shop coat of quick drying primer approved by the Engineer which is compatible with the material to be subsequently used for moulding or painting.

9.4.9 Sampling

For quality control during manufacture sampling and testing shall be carried out as recommended in KBS 06-149.

5% of all moulded uPVC fittings shall be pressure tested by the manufacturer.

9.4.10 Inspection and Testing

The Contractor shall supply furnish and prepare the necessary test pieces and samples and supply the labor and appliances for such testing as may be required to be carried out on his premises according to this specification.

If there are no facilities of his own for making the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere.

The Engineer shall have full access those parts of the plant that are concerned with the testing furnishings or preparation of materials for the performance and testing of work under this Specification.

The Contractor shall furnish the Engineer with reasonable facilities and space (without charge) for the inspection testing and obtaining of such information as he desires respecting the character of material in use and the progress and manner of the work.

9.4.11 Acceptance or Rejection of Consignment

Any pipe fitting or joint which fails to satisfy the requirement of this Specification shall be rejected.

If any pipe or fitting fails to satisfy any of the tests, the tests in question shall be repeated on two further samples. Such samples shall be selected from the same pipes or from a second selection by agreement between the Contractor and the Engineer and should either of these further samples fail any of the tests the pipes or fittings represented shall be deemed not to comply with those tests in which the sample failed and such pipes or fittings so represented shall be rejected.

9.4.12 Marking

Each pipe fitting or special casting shall bear the mark of the Manufacturer and indication of its nominal of its normal diameter and class. Such marks may be either cast on or stamped on when cold.

9.4.13 Protection of Ends

The Contractor shall provide protection to the approval of the Engineer for the ends of all pipes and fittings prior to the pipes and fittings leaving the place of manufacture in order to guard effectively against damage during transit and storage and the ingress of foreign matter inside the pipes and fittings.

All details of the proposed method of providing such protection shall be submitted at the time of tendering.

9.4.14 Storing Handling and Hauling of Pipes and Fittings

Every precaution shall be taken to avoid damage to pipes and fittings.

In handling pipes and fittings every care shall be taken to avoid distortion flattening denting scoring or other damage. Pipes and fittings shall not be allowed to drop or strike objects and shall be lifted or lowered from one level to another by means of approved equipment only.

Pipes should be given adequate support at all times, and not stacked in large pipes. Stacking of pipes with socket joints should be arranged so that the sockets are placed at alternate ends of the stack and with the sockets protruding to avoid lop-side stacks. Stacks should not exceed three tiers high.

The Contractor shall be responsible for all stacking and protecting the uPVC pipes and fittings from direct sunlight at the place of delivery. All details of the proposed method of stacking, storing and shading shall be submitted at the time of tendering for the approval of the Engineer.

Whilst in transit pipes must be well secured over their entire length. Pillows shall be provided between securing chains or lashings when loads are being transported. Pipes in transit must not extend beyond the end of the vehicles carrying them.

Pipes may be off loaded from lorries/railway bogies by gently rolling them down smooth timbers, care being taken to ensure that pipes do not fall one upon another nor into any hard or uneven surface.

9.4.15 Protection and Moulding of Joints

All Dresser Viking Johnson or similar type mechanical coupling will be protected externally after assembly with bituminous or coal tar composition poured into moulds.

The Contractor shall allow for and shall supply all the necessary bituminous or coal tar composition and moulding boxes required for this work.

Moulding boxes shall be of cast aluminium alloy and to the approval of the Engineer. They shall be of economical design sized so that the minimum clearance over any part of the joint shall be 6mm and also take a close fit over the external surface of the pipe.

9.4.16 Packing of Bolts, Rings and Gaskets

Bolts of the same length and size (and their accompanying nuts and washers) shall be packed together in boxes not exceeding 100kg gross weight.

Joints, rings and gaskets shall be packed in boxes and separate packages shall be provided for each size and description of ring or gasket.

Each box and package therein shall be clearly labelled stating the number, size and description of the contents.

9.5 Ductile Iron Pipes and Fittings

9.5.1 General

Ductile iron pipes and fittings where required in the contract/drawings shall conform to the BS EN 545:2006.

Flexible joints of pipes and fittings shall be of the "Tyton" spigot and socket type. All puddle flanges shall be of the thrust resisting type.

Flanged joints shall be drilled in accordance with BS EN 1092:2007, and shall be supplied complete with nuts and bolts, and appropriate gaskets.

The external protection for ductile iron pipes shall be in accordance with DIN 30675 Part 2 for Type III soil and shall be either:

- In general accordance with BS EN 545:2006, comprising a sprayed zinc coating to give a coverage of 130 g/m^2, followed by a bituminous varnish of 70 micron minimum dry film thickness, followed by wrapping with polyethylene sheeting; or
- An extruded polyethylene coating in accordance with DIN 30674 Part 1.

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

9.5.2 Supply of Materials

The Contractor shall supply and fit all pipes, fittings, valves and all other appurtenances needed to construct and finish the pipe works. All pipes, fittings,

specials, valves, nuts, bolts, washers, flanges, gaskets, flanged tied adapters, drain valves, special connection pieces, together with all terminal point connection materials, and anything else needed to finish the works, shall be supplied and fitted by the Contractor under this Contract.

BS standard or equivalent flange adapters as approved by the Engineer shall be fitted where necessary to facilitate the connection of pipes and removal of valves. Adequate provision shall be made for anchoring pipes at these joints.

All pipes shall be carefully inspected for defects before installation. No pipe or fitting that shows defects shall be used. Any injury to the protective coating of the pipe or fitting shall carefully be repaired before installation at no extra cost to the Employer.

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied by the Contractor to support the pipe works in a manner subject to the Engineer's approval. Valves, meters, strainers and other devices mounted in the pipe works shall be supported independently of the pipes to which they connect.

Flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust as a whole so that external anchorages may be kept to a minimum, subject to the approval or requirement of the Engineer.

All costs involved in the supply of equipment, materials and incidentals shall be deemed covered by the Contractor within the rates and prices of the Contract.

9.6 Handling and Storage of Pipes and Fittings

Pipes, fittings and specials shall only be transported on properly constructed or adapted vehicles containing correctly shaped and padded cradles, or with strong, sawdust filled bags separating pipes and vehicle body as well as individual pipes from each other.

Pipes, fittings and specials shall not be subjected to rough handling at any time. Under no circumstances shall they be dropped during loading or off-loading or be allowed to collide with one another. Any materials that have been dropped from a vehicle shall immediately be rejected for use on the works. The same shall apply for any pipes found defective.

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

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

Pipes shall generally be distributed and stored as close as possible to the pipe laying position in order to minimize double handling. Where pipes are strung alongside the trench, they shall be placed on the side away from excavated material.

Where pipes, fittings and specials are to be stockpiled in bulk storage yards, the Contractor shall make his own arrangements for a suitable area subject to the

Engineer's approval. The stockpiling area shall be adequately fenced and protected by a lockable gate, and a watchman shall be maintained at all times.

Pipes, fittings and specials shall be strung or stockpiled on level, well drained ground in a manner such that they will not be in contact with the ground, tree stumps, or other sharp objects. All vegetation and other combustible material shall be completely removed to at least five meters from the nearest pipe, fitting or special.

The height and method of pipe stacking shall be in accordance with the manufacturer's recommendations such that excessive deformation of the lower pipes is avoided. Pipes shall always be supported on a sufficient number of approved soft bolsters to prevent damage.

All rubber rings or other materials which will deteriorate under the action of sunlight, ozone or inclement weather, shall be stored in permanent shade in lockable weatherproof sheds.

Welding and the running of welding machines and electric machinery shall not be permitted in or near places where rubber or plastic products are stored, and care shall be taken at all times to prevent contamination of these products by oil or other petroleum-derived solvents.

Valves shall be stored in orderly groups on prepared floors to prevent damage, distortion or corrosion of flanges or working parts. Full protection shall be afforded to valves with non-metallic seals or working parts. Under no circumstances shall valves be stored in direct contact with the ground.

9.7 Records of Materials on Site

The Contractor shall keep and maintain a complete and comprehensive record of each pipe, special and fitting delivered to all work sites for installation in all works. The record shall at least denote the reference number, size, pressure class, location in the pipeline, date and condition of delivery, location of delivery, and location of storage. Copies of the record shall be submitted to the Engineer whenever requested by the Engineer.

Where pipes, specials and fittings are delivered without reference numbers, same shall be provided by stenciling, labeling or other methods approved by the Engineer.

9.8 Inspections and Repairs

The Contractor shall be responsible for the repair of all defects in pipes, fittings, specials, etc. delivered to work sites. However, no repairs shall be permitted on pre-stressed or reinforced concrete pipes and specials, without the Engineer's approval.

Defective areas of linings and coatings shall be marked when detected and shall be repaired, to the Engineer's approval, in accordance with the manufacturer’s recommendations. Repaired linings and coatings shall be inspected and re-tested after repair, and shall have the same properties as specified for the original ones.

9.9 Connections to Existing Pipelines

The Contractor shall supply all labor, tools and equipment required to connect the new pipelines to the existing pipes, according to the requirements of the Contract or as required by the Engineer.

The Contractor shall excavate at the point of connection and inspect the existing works and make necessary records. On completion of this data collection, the hole shall be backfilled, and the surface temporarily reinstated.

Based on the field data, the Contractor shall prepare and submit Working Drawings showing the method proposed for making the connection, as required by the Engineer. Field data collected shall be clearly indicated on the Contractor's Working Drawings.

The Contractor shall prepare a detailed plan for shutting down of existing water supply pipelines to facilitate interconnections in dry condition. The Contractor shall determine the locations of all isolating valves required to be shut down and check their operational functionality. The Engineer will provide necessary assistance in developing this plan. Existing valves shall be operated by the personnel of the Employer.

The Contractor shall clean up the inside of the existing pipes prior to the connection to the new line. The Contractor shall be fully responsible for testing and disinfection of that portion of the existing pipeline from the point of connection to the extent that has been affected by the connection work as required by the Engineer.

Prior to any connection work to the existing service pipelines, the Contractor shall notify the Engineer of his intention to commence this particular work. No connection work shall be commenced unless an approval by the Engineer has been given in writing.

9.10 Installation of Valves, Meters and Marker Posts

The Contractor shall supply all labor, plant and materials required to install valves, meters and marker posts, as well as to construct valve chambers and valve surface boxes, according to the requirements of the Contract or as required by the Engineer. This work includes surface breaking; excavation and backfilling; sheeting and bracing; on-site forming; installation of pipes, fittings, valves, and appurtenances; installation of miscellaneous metal work, surface restoration and all other work needed to finish the works.

New valve installations shall be located at a distance reasonably away from road junctions so that the installation is not adversely affected by future road widening or surfacing by the road maintenance authorities, as approved by the Engineer.

The weight of valves and meters shall at no time be carried by the pipe, the flange or the coupling. Valve chamber floors shall preferably be cast complete with valve stools and supports immediately after the installation of valves and meters. Stools shall not be permitted to carry the mass of a valve until at least seven days after casting the concrete.

Butterfly valves shall be installed with the blade-seal retaining-ring facing upstream.

Valve boxes shall be constructed with the top of cover lower by 200 mm from the grade of the finished ground surface, or as required by the Engineer. The manhole frame and cover shall be raised with its top conforming to the grade of the pavement or finished ground surface. Slopes to sump at bases of boxes shall be formed by the concrete. No mortar layer shall be allowed.

Bends shall be installed true to line, level and deflection and shall be anchored in concrete where required to counteract thrust. Bends shall normally be supplied with

center planes marked with two small punch marks close to both ends of the bends to facilitate correct positioning of the bends in laying.

Flanges shall be installed with bolt holes off-center and symmetrically off-set from the vertical center line of the flange. Flanges shall be installed truly square to the axis of the pipe.

Insulated joints shall be provided and installed by the Contractor as required by the Engineer. The Contractor shall supply all materials, labor and equipment and shall complete and prove that each insulated joint after installation in the pipeline has a resistance well in excess of the resistance to earth of the pipeline on both sides of the insulating joint.

Dismantling joints shall be installed to facilitate the removal of valves or similar fittings from the pipeline, according to the requirements of the Contract or as required by the Engineer. The Contractor shall supply and install dismantling joints with due regard to their pressure rating and mating flanges. The hydraulic pressure restraining tie-bolts shall be carefully installed to tie the pipe work across the dismantling joint. Dismantling joints shall be watertight.

Hydrostatic Testing of Pipelines

After laying, new pipelines shall be tested under pressure and where in trench, such tests shall be made before it is completely back- filled. During the test, all joints shall be clear of earth, timber, etc. to allow visual inspection. Testing shall commence when not more than 20% of all pipework has been laid and at no time may there be more than 20% untested.

Where old pipelines that are yet to be taken into service are involved, they shall be similarly tested, except that the Engineer may specify at what stage testing is required.

The pipeline shall be tested in lengths between valve locations or in such shorter lengths as the Engineer may approve on the understanding that no extra cost will be incurred to the Employer but the maximum length of main to be tested, shall not normally exceed 1.0 km.

The Contractor shall supply all necessary materials to carry out the test in accordance with the requirements including force pumps, water pressure gauges, including tools for the use of the Engineer, interconnecting pipework, feeding tank, blank flanges, temporary stop-ends, struts and water for the test. The test section shall be capped or flanged off at each end and all branches. Testing shall not take place against closed valves.

9.11 Hydrostatic Testing of Pipelines

After laying, new pipelines shall be tested under pressure and where in trench, such tests shall be made before it is completely back- filled. During the test, all joints shall be clear of earth, timber, etc. to allow visual inspection. Testing shall commence when not more than 20% of all pipework has been laid and at no time may there be more than 20% untested.

Where old pipelines that are yet to be taken into service are involved, they shall be similarly tested, except that the Engineer may specify at what stage testing is required.

The pipeline shall be tested in lengths between valve locations or in such shorter lengths as the Engineer may approve on the understanding that no extra cost will be incurred to the Employer but the maximum length of main to be tested, shall not normally exceed 1.0 km.

The Contractor shall supply all necessary materials to carry out the test in accordance with the requirements including force pumps, water pressure gauges, including tools for the use of the Engineer, interconnecting pipework, feeding tank, blank flanges, temporary stop-ends, struts and water for the test. The test section shall be capped or flanged off at each end and all branches. Testing shall not take place against closed valves.

For a pipeline incorporating flexible joints, testing shall not commence until after all the permanent anchor blocks along the pipeline have been constructed and soil around them backfilled and compacted. Capped or flanged ends along the pipeline shall also be anchored adequately to withstand the force due to test pressure. The Contractor shall submit his proposals for temporary anchoring to the Engineer for approval.

After the main has been clear of debris, and all necessary stop- ends and gauges fitted to the Engineer's approval, the Contractor shall fill up the pipe with water free from silt, and sand and grit and bring up the pressure steadily to the nominal pressure of the pipe or incorporated fittings, whichever is the lesser, (except for old pipelines where a lower value may be specified by the Engineer), and maintain it with a force pump for 24 hours.

The pressure shall then be increased steadily in increments of 1.0 kg/cm2 with a pause of one minute between each increment to the specified test pressure for the section. Unless otherwise specifically mentioned, the applied test pressure shall be measured at the lowest point along the section being tested.

Where test pressure has not been specified, it shall be assumed to be 1.50 times the rated nominal pressure (PN) of the pipe.

After a period of half an hour, the fall in test pressure shall be recorded and sufficient water again pumped into the line under test to bring the pressure back to the test pressure. The procedure shall be repeated every half-an-hour for a total period of 3 hours, or longer, if the Engineer so directs, and the amount of water pumped in recorded.

The rate of leakage shall be calculated from the amount of water pumped in during testing and if it is less than 1 litre of water per 10 mm diameter of pipe per km of length of pipeline, for each 24 hours and for every 30 m head, the pipeline will be considered to have passed the test.

Leaks exceeding permissible amounts shall be made good. And faulty pipes, fittings, and specials, shall be replaced by the Contractor at his own expense and the section tested again before approval is given for backfilling. Payment for the section will not be certified, until the test has been passed and backfilling completed.

9.12 Measurement for Pipelaying

Pipe laying and jointing where in trench is included in the Bill of Quantities with excavation, backfilling, and temporary reinstatement, all as described in the Bills of Quantities. Measurement of the work done will be along the center-line of junctions

in the pipe network, and branches, unless otherwise indicated in the Bills of Quantities.

9.13 Flushing and Sterilization

This shall be done in accordance with the recommendations set out in SSRN 651.

All pipework shall be flushed and cleaned, and all treated water pipework shall additionally be sterilized. The rates inserted are to be for the flushing and sterilizing, and where appropriate for cleaning shall be inclusive for, sampling, testing and inclusive of the reports on the bacteriological quality of water.

9.14 Concrete Protection of Pipe

Unless otherwise provided in the Special Specification or Bills of Quantities or directed by the Engineer, a 0.15 m concrete surround shall be provided to water mains in the following circumstances:

(a) Water mains with less than 0.6 m or more than 6.0 m of soil cover over the pipes.
(b) Water mains under carriageways if depth of soil cover is less than 1.30 m
(c) In the places where shown on the Drawings or directed by the Engineer.

All concrete for beds and surrounds shall be class 15 concrete.

Alternatively under carriageways and where indicated on the drawings, the pipeline shall be laid in a stepped trench with the immediate surround backfilled with approved granular material and then across the step shall be laid precast reinforced concrete slabs of class 25 concrete.

The unit of measurement shall be cubic meter or linear meter as indicated in the Bills of Quantities.

The rate shall include for the provision, transporting and placing of concrete, all strutting and formwork, protection and curing and all labor, tools, plant, supervision overheads and profit.

9.15 Anchor Blocks

Pipelines with mechanical (or flexible) joints shall be adequately anchored at bends, tees, sluice or butterfly valves, tapers, blank ends, etc. Anchor blocks shall be constructed from Class 20 concrete to the dimensions indicated on Drawings unless otherwise directed by the Engineer. Support blocks shall be constructed from Class 15 concrete. Soil around anchor blocks shall be compacted thoroughly before the hydraulic testing of the pipeline. Payment for anchor blocks will be per unit volume of concrete in the blocks and shall include for all the earthwork, formwork and other operations required for their construction. No separable payment shall be made for any temporary or permanent anchor blocks constructed by the Contractor specifically for the testing of the pipeline.

Anchor and Thrust blocks at proposed tie-in points will be cast at least 7 days prior to the proposed tie-in works and post tie-in pipeline testing for the affected section. The proposed tie-in works described in Clause 552 will therefore be preceded by the required anchor/thrust block casting.

9.16 Indicator Plates and Marker Posts

Precast concrete indicator plates to the dimensions indicated on the Drawing shall be installed at all sluice valves, single-air valves, double air valves, fire hydrants and washouts, with letters SV, AV, FH, WO, respectively, indented in them. The plates shall be painted with at least two coats of all-weather plastic emulsion paint of approved colour.

Marker posts to the dimensions indicated on Drawings shall be installed at 100 m spacing along the pipelines installed in open country or as directed by the Engineer. Marker posts shall be painted with at least two coats of all-weather plastic emulsion paint of approved colour.

9.17 Instructions for Site Repair of Damage to Coating and/or Lining of Steel Fittings

Site repair to the coating or lining of pipes and steel fittings of existing pipes shall be carried out as detailed below to the satisfaction of the Engineer.

(a) Pipes and fitting coated externally shall first have the damaged areas and its surround cleaned (by wire brushing) and dried. The damaged area and surrounding coating shall then be painted with coal tar or bituminous solution so as to leave no bare metal exposed. The type of solution used for painting will depend upon the original coating applied to the affected pipes and fittings and must be compatible with the original coating.

(b) Pipes and fittings sheathed externally shall first be holiday detected, and then like the coated ones mentioned in (a), have the damaged area or 'holiday' cleaned and dried to remove all whitewash from the surrounding sheathing by wire brushing. Where the sheathing reinforcement has been damaged in any way or where the sheathing has separated from the pipe wall, the affected sheathing shall be cut out in a neat rectangular or polygonal shape, the cut being made in sound and well bonded sheathing.

The exposed metal and its surrounding shall be thoroughly wire brushed and painted with Type B (fast drying) primer to SSRN 221.

The enamel for affecting the repair shall be heated in sufficient quantities, in a pot or boiler fitted with an efficient thermometer, until it all melts and to a temperature recommended by its manufacturer. The enamel shall be stirred during melting to prevent overheating and charring and ensure the filler does not settle. Only sufficient enamel shall be melted at any one time since the enamel must under no circumstances be reheated.

The damaged area and its surrounding shall be gently heated using a gas torch or blow lamp. The area will then be flood coated. Where the sheathing reinforcement has been cut out a new patch of fibreglass reinforcement shall be applied to overlap the original sound sheathing and the area shall be flooded with hot fluid enamel in such a way that the thickness of the original sheathing is maintained and no metal is left exposed. The repaired area shall then upon drying, be painted with whitewash.

The efficiency of the repair shall be checked using a holiday detector operated at a voltage of not less than 12000 V and not greater than 14000 V.

Should the repairs prove to be unsatisfactory in any way the Contractor shall undertake afresh the repairs to the satisfaction of the Engineer.

(c) Pipes and fittings with enamel lining will have the following procedure taken for their repair:

(i) Where the internal enamel lining has been damaged, crazed or cracked the surface of the lining shall be heated using a gas torch or blow lamp sufficiently to allow the lining to flow and fill in the cracks or damaged portions. Where the damage is more extensive, a suitably shaped iron shall be used to produce a smooth finish.

(ii) Where small areas (n.e. 200 sq.cm) have loosened or entirely detached from the pipe or fitting, the affected area shall be cut out in a neat rectangular or polygonal shape ensuring the cut is made through sound and well bonded lining. The damaged area shall then be prepared for priming and flood coating in a similar manner as that for damages described under (a) and (b) above. The repaired lining shall be to the same contour and thickness as the original lining.

(iii) Where larger areas of enamel lining have become entirely detached or disembarked from a pipe or fitting, the pipe or fitting (or portion of pipe) shall, at the discretion of the Engineer, be discarded.

(iv) No repair to any damaged or cracked area shall be permitted in pipes less than 550 mm nominated diameter where the damaged area extends for more than 1 metre from the end of the pipe or the cut end where tie-in works are to be effected.

(d) Pipes and fittings with concrete or cement mortar lining shall be thoroughly cleaned and dried prior to any repair works. Any cracks or chips in the concrete or cement mortar lining shall likewise, be cleaned and freed of loose materials, dust or any other deleterious matter.

The repair shall be effected using an approved epoxy resin mortar that shall be applied in accordance with SSRN 215.

(e) New pipes and fittings with epoxy coating or lining shall be repaired in accordance with the manufacturer's specifications prior to laying to the complete satisfaction of the Engineer. If so required by the Engineer this shall be carried out and at no additional cost under the site supervision of the manufacturer.

9.18 Completion of External Protection at Joints on Sheathed Pipelines

The completion of the external protection at the joints on sheathed pipes and fittings shall be carried out by one of the methods as detailed below as appropriate and shall be to the satisfaction of the Engineer. The costs thereof shall be deemed to be allowed for within the Tender.

In all cases where the pipe joint has involved the use of nuts and bolts, the exposed threads of every bolt shall first be thoroughly cleaned and then coated with an approved zinc-rich paint allowed to dry for not less than 24 hours before proceeding with the further protection.

(a) Above ground pipelines and fitting and in backfilled trenches Bolted by Flexible Couplings (Moulding Method)

Where exposed ends of steel pipes have not been factory coated with epoxy as indicated in Clause 504 (b) or the flexible couplings have not been factory epoxy coated then the external protection to sheathed pipes and fittings jointed by mechanical couplings shall be completed by moulding the couplings with an enamel composition compatible with the enamel used for the pipe sheathing i.e. a bituminous composition shall be used on pipes and fittings sheathed with bitumen

(asphalt) enamel, and a coal tar composition shall be used on pipes and fittings sheathed with coal tar enamel.

The assembled coupling shall be thoroughly cleaned (including removing whitewash from that portion of the sheathing adjacent to the joint) and dried together with that portion of the pipe that will come within the moulding box and the whole shall be painted with the quick drying primer supplied.

The inside of the moulding box and externally around the pouring gate shall be coated with a thick wash of lime of similar material to prevent any possibility of the moulding box sticking, and shall be dried thoroughly.

The moulding box shall be fitted around the coupling so that the pouring gate is at the top and the flanges and bolts of the coupling sit centrally in the recesses provided for them in the moulding box. The clip or bolts of the box shall be fitted and tightened and all joints sealed, including the joints between the box and pipes, with clay or similar material to prevent the hot composition from running out.

The enamel composition shall be heated in an approved boiler (to be provided by the Contractor complete with an accurate thermometer) to the temperature recommended by the supplier, and stirred during melting to prevent overheating and the filler settling to the bottom.

The fluid enamel composition shall be slowly poured (at the temperature recommended by the supplier), taking care to prevent air- locks, until the gate is filled. The gate shall be kept filled by toppling up as necessary to allow for cooling shrinkage.

The moulding box shall be removed as soon as it is cool enough to handle by which time the enamel will have set. The moulding may be cooled with water to make the enamel set more quickly.

Any defective part of the moulding shall be immediately repaired by applying hot enamel composition with a trowel.

It may be necessary to support the moulding box on larger diameter sheathing pipes to avoid the box from sinking into the pipe sheathing which may have become softened by the hot enamel in the box. The moulding box must be re-coated with lime wash before being re-used.

The Contractor shall provide all other materials required for completion of external protection by the moulding method.

(b) Where pipes and fittings are to be concreted in (Wrapping Method)

The external protection to pipes and fittings jointed by flanged joints, "Tyton", type or Bolted Gland joint, or similar shall be completed by wrapping the joint with approved petrolatum tape prior to which the area shall have been cleaned by an approved proprietary paste and the area protected by an approved proprietary mastic. It shall then be wrapped in uPVC 'outer wrap' or similar material. Mechanical couplings may be similarly protected.

The whole joint shall be thoroughly cleaned removing all loose rust and extraneous matter and the approved paste rubbed well over the whole of the joint and for a few centimetres either side of the joint over the pipe sheathing. A liberal amount of paste shall be left around all bolt heads, narrow cavities, etc.

The approved mastic shall be applied to cover all bolt heads and nuts, forced into the annular gap between the spigot and socket in the case of 'Tyton' type or bolted gland joints, formed as a triangular fillet against the face of socket or flanges and filled in all gaps and abrupt change in contour to provide an even contour for wrapping.

The approved tape shall be applied circumferentially, starting and finishing at the top of the joint care being taken to smooth and eliminate any air pockets and to form the tape well into all angles and changes in contour. The tape should extend on to the pipe sheathing on either side of the joint by at least 50 mm and the tape should be applied with a minimum overlap of 25 mm.

An outer wrapping of 'PVC OUTERWRAP' shall be finally applied over the approved tape'. This wrapping should extend at least 50 cm on to the pipe sheathing and should be applied with a minimum lap of 50 mm.

All the above-mentioned materials shall be provided by the Contractor and deemed covers in his rates.

9.19 Protection to Flexible Couplings and Flange Adaptors in Chambers and/or above Ground

Such mechanical joints e.g. flexible couplings, flange adaptors, etc. in chambers and/or above ground should first be cleansed by brushing away soil and then shall have a primer applied around the component. Moulding around the component shall be with an approved mastic blanket to provide a contour suitable for wrapping the component with an approved petrolatum anti-corrosion tape suitable for tropical climates which shall be done so as to achieve a clean and neat good tape finish.

9.20 Protection to Flexible Couplings and Flanged Adaptors Fitted to Epoxy Coated Pipe Spigot

Where factory coated flexible couplings have been used on pipes whose exposed surfaces beyond other protection materials have been factory protected using epoxy, then such joints shall be site protected by a polythene outer wrap sheathing of minimum thickness 200 microns that shall extend beyond the pipe epoxy coating by at least 50 cm. This outer wrap shall be double strapped using a non-metallic strap to each pipe end beyond and not to the epoxy coating.

9.21 In-situ Welding of Steel Pipes and Flanges

Wherever it is necessary to undertake in-situ welding of steel fittings and flanges the work shall be undertaken under cover, temporary or otherwise. Outside of buildings, the cost of providing such cover shall be deemed included in the Contractors rates. Only suitably qualified welders shall be employed.

Welding procedures used shall comply with SSRN 670.

Prior to deployment of any welder he shall within the preceding 3 months have satisfactorily undergone an 'approved testing' in accordance with SSRN 671 and certification thereof shall be provided to the satisfaction of the Engineer. Each welder deployed shall at intervals of not more than 6 months undergo similar approved retesting and only those who pass such retesting will be allowed to continue to undertake the in-situ welding works. All testing and retesting will be deemed to be covered in the Contractors rates.

9.22 Flanged Joints

Flanges shall be truly parallel with all bolts evenly firm before being finally drawn up with torque wrenches to water-tightness. Taper gauges shall be used to check that there is a uniform gap before and after final tightening of bolts. Bolts shall be tightened in a sequence with bolts equally spaced and at opposite ends tightened equally first.

The Contractor shall ensure that the correct jointing materials, including gaskets, bolts and nuts are used. Only correct diameter and lengths of bolts and studs shall be used. Flat washers shall be used under all nuts. The length of bolts and studs shall be such that at least two threads protrude from the nut when fully tightened. The threads of bolts, studs and nuts shall be thoroughly cleaned and thereafter coated with a graphite/grease compound immediately prior to assembly.

Uncoated flange faces shall be given two coats of an approved bituminous primer before mating. Flanged fittings shall be so installed that there are no stresses induced into the pipe works, specials or fittings by forcing ill-fitting units into position or by bolting up flanges with faces not uniformly in contact with their gaskets over their whole faces.

9.23 End Caps

The Contractor shall prevent trench water, mud, sand or sewage from entering the trench or pipe during installation. Materials to be used for plugging shall be approved by the Engineer, and shall adequately protect the pipe from damage, and prevent dirt, debris and water from entering the pipe.

Open ends of installed pipes shall be securely covered or plugged with water-tight end caps or by other means approved by the Engineer, following the work at the end of each and every working day, and maintained closed until continuation of work.

The Contractor shall also, at his own expense, blank-off all air valves, scour valves and off-takes with blank flanges which shall be bolted with at least four bolts. These shall be watertight and shall not be removed until the valves or other fittings are about to be fitted.

The Engineer reserves the right to order the Contractor to remove any pipe works that have not been plugged as required, for cleaning the inside of the pipes before reuse.

9.24 Surface Treatment of Existing Installations

The Contractor shall provide surface treatment of existing installations for corrosion protection as specified in the Contract, or as required by the Engineer. Surface treatment shall comprise surface preparation followed by painting.

The Contractor shall first remove all loose corrosion and any loose, flaking, and deteriorated paint, by hand brushing with stiff fiber or wire brushes, along with hand scraping and emery cloth abrading. After all non-adherent oxide is removed, the Contractor shall then scrub and wipe the surface with brushes and rags wetted with solvent, using clean solvent and clean brushes and rags for the final wiping. After solvent cleaning, the Contract shall then remove all dirt, dust and other contaminants from the surface prior to painting the surface.

Painting shall comprise the application of a primer, followed by the application of an undercoat, followed by the application of a topcoat. The primer shall be zinc phosphate type to provide a resulting DFT of minimum 40 µm. The undercoat shall be micaceous iron oxide type to provide a resulting DFT of minimum 80 µm. The topcoat shall be synthetic-resin type to provide a resulting DFT of minimum 40 µm. Each coating shall be applied according to the manufacturer's instructions or guidelines.

9.25 Replacement of Existing Nut and Bolt Installations

Refurbishment works include the removal and disposal of existing bolts, nuts and washers, and the supply, fitting and installation of new bolts, nuts and washers.

Existing nuts and bolts shall be replaced one-by-one in sequential manner. Priority shall be given to removing existing nuts and bolts by lubricants. The threads of new bolts and new nuts shall be thoroughly cleaned and then coated with a graphite or grease compound immediately prior to assembly. A torque wrench shall be used to tighten each nut after each replacement to the necessary bolting torque.

New bolts, nuts and washers shall conform to ISO 4014:2011 and BS EN ISO 4032:2001. Bolts shall be high tensile steel to BS 4882 Grade MB7 or similar, nuts shall be steel to BS4190:2001 Grade 4, and washers shall be ASI Type 316 stainless steel. Nuts and bolts shall be Sheraplex coated to WIS 4-52-03 or equivalent.

Washers shall be used under all nuts and bolt heads. The lengths of bolts shall provide at least two threads protruding from the nut when fully tightened. All bolts shall be threaded for the total length of the bolt.

9.26 Water Meters

Water meters shall conform to BS EN 14154:2005 and 75/33/EEC. Water meters shall have maximum working pressures, according to the Contract.

All water meters shall be clearly and indelibly marked with the following information, either grouped or distributed on the casing, the indicating device dial or an identification plate; the water meter cover shall never be used for this purpose:

(a) Manufacturer's name;

(b) Meter class and nominal flow rate;
(c) Year of manufacture;
(d) Serial number;
(e) Arrow indicating the direction of flow; and
(f) Maximum working pressure.

All water meters shall be tested for Qmax, Qt, Qmin, head loss, and maximum working pressure. All test results shall be certified by the manufacturer and provided to the Employer.

All water meters shall be supplied and installed with AMR capability. All water meters and AMR technology shall be installed in meter chambers, according to the Contract.

The Contractor shall refer to the Drawings and Supplementary Information forming part of the Contract when bidding, organizing, scheduling and carrying out meter installations.

Each meter installation shall be supplied and installed complete, with all accessories (gaskets, nuts, bolts, etc) provided by the Contractor.

All meter and pipe works shall be disinfected prior to final assembly and installation, by either spraying or flooding the fittings and equipment with a solution of sodium hypochlorite of concentration not less than 1%, or with a solution of 80/20 ethanol/water solution, with a contact time of at least one minute, to the full satisfaction of the Engineer.

9.26.1 Turbine Water Meters

Turbine water meters shall be Class B, cold water, dry dial, Woltmann type, with tamper-proof features. Materials and workmanship shall conform to ANSI/AWWA C701-07.

Turbine meters shall have a pulse output mechanism with the pulse unit incorporated within the register as standard feature. The register shall be mounted in a vacuum-sealed water-tight compartment. The magnetic drive shall be direct, with no gearing exposed to water, and shall not be affected by external magnetic interference.

For maximum working pressure of 16 bars or less, turbine meters shall have cast iron body with two-pack epoxy coating to DIN 30677-2 or WIS 4-52-01. Meters shall be flanged according to BS EN 1092:1997 for the specified pressure rating of associated pipe work, with flange nuts and bolts of Sheraplex coating to WIS 4-52-03 or equivalent.

For maximum working pressure greater than PN 16 bars, turbine meters shall have ductile iron body with two-pack epoxy coating to DIN 30677-2 or WIS 4-52-01. Meters shall be flanged according to BS EN 1092:1997 for the specified pressure rating of associated pipe work, with flange nuts and bolts of Sheraplex coating to WIS 4-52-03 or equivalent.

Turbine water meters shall have a hinged metallic lid to cover the register window as standard feature. The register window shall be made of durable glass material, thick and tempered type, which resists breakage, scratching and abrasion.

Each turbine water meter shall be supplied and installed complete with bolts of high tensile steel to BS 4882 Grade MB7 or similar, nuts of steel to BS4190:2001 Grade 4, washers of ASI Type 316 stainless steel, and flange gaskets of BS EN 681-1:1996 vulcanized rubber.

Each turbine water meter shall be installed with a separate Z-plate strainer assembly on the inlet side of the meter.

9.26.2 Electromagnetic Water Meters

General Provisions

Electromagnetic flow meters shall operate on electromagnetic induction principles consisting of a detector head and signal converter system. The flow metering system shall provide pulse and analogue current outputs proportional to volume and rate of flow, respectively.

Electromagnetic flow meters shall function primarily by external power supply, but shall also have battery back-up power supply. Rechargeable battery back-up supply shall provide back-up power for a minimum period of 30 days. Replaceable battery supply shall use battery cells with a battery power supply life of minimum five years before replacement. The totalized flow value shall be retained throughout any power failure.

The instrument and pipe work shall be designed and installed in such a way that air or other gases will not be trapped in or around the sensor.

The detector head shall have a stainless steel metering tube and non-conductive, abrasion-resistant lining. The detector head shall have IP68 protection. Power and signal cables to the detector head shall be factory sealed.

The flow meter body shall be bonded by tinned copper braid links at each end to the adjacent pipe work to ensure a good connection between the body and the metered liquid. When fitted in lined, non-metallic or internally coated pipe work, the detector head shall have a grounding electrode with corrosion-resistant grounding rings.

Each meter shall have a range to measure water velocities from 10 mm/sec to 10 m/sec. Accuracy shall be better than + 0.25% of reading (actual flow rate) at flow velocity > 1 m/s with repeatability with + 0.1% of flow rate. The measurement shall be insensitive to entrained solid particles. Each converter shall be completely interchangeable with any other electromagnetic flow meter converter of the same design.

Each electromagnetic water meter shall be flanged according to BS EN 1092:1997 for the specified pressure rating of associated pipe work. Each electromagnetic water meter shall be supplied and installed complete with bolts of high tensile steel to BS 4882 Grade MB7 or similar, nuts of steel to BS4190:2001 Grade 4, washers of ASI Type 316 stainless steel, and flange gaskets of BS EN 681-1:1996 vulcanized rubber. Flange nuts and bolts shall have Sheraplex coating to WIS 4-52-03 or equivalent.

Flow Sensor

The flow sensor shall be manufactured from AISI Type 304 stainless steel metering tube with a Neoprene or non-conductive hard rubber liner. The liner material shall be abrasive resistant and approved for potable water use.

There shall be two measuring electrodes with built-in reference electrode and empty pipe detection electrode as a standard item. The reference electrode shall ensure potential equalization between the sensor and the fluid and proper grounding of the installation. Electrode material shall be AISI Type 316 stainless steel.

The input impedance shall be 10^{15} ohms or greater so that electrode fouling does not affect signal and electrode seal integrity. Sensor data shall be stored in a built-in EPROM module.

It shall be possible to validate the instrument on site without removal of the sensor for ease of fault diagnosis and maintenance.

The flow sensor shall be provided with robust powder-coated die-cast aluminum housing, certified for IP68 protection. The manufacturer shall provide necessary type test certificates for the enclosure.

Transmitter Unit

The following features shall be provided as a minimum:

(a) Pulsed DC field excitation;

(b) Scaled pulse output for integration counter drive;

(c) Capability of bi-directional measurement with differing forward and reverse ranges and with local and remote indication of flow reversal;

(d) Contact operation at a programmable measured value;

(e) Integral display of current flow and integrated quantity;

(f) Galvanic isolation between each output circuit and between the electrode circuit and output circuit;

(g) Each output circuit to be isolated from earth within the instrument but suitable for grounding at any point in the external circuit;

(h) Key entry for basic parameters, range, etc;

(i) Commissioning and rescaling to require no special programming knowledge;

(j) An adjustable low flow cut-off;

(k) Self-diagnosis;

(l) Terminals to have a compartment separate from the electronic components;

(m) Minimum fluid conductivity 20 micro-Siemens/cm or less; and

(n) Continuously adjustable velocity range setting 0.5 to 10 m/s or better.

The transmitter unit shall be microprocessor based, of modular design and shall be easily configurable through integral keypads. The electronics shall be of modular construction for ease of maintenance and future expandability.

The transmitter shall be provided with at least three lines illuminated display for rate of flow and totalized flow indication. The data storage shall be EEPROM to preserve data on power failure without backup.

Transmitters shall be housed in robust die-cast aluminum enclosure with IP68 protection. Signal converter enclosures shall also have IP68 protection.

9.26.3 Automatic Meter Reading Technology

General Provisions

Bulk water meters shall be supplied and installed with Automatic Meter Reading (AMR) technology, as specified in the Contract.

AMR technology shall comprise bi-directional radio transmission of logged pulse outputs of the water meter, between the water meter and a hand-held device for walk-by readings.

Each water meter shall be compatible with the Employer's available AMR technology. Each meter transceiver and hand-held reader transceiver shall be capable of transmitting and receiving data for each water meter, without the need to physically access the locked chamber where the water meter and associated radio transceiver is installed, within a minimum range of 10 m outside from the meter chamber, without the aid of an additional extended antenna.

The meter and reader transceivers shall have the capability to send and receive radio signals, with bi-directional data transmission to provide a two-way wake-up system. Hand-held reader transceivers shall also provide for communication with the computer which is used by the Employer for archiving and billing purposes, which shall be installed with the software application to download data communicated from the hand-held reader transceivers.

9.26.4 Meter Chamber Works

All water meters, AMR transceiver units and accessories shall be installed in new meter chambers of reinforced concrete construction, according to the Drawings of the Contract.

Each new meter chamber shall be provided with a composite chamber cover providing easy physical access to the chamber. Water-proofing using a surface applied capillary water-proofing material shall be provided for the walls and floor of the chamber.

9.26.5 Separate Meter Strainers

Strainers installed as a separate assembly from the water meter shall be Z-plate type, which allows the strainer to be installed immediately upstream from the meter, to improve the velocity profile, minimize the effects of turbulence and increase the overall accuracy of the associated turbine meter, according to manufacturer guidelines and instructions. The strainer design shall provide an effective open area which is minimum two times greater than the size of the water meter case it precedes. The strainer shall have minimal head loss while protecting the associated turbine meter from damage caused by debris.

The main body and top plate of the strainer shall be cast iron with two-pack epoxy coating to DIN 30677-2 or WIS 4-52-01. The strainer element shall be ASI Type 304 stainless steel. The strainer element shall be removable from the top for cleaning purposes without disturbing the flange joints. The top plate gasket shall be full-face of BS EN 681-1:1996 vulcanized rubber. The top plate bolts shall be ASI Type 316 stainless steel.

The strainer shall have flanges conforming to BS EN 1092:1997 for the specified pressure rating of associated pipe work, with flange nuts and bolts of Sheraplex coating to WIS 4-52-03 or equivalent. The strainer shall be installed with the top plate vertically accessible for under-pressure flushing and maintenance. The strainer shall also be fitted with a drain plug of ASI Type 316 stainless steel at the bottom of the strainer.

Each strainer shall be supplied and installed complete with bolts of high tensile steel to BS 4882 Grade MB7 or similar, nuts of steel to BS4190:2001 Grade 4, washers of ASI Type 316 stainless steel, and gasket of vulcanized rubber to BS EN 681-1:1996, for the flanged fittings.

9.27 Valves

9.27.1 General Provisions

Valves shall be of the type and nominal size, according to the Contract or approved by the Engineer. Valves shall be flanged according to BS EN 1092:1997 for the specified pressure rating of associated pipe work, unless specified otherwise.

Valve bodies for all new valves shall give the following information:

(a) Manufacturer's name;
(b) Hydraulic test pressure;
(c) Nominal size of valve; and
(d) Direction of flow arrow.

All new valves, hand-wheels, spindles and headstocks shall be positioned to give good access for operational personnel. Extension spindles shall be supplied wherever necessary to achieve the specified operating requirements. Valves buried or installed in underground chambers where access to a hand-wheel would be impractical shall be key-operated.

New valves shall have the possibility to either remove and replace, or to recondition seats and gates. Gland packings shall be accessible without removal of the valve from the pipe work.

The operating gear of all new valves shall be such that they can be opened and closed by one man against an unbalanced pressure 15% in excess of the maximum service pressure and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required operating torque of 150 Nm.

All new hand-wheels shall be arranged to turn in a clockwise direction to close the valve or penstock and the direction of rotation for opening and closing shall be indicated on the hand-wheels. The new hand-wheels shall be coated with black plastic and incorporate facilities for padlocking in either the open or closed position.

The headstocks of new valves of DN 50 mm, or greater, 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, 1.0.

Unless otherwise specified, all new valves, the valve bodies, discs and wedges shall be of cast iron, with facing rings, seating rings, wedge nuts and other trim of corrosion resistant bronze. The valve stem, thrust washers, screws, nuts and other components exposed to the water shall be of a corrosion resistant bronze or stainless steel. The valve bodies and other components of plastic or other non-metallic materials shall be of robust industrial design.

Each flanged valve shall be supplied and installed complete with bolts of high tensile steel to BS 4882 Grade MB7 or similar, nuts of steel to BS4190:2001 Grade 4, washers of ASI Type 316 stainless steel, and gasket of vulcanized rubber to BS EN 681-1:1996, for the flanged fittings. Flange nuts and bolts shall be Sheraplex coated to WIS 4-52-03 or equivalent.

9.27.2 Air Release Valves

The material of the body and cover shall be cast iron, and shall have two-pack epoxy coating to DIN 30677-2 or WIS 4-52-01 or equivalent.

The valves shall be flanged according to BS EN 1092:1997 for PN 25 bars pressure rating for Marere Pipeline.

All new air release valves shall be suitable for the maximum working pressures in the systems and tested for pressure tightness in steps of 200 kPa up to the maximum working pressures and then for mechanical strength at 1.5 times maximum working pressures. The valves shall be provided with isolating valves and flanged end connections.

The orifice of the new air release valves shall be positively sealed in the closed position but the float shall only be raised by the water and not by a mixture of air and water spray. The seating shall prevent the float sticking after long periods in the closed position. Where air valves need to be replaced, the Contractor shall remove and replace existing air release valves with new air release valves. In addition, new air release valves are foreseen (or where air release valves are missing, these have to be added).

Each new air release valve shall be supplied:

- As non-slam air release valves acting as both air-release valve and air/vacuum valve
- Working pressure ranges: 0.2-25 bars on
- Test pressure for air valve: 1.5 times its working pressure
- Working temperature: 60ºC
- Maximum working temperature for short time period: 90ºC
- Nozzle design in combination of metal and EPDM rubber and be screen protected outlet.

Key operating features to include:

- Air release component to automatically release all small pockets of air to the atmosphere
- Air-vacuum to automatically discharge or admit large volumes of air during the filling or draining of pipeline.
- Air-vacuum to facilitate opening to relieve negative pressures whenever column separation occurs.
- The Air-vacuum shall be capable of facilitating opening to relieve negative pressures whenever column separation occurs
- Air valve to offer protection from pressure surges in the pipeline system.
- Complete with new isolating gate valve, with non-drilled flanges so that assembly onto the existing pipe fitting will be possible on-site without the need of greatly altering the existing pipe works onto which the valve assembly will be fitted.

All new air release valves to be supplied by the Contractor shall be supplied and installed complete by the Contractor, including all associated accessories (nuts, bolts, gaskets, etc).

All costs to execute the works, including any works associated with existing installations, and including any removal or modification of existing installations as required by the Engineer, shall be deemed to be covered in the rates and prices of the Contract.

As soon as practically possible, the Contractor shall perform site investigations and list locations for new air release valve installations.

9.27.3 Butterfly Valves

New butterfly valves shall be rubber seated and air-tight when shut-off, and shall conform to BS EN 593:2009 for double flanged valves.

New butterfly valves shall be suitable for frequent operation as well as for operation after long periods of idleness in either the open or closed position.

All bolts, nuts and other fixings that will be in contact with the contents of the pipelines or, in the case of buried valves within the ground, shall be stainless steel.

The valve body shall be cast iron, the flanges and hubs for the shaft bearing housing being integrally cast with the valve body, and shall have two-pack epoxy coating to DIN 30677-2 or WIS 4-52-01.

The disc shall be ductile iron having edges machined with rounded corners and polished to a smooth finish. The valve disc shall rotate through an angle of 90° from the valve opened to the fully closed position where the seating shall be at an angle normal to the axis of the pipe. Adjustable mechanical stops shall be provided to prevent over-travel of the valve disc in both the open and closed positions.

The shaft shall be fabricated of stainless steel. The shaft, disc and mechanical stops shall be capable of absorbing the full operating torque with a minimum design safety factor of five. Shaft seals, when used, shall be rubber O-ring type. Packing shall be either rubber O-ring or self-adjusting chevron type. Shaft seals, when used, shall be rubber O-ring type.

The valve seat shall be replaceable and formed of PDM or NBR (suitable and approved for potable water) securely clamped into a machined groove in the valve body or to the edge of the disc by seat retention members, or equivalent so as to prevent leakage and to hold the seat securely during operation. The seat retention members shall be of stainless steel and securely clamped with stainless steel fasteners. All fastenings shall be set flush offer the least resistance possible to the flow through the valve.

Valve seats which extend over the face of the flanges to secure the seat in place, or which require surface grinding and/or hand fitting of the disc, or designs which require the adjoining pipe flange to retain the seat in place and resist line pressure, are not acceptable.

9.27.4 Non-Return Valves

Non-return valves shall conform to BS EN 12334:2001.

Flaps shall be fitted with renewable bronze or gun-metal sealing faces, which shall mate accurately with renewable bronze on gun-metal seating rings in the valve body. All seating/seals shall be positively located.

Valve body shall have two-pack epoxy coating to DIN 30677-2 or WIS 4-52-01. These shall be adequate clearance around and at the back of the flap to prevent jamming.

Hinge pins/shafts and internal fixing devices shall be stainless steel. Hinge pins/shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixings. For valves with external levers and adjustable balance weight, the hinge pins/shafts shall extend through a renewable sealing gland on the side of the body.

Covers shall be provided to allow access for inspection, cleaning and servicing, and shall be supplied complete with tapped boss fitted with an air release cock. New valves greater than DN 500 mm diameter shall be provided with lifting eyes, feet and jacking screws.

9.27.5 Ball Float Valves

Ball float valves shall be designed for installation on the inlet pipe to a storage tank and shall automatically shut-off when the water reaches a predetermined level. They shall be of the single-beat type with balancing piston and direct float and lever operation.

New ball float valves shall be designed for a working pressure of 1,000 kPa. Valves shall be drop-tight when they are held shut by the floating ball. Valves shall be tested for leakage at 1,000 kPa when they shall be drop-tight, and shall be tested for body and valve element strength with the valve closed and a test pressure of 1,500 kPa applied to the inlet end.

9.27.6 Float Control Valves

They shall be of the single-beat type with balancing piston and direct float and lever operation.

Valves shall be designed for a working pressure of 1,000kPa. Valves shall be drop-tight when they are held shut by the floating ball. Valves shall be tested for leakage at 1,000kPa when they shall be drop-tight, and shall be tested for body and valve element strength with the valve closed and a test pressure of 1,500kPa applied to the inlet end.

Valves shall be constructed of methanide cast iron to BS EN 1561:1997 with gun-metal trim to BS EN 1982:1999. The valves shall incorporate rubber faces. The ball float shall be made in tinned copper and the float lever shall be mild steel.

Flow control valves shall be provided that are hydraulically operated and throttled to maintain a preset flow rate and/or limit the maximum flow rate regardless of changing upstream and downstream pressures and temperature. The throttled position of the main valve is controlled by an adjustable pilot valve which senses pressure across an orifice plate.

As the flow rates tend to vary because of changing line pressures or downstream demand, the differential pressure across the orifice plate also tends to vary. When

this occurs, the pilot valve repositions to compensate, and changes the throttled position of the main valve piston which controls and maintains the desired flow rate.

The Flow Control Valve shall be rated for maximum pipeline pressure of 25 bars and minimum of 16 bars, while the flow rate shall be minimum 3000l/min and maximum of 5500 l/min

The constant flow valve shall be of the Wafer valve type or screw valve type, capable of operating in the range 140-1000 kPA suitable for flange mounting.

9.27.7 Flange Coupling Adapters

Flanged coupling adapters shall conform to AWWA/ANSI C219 for bolted couplings, absorb up to 10 mm expansion and contraction and allow up to 6° of angular deflection.

Flanged coupling adapters shall be made of steel to BS EN10025-2:2004 Grade S275. Each adapter shall be flanged according to BS EN 1092:1997 for the specified pressure rating of associated pipe work. Each adapter shall be supplied and installed complete with bolts of high tensile steel to BS 4882 Grade MB7 or similar, nuts of steel to BS4190:2001 Grade 4, washers of ASI Type 316 stainless steel, and flange gasket of vulcanized rubber to BS EN 681-1:1996. Each adapter shall have two-pack epoxy coating to DIN 30677-2 or WIS 4-52-01. Nuts and bolts shall be Sheraplex coated to WIS 4-52-03.

9.27.8 Flanged Dismantling Joints

Flanged dismantling joints shall be fully restrained, double flanged type, which can provide up to 100 mm longitudinal adjustment and can be locked at the required length with the tie bars supplied with the fitting. Harnessing shall be provided within the bolt circle. The gasket shall be compressed independently of the tie bars with the sealing capability secured as soon as the fasteners reach required torque.

The body and end rings of both the flange adapter and flanged spigot shall all be made of steel to BS EN10025-2:2004 Grade S275. Tie rods shall be high tensile steel to BS 4882 Grade MB7, or stainless steel of B7 Yield 725 N/mm^2 to BS EN3506-1:2009 Grade A2/A4 Property Class 70 (450 N/mm^2), or such grade for the specified pressure rating.

Each dismantling joint shall be flanged according to BS EN 1092:1997 for the specified pressure rating of associated pipe work. Each adapter shall be supplied and installed complete with bolts of high tensile steel to BS 4882 Grade MB7 or similar, nuts of steel to BS4190:2001 Grade 4, washers of ASI Type 316 stainless steel, and gasket of vulcanized rubber to BS EN 681-1:1996. Each dismantling joint shall have two-pack epoxy coating to DIN 30677-2 or WIS 4-52-01. Nuts and bolts shall be Sheraplex coated to WIS 4-52-03.

9.27.9 Compression Couplings and Fittings

Compression couplings and fittings shall create both a seal and restraining connection when joining any combination of steel and polyethylene pipe, and shall comprise: a forged steel body; two resilient NBR gaskets; two steel, self-centering protective gasket retainer cups; and two heavy end nuts. The locking design shall create positive pipe restraint. Tightening of the nuts shall compress the gaskets and force the steel lock rings to collapse around the pipes to create a strong grip which

increases if the pipe moves or attempts to pull out of the coupling. Insert stiffeners shall be provided when jointing polyethylene pipes.

9.27.10 Extension Spindles and Pedestals

New extension spindles shall be adequately sized to prevent buckling and shall be attached to the valve stem by a suitable adapter incorporating two muff couplings, scarf lap jointed and pinned with at least two coupling joints included. Universal joints and waterproof sleeves shall be provided as required to complete the works.

Intermediate bearing supports or guide brackets of cast iron, with slotted holes for site adjustment, shall be fitted to long shafts where necessary.

New pedestals shall be of cast iron or heavy duty, welded, mild steel construction, with a substantial base and fixing provision. The base and top of the pedestals shall be machined normal to the axis of the drive shaft.

Where necessary, support guide bushes shall be fitted at the base of the pedestal.

The pedestal height shall be such that the hand wheel is approximately one metre above the operator's floor level.

Covers of an approved type shall be provided for all rising spindles to totally enclose them when in the fully raised position.

10. MISCELLANEOUS ITEMS

10.1 Rehabilitation of Water Retaining Structures

These rehabilitation works will be executed by the Contractor while minimizing the shut-down, and shall be coordinated with other works requiring shut-down in the entire system. These shall conform to the Method Statements submitted by the Contractor in his Bid and forming part of the Contract.

In order to proceed, the quantities to determine are:

- Volume of sediment (m^3)
- Internal superficies to clean (m^2)
- If relevant, concrete demolition and shotcrete
- Length of grouting (m)
- Surface of waterproofing mortar (m^2)

Aged concrete undergoes carbonation, significantly lowers its alkalinity and loses the protective oxide layer on the steel which allows corrosion to begin.

The useful life of such concrete may be extended by protecting the concrete against further corrosion.

Firstly, such concrete may need to be repaired and then suitable material spread on it to impede carbonation and concrete deterioration.

(c) Water-proofing of the reservoir floor and walls;
(d) Surface treatment of metal surfaces; and
(c) Filling of float chambers.

The following steps will be followed:

STEP 1: Sediment removing

All sediments have to be removed from the reservoir

STEP 2: cleaning

Reservoir shall be cleaned with high pressure water jet and/or high pressure air with sand. The objective is to have a perfectly clean surface on the internal face of the reservoir.

STEP 3: identification of areas to be repaired

Reservoir has to be filled with clean water, and filling shall be maintained during 24h. This will allow the identification of areas where leakages on the external face of the reservoir can be observed.

If some very important leakages occur (approximately 1 litter per min or more in a single area), it means that important cracks of degradations are present.

STEP 4: Identification and repair of major concrete defects

If the observation of the internal face of the reservoirs allow one to see some important degradations (holes in the wall, visible gravels from the concrete...), these areas of very poor quality concrete have to be removed and rebuilt with shotcrete.

Areas where very important leakages have been observed have to be further investigated with a manual hammer in order:

- to ensure that the concrete is able to withstand the choc of the manual hammer,
- to listen to the noise of the shock, in order to identify potential areas of very poor quality concrete inside the wall.

This hammer investigation has to be performed on both faces of the reservoir wall (in areas showing important leakages). If this investigation indicates the presence of an area of very poor quality concrete, this very poor quality concrete has to be removed, and replaced by shotcrete.

STEP 5: Identification and repair of cracks

Cracks are identified on both faces of the reservoir, with a special care for the internal face. If some very large cracks are identified (2mm or more), they can be grouted with cement grout.

All identified cracks on the internal face have to be grouted with a resin (polyurethane or similar), that needs to be approved for the use in drinking water (example: WEBAC 1403, Dynasylan BHN and Migrating Corrosion Inhibitors (MCI 2020 series). Any one or the other may be used.

Should the contractor propose an alternative protective material, the responsibility will be on the contractor to give specifications and application methodology backed by manufacturer’s literature to the Engineer for approval. Such approval will not indemnify the Contractor against the failure of the protection material to achieve the desired results. Additionally, such new material should have no additional cost implications to the Client and such a confirmation will be required from the contractor in writing.

STEP 6: Waterproofing

A special waterproofing mortar must be applied on the internal face of areas where leakages have been observed (no matter whether these areas have been grouted or not). The width of the area to be covered with this mortar is the area that presented leakages plus twice the thickness of the reservoir wall.

STEP 7: Installation of New Ball float valves

Ball float valves shall be designed for installation on the inlet pipe to a storage tank and shall automatically shut off when the water reaches a predetermined level. They shall be of the single-beat type with balancing piston and direct float and lever operation.

Valves shall be designed for a working pressure of 1,000kPa. Valves shall be drop-tight when they are held shut by the floating ball. Valves shall be tested for leakage at 1,000kPa when they shall be drop-tight, and shall be tested for body and valve element strength with the valve closed and a test pressure of 1,500kPa applied to the inlet end.

Valves shall be constructed of meehanite cast iron to BS EN 1561:1997 with gun-metal trim to BS EN 1982:1999. The valves shall incorporate rubber faces. The ball float shall be made in tinned copper and the float lever shall be mild steel.

STEP 8: Testing for Water Tightness of Reservoir

All water-retaining structures shall on completion be tested for water tightness in the following manner. The structure shall be filled with potable water in stages and held at each stage for such time as the Engineer may require. Should any dampness or leakage occur at any stage, the water shall be drained off and the defects made good. The procedure shall be continued and finally the structure shall after a period allowed for absorption remain full for seven days. Within those seven days, the level of the surface of the water should be recorded and measurements made at intervals of 24 hours. The total leak must not exceed 0.3% of the total volume of water in the tested structure.

If the structure does not satisfy the conditions of the test, and the daily drop in water lever is decreasing, the period of test may be extended for a further 7 days, and if the specified limit is then not exceeded, the structure may be considered as satisfactory.

Should any dampness or leakages or other defects occur they shall be made good and the structures re-tested until the water tightness is approved by the Engineer. Faces of submerged structures may not be covered before testing. The Contractor shall allow in his rates for all expenses and shall provide water and all necessary labor and materials for testing the structures.

10.2 Testing of Water-Retaining Structures

Water retaining structures shall be tested for the water tightness at appropriate stages or on completion. They shall be filled with water in stages and held at each water level for such lengths of time as required by the Engineer. Should leakage occur at any stage, the water shall be drawn off and the defects remedied. The procedure shall be continued and finally the structure shall be allowed to remain full for 7 days. At the expiration of this period, the level of the surface of the water shall be recorded and further measurements made at intervals of 24-hours for 7 days. The structure shall be deemed to be watertight if the total drop in surface level does not exceed 10 mm in 7 days. For open structures, additional allowance shall be made for evaporation. If the structure does not satisfy the condition of the test and the daily drop in water level is decreasing, the period of test may be extended for a further 7 days, and if the specified limit is then reached, the structure may be considered as satisfactory.

The Contractor shall provide a hook gauge to measure variations in water level during the tests.

The testing shall be carried out before the excavations are backfilled and embankments placed.

The Contractor shall be solely responsible for the water tightness of the structure and any remedial measures necessary.

10.3 Cleaning and Sterilizing of Water-Retaining Structures

The inside of all water-retaining structures and all interior pipework and fittings shall be thoroughly cleaned and washed to remove all contamination and the water from these operations removed by squeezing and drained away.

The inside of water-retaining structures shall be filled to overflow level with water containing 50 parts per million of chlorine and left for at least 24-hours. They shall then be drained and refilled with clean water from which samples and analyses shall be taken as instructed by the Engineer. If the results of the analyses are unsatisfactory, the sterilizing process and refilling and sampling shall be repeated until the results of the test are satisfactory.

The provision of all necessary water, labor and materials for carrying out the foregoing operations, shall be included in the Contractor's rates and prices. The cost of sampling, testing and the reports on the bacteriological quality of the water will be borne by the Employer, provided the results of the tests are satisfactory, otherwise the cost of such sampling, testing and reporting shall be borne by the Contractor.

10.4 Chemical Waterproofing of Concrete

Should it become necessary or if indicated in the Bills of Quantities or directed by the Engineer, the Contractor shall apply a concrete waterproofing chemical to concrete surfaces. For surfaces in contact with potable water, such a chemical shall have been certified as suitable for use in potable water retaining structures by competent and internationally recognized authorities.

Products acceptable include waterproofing chemicals consisting of rapid hardening Portland cement, oven-dried quartz sand and active inorganic chemicals of a type that upon application to a concrete surface a crystal chain reaction starts as the active chemical ingredients react with the free lime and water in the concrete capillaries resulting in the formation of insoluble crystals which drive out the surplus capillary water ensuring a permanently water tight concrete but which however at the same time allow the concrete to breath.

10.5 Geo-membrane Lining to Water Reservoirs

Any geo-membrane lining shall be suitable for potable water, and comprise an ultra - violet light resistant high density polyethylene (HDPE) to SSRN 307, suitable for onsite fusion/extrusion welding. It shall be provided in seam free rolls of at least 7 m width, and of thickness not less than 500 micrometers, and breaking strength not less than 180 N/25 mm. When used to line compacted earth or sand, it shall be underlain by an appropriate geotextile layer. It shall be provided rolled on hollow cores of diameter not less than 150 cm, and each roll shall be provided with slings to assist handling on site. The length of rolls shall be such that only longitudinal welds between rolls are required. In situ jointing shall be undertaken by a person or persons well experienced in the technique and approved by the manufacturer. The Contractor will have specified both the proposed manufacturer, and provided full details of laying and jointing techniques, complete with examples of previous similar usage in a tropical environment. The material manufacturer shall have a locally based agent of technically proven capability.

10.6 Structural Steel

All structural steel work shall be of mild steel confirming to SSRN 905. All sections shall be at least equivalent to those shown in SSRN 913.

Ends of beams and joints, etc. shall be cut to exact lengths true and square and shall be cleaned of burrs or rough edges. Drilled or punched holes shall not be greater than 1/16" more than the bolt diameter and they shall be cleaned of burrs and rough edges. Punching of holes shall be allowed for plates thinner than 8 mm.

Prices for all mild steel shall include for removing all rust and mild scale and applying one coat of red lead or other approved priming paint to all surfaces before vising. Following erection, all structural steel not galvanized shall receive three coats of lead paint and be finished in an approved colour.

10.7 Bolts, Nuts and Washers

Bolts, nuts and washers shall conform to SSRN 914 threaded to SSRN 923. Washers shall be to SSRN 925 except that the outside diameter shall be at least 2.5 x the bolt diameter. Tapered washers shall be supplied where required. Where specifically called for, nuts, bolts and washers shall be electroplated. For below ground environments including chambers, the electroplating shall be to SSRN 922. Elsewhere it shall be to SSRN 92

10.8 Hot Dip Galvanizing

All hot dip galvanizing shall conform to SSRN 903.

10.9 Step Irons

All step irons shall conform to SSRN 845 - General Purpose Pattern. The weight of each step iron shall be at least 2.15 kg.

10.10 Fencing

The fencing shall be as detailed on the Drawings, and in general shall follow the recommendations set out in SSRN 849, unless otherwise indicated.

10.11 Gates

The gates shall be as detailed on the Drawings. They shall be complete with a sliding padbolt locking device and gate stops.

The gates shall be primed with calcium plumbate and painted with three coats of approved oil paint.

10.12 VIP Latrines

The VIP latrines shall be as detailed on the Drawings. The VIP latrines shall be constructed using 1500 DN precast concrete rings, joints will be made watertight using concrete (see Section 7 ‘Concrete Works’) and with a protective thick bitumen outer lining (/as on the Drawing) to reduce seepage and to allow for exhaustion. The bitumen layer must be minimum 20mm thick. Water tightness must then be tested according to Section 10.2. If leaks are detected, Section 10.1 shall apply.

11. BOREHOLE REHABILITATION AND DRILLING WORKS

11.1 Geophysical Investigations

The following minimum specifications shall be adhered to in undertaking hydrogeological investigations before borehole rehabilitation and drilling works.

11.1.1 Minimum technical specifications

- Resistivity/IP/SP meter electrode cable with electrode take-outs at regular spacing stainless-steel stakes
- AC/DC power supply with a gas generator or 12 V deep cycle batteries
- Measurement and storage of the contact resistance of electrodes
- Measurement, storage and appropriate compensation for potential
- Execution of repeated cycles of measurement and calculation of the “Standard deviation”
- Ability to set measuring cycles of different duration
- Storage of individual measurement values: Resistivity ρ, potential V, current I, develop Stand Unit control and management of electrodes (up to 256)
- Sensibility Resolution minimum 0.001 millivolts.
- Possibility to use an external generator
- Max current emission up to 800V, 2.5A
- Modeling software to compute resistivity values in 1D, 2D or 3D,
- Possibility to import data of different formats and from multiple instruments
- Data pre-processing: statistical analysis, sorting and filtering, pseud-section
- Mesh generation: Import files from topography, variable size of the cells, starting model defined by user or imported from files.
- Inversion module: Least squares inversion processing with constraint of smoothness. Finite element inversion algorithms
- Apparatus to be supplied with: technical manuals in English. calibration certificate according to EN ISO 7500-1 Class 1

11.2 General Guidelines for Works on Boreholes

The following sections refer to the rehabilitation of the existing boreholes within the Tiwi System as well as for any additional, new well drilling.

11.2.1 Environmental protection of the site

Care must be taken in the handling and storage of all drilling fluids, oils, greases and fuel on site, to avoid any environmental degradation. The Contractor shall dispose of any toxic materials, drilling fluids and other additives, cuttings and discharged water in a manner approved by the Engineer so as not to create damage to public and private property. The Contractor will be closely monitored by the Engineer, and any infringement by the Contractor may render unacceptable the particular portion of the Works to which it applies. The Contractor shall ensure that all its personnel are aware of these Environmental Guidelines and the consequences of not adhering to them.

11.2.2 Workmanship

The Contractor is expected to carry out all works as instructed by the Engineer in a thorough and workman-like manner, and up to today's professional standards. The Contractor shall carryout operations with due efficiency and dispatch in accordance with the terms of the contract and to the satisfaction of the Engineer. For this purpose, the Contractor shall use suitable equipment, and supply efficient and experienced staff.

11.2.3 Equipment and materials

All necessary machinery, equipment and materials to carry out the drilling, test pumping, headwork construction, etc. as specified are to be mobilized for the Works. Test pumping equipment should be independent from the drilling rig(s). Prior to mobilization the Engineer will verify the specifications and state of repair of all major items of plant and transport and shall have the right to order the removal and/or replacement of any items which in his opinion is insufficient or in unsatisfactory condition. Acceptance by the Engineer of the Contractor’s proposed plant and transport does not, however, relieve the Contractor of his obligations under this Contract, in case such plant and transport accepted by the Engineer fails to successfully complete the required Works. All machinery, equipment and materials to carry out the said Works shall be handled, transported and stored in accordance with the manufacturers’ recommendations to minimize deterioration.

11.2.4 Supervision of the works

The execution of the Works is to be supervised by the Employer's appointed Engineer.

11.2.5 Water supply for drilling

The Contractor shall make his own arrangements for obtaining, storing, transporting and pumping of water, required for drilling purposes and for use by the drilling crew at their campsite.

11.2.6 Personnel

a) The Contractor will provide an experienced project Coordinator to oversee the drilling and testing to be carried out under this Contract. The name and work resume of the Project Coordinator shall be included in the tender.
b) The Contractor will maintain a full crew on each drilling unit and test pump unit. If a member of crew quits for personal reasons or must leave because of illness or injury, the Contractor will replace him as soon as possible with a worker of similar experience.
c) If the Employer is dissatisfied with the performance of members of the crew, such members shall be informed of their shortcomings and warned by the contractor. If no change results within a reasonable period, the Contractor will be notified and requested to take necessary measures on the unsatisfactory crew member.
d) If the Employer wishes to operate drilling equipment more than one shift per day, the Contractor shall increase the size of the drilling crew as required. However, in the percussion drilling, the rig will be operated for a minimum of 20 hours a day.

e) In the case of absence of one or more members of the drilling crew the decision of whether to proceed with drilling operations will be at the discretion of the Engineering Engineer.

11.2.7 Borehole disinfection

All boreholes shall be disinfected after completion. This can be achieved by placing a chlorine solution into the well so that a concentration of at least 50 mg/l (0.005%) of available chlorine exists in all parts of the well at static conditions. All borehole parts above the water level should be completely flushed with the solution. The solution shall remain in the well a minimum of 12hours before pumping the well to waste.

11.2.8 Water level observations

The Contractor shall supply appropriate electric contact water level gauges, suitably calibrated such that measurements can be made to an accuracy of 5mm, for measuring water levels in the boreholes. Water levels shall be measured during test pumping at pre-determined intervals, dependent on the nature of the test. The frequency of measurement shall be specified in an agreed test pumping data form or as otherwise determined by the Engineer. Well head arrangements shall permit these gauges to be inserted and passed freely. Any other method of measuring water levels will be subject to approval by the Engineer. The contractor should have on the site at least 2 electric gauges suitable for a maximum depth of 100m. The devices should fit into the ¾ -1" observation pipes and should permit direct, convenient and accurate reading of depth of static and dynamic water levels.

11.2.9 Wastewater Treatment and Disposal

All wastewater shall be contained in tanks until discharged. The Contractor shall employ approaches necessary to work within site space restrictions and wastewater discharge requirements. The Contractor shall comply with the discharge requirements set by the sanitary district in the wastewater discharge permit for the project.

11.2.10 Water sampling and quality testing

The Contractor shall take water samples for testing the physic-chemical and bacteriological quality at the end of the test pumping. For this purpose, the Contractor shall supply and keep onsite a minimum of 4 suitable two-liter capacity water containers and shall collect water samples as directed by the Engineer. Samples shall be tested at a certified laboratory, and the test results shall form part of the monthly and End of Contract Reports.

11.2.11 Capping of borehole

During borehole construction, installation, development and test pumping, the contractor shall use all reasonable measures to prevent entry of foreign matter into the borehole. The Contractor shall be responsible for any objectionable materials that may fall into the borehole and any effect it may have on the water quality or quantity until completion of the Works and acceptance by the Engineer.

11.2.12 Acceptance of boreholes

The borehole shall only be acceptable by the Engineer upon satisfactory completion of all drilling operations, installation of casing and screens, development works, and test pumping.

11.2.13 Loss of equipment

Any equipment lost down a borehole must be removed by the Contractor or the borehole will be considered a lost bore. A replacement borehole will have to be constructed and test pumped at the Contractor's expense. The Contractor shall be entitled to NO payment for such tools or equipment.

11.2.14 Lost bore

Should any incident to the plant, behavior of the ground, jamming of the tools, or casing, or any other cause prevent the satisfactory completion of the borehole, a borehole shall be deemed to be lost and no payment shall be made for that bore or for any materials not recovered therefrom, nor for any time spent during drilling or while attempting to overcome problems. In the event of a lost bore, the Contractor shall construct a borehole at a site indicated by the Engineer. The option of declaring any bore lost shall rest with the Contractor, subject to the approval of the Engineer. A lost bore shall be treated as follows:(a) The Contractor may salvage as much casing and screen from the lost borehole as possible, and may use it if not damaged in a replacement borehole, with the approval of the Engineer.(b) Any material supplied by the Employer and salvaged damaged shall become the property of the Contractor, and the Contractor shall compensate the Employer accordingly.(c) The lost bore shall be backfilled with native soil from the bottom upward and 2 of the last 3 meters shall be sealed by concrete, cement grout, or neat cement, which shall be placed by a method approved by the Engineer that will avoid segregation or dilution of material.(d) The upper 1 meter of the lost bore shall be backfilled with native top soil. Sealing of such abandoned boreholes shall be done in such a manner as to avoid accidents or subsidence, and to prevent it from acting as a vertical conduit for transmitting contaminated surface or subsurface waters into the water bearing formations.

11.2.14.1 Clearing the site

On completion of each borehole the site shall be left clean and free from all debris, hydrocarbon sand waste, and all pits filled to the satisfaction of the Engineer. A site not delivered clean may render the borehole unacceptable. The borehole shall be numbered as specified by the Engineer and the number marked on the casing with indelible ink or in such a way that the marking is permanent.

11.2.14.2 Submersible pump installation

The Contractor shall supply and install submersible pumps according to the mechanical specification for these pumps. Refer to Chapter 5 for sequencing of works and adequate timing in the Work Program.

11.3 Borehole Rehabilitation - Specifications and Guidelines

The following sections refer to the rehabilitation of the existing boreholes within the Tiwi System.

11.3.1 Test Pumping

Test pumping may not be allowed during or immediately after rain events. The Contractor shall seek written approval from the Engineer prior to the commencement of any test pumping.

Test pumping shall be performed to establish the hydraulic performance of the well and provide data for additional analysis by the Engineer. The Contractor shall provide a test pump appropriate for determining the maximum sustainable pumping rate for the well. The pump intake shall be set approximately 3.0 m above the top of the shallowest screened interval. All water level data recorded during the testing shall be provided to the Engineer within 48 hours of test completion.

The following procedure shall be performed:

Step 1: The pumping rate shall be adjusted until a rate is found that stresses the well near its maximum sustainable rate. During the adjustment process, the pumping rates and resulting water levels shall be monitored and recorded. Once the pump has been adjusted to near the maximum sustainable pumping rate, the well shall be pumped for one to two hours with the pumping water level monitored and recorded every five minutes. The pumping water level shall not be allowed to fall so low that the pump cavitates. If pump cavitation occurs, the pumping rate shall be reduced to eliminate cavitation. The well shall be pumped at the adjusted rate for a minimum of one hour with the pumping water level monitored and recorded every five minutes.

Step 2: A step-discharge test shall be performed on the well. The test shall not begin until the non-pumping water level in the well has stabilized near the level observed before Step 1 was performed. The well shall be pumped in four steps at successively higher rates. The rates shall be approved by the Engineer before the test begins. The range of these pumping rates may vary from 50% to 100% of the estimated maximum sustainable pumping rate of the well determined in Step 1. The pumping water level shall be monitored and recorded frequently during the test. The recording intervals shall be documented and approved by the Engineer before the test begins. Each step shall continue until

1) a straight line water level trend with time is established and

2) the Engineer agrees that it is appropriate to progress to the next discharge rate. It is anticipated that each step shall not last more than two hours.

The discharge from Steps 1 and 2 shall be contained in a tank until released as wastewater in accordance with local regulations. These same general requirements apply to solids generated during the work.

11.3.2 Brushing and Sediment Removal

The removal of material in the well shall be accomplished by brushing and pumping (or airlifting). Any oil floating on the water surface shall be removed before the work begins. The brushing and sediment removal shall be performed in a single trip down the well. The following procedure shall be performed:

Step 1: The well screen and casing shall be brushed to remove encrusting and biological material attached to the inside of the well. The brushing shall be performed in a manner that achieves maximum contact with the louvers and

perforations; however, care shall be taken not to damage the aged screens and casings. Nylon, instead of wire brushes shall be used on all screens. Simultaneous with the brushing, water shall be removed by pumping or airlifting. The rate of brushing shall not exceed 12.0 m per hour below the static water level, and brushing shall progress from the shallowest to deepest portions of the well. The rate of pumping or airlifting shall be no less than 1 m^3 per minute.

Step 2: Once the brushing is complete, sediment accumulated in the bottom of the well shall be removed by pumping or airlifting. The sediment removal process shall continue until the discharge is visibly clear. The discharge from Steps 1 and 2 shall be contained in a tank (capacity: 10 m^3) until released as wastewater in accordance with local regulations. These same general requirements apply to solids generated during the work.

11.3.3 Well Casing Video Surveys (CCTV inspection)

Detailed video surveys shall be performed in the presence of the Engineer. Videos shall be taken after brushing and after chemical cleaning or as requested by the Engineer. The video logging shall be in colour, include down-hole viewing and side-scan viewing (with 360-degree capability), and extend to the total well depth up to 120 m. Potable water shall be added to the well at a slow rate (approximately 20 l per minute) for at least 8 hours before the video logging in order to reduce suspended sediment and improve viewing conditions. The log shall methodically inspect the casing and screened interval(s) in order to assess the current well condition and identify any damage. A down-hole view shall be maintained while descending through the well with use of sides-can views as necessary to inspect areas for potential casing or screen damage until the bottom of the well is reached. A sides-can view with slow continuous rotation shall be maintained while ascending at a rate no greater than 0.1 feet per second through the well with stops as necessary to inspect areas for potential casing or screen damage until the top of the well is reached (video to continue above the water level). The contractor shall include the prices of providing, mobilization, demobilization, documentation and personnel of two CCTV vehicles. The Contractor shall provide two copies of the video log on DVD to the Engineer within 48 hours of completing the video and before subsequent tasks are performed.

11.3.4 Additional Brushing and Sediment Removal

Based upon the results of the video logging performed after the brushing and sediment removal, additional brushing and sediment removal may be required. The need for and extent of this additional work shall be determined through consultation with the Engineer.

11.3.5 Agitating the Near-Well Environment

The near-well environment shall be agitated to improve the efficiency of subsequent mechanical and chemical treatment steps. The following procedure shall be performed:

Step 1: Encrusting and biological material present outside the well in the gravel pack and aquifer material located close to the well shall be loosened by use of hydraulic/compressive or acoustic energy tools. No explosives shall be used in this work. The work shall be performed along the screened interval(s). The number of locations along the screened interval(s) at which the work is performed may depend

upon the method used. The plans for this work shall be finalized in consultation with the Engineer.

Step 2: Once the agitation is complete, sediment accumulated in the bottom of the well shall be removed by pumping or airlifting. The sediment removal process shall continue until the discharge is visibly clear. The discharge shall be contained in a tank until released as wastewater in accordance with local regulations. These same general requirements apply to solids generated during the work.

11.3.6 Mechanical Cleaning – De-sanding

Mechanical cleaning of each screened interval shall be accomplished by injecting, swabbing and pumping (or airlifting). The swabbing tool (double surge block) shall be sized to allow approximately one inch of clearance between the tool (surge block circumference) and the screen. (Note that mechanical cleaning may be performed after chemical cleaning depending upon the condition of the well screen as determined from the post-brushing video survey. This potential change in the order of tasks shall be requested by the Engineer as necessary.)

If De-sanding was not achieved after 6 hours, airlift will be carried-out until the water becomes limpid, but up to a maximum of 12 hours with any extra hours on top of 6 hours to be invoiced accordingly. Upon completion of development, any accumulation of material shall be removed from the bottom of the borehole by airlifting.

The following procedure shall be performed:

Step 1: A surfactant and bio-dispersant shall be injected during the swabbing to enhance mobilization of materials clogging the well screen and near well environment. The chemical solution shall be at a concentration consistent with manufacturer specifications and of a volume generally equal to 1.5 times the standing well volume. For situations where the screened length is a relatively short portion of the well depth, the solution volume shall be reduced. Volumes to be used are specified below for each well. Only potable water shall be used to prepare the chemical solution. This process shall be performed on the deepest part of the screened interval first and then progress to the shallowest portion of the screened interval in 3.0 m sections. Each 3.0 m section shall be swabbed for approximately 20 minutes at a slow rate that shall not damage the well.

Step 2: Once chemical addition is complete, water shall be removed by pumping or airlifting at a rate of no less than 1 m^3 per minute simultaneous with swabbing. The swabbing shall begin slowly and progress to a faster action only when doing so shall not damage the well. The swabbing shall progress in 3.0 m sections from the shallowest to deepest portions of the well. The amount of settleable solids in the discharge shall be evaluated as the swabbing progresses. The process shall continue for at least 60 minutes per 3.0 m section. The process shall continue for each screened interval until the discharge is visibly clear and contains less than 10 parts per million settleable solids as estimated using an Imhoff.

Step 3: Once the swabbing is complete, sediment accumulated in the bottom of the well shall be removed by pumping or airlifting. The sediment removal process shall continue until the discharge is visibly clear. The de-sanding shall be carried out until the technical absence of sand, which is 0.1 g/m^3

Step 4: The discharge from all mechanical cleaning work shall be contained in a tank until released as wastewater in accordance with local regulations. These same general requirements apply to solids generated during the work.

Depending on the site conditions, the Contractor shall choose an adequate method. This could either be surging and swabbing, intermittent pumping, intense de-sanding, high pressure de-sanding or surging combined with pumping. The Contractor shall propose an adequate method to the Engineer. Works shall only start following approval by the Engineer to the process and the presented Method Statement.

11.3.7 Chemical Cleaning

Chemical cleaning of each screened interval shall be accomplished by injecting, swabbing and pumping (or airlifting). The treatment solution shall consist of 5 percent hydrochloric acid with an inhibito Fr and a bio-dispersant. Any on-site preparation of chemical solutions shall be conducted such that no vapours migrate off-site. Due to the close proximity of the public at each site an exclusion zone to be implemented in the field for each site shall be identified in the health and safety plan submitted by the Contractor.

The chemical solution which should be used in this process depends on the conditions of each borehole. The contractor shall propose an adequate chemical solution and the method to the Engineer. Several chemicals could be used such as treatment with acids, with polyphosphates, with chlorine. Works shall only start after the approval of the Engineer.

Only potable water shall be used to prepare the treatment solution. The Contractor may choose methods for obtaining water at a higher rate than available on-site. Prior to water being transported to the site the Contractor must provide certification to the Engineer that the tanks used have been thoroughly cleaned prior to use or have only previously been used to transport potable water.

The following procedure shall be performed:

Step 1: A chemical solution (sulphamic acid e.g.) with a volume equal to 1.5 times the standing well volume shall be added to the well. For situations where the screened length is a relatively short portion of the well depth, the solution volume shall be reduced.

The addition shall be accomplished by injecting through a double surge block and swabbing the chemical solution into the well screen. Because a significant amount of calcium carbonate is present in each well, the acid solution shall be injected slowly in order to avoid a violent chemical reaction. This process shall be performed on the deepest part of the screened interval first and then progress to the shallowest portion of the screened interval in 3.0 m sections. Each 3.0 m screen section shall be swabbed for at least 20 minutes at a slow rate that shall not damage the well.

Step 2: Once the chemical addition is complete, the pH shall be

1) Measured and compared to the pH before the acid was injected and

2) Monitored hourly until the pH stabilizes. If the pH rises above 3.0 at any point in the pH monitoring process, an additional volume of chemical solution shall be added using the above-described process and the pH monitoring begun again.

Once the pH has stabilized at or below 3.0, the well shall be left to stand until the next morning.

Step 3: After the well has been allowed to stand overnight, swabbing and pumping shall be performed for each screened interval as described above. The amount of settleable solids and pH in the discharge shall be evaluated as the swabbing progresses. The process shall continue for at least 60 minutes per 3.0 m section. The process shall continue for each screened interval until the discharge is visibly clear, contains less than 10 parts per million settleable solids as estimated using an Imhoff and the pH has returned to the pre-treatment level.

Step 4: Once the cleaning is complete, sediment accumulated in the bottom of the well shall be removed by pumping or airlifting. The sediment removal process shall continue until the discharge is visibly clear.

Step 5: The discharge from all chemical cleaning work shall be contained in a tank until released as wastewater in accordance with local regulations. These same general requirements apply to solids generated during the work.

11.3.8 Post-Cleaning Test Pumping

Test pumping may not be allowed during or immediately after rain events. The Contractor shall seek written approval from the Engineer prior to the commencement of any test pumping as described above.

11.3.9 Disinfect Well

The well screen and casing shall be disinfected. Barring any uncontrollable delays (weather, supplier delay, equipment failure) installation of each new submersible pump shall commence within 48 hours of completion of well disinfection at each well. The following procedure shall be performed:

Step 1: A pH-adjusted, slightly acidic (i.e., pH 6.0 to 7.0) chlorine solution of 100 mg/l, with a volume equal to four times the standing well volume, shall be used. For situations where the screened length is a relatively short portion of the well depth, the solution volume shall be reduced. Any on-site preparation of chemical solutions shall be conducted such that no vapours migrate off-site. Only potable water shall be used to prepare the treatment solution. The Contractor may consider methods for obtaining water at a higher rate than available on-site. The solution shall be added to the well by injecting through a tremie pipe or equivalent approach. This process shall start at the bottom of the well and progress to the standing water level. Each 3.0 m section of screen shall be swabbed for at least 20 minutes at a slow rate that shall not damage the well. The chlorine solution shall be allowed to remain in the well for at least 12 hours.

Step 2: After the well has been allowed to stand the required amount of time, water shall be removed by pumping or airlifting at a rate of no less than 1 m^3 per minute. Within the screened interval(s), the pumping shall be performed simultaneous with swabbing starting at the standing water level and progressing to the bottom of the well. The swabbing shall be performed at a rate that shall not damage the well and progress in 3.0 sections of the screened interval(s). Each section shall be pumped for at least 60 minutes. At least 5 times the chlorine solution volume used in Step 1 shall be removed from the well. The chlorine content in the discharge shall be evaluated as the pumping progresses, and the pumping shall continue until the discharge contains no chlorine.

Step 3: The discharge shall be contained in a tank until released as wastewater in accordance with local regulations. These same general requirements apply to solids generated during the work.

11.3.10 Additional Specifications

a) Water level observations

The Contractor shall supply appropriate electric contact water level gauges, suitably calibrated such that measurements can be made to an accuracy of 5mm, for measuring water levels in the boreholes. Water levels shall be measured during test pumping at pre-determined intervals, dependent on the nature of the test. The frequency of measurement shall be specified in an agreed test pumping data form or as otherwise determined by the Engineer. Well head arrangements shall permit these gauges to be inserted and passed freely. Any other method of measuring water levels will be subject to approval by the Engineer. The Contractor should have on the site at least 2 electric gauges suitable for a maximum depth of 120 m. The devices should fit into the ¾ -1" observation pipes and should permit direct, convenient and accurate reading of depth of static and dynamic water levels.

b) Electrical conductivity measurements

The Contractor shall provide an operational Electrical Conductivity meter and shall take electrical conductivity readings of the discharge water during test pumping.

c) Records and reporting

The Contractor shall keep daily activity records for each borehole. The records shall contain the information as specified below. In addition, separate records should be supplied for each borehole upon completion.

i) Daily Record Site name Reference number of borehole GPS Co-ordinates of borehole (latitude / longitude) Date of reporting Names of foreman. Water level at the start of each working day Electrical conductivity measurements during test pumping Problems encountered during drilling Details of installations in the borehole (if any) Depth, size and description of well casing Depth, size and description of well screens Aquifer depth and SWL after completion of well A copy of the Daily Record shall be made available daily to the Engineer, and should include any other pertinent data as may be requested by the Engineer.

ii) Monthly Contract progress report. The contractor shall submit a monthly progress report detailing progress on the contract. The month report shall include the progress of projects successfully completed, problems accounted that are hindering progress and remedial recommendations to accelerate contract progress.

iii) End of Contract Report. The Contractor shall prepare an end of Contract report, which should address at the minimum the following issues;

- The selected sites (Suitability, accessibility)
- The test pumping methodologies (Type of test-pumping methods)

- Contract schedules and duration (Summarized diary of events and actual durations)
- Summary of results and analysis (Table showing locations, well numbers, driller's and test pumping yields, water quality and any other information necessary)
- Problems encountered (With accessibility, formations, equipment and community, etc.)
- Suggestion for improvement (On supervision, documentation, durations, etc.)
- Any other information that the Contractor may deem important or necessary two copies of the End of Contract Report (one without the Completion Records) shall be submitted to the Engineer.

d) Water sampling and quality testing

The Contractor shall take water samples for testing the physic-chemical and bacteriological quality at the end of the test pumping. For this purpose, the Contractor shall supply and keep onsite a minimum of 4 suitable two-liter capacity water containers and shall collect water samples as directed by the Engineer. Samples shall be tested at a certified laboratory, and the test results shall form part of the monthly and End of Contract Reports.

11.4 Drilling of New Boreholes - Specifications and Guidelines

The following sections refer to the drilling of 2 new boreholes at BH A and BH 9 and any additional sites that may be instructed by the Employer.

11.4.1 Drilling site

The Contractor shall drill the borehole(s) at the exact location(s) designated by the Employer or the Engineer. Tracks required for access of drilling plant, gear, camp and accessories to the borehole site shall be made by the Contractor and should as little as necessary interfere with existing fences and cultivated land.

11.4.2 Borehole depth and diameter

The Contractor shall drill to the total appropriate depth depending on the geological formation and to a diameter that shall allow minimum borehole nominal diameter specified in the BoQ at the completion of the borehole, including casing installation. In any case the minimum drilled depth should be 80 meters and maximum 120 meters.

11.4.3 Drilling method

The Contractor may use any rotary drilling technique that he feels applicable to achieve the depth and diameter required, provided that the techniques used are those specified in his proposal or are approved by the Engineer. The use of bentonite mud, lost circulation agents or any form of plugging material that may ultimately affect the production capacity of the water bearing strata intersected may be used in exceptionally cases. Any drilling fluid additives must be approved by the Engineer, and must be of low solids, non-toxic degradable type.

11.4.4 Sampling

Cuttings (min. 100 grams) of the strata penetrated shall be collected on site at every 1 meter interval and when required by the Engineer, by whatever method is standard for the drilling technique in use and approved by the Engineer. The Contractor shall take every possible precaution to guard against cutting contamination. Cuttings are not to be washed! Representative samples from the cuttings shall be put into approved containers supplied by the Contractor, labeled in a manner approved by the Engineer with the borehole location, number and depth interval, and stored in a position where they will not be contaminated by site conditions or drilling operations.

11.4.5 Temporary casing

Installation and diameter of any temporary casing required for the successful construction of the boreholes will be at the discretion of the Contractor provided that the completed borehole meets the specifications and design required under this Contract and is approved by the Engineer. The cost for supply, installation and removal of temporary casing shall be entirely for the Contractor. The Contractor cannot claim any casing left in the borehole that is not retrievable, from the Employer.

11.4.6 Borehole design

The final design of the borehole shall be confirmed by the Engineer in consultation with the Contractor during the drilling process, or immediately after drilling is completed.

Following types of standard borehole designs are given below:

Type 1 - protected borehole in collapsing rocks

1) Percussion, air rotary or mud rotary through overburden (alluvial, laterite, weathered or soft bedrock), minimum final drilling diameter is 17" (430 mm).
2) Down the hole hammer in consolidated hard rock
3) Fractured bedrock - water-bearing - considered to be collapsing and needs to be protected with casing/screen
4) If necessary to prevent collapsing of overburden, installation of casing of suitable diameter; sealing of casing with grouting, backfilling, cementation of top 5 meters.

Type 2 - Screened borehole with artificial gravel pack

1) Percussion, air rotary or mud rotary through alluvial or unconsolidated rocks, minimum final drilling diameter is 17” (430 mm). Final diameter of 17" (430 mm) is recommended.
2) A minimum annular space of 1\"1/2 (38 mm) between casing and borehole walls is required for gravel pack installation. Annular space of 2\" or even 3\" is recommended.
3) Installation of screen or slotted casing with minimum inner diameter 8\" (200 mm).
4) Installation of gravel pack at least 3 meters above the top of the first screen, topped with a one-meter clay seal, with backfilling material and cementation of the top 5 meters.

Boreholes should be drilled at least 6 meters below any water bearing layers or fractures to allow sufficient space for sump. As far as possible, boreholes shall be drilled into the under lying bed rock or, if the depth to the bedrock is too deep, drilling should stop in an impervious formation underlying the aquifer - a clay layer for example. The bottom of the hole acts as a sedimentation sump and a support for the casing and screen. The sump shall be a bottom plain casing of at least 1.5-meter length - 3 meters recommended- with the same diameter as the screen, and with its underside sealed with a bottom plug (wooden or PVC).

11.4.7 Casing and screens

Aquifer zones shall be completely or partly lined with uPVC screen as approved by the Engineer. The uPVC casings and screens to be supplied by the Contractor shall have a minimum wall thickness of 6mm for 8" ND casing. The Engineer however reserves the right to vary these specifications and reject materials if found substandard. The permanent casing shall comply with DIN 8061 2016-5 and DIN 8062: 2009-10 or (ISO 161/1) standards. The casings shall be minimum102 mm nominal diameter and shall have a minimum thickness of 6 mm and tensile strength of at least 45MN/m2.. Screens shall be of slotted uPVC, complying with DIN 4925-1: 2017-10 and IS 12818: 1995.Sections of the screen shall be provided in maximum 3m length and joined water tight by either flush threaded connections or by an appropriate method recommended by the screen manufacturer or an equivalent standard, so that the resulting joint shall be strong and have the same structural integrity as the casings and screens. In particular cases the lower end of the screen should be completed with a sump of minimum 0.5 m and maximum 2 m length. The bottom end should be sealed with an uPVC bottom cap.

11.4.8 Verticality

All boreholes shall be vertical, shall be drilled and cased straight, and all casings/screens shall be set round, plumb and true to line. If required by the Engineer, the Contractor will make a verticality test during and after drilling by approved methods and at his own expense to demonstrate that the departure from the vertical does not exceed 3 mm per 1,000 mm between ground level and the bottom of the borehole. If this departure is exceeded, the Contractor shall make the necessary corrections to the approval of the Engineer, without additional payment. If the error cannot be corrected, then drilling shall cease, and a new borehole shall be drilled at a position nearby, indicated by the Engineer. The abandoned borehole shall be backfilled and/or capped by methods approved by the Engineer. No payment will be made for the re-drilling, the sealing/backfilling of the abandoned borehole, or for moving to the new site. Any materials (i.e. Casing, screens, gravel pack, cement, etc.) lost in the abandoned borehole will be to the Contractors cost.

11.4.9 Gravel pack

Suitable gravel pack shall be supplied by the Contractor. Gravel pack should consist of washed, well-rounded particles of a uniform grading of between 0.3 to 4.0 mm, shall comprise 90% siliceous material and must contain no clay, shale, silt, fines, excessive amounts of calcareous material or crushed rock. In terms of grain size, 90% of the gravel pack material shall conform to the grading specified by the Engineer prior to the commencement of the Works.

Mixture of the Gravel Pack shall follow Terzaghi's Rules, depending on grain size distribution scales of the encountered aquifer (Kilindini Sands).

Prior to delivery, the Contractor shall subject samples of the gravel to a grain size analysis at the Contractor's expense and the results submitted together with a sample of the gravel to the Engineer for approval. The Engineer shall approve the gravel before its installation. Sufficient gravel pack shall be installed to cover completely the uppermost screen, including an additional 2m length (to allow for settling). Emplacement should be by means of a conductor pipe, and a good supply of water should be introduced with the gravel to prevent "bridging". The tremie (conductor) pipe should be raised gradually as the level of the gravel builds up. The gravel pack should be capped with a clay seal to prevent contamination. The annular space above this seal can be backfilled with inert drill cuttings up to 3 meters below the ground level.

11.4.10 Sanitary seal

To provide an effective seal against the entry of contaminants, the space between the casing and the borehole wall must be sealed using cement slurry of 1.85 – 2.15 kg cement/liter to a depth between 3 – 5 m. Grout shall be injected into the annulus in a single operation so that a complete and continuous seal is achieved, by a method approved by the Engineer. However, the top 0.4 meters of the annulus shall be left un-grouted but temporarily backfilled with inert drill cuttings, to allow for installation of the hand pump pedestal.

11.4.11 Yield estimates during drilling

Yield estimates shall be made during drilling using a method agreed upon by the Contractor and Engineer. Preferably the calibrated bucket or velocity-area method should be used. Average yields shall be read as directed by the Engineer and recorded.

11.4.12 Development and cleaning of boreholes

The Contractor shall develop and clean the boreholes upon completion of the drilling and installation of casing, screens, grouting and filter pack are installed, in order to remove native silts, clays, loose rock particles and drilling fluid residues deposited on the borehole wall during the drilling process, If organic drilling fluids are used, they shall be broken down chemically according to manufacturer's recommendations before or during development. Cleaning may be carried out by airlift pumping, surging, backwashing or jetting, to the approval of the Engineer. Clay desegregation by means of Sodium Hexametaphosphate (\"Calgon\") treatment may, in some cases, also be called for by the Engineer. The minimum requirement is the "air-lift" method until the ground water runs clean and turbidity free, but in any case, for a minimum of 3 hours.

11.4.13 De-sanding up to the technical absence of sand (0.1 g/m^3).

If this condition is not achieved after 6 hours, airlift will be carried-out until the water becomes limpid, but up to a maximum of 12 hours with any extra hours on top of 6 hours to be invoiced accordingly. Upon completion of development, any accumulation of material shall be removed from the bottom of the borehole by airlifting.

11.4.14 Test pumping

The Contractor shall perform test pumping to establish the performance and yield of the borehole, and shall provide a suitable, self-contained, mobile test pumping unit, approved by the Engineer, for this purpose. The method for varying the discharge rate of the pumps will depend on the type of pump used, but the Contractor shall ensure the provision of a suitable means of achieving the range of constant flow rates specified by the Engineer.

Test pumping will be undertaken in each productive borehole, as assessed by the Engineer from the yields indicated during drilling. A 144-hour pumping test shall be conducted, with a minimum of three (3) different stages, each stage reaching a stable level of drawdown. Indication of maximum drawdowns will give the records from the well developing stages. The final step should lower the dynamic water level to approximately three meters above the level of the pump. Discharge for each step should be kept constant

On completion of the final step, the recovery of water level should be monitored by the Contractor until 95% recovery has been achieved, or until advised by the Engineer. Discharge shall be measured by volumetric methods, or by means of some other approved calibrated measuring device.

During the test pumping, the discharged water must be handled and disposed of in an appropriate manner to a point of overland drainage sufficiently far from the borehole to prevent recharge. This distance shall be at least 100m from the borehole but may be reduced with the approval of the Engineer if the pumped aquifer is confined. A erosion protection to prevent wash out is mandatory. During all testing operations, once the flow rate has been determined and preliminary adjustments made, the measured discharge rate shall be maintained within 5% of the required rate for the duration of the test or test stage. Persistent fluctuations beyond this tolerance will require abortion of the test. When continuous pumping at a uniform rate is specified, failure of the pump operation for a period greater than one percent of the elapsed pumping time shall also require abortion of the test. Any test which is aborted due to the reasons above shall be repeated, after full recovery of the water level. No payment shall be made to the Contractor for aborted tests, nor for standing time during water level recovery after aborted tests.

11.4.15 Electrical conductivity measurements

The Contractor shall provide an operational Electrical Conductivity meter and shall take electrical conductivity readings of the discharge water during test pumping.

11.4.16 Records and reporting

The Contractor shall keep daily activity records for each borehole. The records shall contain the information as specified below. In addition, separate records should be supplied for each borehole upon completion.

i. Daily Record Site name Reference number of borehole GPS Co-ordinates of borehole (latitude / longitude) Date of reporting Names of foreman and drillers Method of drilling Make, model, type and size of drilling rig Diameter of hole, and depth of changes in diameter Depth of hole at start and end of shift or working day Depth and size of casing at start and end of shift or working day Description of strata drilled with depth of transitions encountered Depth at which water is struck Yield of air lifted water, when drilling or developing with

air in liters per second. Time log showing rate of penetration in minutes per meter, type of bit, standby time due to breakdown. Depth intervals at which formation samples are taken Records of components and quantities used or added to the drilling fluid or air. Water level at the start of each working day Electrical conductivity measurements during test pumping Problems encountered during drilling Details of installations in the borehole (if any) Depth, size and description of well casing Depth, size and description of well screens Aquifer depth and SWL after completion of well A copy of the Daily Record shall be made available daily to the Engineer, and should include any other pertinent data as may be requested by the Engineer.

ii. Borehole Completion Record As per standard Borehole Completion Form. Detailed drillers geological log. Borehole design and installation details (as-built drawing)

iii. Monthly Contract progress report. The contractor shall submit a monthly progress report detailing progress on the contract. The month report shall include the progress of projects successfully completed, problems accounted that are hindering progress and remedial recommendations to accelerate contract progress.

iv. End of Contract Report. The Contractor shall prepare an end of Contract report, which should address at the minimum the following issues;
- The selected sites (Suitability, accessibility)
- The drilling /test pumping methodologies (Type of drilling, designs used, test-pumping methods)
- Contract schedules and duration (Summarized diary of events and actual durations)
- Summary of results and analysis (Table showing locations, well numbers, depths, casing type and depths, driller's and test pumping yields, water quality and any other information necessary)
- Casing /screens received and used on the Contract (if any) (Table showing casings received, used, damaged and balances)
- Problems encountered (With accessibility, formations, equipment and community, etc.)
- Suggestion for improvement (On supervision, documentation, durations, etc.)
- Borehole Completion Records, (Original Drilling and test pumping logs bound separately from the report)
- Any other information that the Contractor may deem important or necessary Two copies of the End of Contract Report (one without the Borehole Completion Records) shall be submitted to the Engineer

11.4.17 Operation & Maintenance tools and equipment to be provided

The Contractor shall provide the below listed tools and equipment in order to enable the Client to carry out regular operation and maintenance of the boreholes:

- 3 Water Level Meter or Dipper; min. cable length 150 m; battery operated
- 2 pH Meters, digital operation with calibration fluids, must be able to operate under field condition; hard cases
- 2 Oxygen Meters, digital operation with calibration fluids, must be able to operate under field condition; hard cases
- 2 Conductivity Meters, digital operation, must be able to operate under field conditions; hard cases
- 3 Torches, LED min. 1000 lm, battery operated
- 3 fully equipped Toolboxes (minimum content, to be specified by the contractor):
  Nuts: 4" – 32" incl. wrenches (1/2" and ¼" and drives, stainless steel, industrial quality
  Allen Keys for 1/2" and ¼" drives: sizes 3/16"; 7/32"; 9/32"; 5/16"; 3/8"; ½"; ¼" 9/16"; 5/8", quality and material as above.

  Set of Screwdrivers as above
  Set of Grippers quality and material as above
  2 Hacksaws, incl. spare blades
  Hammers, different sizes 300 g to 1 kg, iron and one rubber mallet
  3 pcs of Rope; PVC, min length 200 m, min. tensile strength 500 kg

- 1 Tripod, min. 3 m high, equipped with winch and 150 m of steel cable.

12. ELECTRICAL INSTALLATIONS

12.1 General

This section covers the supply and installation of all electrical plant including all necessary calculations, technical details, catalogues, drawings, etc., for the plant, machinery, apparatus, systems, articles, and associated accessories.

The ratings of switchgear, electrical protection devices, cables, etc. shall be dependent upon the ratings and characteristics of the pumping sets and mechanical plant being supplied and the adopted method of motor starting. In this respect, it shall be deemed that the Contractor has considered this and has offered compatible electrical and mechanical components.

The final arrangement of switchboards, switchgear and motor control panels is dependent upon the plant offered and therefore subject to approval.

12.2 Regulations and Standards

The electrical installation shall comply with all relevant statutory regulations and standards current at date of tender, unless otherwise indicated within this Specification. In general the following shall apply:

a) The IEE Regulations for Electrical Installations, 16th Edition

b) The Health and Safety at Work Act, etc.

c) Factories Act (UK)

d) British Standards (BS) and International Standards stipulated in SSRN (Standard Specifications Reference Numbers)

e) British Standards Codes of Practice (CP)

f) International Electro-technical Commission (IEC)

g) Regulations under the Electricity Acts of Kenya.

If no standard is specified, the relevant British Standard or, in the absence of such standard, International standard shall apply.

Note: A list of the Standard Specifications Reference Numbers (SSRN) is provided at the end of these Electrical and Mechanical specifications.

12.3 Abbreviations of Electrical Items

- R -red phase
- Y -yellow phase
- B -blue phase
- N -neutral
- ac -alternative current
- dc -direct current
- A -amp
- mA -milliamp
- V -volt
- kW -kilowatt

- kWH -kilowatt hour
- kVAr -kilovar
- MVA -megavolt amp
- Hz -hertz (cycles per second)
- SP -single pole
- SPN -single pole and neutral
- DP -double pole
- TP -triple pole
- TPN -triple pole and neutral
- SPSwN -single pole and switched neutral
- TPSwN -triple pole and switched neutral
- MCB -miniature circuit breaker
- MCCB -moulded case circuit breaker
- RCD -residual current device
- MCC -motor control center

12.4 Polarity

The polarity of all electrical apparatus used for the Works specified shall be arranged as follows:

- for two pole apparatus the phase of 'live' pole at the top (or left hand side) and the neutral or 'earthed' pole at the bottom (or right hand side),
- for three or four pole apparatus the phases in order of red, yellow, blue and neutral reading from top to bottom or left to right in the case of vertical and horizontal layouts respectively and as viewed from the front.

All non-flexible cables shall be so connected between main switchboards, distribution boards, plant and accessories so that the correct sequence or phase colours are preserved throughout the system.

All non-flexible cable cores shall be identified with phase colours for three and four wire circuits. Single-phase circuits shall be red and black.

12.5 Voltage and supply system

The electric supplies to the sites are provided by The Kenya Power and Lighting Company (KP) and will, in general, be 33 kV, three phases, three wires, 50 Hz stepped down through suitably rated transformers to 3.3 kV for the pump motors and to 415V/240 V for distribution and reticulation to the various installations.

12.6 HV switchgear

HV switchgear shall generally conform to BS EN 60265-1:1998, IEC 60265-1:1998, BS EN 62271-100:2001, IEC 62271-100:2001, or BS EN 60298:1996, IEC 60298:1990 as appropriate. Switchgear shall be either air-break or vacuum type in accordance with the following requirements and details contained within the particular Specifications.

12.6.1 Air break isolators

Air break isolators shall generally be restricted to pole mounted switches or fused switches and shall comply with BS EN 60129:1994, IEC 60129:1984 and ASTA certified.

Switches shall be supplied and installed complete with all necessary insulators, coupling tubes, drive rods and manually operated mechanisms and shall be capable of accommodating solid links or expulsion or current limiting fuse links in spring loaded carriers. Fuses shall conform to BS EN 60282-1:2002 and shall be of the fast blow type.

Switches shall be capable of being locked in either the ON or OFF position. The switches shall be suitable for operation at the relevant ambient conditions and shall be rated to suit the maximum working voltage, load current and normal fault conditions of the system to which they are fitted. Switches shall be capable of breaking full load current and making online or transformer charging current.

Three phase switches shall be mechanically coupled to ensure simultaneous switching action of all the three units.

Expected normal characteristic ranges are as follows:

- working voltage 11 - 33k V
- current rating 400 A
- fault level 47 kA

12.6.2 HV and LV motor control cubicles - general requirements

In addition to the electrical protection specified elsewhere herein, safety cut-outs for both HV and LV control cubicles and switchgear shall be provided to protect against any operating conditions which could arise and which would be liable to cause damage to the plant, for example lack of water at pump suctions.

Motor protection relays for electric motors above 100 kW shall be of the electronic composite type. The relay shall incorporate the following protection within the composite unit:

- wide range adjustable over-current;
- overload;
- phase failure;
- under voltage;
- IDMT and earth fault:
- single phasing and successive start protection.

The operating push buttons, switches or handles of all circuit breakers, motor starters, isolators, etc., whether HV or LV shall be located on the front of cubicles, or for cubicles of the desk type, on the face of the desk. There shall be visual indications of the "ON" and "OFF" positions.

All operations of fault and alarm circuits shall be clearly and individually indicated by lamps on the fascia of the switchboard.

Fault and alarm lights shall remain on until the associated fault or alarm condition has been cleared and the system reset.

An audible alarm shall also be provided to indicate operation of any major fault or alarm function. Acknowledgement of the major fault or alarm condition shall also cancel the audible alarm.

Indicating lamps shall incorporate a lamp test feature with either individual push to test or a common lamp test button.

Push buttons fitted on the panel shall be of the shrouded type, unless otherwise specified, and shall have a label indicating their function.

Indicating lamps on panels shall be rated to withstand not less than 20% continuous over voltage and shall be so designed that the heat from the bulb does not discolor the cubicle.

Indicating lamps and push buttons shall be colored in accordance with IEC 73:

Indicating lamps	Color
On	Red
Off	Green
Fault	Yellow/amber
Alarms	White/yellow
Heaters	Blue

Push buttons	Color
Start	Green
Stop	Red
Alarm accept acknowledgement and mute	Black
Emergency stop	Red

All electrical indicating instruments shall comply with BS 3693, be of the moving iron type and to Class 1.5 or better. Instrument size shall be 96mm square with quadrant scale.

Instruments shall be flush mounted on the cubicles and effectively sealed against ingress of moisture, dust and insects. Instrument mounting height shall not exceed 1.80 meters above floor level. Unless otherwise specified instrument full-scale deflection shall be at least 120% of the normal operating point (i.e. nominal voltage or full load current).

Ammeters in motor circuits shall be capable of withstanding the starting current of the motors and shall have a compressed overload scale for this purpose. The full load current shall be defined with a red line. Voltmeter scales shall have a red line indicating normal voltage.

All voltage circuits of instruments shall be protected by a fuse in each unearthed phase, situated as close as practicable to the point of connection.

Current transformers (Cuts) shall have short circuit ratings not less than those of the circuits with which they are concerned, and shall fully comply with BS EN 60044-1:1999, IEC 60044-1:1996

The secondary winding of all current transformers shall be earthed. The rated burden of each CT shall be a minimum of 150% of the designed load burden.

Where specified, capacitors for correcting power factor shall be incorporated in the panel. Such capacitors shall comply fully with BS EN 60831-1:1998, IEC 60831-1:1996 and BS EN 60871-1:1998, IEC 60871-1:1997 as appropriate

All motors shall be provided with emergency stop push buttons mounted on or adjacent to the motors that shall lock out the control circuit and shall require a key to reset the circuit.

Control wiring for both HV and LV motor control panels, switchgear, etc., shall be 600V grade PVC or XLPE insulated multi-stranded copper wire to BS 6004:2000 or BS 6007:2000. The minimum size shall be 1.5mm2 stranded conductors

All terminals shall be referenced and detailed on the schematic diagrams to be submitted to The Engineer.

It shall be possible to gain access to any terminal of any component so as to be able to remove and replace the wire from that terminal without recourse to special tools, and without the need to disturb other components.

All wiring shall be neatly run bunched in neat forms. All wiring accessories of plastic material, such as cleats, conduits, strapping, etc., shall be non-corrodible and resistant to flame propagation.

Crimped pin extensions shall be fitted to all control circuit cables to prevent wandering strands before being inserted into Klippon type terminal blocks.

Cabling shall enter the panel from above or below as applicable and as specified elsewhere in the Specifications. Cables shall be terminated using external boxes or internal gland plates.

Where necessary cable tray work shall be provided for supporting and fixing cables and full glanding and terminating acilities shall be provided. Gland plates shall be mounted not less than 150mm above the cubicle bottom. It shall be possible to terminate all cables without requiring access to live interiors.

Primary cabling shall be completely isolated from all control wiring, etc., and auxiliary terminals shall be likewise isolated from primary terminals.

All terminal boards and terminal blocks shall be of a type providing a positive mechanical clamp on connection. Terminals for the connection of all external cabling shall be situated near their respective gland plate and at a minimum distance of 300mm from it.

Separate terminals shall be provided for incoming and outgoing connections and not more than two wires shall be connected to any one terminal.

Incoming units for LV panels shall incorporate:

- triple pole main switch and fuse combination;
- voltmeter with selector switch;
- ammeter with selector switch.

Motor starter cubicles shall incorporate the following:

- for low voltage switchboards a main triple pole switch/fuses and contactor combination;
- for high voltage switchboards a main disconnecter/fuses and vacuum contactor combination.

Motor protection for low voltage motors shall comprise:

- adjustable thermal overload protection;
- under voltage and single phasing protection;
- over voltage protection.

Motor protection for high voltage motors shall comprise:

- over current and earth fault protection;
- unbalanced load protection;
- under voltage and phase failure protection;
- over voltage protection.

Power factor correction shall be provided for all motor circuits to satisfy the requirements specified.

Starting control plant incorporating all necessary contactors, timers, fuses, etc.

- one ammeter with phase selector switch;
- motor start/stop push buttons;
- motor auto/off/manual selector switch as necessary;
- on/off/fault indication lights;
- hours run counter.

Outgoing distribution units shall be:

- switch fuse combination or circuit breakers;
- 240 V socket outlet for test/maintenance purposes, separately fused and protected.

12.7 Power Transformers

12.7.1 General

Three phase distribution power transformers shall be of the liquid immersed naturally cooled type, for indoor or outdoor use as specified and shall conform to BS EN 60076-1:1997, BS EN 60076-2:1997, BS EN 60076-3:2001, BS EN 60076-5:2001, IEC 60076-5:2000 and BS IEC 60076-8:1997, IEC 60076-8:1997.

The transformers shall be of double wound type designed for the frequency and full load primary and secondary voltages stated

Transformer ratings stated are the actual requirements under site conditions and temperature specified. The necessary derating factors shall be applied.

Transformer primary connections shall be “delta” and the secondary connections shall be “star” in accordance with Vector Group Reference Dyn 11. The neutral point of the secondary connections shall be brought out fully rated on an insulated terminal suitable for connection to a remote earthing facility.

Where required, primary and secondary sides shall be fitted with all necessary overhead line jumper termination insulators and dividing boxes, sealing ends, glands, etc.

Tappings shall be provided on the primary windings corresponding to an increase of +2½% and +5% and a decrease of -2½% and -5% of the primary voltage. Alterations

of the tappings shall be effected by means of an "off-circuit" tapping switch rigidly attached to the core structure and located beneath the surface of the insulant.

Means shall be provided for mechanically operating the switch outside the tank and for ensuring that the switch is making full contact. The tapping switch shall be fitted with a padlock to prevent tap changing by unauthorized persons. Padlocks and four sets of keys shall be supplied with the transformers.

The indication of the tapping switch shall be given by means of a number that shall conform to a corresponding number engraved on the diagram plate, and correspond to a particular voltage.

A breather filled with silica gel air dryer shall be fitted on all transformers.

The windings shall be adequately braced to withstand all shocks likely to be met during transport due to rough handling and vibration, and during service resulting from short circuit or other transient conditions.

When shrinkage is likely to occur adjusting clamps shall be provided and they shall be so arranged as to make it possible for the clamps to be tightened up by means of a suitable spanner.

The cores, framework, clamping arrangements and general structure of the transformers shall be of robust design and shall be amply strong to allow each unit, complete in its tank with insulating oil to be transported by road or otherwise, without damage and without overstraining the joints and causing leakage of insulating oil.

The tanks shall be of the best construction, fabricated from boilerplate of an approved thickness, and shall be stiffened where necessary. The cooling tubes and all joints in the tanks shall be welded by an approved process.

Transformers shall be complete with the following components:

- oil level indicator;
- silica gel breather;
- thermometer pocket;
- lifting lugs;
- drain valve;
- fill hole fitted with plug;
- earth terminals;
- electrical diagram & rating plate.

Transformers shall be provided with routine test certificates and with type-test certificates

The tanks and all exposed parts of the transformers shall be suitably protected and coated before leaving the manufacturer's works

The finishing coat shall be dull black or light grey.

A sufficient quantity of insulant shall be provided with each transformer

Pole mounted isolators and transformers

11 kV pole mounted isolators and transformers shall be supplied for installation at specified locations where it is found necessary to improve the electricity supply to pump stations, boreholes, etc.

Pole mounted isolators shall be of the vertical mounting fuse isolator pattern and shall be supplied complete with fuse cut-outs, switch units and surge diverters.

Pole mounted isolators and transformers shall include for the supply of all supporting steelwork, fixings, brackets, bolts, connections and similar items necessary for the complete installation (by others) on standard wooden H pole structures.

The incoming power cable from the pole mounted transformer to the change-over switch unit within the pump house shall also be supplied complete with supports, fixings, glands, cable marker tape and all accessories required.

12.8 Cables

12.8.1 General

This Section of the Specifications deals with the materials and types of cables that may be used along with termination and identification requirements for the cables. Full details, catalogues, etc., shall be submitted.

All cables supplied for use under the Contract shall be British Approvals Service for Electric Cables (BASES) approved and shall be manufactured to the following British Standards, as appropriate:

- BS 5308-1:1986 Instrumentation cables. Specification for polyethylene insulated cables;
- BS 5308-2:1986 Instrumentation cables. Specification for PVC insulated cables;
- BS 5467:1997 Specification for 600/1000 V and 1900/3300 V armored electric cables having thermosetting insulation;
- BS 6004:2000 Electric cables. PVC insulated, non-armored cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring;
- BS 6007:2000 Electric cables. Single core unsheathed heat resisting cables for voltages up to and including 450/750 V, for internal wiring;
- BS EN 60702-1:2002, IEC 60702-1:2002 Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. Cables;
- BS 6346:1997 Specification for 600/1000 V and 1900/3300 V armored electric cables having PVC insulation;
- BS 6480:1988 Specification for impregnated paper-insulated lead or lead alloy sheathed electric cables of rated voltages up to and including 33000 V;
- BS 6500:2000 Electric cables. Flexible cords rated up to 300/500 V, for use with appliances and plant intended for domestic, office and similar environments.

The Contractor shall submit full descriptive pamphlets and technical literature of the types of cables and cable manufacturers offered.

Manufacturer's test certificates for multicore cables shall be submitted to the Engineer for approval before any cables are installed. All cables shall be accompanied by the manufacturer's original guarantee, and shall be delivered to Site in the original wrapping.

The Contractor shall be responsible for determining the sizes/ratings of all cables and overhead line conductors to suit the loads. The sizes of the cables and

conductors shall take into account voltage drops, fault levels, de-rating factors and ambient conditions.

12.8.2 Materials and minimum sizes

Cables shall have standard copper conductors, with minimum cross sectional areas as follows:

- Motor supply cables $4mm^2$
- Cabling to control devices external to switchboards $2.5mm^2$
- Telemetry control/digital signal cables $0.75mm^2$
- Domestic lighting $1.5mm^2$
- Domestic general power $2.5mm^2$

The neutral core of a cable or the neutral cable of a circuit shall be of the same cross sectional area as the associated phase.

12.8.3 Paper-insulated, lead-sheathed cable

These cables shall be of the mass impregnated, non-draining type, to BS 6480 and shall only be required for use on high voltage work (multicore armored) or on transformer “tails” to switchgear (single core non-armored) which will require mechanical protection.

12.8.4 XLPE for 3.3 kV systems

XLPE/SWA/PVC - cross linked low density polyethylene insulated, stranded copper conductors, extruded PVC bedding, galvanized steel wire armored, flame retardant black PVC sheathed overall, suitable for use on an earthed system at a rated voltage of 1.9/3.3kV as specified. Conductor temperature shall not exceed 90oC for continuous operation and 250 oC for short circuit. Cables shall comply with BS 5467.

12.8.5 XLPE single wire armored cable

XLPE/SWA/PVC cross-linked, low-density, polyethylene-insulated, stranded copper conductors extruded PVC bedding, galvanized steel wire armored, flame retardant black PVC sheathed overall, suitable for use on an earthed system at a rated voltage of 0.6/1kV as specified. Conductor temperature shall not exceed 90oC for continuous operation and 250 ^{o}C for short circuit. Cables shall comply with BS 5467.

Non-magnetic amour of hard drawn aluminum shall be used on single core cables.

12.8.6 PVC insulated single wire armored cable

PVC/SWA/PVC PVC insulated, extruded PVC bedding, galvanized steel wire armored, flame retardant black PVC sheathed overall, stranded copper conductors suitable for operation on a system at a rated voltage of 0.6/1 kV. Conductor temperature shall not exceed 70oC for continuous operation. Cables shall comply with BS 6346:1997 and sheathing with BS 7655-2.2:1993.

Non-magnetic amour of hard drawn aluminum shall be used on single core cables. The cables shall be used on the low voltage (415V) systems for cable ratings up to and including 10mm2, or control systems as appropriate shall be:

multi-core, PVC insulated, extruded PVC bedded, single steel wire armored, PVC over sheathed, or single core, PVC insulated and sheathed, unarmored, or single core, PVC insulated, aluminum wire armored with overall black PVC sheath.

12.8.7 Polyethylene insulated armored instrument cable

Cables for use as instrument cables shall be to BS 6622 and shall be multi-pair, polyethylene insulated and bedded, single wire armored PVC over sheath.

12.8.8 Sheathed and insulated flexible cords

These cords shall be to BS 6500 and shall be 85o rubber insulated, H.O.F.R sheathed.

Flexible cords shall only be used for the following:

final connection between fused connection units, having flex outlets, junction boxes, and their associated appliance.

lighting pendants.

The minimum cross sectional area of conductors in flexible cords shall be 0.75mm2 (24/0.2mm) and the length not exceeding 400mm.

12.8.9 Flexible power cables

Flexible cables where required and used to supply submersible motors shall be 600/1000 V grade EP rubber insulated with Niplas outer sheath having flexible, annealed and tinned copper conductors. Alternatively, standard manufacturers' cables may be considered, subject to approval of the details.

12.8.10 PVC insulated cable

This cable type shall be PVC insulated 600/1000 V grade copper cable to BS 6004 and shall only be used when enclosed within a conduit or trunking.

12.8.11 PVC insulated and sheathed cable

This cable type shall be PVC insulated PVC over sheathed 600/1000 V grade copper cable to BS 6004 and BS 6346 and shall be used as meter tails or transformer tails to switchgear provided that it is protected from mechanical damage. This type of cable shall also be used for direct surface run domestic wiring.

12.8.12 Screened cable

These cables shall be PVC insulated, lapped with a non-hygroscopic tape, and tinned copper wire braided. Signaling cables shall conform to BT Specification CW 1128 with armoring to CW 1198.

12.8.13 Mineral insulated cable

These cables shall be to BS 6207 and shall have copper conductors with copper outer sheath and PVC over sheath, 600/1000 V grade.

This type of cable may only be used in specific environments or for specific services such as fire alarm systems, or similar type requirements.

12.8.14 Telephone cables

Telephone cables shall be thermoplastic insulated multipair telephone type cables having twisted pairs of copper conductors.

12.8.15 Bare copper earth wire (BCEW)

An earth wire shall be run with any selected cable, and be buried in the trench with it. The minimum size of earth wire shall be half the cross sectional area of the cable with which it is laid, and fixed to the power cable with nylon tie clips at regular intervals not exceeding 2,000mm. The earth wire shall consist of annealed bare stranded copper conductor.

12.8.16 Earth bonding cables

Earth bonding cables shall be PVC/PVC type and have stranded copper conductors PVC insulated and sheathed.

12.8.17 Cable installation

General

The Contractor shall plan and position all cable runs so that they do not foul other services, maximum accessibility is maintained and unsightly crossovers are avoided. The cable routes shall be planned along with other services so that agreed service reserves are followed.

All cables shall be neatly run, dressed and supported to the approval of The Engineer.

All cable supports and racks together with fixing bolts, clamps, nuts and screws for indoor situations and in cable trenches shall be included, and shall be made from galvanized steel or cast silicon aluminum. Cable supports and racks shall be made by a recognized manufacturer and to the approval of The Engineer. All supports and racks shall be arranged for the easy removal of any single cable in a multi-cable run without threading cables through supports and racks.

The Contractor shall produce a cable schedule so that all information relating to the cables is maintained. This information includes dates of manufacture, dispatch, delivery to Site, installation, initial tests, connecting up and final testing and commissioning. In addition, the Contractor shall maintain a daily/weekly record of the cables as installation proceeds. These records shall be witnessed as necessary and shall form the basis of the record drawings.

Where cables are run together in the same tray, trench or conduit they shall be suitably derated or spaced to maintain current rating. Crossovers shall be avoided where possible. Power and signal cables shall be run separately to minimize interference.

Where a number of cables are terminated in plant, they should finally approach the plant from a common direction.

The Contractor shall supply all cable tray, cable trunking, saddles, cleats, hangers, brackets, trays, ladders, ties, nuts, bolts, screws, washers, packing and marker tape as may be necessary to complete the installation.

Marker tape shall be 150mm wide, yellow with black printing "DANGER-ELECTRIC CABLES".

Where cables cross other services or other cables the required separation shall be maintained. In addition, concrete cable tiles shall be provided between the services to maintain the separation and protection, the tiles extending for a distance of 1000mm either side of the existing services.

Power cables shall be installed without tees or joints unless approved by the Engineer. Cables shall not be installed in areas of direct sunlight. Where this is unavoidable, approved sunshields shall be supplied and installed.

All cables shall be suitably protected. Those running on the external surfaces of structures shall be protected against the effects of ultra-violet light. Where cables are sleeved through conduit or ducts, all ends shall be bushed to prevent damage to cable sheathing. The Contractor shall be deemed to have allowed for cable protection in his rates.

The as-installed drawings provided by the Contractor shall clearly show all services and cable details and dimensions.

Installation direct in the ground

The Contractor shall carry out all excavation, supply and install pipes or ducts where required, prepare the trench bottom, lay cables, provide and install markers warning slabs and warning tape, backfill, consolidate, compact and make good, including the removal and disposal of all surplus material.

Power cables of rated voltage up to 1,000 V shall be buried at a minimum depth of 600mm to the cable. Power cables of rated voltage above 1,000 V up to and including 15kV shall be buried at a minimum depth of 1,000mm to the cable centre. This may only be varied due to the presence of other cables or services.

The bottom of excavated trenches shall be free of sharp stones and other obstacles and shall be covered with sand or fine sifted soil compacted to a depth of 75mm.

Cables shall be unrolled from the drums in such a manner as to avoid loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp obstacles or stones. A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered with a minimum depth of 100mm of sand or fine sifted soil. The cables shall be overlaid with marker tape, before backfilling the trench with soil.

Where cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to separate the cables.

Controls and communication cables shall be laid not closer than 1,000mm to high voltage cables.

When cables are in position in the trenches, an inspection will normally be required by the Engineer before backfilling commences. 1st lay warning (Hatari) protective slabs above cable before backfilling. The first stage of backfilling is to be sifted soil or sand (as specified for the trench bottom) with cover being provided to a minimum of 70mm over the cable. Soft excavated material free of stones is then backfilled with the backfill rammed every 150mm.

Small stones extracted from the excavated material may be mixed in with the backfill in the final stages, but large stones are to be removed from site. Surface material and any hard core removed prior to excavation is to be backfilled last and well rammed to restore the undersurface to original condition. Excess backfill is to be removed from the site.

The Contractor is responsible for reinstating any damage to gates, hedges, kerb stones, concrete paving, etc, and normally for the surface of any privately owned made up roads. For public roads reinstatement of made up road surfaces will be carried out by the road authority and the trench backfill must be left in a suitable condition as required by the road authority.

Approved surface route markers shall be situated at all joints, bends and at minimum intervals of thirty meters on straight runs, as specified. Whenever the cables change direction markers shall be so placed that the change in direction is readily seen.

No cables shall be buried direct in the ground within buildings or concrete covered areas.

Installation in underground ducts

Where cables are laid under roads and paved areas more than 1,000mm wide, they shall be installed in continuous runs of approved underground ducting.

Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 600mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100mm shall be laid at a minimum depth of 1,000mm (to the duct centre). The duct shall be encased by 150mm concrete on all sides.

When installing cables in ducts the following measures shall be observed:

- cables shall be pulled in a straight line.
- rollers shall be positioned at the edges of draw pits both at the drawing in and drawing out points over which the cables shall be drawn.
- uPVC pipes and cables sheaths shall be coated with an approved lubricant.
- sufficient draw-in points shall be provided and adequate room allowed for installation of cables.
- the pulling rope shall be guided by rollers.

In general, only one power cable shall be drawn into one duct. Where multiple cable systems are used, smaller cables (16mm2 and below) may occupy the same duct.

However, details must be agreed with the Engineer, and included on the Contractor's working drawings.

When a duct is laid in the ground, a draw wire shall be pulled through with at least 1,000mm excess at each end and the draw wire left if the duct is not to be used immediately.

Sealing cable entries into buildings

Where cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with "petroleum tap" and mastic or silicon foam.

Where cables pass in or out of any duct entries into or within buildings, such entries together with any spare ducts, shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least thirty minutes.

Marking of underground cables

The location of all direct buried underground cables shall be identified by:

- brass plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass though the wall;
- marker posts on road verges, etc., at intervals of not more than 100 m and at all junctions and changes of direction along the route;
- marker posts at ten meter intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 150mm high above ground level with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of a cable below, the depth and voltage rating.

Installation in cable trunking

Cabling trunking shall be manufactured from heavy duty mild steel of thickness not less than 125mm and hot dipped galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity. Trunking shall have minimum dimensions of 50mm x 50mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.

The trunking shall have two return flanges for rigidity.Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining “quick fix” type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

Earth continuity straps shall be provided at all connections and jointing points along the route of the trunking to ensure complete earth continuity.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals as detailed in the IEE Wiring Regulations. Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking or a trunking fitted the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.

Cable and trunking runs shall be determined by the Contractor and agreed by The Engineer before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services.

Trunking systems erected outside a building shall be weatherproof.

Installation in troughs and trenches

Where the building structure incorporates purpose built covered trench systems, to accommodate the cables, power distribution cables may be laid on the floor of the trench providing all cables are readily accessible without the need to disturb other cables. Where the Engineer considers too many cables are present, or where the trenches are not suitable for laying cables on the floor of the trench, supports shall be provided. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.

The layout, fixing arrangement and the laying up of all cables shall be agreed prior to installation. All cables shall be accessible for easy removal without the need to disturb adjacent cables. The required cable separation shall be maintained at all times.

Where the building structure incorporates general service trenches containing pipe work, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls, Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipe work.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1mm for trays up to 100mm width, not less than 1.25mm for trays from 100mm to 150mm width and not less than 1.5mm width for trays from 150mm to 300mm width.

Cable tray and supports shall be to BS 6946 and hot dipped galvanized to BS EN ISO 1461:1999.

Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc rich cold galvanizing paint. Similarly for PVC coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Engineer, together with proprietary cable cleats.

Installation in buildings

Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or singly at spacing determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

No cables shall be buried directly in the ground within buildings or concrete covered areas. Cables inside buildings, crossing floors shall be laid in conduits or otherwise laid flush, in channels covered with chequer plate or laid in sand with a 20mm mortar screed on top.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Allowance shall be made for expansion and contraction of the cables.

Where cables cross a building expansion joint, due allowance shall be made for cable movement.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips, etc. shall be by means of non-corrodible screws inserted into approved wall fixings.

Cables hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to the recommendations in the IEE Wiring Regulations.

Ladder racking shall be constructed from heavy galvanized steel secured to walls or ceilings, or by preformed galvanized interlocking channel, cast into the structure.

Cables shall be located between 5mm pegs spaced at 40mm centers across a rung so that a 40mm or 80mm space is maintained between cable centers. Cleats shall be used where the ladder racking is vertical.

Wherever ladder sections are cut and shaped on site, cut edges shall be dressed and immediately painted with a coat of cold galvanizing compound.

Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipe work.

Cable installation in conduit

Conduits shall, in general, be galvanized heavy duty gauge steel screwed type for outdoor applications. Accessories shall either be malleable cast iron or pressed steel. PVC conduit will be considered for certain installations as specified. Conduits and fittings shall comply with BS EN 50086-1:1994, BS 4607 and BS EN 50086-2-1:1996 as appropriate and shall not be less than 20mm diameter.

A space factor of 40% shall not be exceeded, and conduit of less than 20mm diameter will not be permitted. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed with all sharp edges removed before erection.

Where conduits converge, adapter boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25mm, straight through joint boxes shall be of the trough type.

Where conduit or fittings are attached to plant casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All junction boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.

Ends of conduits that are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress or dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanized flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

Surface conduits shall be secured and fixed by means of distance spacing saddles or clips which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. Runs shall be properly ventilated and allow for drainage of condensation. All surface conduit runs shall be marked out for approval by the Engineer before the installation is carried out. Where large multiple parallel conduit runs occur, galvanized trunking may be used instead.

Conduits installed on structural steelwork shall be secured by girder clips, drilled and tapped to the steelwork. Power driven fixings shall be used only with the approval of the Engineer. Any drilling or access that is required through any structural member of the building shall be clearly shown on the Contractor’s Documents submitted to The Engineer for approval. The Engineer may either restrict the size and locations of approved drilling or access, or may instruct the Contractor where such drilling or access shall not be allowed.

Exposed threads and plates where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

Concealed conduits shall be securely fixed to prevent movement before laying of screed, floating of plaster, casting of columns or other building operations necessary after the conduit installation.

Crampers or similar fixings shall be used for attaching the conduit to block work, etc. Building nails will not be accepted.

At least 15mm shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted over the conduit. Conduit cast into reinforced concrete shall be fixed to shuttering to give a flush finish, and the conduit boxes shall be of a type approved by the Engineer for use in such locations.

Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for surface conduits. Draw-in wires shall not be pulled into the conduits during erection. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture. The conduit installation shall be inspected by the Engineer before the building operation conceals the work.

Flexible conduits shall be of the waterproof galvanized type of PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the plant to which it is attached and shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough type box. The flexible conduit shall extend from this box to the plant; the earth continuity cable shall be secured to the box and to the item of plant. The use of lid facing screws, etc. will not be permitted.

Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

In locations where galvanized conduit would be liable to corrosion, PVC conduit shall be considered.

PVC conduit shall be of the oval or round high impact non-flame propagating type as specified and self-extinguishing. Surface and concealed installations shall be generally as described for steel conduit.

PVC conduit fittings shall comply with BS 4607-1:1984. They shall all be white unless specified otherwise.

Jointing shall be carried out using PVC solvent and socketed accessories. Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures of between 10°C and 60°C and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth continuity conductor) shall be installed.

Adaptor boxes and accessories shall be made from heat resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaries or other heat sources shall have either external fixing lugs riveted to the metal fixing inserts or utilize steel insert clips.

12.8.18 Cable terminations, joints and identification

General

Cable terminations shall be provided to suit the requirements specified and shall be either crimp type lugs, crimp type insulated wiring pins or soldered connections.

Where crimp type terminations are used lugs shall only be applied using a crimping tool having a ratchet which only releases after the correct pressure has been applied.

Excessive solder and "dry" solder connectors will not be accepted. Care shall be taken to eliminate "dry" solder joints and in removal of excess solder.

Cable lugs shall be of such a size that only the minimum amount of solder is required in order to sweat the lugs solidly onto the tail ends.

The foregoing termination methods are not essential in "domestic" lighting and power installations beyond the final distribution board.

At terminations the cores of the cables shall be left of sufficient length beyond the termination to form cable tails for connecting to the plant. Tails shall be adequately insulated and each cable core shall have its phase identification clearly marked.

Terminations shall be long enough to allow one additional termination.

The installation requirements associated with both the low voltage and control cables are such that, in general, no joints are necessary, the cable distances being such that one complete cable length is required between the various items of Plant. Where joints are permitted, they shall be made as set out below.

- joints in cables shall be made in accordance with the cable manufacturer's recommendations to suit the particular cable type;
- all cables shall be joined color to color and shall be tested for insulation resistance and continuity before jointing commences;
- the seals of the cables shall not be removed until preparations for jointing are complete;
- joints shall be finished on the same day they are begun, and protection from weather shall be provided by the Contractor;
- cast resin molded type joints shall be used for PVC multicore cables;
- the jointing cores shall be insulated by means of several wrappings of PVC tape and then coated with PVC paste;
- the cable armoring shall be made continuous within the joint with copper bonding tape and clamps;
- a split mould, preferably of PVC, shall encase the joint and be filled with a proprietary brand of polyester resin.

Termination of screened signal cables

Where the termination of a screened signal cable is required the cable shall be bonded to earth at one end only and the termination carried out as follows:

Screen to Earth Connection - A suitable length of overall sheath shall be removed, the conductors separated from the screen and the screen insulated using a PVC sheath self-colored green/yellow. A 30mm long silicone rubber over sleeve shall be installed over the point of separation of the conductors, screen and overall sheath.

Isolated Screen - A suitable length of the overall sheath and the screen shall be removed and a 30mm long silicone rubber over sleeve installed over the point of separation of conductors and overall sheath.

Cable glands - general

Glands shall comply with BS EN 50262:1999. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide mechanical support. Where cable glands are exposed to the weather these shall be protected by heat shrink plastic tape or purpose molded sleeves covering the gland continuously from overall sheath to the gland neck.

Where the apparatus enclosure classification requires sealed cable gland entries, sealing shall be achieved by using threaded cable gland holes and polyfluorethylene (PTFE) tape.

Where terminations are to be effected for XLPE or PVC insulated cable, a compression type gland shall be used with means of securing amour wires within the body of the gland, and shall be of a size suitable for the cable used. The gland shall provide both amour moisture seal and outer sheath seal.

PVC gland shrouds shall be provided for all terminations.

Cable glands shall be both electrically and mechanically sound and shall be complete with backnuts and bonded earth tags.

BW type indoor glands shall have a minimum of exposed armoring between sheath and gland. Self-adhesive PVC tape shall be applied to exposed armoring and glands before the shrouds are fitted.

Identification of cores and wires

Terminals shall be identified by using purpose made indelible markers.

Each core shall be identified, at points of termination, using color coded slip-on ring type markers.

The wire and associated terminal numbers shall be identical.

Where source and destination terminal blocks have different numbers, cores shall be double ferruled with both numbers.

Unless otherwise specified it shall not be necessary to identify terminations in domestic installations beyond the final distribution board.

Power cable terminations and joints

Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors. Each cable entry into a terminal box shall be made through a suitable gland.

Boxes shall be of adequate proportions to accommodate all cable fittings including stress cones or other means of insulation grading. Boxes shall be openable for inspection without disturbing the gland plate, cable or termination.

Where air insulated terminations are used, the cable crutch shall be protected by a heat-shrink sleeve.

Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

Glands for armored cables shall provide a positive amour clamp to the box or switchgear coating. This clamp shall completely support the cable weight so that no tension is applied to the termination. The clamp shall also provide earth continuity and be of adequate size to withstand the full fault current of the system for one second.

Where single core glands are required, these shall be non-magnetic. The gland plate shall also be of a non-magnetic material. Removable connections for bonding across the gland insulation shall be provided. The gland insulation shall withstand a test of 2 kV ac for one minute.

Aluminum cores of power cables shall be terminated using approved bimetallic connectors. All glands shall be provided with an earthing tag. For cables of 4mm2 or less, a serrated washer may be used instead for earth continuity.

Multicore and control cable terminations

A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

Terminal blocks for terminating cables up to and including 35mm2 shall securely clamp the conductor, without damage, between two plates by means of a captive screw; pinch screw type terminal blocks shall not be used.

For cables above 35mm2, stud or bolted terminals shall be used, each cable being fitted with a suitable lug.

Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose made solid links shall be incorporated in the design of the terminal blocks.

Terminals that remain energized when the main plant is isolated shall be suitably screened and labeled.

Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labeled.

Plant that has to be dismantled for maintenance shall have multicore cable terminations made off through glands onto an adaptable box. The box shall have terminal blocks, and connections shall be made to the plant by single core wires and

flexible, waterproof plastic conduit. A separate earth core shall link the box to the plant.

The Contractor shall supply and install complete approved marshalling boxes for both indoor and outdoor use, as required for terminating and marshalling all power and control cables at each item of Plant or en route as required. Spare pairs shall be included to facilitate cross-patching in the event of a fault developing on the operational pairs. All marshalling boxes and terminals within panels and mimic panels shall accommodate all control cable requirements. Details of which, shall be agreed and approved by the Engineer.

12.9 LV Switchgear and Control Gear

12.9.1 Introduction

This section of the Specifications covers all switchgear and control gear up to 1,000V AC, including distribution switch and fuse boards, multicolor control centers, control panels and desks, as well as individual units.

LV switchboards and panels shall comply fully with BS EN 60439, and be rated and ASTA certified for operation on a 415/240 V, -3 phase, 4 wire, 50 Hz supply. They shall have a minimum prospective short circuit fault rating of 5 kA. The fault ratings shall be commensurate with the fault levels of the network to which the components are connected. The Contractor shall be responsible for establishing the fault level at each site and designing the panels accordingly.

The Contractor shall be responsible for checking the panel and switchgear manufacturer's drawings, together with all necessary interfacing requirements with THE KENYA POWER AND LIGHTING COMPANY and others. He shall signify his approval in writing to the Engineer and submit copies of all manufacturers' drawings for the Engineer's approval. The Contractor shall be responsible for carrying out measurements of prospective short circuit current and earth fault loop impedance at each LV switchboard/distribution board upon completion of the works and shall incorporate the actual values onto the "as-installed" drawings.

12.9.2 Construction – general

Switchboards and control panels shall be flush fronted and accessed, manufactured from 2.0mm minimum thickness mild steel, multi-cubicle type. They shall be of folded and welded construction forming rigid units. Floor mounted panels shall be equipped with a mild steel channel bed frame at least 100mm high to ensure rigidity and shall be impervious to corrosion by rust. Small units may be of the wardrobe type.

The switchboards and control panels shall generally be of the industrial/enclosed modular cubicle type. The switchboards and panels shall be of the cubicle pattern suitable for floor or wall mounting, comprising a sheet steel cubicle with front access as required and specified complete with bus bars, circuit breakers, fuse switches and MCCB's. They shall be of uniform height, rigid construction and neat appearance.

Where rear access is possible, removable covers shall be provided for cabling etc. Separate cable compartments shall be provided.

All switches and breakers shall be individually labeled, showing the circuits controlled, by means of laminated plastic labels showing black letters on a white background.

Busbars shall be copper on insulated supports and capable of withstanding the fault level on the system at that point.

Switchgear shall be heavy duty, cast metal enclosed type, dustproof, and capable of operating on load at the rated current. Contacts shall be heavy duty silver surfaced type.

Cubicles shall be rigidly constructed. Those accommodating heavy duty switchgear shall be provided with an angle iron or heavy gauge folded steel framework, paneled in zinc anneal or galvanneal.

All mounting brackets and additional items shall be supplied and installed to suitably support the switchboard in the position in which it is to be erected.

Ventilation shall be provided where required, with fine bronze mesh and suitable trim fitted to prevent entry of insects.

Dust tight enclosures shall have ample volume to dissipate heat that may be generated in service, and doors shall be provided with a neoprene seal fitted with a channel and closing against a suitable folded edge or ridge. Molded sealing strips may be submitted for approval as alternatives.

Switchboards and control panels shall consist of incoming fused switches, circuit breakers or isolators, and outgoing circuits controlled by fused switches, switch fuses, MCB's and MCCB's as required.

No live metal shall be exposed by the removal of normally closed or fixed doors or panels. Shrouds or insulated barrier pieces shall be provided.

The use of either circuit breakers or fused units is subject to final approval by the Engineer. Alternatives to the use of the circuit breakers indicated will be considered, but only as an alternative.

Entry of cables, ducts, and conduits shall be neatly made and head boxes shall be provided as required. All entries and openings shall be vermin-proof.

The maximum height of panels shall be 2,200mm above finished floor level.

Where switchboards are split for delivery each section shall have a maximum width of 2,000mm and a maximum mass of 1,000kg with removable eyebolts provided for lifting.

Unless otherwise specified, all contactors and relay control circuits shall be connected to an ac supply of a maximum of 240 V.

Isolation of a control circuit supply to one or a group of starters shall not interrupt supplies to other starters.

All fuses shall be of the HRC type to BS 88. Fuses rated 30 A and below shall be mounted in approved, withdrawable fuse carriers. Carriers containing links shall be colored white, whilst carriers containing fuses shall be colored black.

Timer delay relays shall have a good repeat accuracy and the direction of adjustment for increasing and decreasing the timing period shall be clearly marked.

The circuit breaker associated with each starter shall be a triple-pole unit rated for stalled motor duty and shall comply fully with the relevant British Standard. A padlocking facility shall be provided for locking in the OFF position.

The circuit breaker shall generally be housed within the same compartment as the starter with which it is associated and shall be mechanically interlocked with the compartment door.

The control supply shall be broken by auxiliary contacts on the circuit breaker in the open position.

The switchboards and panels shall be designed so that they can be extended in the future with the addition of further busbar/cubicle sections.

12.9.3 Mounting

Fixings for floor mounted switchboards and panels shall be by not less than four holding-down bolts at the front and rear of the plant. They shall not be visible from outside the panel, but be readily accessible from within.

At least four lugs shall be provided for bolting wall-mounted switchboards and panels to the wall. Fixings holes shall not be provided inside the panel, which shall stand at least 10mm off the wall surface.

Fixings for post/column switchboards and panels shall be provided outside the enclosure. The back of the enclosure shall be drilled to accept fixings.

All mounting brackets, supports and additional items shall be supplied and installed to securely support the switchboards, panels and cubicles in position.

12.9.4 Cubicles

Separate cubicles shall be provided for each of the following:

- incomer;
- bus-section;
- motor starters
- common controls;

- telemetry;
- distribution board;
- feeder;
- outgoing terminations;
- other specified plant;
- spare.

Each cubicle having its own door shall be totally separate from any other so that work can be safely carried out in one cubicle while others are still live.

12.9.5 Doors and covers

Doors shall be adequately sized to readily and neatly accommodate all plant to be mounted on them. They shall open at least 120o, be rigidly constructed, suitably braced and provided with at least two substantial hinges which shall be captive when the door is closed.

Lockable catches shall be used, each being provided with three keys on individual rings having a nameplate showing its identity details. Locking combinations requiring different keys shall be approved before manufacture.

Where padlocking facilities are specified, the padlocks will be supplied.

No plant shall be mounted on covers. Large covers equivalent to half full height and above shall be provided with handles to facilitate removal and replacement.

Each door and cover shall be provided with an internal welded earthing stud, and shall be bonded to the switchboard main earth bar.

Doors and covers giving access to potentially live conductors shall be provided with prominent warning labels.

Suitable shrouds or covers shall be provided for all live terminals and terminations, such that accidental contact cannot be made by the operators or maintenance staff.

Where required, provision shall be made for inter-locking the incoming THE KENYA POWER AND LIGHTING COMPANY supply and standby diesel supply such that paralleling cannot take place under any circumstances, where installed. The inter-locking shall be by an approved means, castelle keys being provided. All other switches or breakers shall be provided with an approved means for locking off. Inter-locks shall be provided such that the front covers for any unit cannot be opened when the switch is in the "ON" position and the switch cannot be operated when the cover is in the open condition. Flexible earth continuity bonds shall be provided for all hinged and swing panels.

12.9.6 Component mounting

Each cubicle shall be provided with a removable rust-proofed steel backplate bolted to studs welded onto the rear of the cubicle. All components, other than door mounted, shall be located on the back plate by bolting into tapped holes or using self-tapping screws. Nuts used to fix components shall be captive on the back plate. DIN rail type fixing may be used where appropriate.

Components shall be so mounted to prevent shock being transmitted from large components and thereby adversely affecting their proper function. The components shall be arranged to give adequate accessibility for maintenance and for removal of any one component with the minimum disturbance to the wiring. Plug-in connectors shall be used where possible.

12.9.7 Cabling arrangement

Cabling shall enter panels through removable gland plates of not less than 3mm thick steel or brass (for single core cables) fitted at least 350mm above floor level, the final height being dependent on the cable sizes and bending radii. They shall be rust-proofed and provided with a welded and bonded earthing stud and adequately sized to accommodate present and known future cabling requirements. Access to both sides of each gland plate when it is in position shall be possible from within the plant. Cabling shall enter at the top and/or bottom of panels as appropriate, and have a suitable means of fixing.

Gland plates are not necessary on small individual starters where access shall be by "knock outs". Gland plates shall be removable for drilling.

12.9.8 Bolts, nuts, washers and screws

All bolts, nuts, screws and washers used for the construction of the switchboard shall be nickel or cadmium plated, except fixings on the face of the switchboard, which shall be stainless steel.

12.9.9 Protection and finish

The internal color shall be white and the protection of externally mounted components shall be no less than that of the panel on which they are mounted. External colors shall be grey unless otherwise specified or approved. Full color details to be submitted with the Tender.

Cases shall be rubbed down, undercoated with suitable primer and finished in not less than two coats of hard enamel, oven baked where practicable.

Outdoor cubicles shall be protected to IP65 (weatherproof), with a rear sloping weather canopy projecting over the front by at least 150mm. Door-mounted components shall be protected by a vandal resistant secondary glazed door so that

all controls and indicators are clearly visible. Doors shall be locked and provided with stays.

Protection classification for all internal boards and panels shall be IP54 unless there is a specific requirement and the manufacturer considers that a particular compartment requires louvered ventilators. In such a case the classification shall be not less than IP31. Louvres shall be provided with fine mesh screens.

Externally mounted panels shall also be protected from the sun, a sun canopy being provided. The canopy shall overhang the panel by a minimum of 500mm on all sides and shall provide an air gap above the panel of at least 200mm. Proposals shall be submitted with the Tender.

12.10 Auxiliary supplies and anti-condensation heaters

Control supplies shall be 110 V or 220 V AC, derived from a transformer within the panel or a 4-wire 3-phase supply fused on its primary and secondary winding, each cubicle being separately sub fused so that a fault in one cubicle does not affect others.

Supplies to plant mounted on the panel such as instruments shall be 110 V or 220 V ac derived from the control supply. Major items of plant shall be separately fused. Other items within the same cubicle may be collectively fused, but separately from the control supplies.

Anti-condensation heaters shall be provided in all cubicles, switchboards and motors to prevent internal condensation due to atmospheric or load variations.

Anti-condensation heaters within switchboards and cubicles shall be provided at the bottom of each cubicle to maintain an internal temperature of 5oC above ambient. An adjustable thermostat with clear scale shall be installed at the top of each cubicle to limit the maximum temperature. Each heater shall be individually fused and provided with an isolation switch.

All heaters shall be rated for 110 V or 220 V ac and shall derive their supply from the control supply circuit.

Motor heaters shall be switched by normally closed contacts on the main contactor(s) such that the heater is energized when the motor is de-energized and vice versa. The heater circuit shall include an isolating switch and indicator lamp to show”Heater Circuit On”. The heaters shall be energized from a 110 V or 220 V 50 Hz supply.

When maintaining plant fitted with heaters it will be necessary to switch off both the main isolating switch and the switch for the heater. A warning notice of this danger shall be fitted near the terminal box of every remote heater and at every panel or switchboard with heaters.

All such plant, whether fitted with a heater device or not, is to be provided with suitable drainage and to be free from pockets in which moisture can collect.

All indicating lamps shall be separately fused and protected.

All panels, switchboards and three phase motor starters shall be fitted with line indication lamps so that the operators and maintenance staff can readily identify the operation of all phases.

All protection components, under/over voltage relays, phase failure relays, etc., shall be provided with a visual identification to show when operation has occurred. Details shall be provided.

In addition to the individual lock-off emergency stops specified for each motor and rotating plant the composite motor control panels and/or switchboards supplying separately mounted starters shall be provided with an emergency "main" button such that all rotating plant can be immediately shut down. Auxiliary contacts shall be provided to enable this shut down circuit to be extended to remotely sited main buttons should this be a future requirement.

All switchboards and motor control panels shall be fitted with a separately fused 13 A switched socket for maintenance.

In addition, larger panels shall be fitted with their own switched internal lighting system to facilitate maintenance. The fused circuit shall be extended from the live side of the incoming switch, suitable warning notices shall be provided to advise operators that the isolation of the main incoming switch/breaker does not render these circuits in operative.

12.11 Busbars and main connections

Each switchboard or control panel as may be required shall be equipped with a set of three phase and neutral air insulated busbars rated for a current of not less than the future connected load

Busbars, risers and droppers shall be ASTA certified and manufactured from solid copper fully complying with BS EN 60439, enclosed in a separate chamber and shall be continuous over each section of panel as assembled prior to shipping, with the facility for future extensions at both ends of the panel. Busbars shall not be drilled for outgoing connections, which shall be made with clamps.

The riser and dropper bars shall be of an approved solid insulation phase segregated type, and fault rated to the same level as the main busbars. Riser and dropper bars shall be fully insulated.

Busbars systems shall be capable of withstanding a minimum prospective short circuit fault corresponding to the let through energy of a protective MCCB of equal rating to the busbar rating and connected to a prospective symmetrical fault level of 5 kA r.m.s.

The busbars shall be housed in their own compartment running the length of the switchboard or panel and shall not be exposed when any of the access doors or plates (other than those provided for busbars access) of the panel are moved for maintenance or other work.

Auxiliary bus wiring between units shall be protected and accommodated in areas other than the main busbar chamber.

All busbars shall be air-insulated, with tinned and bolted connections, clearly painted in correct color of red, yellow, blue for the phases and black for the neutral.

It shall be possible, by removing covers, to readily gain access to all busbar, riser, and dropper joints in order to check tightness of nuts and bolts.

The framework and cable armoring clamps shall be efficiently bonded (with continuous copper strip) mechanically and electrically to the building and switchboard main earthing system. A high conductivity copper earth bar shall be bolted and efficiently bonded to the main frame to run the full length of each panel. This shall be color coded yellow/green. Flexible earth continuity conductors/bonds shall be provided for all hinged doors and swing panels

12.12 Balance

The entire installation shall be balanced to the satisfaction of the Engineer and the Contractor shall carry out such alterations to switchboard connections as may be required to balance the installation.

12.13 Circuit lists

The switchboards and distribution boards shall be fitted with a typed circuit list in the form of a card within a transparent envelope fixed to the inside door of each panel and distribution board. The form of the chart shall be to the approval of The Engineer and shall contain the following details:

- incoming cable type and size including any circuit protective conductor.
- size and type of incoming protective device.
- measured values of earth fault loop impedance and prospective short circuit current at the board.
- size and type of protective device on all outgoing circuits.
- size and type of cables on all outgoing circuits including circuit protective conductors.
- block layout of switchboard components to assist maintenance staff in the identification, operation and function of each component.

12.14 Motor start

12.14.1 General

All starters and controllers shall comply in all respects to BS EN 60947, IEC 60947 or BS EN 60470:2001, IEC 60470:2000, and shall form complete individual package units or complete units within the switchboards.

The control and protection arrangements shall be suitable for the type, size, voltage and duty capability of the relevant motor and the Contractor shall state in detail the control and protection gear which he proposes to use for each type and size of motor.

The starters shall be of the triple-pole, air breaker type. Unless otherwise stated, for motors up to and including 3kW the starters shall be of the "Direct-on-Line" type capable of operating the relevant motor fifteen times per hour, suitable for remote automatic and local push button manual operation.

Unless otherwise stated, for motors over 3-10 kW the starters shall be of a current limiting type suitable for remote, automatic and local manual operation. For motors of over 20KW, they shall be soft start. The type of starter shall be selected with due regard to the nature of the load being driven to ensure that the starting current does not exceed 2.5 times the full load current. Current limiting starters shall be of the star-delta or electronic soft-start type. The number of starts per hour for each motor rating shall be stated, this generally being a minimum of five. Details are to be included in the supplementary information submitted with the tender.

In general, each motor starter shall be equipped with the following basic plant:

- door interlocked, fault make/ load break, on load, incoming main circuit breaker.
- contactors of the air break type fitted with arc chutes, magnetic blow outs and heavy hard drawn copper main contacts. Interlocks shall be provided to prevent simultaneous closure of the star and run contactors.
- timing relay, where required, shall be electromagnetically-operated controlled timing of contactor sequence; a fully adjustable eddy current retarding mechanism shall be provided where necessary to suit the nature and conditions of the motor.
- continuously rated operating coil (voltage to suit control conditions of 240V).
- auxiliary contacts for remote automatic control.
- adjustable over voltage relay unit.
- adjustable under voltage relay unit.
- overload relay device suitable for adjustment with calibration plates scaled in amperes. a door mounted reset facility shall be provided.
- control circuit fuses and links. *
- relay to protect against single phasing.
- ammeter of the moving iron type mounted on the starter and operated by a current transformer, where justified by rating, and complete with phase selector switch.*

- provision for remote emergency stop button, float controls, etc.
- hours run counter. *
- anti-condensation heater with thermostatic control.
- supply on, running and tripped indicator lights .*
- phase identification lights.
- test facility.
- hand/off/manual selector switches as required. *
- motor winding over-temperature release shall be provided in conjunction with the specified thermistor protection.
- duty selection switch as appropriate.*
- manual stop/start push-buttons *.
- relays to operate in conjunction with anti-vibration protection on larger motors shall be provided where specified.
- relays to operate in conjunction with bearing temperature thermocouples on larger vertical spindle motors are to be provided where specified.

  * These facilities shall be door mounted.

Each starter shall be provided with a test facility enabling the control circuits to be energized only when the starter isolator and cubicle door are open. It shall not be possible to close the cubicle door with the test facility still switched on.

General layouts of the switchboards, control panels, etc. shall be submitted for approval before commencing manufacture. The final layout of all switchboards, panels, etc. shall be to suit the motor loads, standby diesel sets and mode of operation.

Suitable relays and timers shall be provided to prevent the simultaneous starting of the pumpsets unless the operating and protection systems are designed to accommodate the resulting starting surges.

12.14.2 Instruments, Indications and Alarm

The operating push buttons, switches or handles of all circuit breakers, motor starters, isolators, etc. shall be located on the front of cubicles, or for cubicles of the desk type, on the face of the desk. There shall be visual indications of the "ON" and "OFF" positions. The stop push-buttons (and remote emergency stop buttons) shall be operable at all times and for all modes of operation.

Lamps on the fascia of the switchboard shall clearly and individually indicate all operations of fault and alarm circuits. Fault and alarm lights shall remain on until the associated fault or alarm condition has been cleared and the system reset. An audible alarm shall also be provided to indicate operation of any major fault or alarm function. Acknowledgement of the major fault or alarm condition shall also cancel the audible alarm.

Indicating lamps shall incorporate a lamp test feature with either individual push to test or a common lamp test button.

Lamps on outdoor plant shall be shaded from sunlight so that their operation can be clearly seen at all times of the day.

Push buttons fitted on the panel shall be of the shrouded type, unless otherwise specified, and shall have a label indicating their function.

Indicating lamps on panels shall be rated to withstand not less than 20% continuous over voltage and shall be so designed that the heat from the bulb does not discolor the panel.

Indicating lamps fitted into the fascias of switch and instrument cubicles or panels shall be adequately ventilated.

Lamps shall be easily replaceable from the front of the panel by manual means preferably without the use of extractors.

The bezel of metal or other approved material holding the lamp glass shall be of an approved finish and easily removable from the body of the fitting so as to permit access to the lamp and lamp glass.

The lamps shall be clear and fit into a standard form of lamp holder. The rated lamp voltage should be 10% in excess of the auxiliary supply voltage, whether AC or DC. For ac circuits lamp units shall be connected to the 110 V supply and shall have an integral transformer providing a 6 V supply to the lamp.

The lamp glasses shall comply with BS 1376 and BS EN 60073:2002 and are to be in standard colors, red, green, blue, white and amber. The color is to be in the glass and not an applied coating and the different colored glasses are not to be interchangeable. Transparent synthetic materials may be used instead of glass, provided such materials have fast colors and are completely suitable for use in tropical climates and remain unaffected by the lamp temperature.

To comply with BS EN 60073:2002, as a general principle, the following colors shall be adopted:

green - supply available but switch, starter, etc., in the open position
white - switch or starter, etc., closed and plant running correctly
red - overload trips operated or major fault on plant
amber - warning signal, i.e. overloading of machine, high temperature, etc.
blue - as necessary for other indication

Indicating lamps and push buttons shall be colored in accordance with BS EN 60073:2002 and in particular as follows:

Indicating lamps	Color
on	red
off	green
fault	yellow/amber

alarms	yellow/white
heaters	blue

Push buttons	Color
start	green
stop	red
alarm accept acknowledgement and mute	black
emergency stop	red

A separate indicator light or other means of indication shall be provided for each separate motor protection device to indicate activated.

Live line indication shall be provided at all panels so that the supply status in all sites, pumps stations or facilities is readily available to operators and maintenance staff.

Indicating light bezels manufactured from plastic will not be acceptable.

All electrical indicating instruments shall comply with BS 89, EN 60051, IEC 60051, BS 3693 or equivalent approved standard, be of the moving iron spring controlled type self-contained instruments to Class 1.5 or better. Instrument size shall be 96mm square with quadrant scale.

All instruments shall be back-connected mechanisms well protected by strong cases that shall be earthed and fully insulated. They shall be clearly readable with black markings on a white background. A red pointer shall be provided, adjustable (with a tool) from the front of the instrument, to indicate the normal or maximum reading.

Instruments shall be of the industrial grade and shall have a means of zero adjustment from the front without the need for dismantling. They shall be capable of sustaining the normal full load current, voltage, (via current transformer or other transducer as necessary) and shall not be damaged by the effects of faults in the system being monitored. Scales shall be of the 270o type.

All wiring, space and connections and other items shall be provided for tariff meters, ammeters, voltmeters, selector switches and the like as applicable.

Instruments shall be flush mounted on the cubicles and effectively sealed against ingress of moisture, dust and insects. Instrument mounting height shall not exceed 1.80 m above floor level. Unless otherwise specified instrument full-scale deflection shall be at least 120% of the normal operating point (i.e. nominal voltage or full load current).

All relay cases shall be black glass finish.

All voltage circuits of instruments shall be protected by a fuse in each unearthed phase, situated as close as practicable to the point of connection.

Voltage selector switches shall give phase to phase, phase to neutral readings. The class of accuracy of all meters, voltage transformers and current transformers shall be provided with the Tender.

Voltmeters shall be suitable for operating from the secondary side of the 110 V voltage transformers.

Ammeters in motor circuits shall be capable of withstanding the starting current of the motors and shall have a compressed overload scale for this purpose. The full load current shall be defined with a red line. Voltmeter scales shall have a red line indicating normal voltage.

Current transformers shall have short circuit ratings not less than those of the circuits with which they are concerned, and shall fully comply with BS EN 60044-1:1999, IEC 60044-1:1996.

Separate current transformers shall be provided for protection and instrumentation duties. The rated burden of all current transformers shall be a minimum of 150% of the sum of the burdens to be imposed.

All current operated instruments and relays shall be suitable for operating on 5 A secondary windings of current transformers.

All protective relays, where provided, shall be fitted with indicating flags.

Instruments and relays shall be removed from the switchboards for transport and delivery and shall be packed in cases and transported and delivered with the associated switchboard.

Where specified, capacitors for correcting power factor shall be incorporated in the panel. Such capacitors shall comply fully with BS EN 60831-1:1998, IEC 60831-1:1996 or BS EN 60871-1:1998, IEC 60871-1:1997 as appropriate.

All motors shall be provided with emergency stop push buttons mounted on or adjacent to the motors that shall lock out the control circuit and shall require a key to reset the circuit.

12.14.3 Control Panel Cabling

Control wiring for motor control panels, switchgear, etc. shall be 600V grade PVC or XLPE insulated multi-stranded copper wire to BS 6004 or BS 6007. The minimum size shall be 1.5 mm^2 stranded conductors.

All terminals shall be referenced and detailed on the schematic diagrams to be submitted to the Engineer.

It shall be possible to gain access to any terminal of any component so as to be able to remove and replace the wire from that terminal without recourse to special tools, and without the need to disturb other components.

All wiring shall be neatly run bunched in neat forms. All wiring accessories of plastic material, such as cleats, conduits, strapping, etc., shall be non-corrodible and resistant to flame propagation.

Crimped pin extensions shall be fitted to all control circuit cables to prevent wandering strands before being inserted into Klippon type terminal blocks.

Cabling shall enter the panel from above or below as applicable and as specified elsewhere in the Specifications. Cables shall be terminated using external boxes or internal gland plates.

Where necessary cable tray work shall be provided for supporting and fixing cables, and full glanding and termination facilities shall be provided. Gland plates shall be mounted not less than 150mm above the cubicle bottom. It shall be possible to terminate all cables without requiring access to live interiors.

Primary cabling shall be completely isolated from all control wiring, etc., and auxiliary terminals shall be likewise isolated from primary terminals.

All terminal boards and terminal blocks shall be of a type providing a positive mechanical clamp on connection. Terminals for the connection of all external cabling shall be situated near their respective gland plate and at a minimum distance of 200mm from it.

Separate terminals shall be provided for incoming and outgoing connections and not more than two wires shall be connected to any one terminal.

Supplies for the motor heaters shall be controlled automatically by the main contactor such that the heater is on when the motor is de-energized. Motor heaters shall be separately fused and provided with termination facilities. Details shall be provided for approval.

12.15 Switchboard Construction

(A) General

This section shall apply to the construction of all panels housing electrical apparatus, including but not limited to the following:

- Switchboards
- Motor control centres
- Circuit breakers
- Control panels
- Monitoring or supervising panels
- Distribution boards – control panels
- Marshalling panels
- Interface panels
- Local control panels

(B) Safety

Access to any enclosure of compartment shall be possible only;

When the circuit switch-disconnector is open and connections within the compartment are isolated or;

- When connections within the compartmental including any on the door or access cover, are fully shrouded to prevent accidental contact or;
- When connections within the compartment operate at a voltage not greater than 55 volts.
- Where a test facility is provided for use with the door or cover open the provisions of (b) shall apply. Connections which may be live with the door or cover open shall be suitably labelled.
- Bolted covers on compartments incorporating live connections shall bear a suitable warning label.
- Labelled isolators, fuses or links shall be provided so that relays, controls and instruments may be isolated but keep other essential circuits energised.

(C) General Construction Standard

- The switchboard and all components shall be constructed to withstand fault currents as specified or required under the relevant standards and regulations.
- Switchboards, cubicles and enclosures for electrical equipment shall be constructed in sheet steel not less than 2.0 mm thick and suitably braced to form a rigid structure. Exterior edges and corners shall be rounded and the use of externally visible assembly bolts or similar shall be avoided.

The design shall provide protection against dust, damp and entry of vermin. Gaskets shall be fitted to doors and removable panels. Ventilation and cooling shall be by natural air circulation under the ambient conditions specified or to be expected.
Unless specified otherwise, switchboards, cubicles and enclosures shall be floor-standing with lockable-hinged front doors and bolted removable rear panels for access to live equipment such as bus bars and terminals.
The switchboard shall fit in the space as stated or indicated on the drawings. If there is any reason will not fit into the space, the attention of the Engineer shall be drawn in good time to enable alternate arrangements to be made either to the board or to its fixing position. It shall be the responsibility of the electrical contractor to verify the suitability of the space provided before commencement of installation.
Each section shall be separately accessible without disturbance to other sections for maintenance and inspection. Live parts with voltages greater than 55 V to earth within the section shall either be isolated automatically when the section door is opened or be fitted with insulating barriers to prevent accidental contact by personnel. Parts still live when the unit is isolated shall be labelled “Danger Live”.
Where integral fuse or MCB distribution boards are incorporated, access to fuse carriers and MCB’s shall be possible without isolating the fuse or MCB distribution board. With the operator’s door open and with fuses and MCB’s in place, the degree of protection of such distribution boards shall be not less than IP20.
A clear access of not less than 1000 mm, and preferably 1500 mm, shall be given at the rear and both ends of the panel.
Controls and switches mounted on any control panel section of a switchboard shall be installed in the height range 750 mm to 200 mm; indicating instruments 900 mm to 1800 mm; recorders 900 mm to 1400 mm. This requirement shall not be applied to starters or feeder sections.

Switchboards shall be equipped with a power transformer and 2 No. 15 A, 110 Vac (±55 V) RCCB protected sockets, suitable for use with electric hand tools. Switchboards shall additional have 2 No. 13 A, 240 Vac RCCB protected sockets.
Each section of cubicle of the board shall be clearly labelled with circuit name and number, and the reference number of the section. The panel shall have a nameplate carrying the manufacturer's name, address, reference and year of construction of the panel.
Cubicles and enclosures shall be earthed. Where a number of cubicles are bolted together, earthing shall be provided via a continuous high conductivity copper bar of minimum cross section 25 mm x 6 mm running the length of the panel. Terminals shall be provided for the connection of earthing from the metal cladding or armouring of incoming and outgoing cables. Holes shall be left at each end of the bar for connection to the main station earth and future extension. The bar shall be fault rated at not less than that of the associated equipment. Warning labels and instructions for earthing and isolating shall be fitted in each switch compartment. Front access doors shall open not less than 120° and shall be fitted with a locking handle and non-ferrous lift-off hinges which shall be captive when the door is closed. Locking combinations requiring different keys shall be approved before manufacture. The door shall be secured by captive screws or locking handles of sufficient number to ensure firm pressure on the door seal around the whole periphery. The door shall be mechanically prevented from opening before isolation of the live parts within. All doors shall be separately earthed to the main frame. Earthing via the door hinge will not be accepted.

Cables shall enter through 3 mm thick undrilled removable steel or brass (for single core cables) gland plates mounted at least 250 mm above switchboard base level. Access to both sides of gland plates for gland tightening shall be readily available. Gland plate knockouts will only be accepted for individually mounted starters and small power distribution boards.
Lifting eyeholes shall be provided at each top corner at each section of the switchboard and shall be removed and replaced with blanking bolts after installation.
Cubicles and enclosures for outdoor locations shall be fitted with lockable outside doors and a housing so designed that all controls, instruments and such like are fully enclosed and the whole assembly is weatherproof and vandal proof. The doors shall be fitted with stays to prevent overstraining of the hinge fixing and allow fixing of the doors in the open position. Switchboards inside cubicles shall also be weatherproof to allow operation of the controls when the outside cubicle doors are open during inclement weather.
When specified, a double skin roof shall be fitted over the whole assembly to give added protection against direct sunlight.
LV enclosures shall be constructed to comply with SSRN 038 and have IP ratings of at least the following: − for outdoor installation IP 65, − for indoor installation IP 54.
Switchboard, cubicle and enclosure construction shall be capable of withstanding without damage the fault current of the system. HV enclosures shall be constructed to standards under SSRN 061 with IP ratings equal to those for LV enclosures.
Protective coatings shall be applied at the place of manufacture and before installation of its internal electrical fittings.

(D) Switchboard Small Wiring

Switchboard wiring shall be carried out in 600/1000 V PVC insulated cable to comply with SSRN 041. The conductors shall be stranded or flexible (where applicable):

solid cores will not be accepted. The conductor size shall be not less than 1.5 mm² for control and indication circuits and not less than 2.5 mm² for CT secondary circuits.
Wiring within the switchboard shall be marked with ferrules at each end for identification. The letters and numbers used shall correspond with the switchboard wiring diagram.
The wiring colour code shall be as follows:
Phases -red, yellow, blue

- Neutral -black
- Control -grey/black
- Earth -green/yellow

The wiring shall be neatly laced and cleated to the switchboard structure or contained within purpose designed plastic trunking and arranged so that access to equipment is not impeded. Where trunking is used the ratio of effective cross sectional area of the cables shall be not greater than 40% of the trunking area. Where wiring passes through metalwork the access hole shall be fitted with a suitable grommet.
Every wire shall be identified by indelibly marked circular ferrules at each end. Slip-on, 'u' type ferrules will not be accepted. Identification shall correspond with the wiring diagram.
Wiring between cubicles or panel sections shall be terminated on terminal blocks at each end.
Wiring onto hinged doors or plates which is subject to movement shall be run in flexible circular section trunking and shall be supported securely at both ends of the moving section. Adhesive fixings of the ends of the trunking will not be accepted.
Crimped flat blades shall be applied to all wire ends to ensure sound connection to terminal blocks and all circuit components.
Small wiring used for control, extra low voltage and instrument signals which are likely to be affected by interference shall be screened and/or spaced from each other and power cables to ensure no distortion or mal-operation.

(E) Switchboards Busbars and Primary Connections

All busbars and primary connections shall be of high conductivity copper to comply with SSRN 020 and SSRN 069. The mechanical and dielectric strengths of busbars and connection supports shall be able to withstand without damage the worst conditions of electrical surge which can occur on the installation. The busbars shall be capable of carrying full rated current continuously without exceeding temperature rise limits indicated in the above SSRNs.
The busbars, assemblies and connections of equipment shall be of a type which does not rely solely on air for insulation purposes. The covering material shall be non-deteriorating at the rated short-time maximum temperature of the busbars and shall have such thickness as is required to withstand rated line to line voltage between busbar and a conducting object on the exterior of the covering material for a period of not less than 60 seconds.
Where independent certification of busbar withstand and continuous rating is not available the Contractor shall include tests to demonstrate the suitability of the equipment.
Busbars and primary connections shall be housed in an air-insulated enclosure segregated by barriers. Direct access to live bars shall not be possible. Access to busbars and connections shall be only by removal of bolted covers. Suitable warning labels shall be provided externally on covers and internally on shutters. Busbars

shall be identified by coloured banks opened at nor more than 1,000 mm and in each compartment.
Baffles shall be provided to prevent the accidental entry of tools, etc. whilst maintenance work is being carried out in the vicinity of the chambers.
Busbars systems shall have a short time rating not less than that of the associated switchgear.
Busbars shall be extensive at both ends.
The conductors shall be separated and supported with the appropriate clearances in air or shall be otherwise adequately insulated or encapsulated.

12.16 Switchboard Components

(A) General

- switchboards
- motor control centers
- circuit breakers
- control panels
- monitoring or supervisory panels
- distribution boards
- marshalling panels
- interface panels
- local control panels

(B) Indicating Instruments and Meters

This section shall apply to components used in all panels housing electrical apparatus, including but not limited to the following:
All instruments and meters shall be flush mounted, 96 mm x 96 mm minimum size and of the same pattern and appearance throughout. They shall be back connected and be similarly protected to maintain the environmental protection standard of the equipment enclosure on which they are mounted. Those which perform similar duties shall be of uniform type and manufacture.
Indicating instruments shall have black marking on a white background, a full-scale deflection of 270° and be fitted with an externally accessible zero adjuster.
They shall have no parallax error and their normal maximum reading shall be approximately 60% full-scale deflection.
Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The scale shall be clearly marked with a red line indicating normal full load current.
Indicating instruments shall comply with SSRN 070 and shall be of industrial grade accuracy, (±5%) unless otherwise specified.
Kilowatt-hour meters: shall comply with SSRN 014 and SSRN 070 and shall have an accuracy of ±1% unless otherwise specified.
The meter element shall be suitable for operation on single phase or three phase as specified, 50 Hertz AC system and shall be of indicator type, capable of continuously carrying the rated current.
The registering mechanism shall be of the cyclometer type giving a reading of six figures, the lowest indicating tenths of a unit.
Voltmeters: Voltmeters shall be of the moving iron flush mounting type, rectangular or circular and size as specified. They shall be suitable for vertical switchboard mounting and studs shall be provided for back connection. The voltmeters shall be suitable for operation on a 50 Hertz system, and be calibrated as required. The

voltmeters shall be manufactured in accordance with BS 89 to industrial grade accuracy as specified therein.
The voltmeters shall be protected by high rupturing capacity cartridge fuses to SABS 172: housed in suitable insulated fuse carriers with a panel-mounting base. Voltmeter selector switches shall be incorporated.
Ammeters: Ammeters shall be and of the moving iron flush mounting type, in accordance with the clause above where applicable, and of the pattern, size and scale range as specified. Ammeters for use in motor circuits shall have a suitably compressed overload range.
Ammeters selector switches shall be installed if specified. Selected switches having spring located contacts running over copper segments are not acceptable.
Combined maximum demand and indicating ammeters: The instruments shall be flush panel mounting, rectangular in shape, the dial size being approximately 125 x 125 mm or 80 x 80 mm as specified. The ammeters shall comply with BS 89.
The instrument shall comprise a moving iron ammeter showing the instantaneous current value, combined with a maximum ammeter employing a bimetallic spiral device which will indicate the mean current value on the basis of a 15 or 30 minute period as noted, and which is fitted with a residual pointer to indicate the maximum mean current reached during any period between manual resetting.
All three indications shall be registered on concentric scales, and instruments having small moving iron ammeters with window cut-outs scales are not acceptable. The bimetallic system shall incorporate ambient temperature compensation.
The instrument shall be used with a current transformer having a 5 ampere secondary winding. 6 Ampere or 8 ampere instruments may be offered, scaled to the full load primary current of the current transformer, with an additional overload scale in the case of 6 amp instruments.
Power Factor Indicators: Instruments shall be housed in pressed steel cases. Shadowless scale plates shall be fitted. Instruments shall comply with BS 89. Indicators shall be suitable for flush mounting in switchboards. Current rating shall be 0.5 to 5 A continuous at the rated voltage. Power factor range shall be from 0.5 PF lead to 0.5 PF lag, and size shall be as specified.
Elapsed time meters: Time meters shall be of the flush mounting type, square phenolic frame, suitable for switchboard mounting. Registers shall be calibrated in hours and tenths of hours. Cyclometer details to be as noted. Voltage range shall be 200 – 250 V 50 Hz unless otherwise noted. Motors shall be self-starting, synchronous, non-reversing and shall be energised from the same supply as the apparatus being metered.
Transducers: Transducers shall be suitable for use in remote indication systems for alternating current and voltage using lightweight telephone type pilot wires. Outputs shall be suitable for operating moving coil instruments and recorders.
Outputs and inputs shall be as specified.
Output currents shall be independent of the load resistance over the stipulated range of load resistance.
Ambient temperature range – 10°C + 50°C.
Accuracies and linearity shall be according to the application as specified.
Open circuit. DC output voltages shall not rise above 18 volts when the load is removed or open circuited. Open circuiting of the output shall not result in damage to the transducer.
Short circuit. DC outputs shall be protected against a short circuit of the output terminals by a current limiting device.

Voltage, kW and kVA transducers shall suitable for 3 wire unbalanced loads or as otherwise specified. Amplifiers shall be utilised where transducer outputs do not meet the required output range for the system.
Where portable instruments are specified they shall be of sub-standard accuracy (±1%)

Instruments shall be positioned between 1800 mm and 750 mm above finished floor level.

(C) Indicator Lights

Indicator lights shall be of uniform type as far as possible, to minimise spares requirements. Glasses and bulbs shall be easily removable without the use of a tool.
Indicator lights shall be not less than 20 mm diameter and shall be of the projecting type so they can be seen from the front and side of the switchboard. They shall be visible under bright sunlight conditions.
The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% of normal value, or by using higher voltage lamps.
Alternatively the lights shall be transformer operated or battery operated where a battery is available.
Colours of indicator lights shall generally comply with SSRN 071. The diffuser glasses shall be coloured and the bulbs shall be clear.
LED indicator lights shall not be used except where they form part of proprietary equipment.
All components, doors and removable covers shall be labelled. Fuse carriers shall also have labels which state the fuse rating to be fitted. Each cubicle door shall bear an identification label (minimum letter size 8 mm) and each switchboard and enclosure shall bear an overall identification label (minimum letter size 12 mm).

(D) Labels

All designating labels shall be of traffolyte or similar finished white with engraved letters and numbers filled with black and fixed by non-rusting screws.
Danger and warning labels shall be of similar material finished in yellow with red letters and numbers. Edges of labels shall be bevelled and lettering shall be at least 4 mm high.

(E) Pushbuttons

Colours of pushbuttons shall generally comply with SSRN 071 and in particular shall be as follows:

- Red -stop, off or emergency buttons
- Green -start or on buttons

Emergency stop push buttons shall have enforced contact separation. They shall be connected in the control circuits so they trip the circuit under all conditions. They shall have mushroom-heads of the stay-put pattern.

(F) Terminal Blocks

Terminal blocks shall be of non-brittle material, screw-clamp or stud type barrier pattern. Pinch screw type blocks shall not be used.
At least 20% spare terminals shall be provided at all blocks.
Every terminal block shall have a clear plastic clip-on cover running the full length of the block to prevent accidental contact with live terminals.
Removable DIN rain terminals shall be provided for all wiring, mounted at an angle to provide ease of access, positioned not less than 150 mm from gland plates, doors or covers.
Power, control, earth and end stop terminals shall be provided and terminals shall be grouped and separated by barriers according to their voltage level and function.

No more than two conductors may be connected to one side of a terminal. Outgoing cables shall be wired so that outgoing wiring is connected to one side only.
Terminal blocks shall be mounted vertically at the side of the enclosure and set obliquely towards the rear doors.
Every terminal block shall have a clear plastic clip-on cover running the full length of the block to prevent accidental contact with live terminals.
Blocks at different voltages or phases shall be grouped and labelled accordingly.

(G) Test Terminal Blocks

Test terminal blocks shall be provided for secondary injection and testing of relays.
A metering block shall be provided for the connection of portable sub-standard instruments for plant testing.
Test terminal blocks shall be provided with shorting links or be of a type suitable for use with portable test plug-in equipment.

(H) Control, Auxiliary, and Selector Switches

Control and Selector Switches shall conform to SSRN 007.
Control Switches shall be of the three-position type with a string return action to a central neutral position. They shall be labelled.
Electrically operated circuit breakers shall be fitted with a control switch labelled Open/N/Close. These shall be of the pistol grip type with a spring return to the neutral position. The switch shall be lockable in the neutral position.
Selector switches shall make before break and shall remain in the position selected and be lockable in that position. They shall have spade shaped handles and each position shall be labelled.
Contacts of all switches shall be shrouded.
A minimum of four spare auxiliary switches, two normally open and two normally closed shall be provided for each circuit breaker and contactor.

(I) Switchboard Ancillary Equipment

The following ancillary articles shall be supplied with each switchboard.
2 pairs rubber gloves to SSRN 077 according to rated voltage of switchboard.
1 No. “treatment for electric shock” metal enamel instruction plate suitable for screen attachment.
Operating handles, tools, spares and lubricants as specified elsewhere.

(J) Voltage Transformers

Voltage transformers shall comply with SSRN 003. The secondary winding shall produce an output line voltage of 110 V, three phase. The accuracy class and VA rating shall be as specified or shall match the requirements of all connected instruments and relays.
The primary circuit shall be protected by HRC fuses having a short-circuit rating of not less than that of the switchgear. The connections between the fuses and the switchgear primary conductors shall be of sufficient cross section and be supported to withstand the short-circuit rating of the switchgear.
The secondary circuit shall be protected by HRC fuses mounted as close as possible to the secondary terminals. Fuses shall be accessible without the need for isolating the switchgear.
Isolatable voltage transformers shall have the facility for padlocking in the service position. Safety shutters shall automatically cover the busbar spouts when the transformer is withdrawn. Shutters shall have the facility for padlocking in the closed position.

(K) Current Transformers

Current transformers shall comply with SSRN 002 and shall be of the wound-primary or bar-primary type according to ratio required. All current transformers shall have a short-time current rating of not less than that of the switch panel in which they are incorporated. For bar-primary current transformers this rating shall be for a period of 3 seconds. For wound-primary patterns the rating shall preferably be for a period of 3 seconds but may be reduced to not less than 0.5 seconds subject to the Engineer's approval.

Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

Current transformers shall be of Class 1 accuracy for use with measuring instruments and Class 10P for use with protective relays.

Class 5P shall be used for combined overcurrent and earth fault protection of the inverse time overcurrent type.

The secondary windings of each set of star-connected three phase current transformers shall be earthed at one point only, via a bolted link.

Separate sets of CTs shall be used for metering and protection.

Shorting links shall be provided at test blocks.

(L) Control Transformers

Unless otherwise specified all contactor control circuit supplies shall be obtained from the 110 v secondary winding of a single phase integral control transformer.

Transformers shall be of the double wound pattern in accordance with SSRN 051 and shall have an earth screen between primary and secondary windings. One leg of the secondary winding shall be earthed. The primary winding shall be protected by carriage fuses, and the secondary winding shall be protected by a fuse and link.

A spare control transformer shall be provided with each new switchboard.

Anti-Condensation Heaters

Anti-condensation heaters shall be fitted to:

- Wall mounted enclosures
- Individual floor mounted enclosures
- Each vertical section of single tier switchgear to control gear
- Each tier of multi-tier enclosures

Each heater shall be controlled by its own thermostat, ON/OFF switch and fuses or MCB. Heaters in exposed positions shall be fitted with a safety guard.

Each section of the panel shall contain an anti-condensation heater, rotary isolating switch, and HRC fuse or appropriate protective device. A bus-wired single-phase supply controlled by a calibrated adjustable thermostat shall energise all panel heaters.

12.17 Air Circuit Breakers

Air circuit breakers shall be 3-pole and neutral or 4-pole where used in conjunction with a standby generation scheme, spring-operated, withdrawable type having the following minimum features:

- mechanical and electrical interlocking.
- mechanical open, closed, spring-charged, and tripped indication.
- trip-free mechanism

- manually or motor wound spring closing mechanism
- facilities for padlocking
- at least one unused volt-free changeover auxiliary contact, wired down to outgoing terminals
- magnetic and thermal adjustable overload, short circuit and earth fault protection with facilities to prevent unauthorized adjustment
- mechanical trip push-buttons

Additionally and where necessary:

- closing solenoid
- shut trip coil
- under voltage trip coil

These features shall be provided to suit the specific operational requirements at the various sites, the details of which shall be agreed.

If circuit breaker carriages cannot be comfortably handled by one man, a suitable trolley shall be provided.

12.18 Contactors

Contactors shall be block type, equipped with auxiliary contacts for all necessary indication, local and remote-control requirements together with a means of mechanical indication to show when it is energized. They shall generally be of the triple pole air break type, electromagnetically operated with inherent no volt feature. Each contactor shall have a minimum of three spare auxiliary contacts.

Rating of contactors shall be strictly according to manufacturer's instructions.

Contactors shall be suitable for continuous heavy duty and normally fitted with 220V coils. They shall be of the robust construction to BS EN 60470:2001, IEC 60470:2000 and BS EN 60947-4-1:1992 where applicable, and rated at not less than the current carrying capacity of the outgoing circuit.

Contactors for motor circuits shall have make and break capacity of the motor starting current, and mechanical duty of double the frequency of starts under the most extreme operating conditions with an absolute minimum of three consecutive starts from cold and five starts in any one hour when hot.

12.19 Fused switches and isolators

Fused switches and isolators shall comply fully with BS EN 60947-3:1999 and shall be air-break, door interlocked and padlockable in the off position, preventing the cubicle door from opening. They shall be mounted on cubicle back plates, with a spindle connecting each switch or isolator to a door-mounted actuator. Spindles shall be kept short or be provided with an intermediate support, so that they readily engage the actuators when the door is closed.

Fused-switch units, where installed, shall be of the flush type, totally enclosed in sheet steel cases and doors. Units shall be dustproof and capable of operating on load at the rated current. Contacts shall be heavy duty silver surfaced type, and in open position the fuse elements shall be disconnected from both line and load terminals. HRC fuse elements shall be fitted to each unit, of correct rating for the outgoing conductors that they protect. Where operating handles of the units protrude in front of the board, they shall be of either the removable or telescopic type.

Fuse switches not forming part of composite panel shall be as specified above but suitable for wall mounting in an enclosed sheet steel case.

Fused switches shall be a fitted with appropriately rated HRC fuse links in each phase and a solid link in the neutral.

Sufficient auxiliary contacts shall be provided to isolate all incoming power supplies to the cubicle. The control supply auxiliary contacts shall close when the fuse switch is in the on and test positions. The fuse switch main contacts shall be open in the test position.

Moving contacts of fused switches shall, for maintenance purposes, be safely and readily removable as a complete assembly when the remainder of the switchboard is energized.

The fuse switch associated with each starter shall be a fully shrouded, triple-pole unit rated for installed motor duty. It shall be housed within the same compartment as the starter with which it is associated and shall be mechanically interlocked with the compartment door.

A padlocking facility shall be provided for locking in the OFF position and a minimum of four spare auxiliary contacts shall be provided in each unit.

Switch fuse units shall be generally as specified for the fused-switch units and shall be of a similar pattern and from the same manufacturer.

12.19.1 Fuses and links

Fuses shall be of the high rupturing capacity cartridge type complying with BS 88 and BS EN 60269-2:1995, BS 88-2.1:1988, IEC 60269-2:1986, rated according to their function in accordance with the manufacturer's recommendations. They shall be fixed inside panels behind a 3mm polished Bakelite escutcheon panel that shall be readily removed, and to face the doors, at sufficient spacing to facilitate easy fuse/link withdrawal.

Fuse holders and carriers shall be colored black, and link holders and carriers white.

Both fuse holder and fuse element where provided shall be correctly rated for the duty required. Fuses and links shall be grouped where appropriate according to their

functions and shall be clearly marked both on the panel and the associated wiring diagrams.

Spare fuses shall be provided and fitted into clips within the switchboards, three fuses to be provided for each of the ratings installed, suitably agreed for each switchboard/panel.

12.19.2 Hours run counters

Hours run counters shall be of the cyclometer type, suitable for flush mounting and non-resettable, having eight digits (minimum) plus tenths, and with a readily visible indicator to show that they are operating.

12.20 Moulded Case Circuit Breakers

Molded case circuit breakers shall be manufactured in accordance with the requirements of BS EN 60898:1991.

Unless otherwise specified circuit breakers shall be of the fixed pattern, triple pole and neutral, and four pole where used in conjunction with a standby generator unit.

Molded case circuit breakers shall employ a trip free mechanism capable of simultaneous operation of all poles and providing contact clearance and contact position indication sufficient to allow the circuit breaker to be employed as an isolator. Contact clearance shall conform to the minimum figures specified in BS 7822-1:1995, IEC 60664-1:1992. Circuit breaker closing mechanisms shall be manually operated unless otherwise specified.

Unless otherwise specified molded case circuit breakers shall be fitted with a thermal overload device to provide an inverse time characteristic and magnetic trip device adjustable for all ratings of MCCB in excess of 100A. The following, minimum, features shall be included:

- mechanical and electrical interlocking
- mechanical open, closed and tripped indication
- trip-free mechanism
- facility for padlocking without the use of loose components
- at least one unused volt free changeover auxiliary contact, wired down to outgoing terminals, for remote indication
- shunt trip coil and under voltage trip where required.

Full details of the units being offered shall be submitted with the Tender.

12.21 Miniature circuit breakers

Miniature circuit breakers shall be manufactured in accordance with the requirements of BS EN 60898:1991.

Miniature circuit breakers shall be single pole or triple pole as specified and shall be suitable for the type of load that they feed. They shall be fault rated so that back-fuse protection is not required and shall include clearly marked ratings.

Miniature circuit breakers shall be suitable for bolted or clip fastening to busbar assemblies and may be assembled together to form a distribution board.

Unless otherwise specified miniature circuit breakers shall be provided with a manual trip free mechanism and thermal and magnetic trip elements to provide inverse time overload and instantaneous overcurrent operation to the characteristic required.

For special application, as required by the IEE Regulations, miniature circuit breakers employing residual current detection and tripping operation shall be employed.

Such units shall be rated to detect and operate at an earth leakage current of 30 mA, unless specified otherwise.

RCD's shall be used in conjunction with, and not in place of, miniature circuit breakers, the MCB's providing the overload and short circuit protection requirements of the circuit.

12.22 Earth Leakage Circuit Breakers

Earth leakage circuit breakers (ELCBs) shall be of the current operated type complete with current balance transformer, test push button, trip coil and thermal overloads. They shall be double pole for single phase and four poles for three phases and neutral circuits. ELCBs shall comply with the requirements of SSRN 006.
The out of balance current shall not exceed 30 mA for circuit breakers up to 60 amp rating and 500 mA for above this rating.
Current operated ELCBs shall not be used where the product of the operating current and the earth loop impedance exceeds 40.

12.23 Power Factor Correction Equipment

(A) General

This specification covers the supply, delivery, installation, testing and commissioning of power factor correction equipment which shall be fully automatic and shall include all the cabling, control and indication.
All the equipment and workmanship shall be in strict accordance with the latest requirements of the relevant standards.
All equipment shall be installed indoors and shall be suitable for either wall or floor mounting as specified. Equipment shall be suitable for working under temperature and humidity conditions as stated.
All the equipment shall be suitable for working at the declared voltage. All the switches, contactors, fuses and breakers supplied shall have the necessary rating to ensure safe and efficient working at all times.

(B) Main Requirements

- Capacitor banks supplying the reactive load as specified; − A rack or frame in which the capacitors shall be mounted, suitable for wall or floor mounting

- Power factor correction panel/s as specified.
- All the necessary internal interconnecting wiring for the complete operation of all the equipment.
- Operating instructions and parts lists for all the equipment supplied.
- The current ratios, rating and characteristics of the current transformers needed for
- the operation of the relay/s and power factor meter. The current transformers shall comply with SSRN 002.
- Wiring diagrams of the system.
- A connection diagram of the equipment
- Drawings or clear sketches showing the dimensions of the panel/s and the rack or frame holding the capacitors.
- Clear markings in the form of plastic ferrules on all terminals.
- Commissioning and testing the equipment after installation by the Electrical Contractor.
- An alarm bell and/or light as specified to warn of any failure of the PF correction equipment.
- A set of spare fuses for each fuse bank in the equipment.

(C) Construction of PF Correction Panel(s)

- The power factor correction panel/s shall consist of a galvanised angle or channel iron chassis covered with minimum 1,6 galvanised sheet metal panels, and shall be vermin and dust-proof.
- The equipment shall be mounted on an angle iron framework within the panels to give a flush from panel.
- The front and back panels shall be removable for access to wiring and equipments, shall be held in position by chromium plated captive coin slot screws and shall be well ventilated.
- Capacitor banks and power factor correction panels shall be designed to permit extensions as specified. Equipment shall be rated to handle the extra load supplied by these extensions.

(D) Equipment in the PF Correction Panels

The following equipment shall be fitted on the power factor correction panel (s):

- An isolator switch as specified in the technical schedule
- A selector switch for selecting manual/off/automatic operation
- Multi-stage relay/s as specified in the technical schedule.
- Contactors as specified in the technical schedule.
- Pilot lights for each step.
- High rupturing capacity fuses as specified in the technical schedule.
- Busbars and interconnecting cabling.

(E) Cables to PF Correction Panel

The main cables feeding the power factor correction equipment shall be of the size as indicated on the drawings. All cables feeding capacitors shall have a current carrying capacity of 1,43 times the normal current required by those capacitors.

(F) Capacitor Banks

The capacitors which shall comply with the relevant BS Standards shall be capable of automatically healing burn-outs caused by over-voltage or ageing.

Protection against thermal overload and internal over voltage shall be provided. This protection device shall be insensitive to harmonics and incorporate a time-delay attachment to prevent unnecessary operation due to transient closing over-currents.
Each bank of capacitors shall be connected through a set of high rupturing capacity fuses. The rating of these fuses shall be 1.8 times the normal current drawn by the capacitors.
The capacitors shall not contain any Polychlorinated Bipheyls (PCB's).

(G) Relay for Capacitor Banks

The relay shall sense reactive power and shall be of the multi-stage type with the number of stages as indicated.

(H) Method of Switching Capacitor Banks

(I) Discharge Devices for Capacitors

Unless otherwise required the capacitors shall be connected to the circuit in progressive increments in approximately equal steps.
Capacitors shall be fitted with discharge devices of such a nature that the capacitors will be discharged in the time between switching operations to such a level that the rating of the protective devices will never be exceeded when the capacitors are connected to the circuit.
If discharge devices other than high ohmic resistors are used, the discharge device shall be disconnected when the capacitors are switched into the circuit.

(J) Protection Devices for Capacitor Banks

The protection equipment on the distribution board to which the power factor correction equipment is connected, shall be as follows:

- Of such a make and type that uniformity of the board is maintained.
- Have the necessary rupturing capacity to safely break the maximum fault current that could exist at that point of the circuit,
- Be of a fault current limiting type that will limit the fault current to such a level that the fault level capacity of the other protection devices on the board will not be exceeded under any fault condition,
- Have the necessary rating to carry at least 1.43 times the current required by the power factor correction equipment under normal conditions.

(K) Isolator Switch for Capacitor Banks

The isolator switch shall be of the triple pole, hand operated panel mounting air break type, unless otherwise stated, having a continuous current rating high enough to carry 1.43 times the current that might be required by the power factor correction equipment under normal conditions. It shall be suitable for operation as the specified voltage. The contacts shall be of silver alloy and the switch mechanism shall be of the quick make-break type. The switch is required to open and close a circuit carrying a current up to the full current rating of the switch and shall be fitted with arc chutes.
The switch shall be housed in a moulded plastic case suitable for back panel mounting.

(L) Contactors for Capacitor Banks

The contactors shall be of the open or totally enclosed triple pole, air break, magnetically operated type, suitable for working at the indicated voltage.
The contactors shall be fitted with silver or silver alloy contacts and shall be fully in accordance with SSRN 062.

The current ratings of the contactors shall be such that they can connect and disconnect
1.43 times the load current supplied by the capacitor banks and shall be valid for duty classification AC4 defined in IEC 158-1. Contactors shall operate without vibration.

12.24 Connections to Motors

(A) General

The Electrical Contractor shall: a) Supply angle form framework and channels as required. b) Erect starters on angle iron framework at motors, on walls, motor control centers or
floor channels as indicated on the drawings. c) Provide wiring from the main LV switchboard to all sub-distribution boards, motor control centers, switches, socket outlets, junction boxes, motor starters and actuating devices. d) Ascertain exact locations of motor starters, motor control centers and control devices prior to installing and wiring up. e) Provide all control and interlock-field wiring. f) Provide isolators, lockout pushbuttons, etc. as noted.
g) All the equipment shall be suitable for working at the rated voltage.

(B) Installation: Connection to Motors

The Electrical Contractor shall supply and install PVC insulated conductors in heavy gauge conduit or PVC, SWA & PVC, XLPE and Tough Rubber Sheath cables as specified on perforated cable trays, with claw type cleats, in ducts and trenches, or MIMS cable as specified.
Final connections to motors shall be made as follows:

a) Flexible conduit soldered or brazed into brass glands shall be used with an earth wire run through the conduit between the distribution board and the motor terminal box. Where motors are exposed to the weather or are mounted in moist environments e.g. sump pumps, the flexible conduit shall be of weatherproof quality and PVC taped overall, including the glands.

b) Mineral insulated copper sheathed, PVC or aluminum sheathed cable installations shall terminate at the entry to the terminal box with a loop of cable, to enable the motor to be removed without damage to the cable, and also to eliminate cable fractures resulting from motor vibration.

c) Where terminal box entries are restricted the conduit may be terminated with a conduit box and the final connection to the motor made by using flexible cable. In these cases, one extra core shall be provided in the flexible cable for earthing purposes.

d) All motors more than two meters from a distribution board shall be fitted with an isolating switch of the correctly rated capacity, adjacent to the motor, supplied and installed by the Electrical Contractor. When this is exposed to the weather the isolator shall be weatherproof. In the case of interlocked systems i.e. air conditioning; the isolator shall be lockable to prevent unauthorized switching.

e) Earth wires shall be run in conduit feeding motors, and control gear.

(C) Motor Disconnecting Devices

Motor disconnecting devices shall be installed at motor locations where indicated and as required by the “standard regulations”. Devices shall not be grouped at central location, except as indicated.
Disconnecting devices shall be provided either by means of a lock-out push button to interrupt the motor control circuit or by means of an isolating switch of ampere rating as noted on the drawings.
The Electrical Contractor shall allow sufficient clearance for removal of the motor(s)

(D) Earthing: Connection to Motors

All non-current carrying metal parts of the equipment shall be effectively earthed.

(E) Tests: Connection to Motors

All the power factor correction equipment shall be set correctly by the Electrical Contractor to the approval of the Engineer before any circuit is energized and tests carried out. The Electrical Contractor shall provide all the material and instruments required for testing and bear all the expenses incurred.

12.25 Local Control Stations

Local control stations or motor control centers (MCC) shall be of heavy duty construction and where appropriate, constructed in accordance with safety and general construction equipment with the Clause entitled ‘Switchboard Cubicle and Enclosure Construction’. Local control stations shall be mounted directly onto the plant to be controlled or be provided with a floor mounting tubular pedestal with provisions to accommodate the incoming cables.
Small covers shall be secured by screws or bolts and be totally removable. In larger sizes and where instruments are to be fitted, the covers shall be provided with heavy-duty hinges.
The bottom face shall be arranged to accept, with adequate space for the use of spanners, gland terminations for the number of cables required.
Terminals shall be provided for interconnections arranged vertically at the side for easy access and marked with identification numbers/letters corresponding with the associated diagrams.
Pendant type local control stations for cranes, hoists, etc. shall be of moulded neoprene or equivalent heavy, flexible, high impact strength materials. The materials shall be connected by a long moulded-in cable-strengthening sleeve, to minimize the possibility of cable fracture at the bending point. The enclosure shall be self-colored in safety yellow.

12.26 Marshalling Boxes

Marshalling boxes shall be constructed of sheet steel with ample space for routing and
terminating cables and cores.
Enclosure protection shall be the same as that for switchboards. Outdoor IP65 Indoor IP54
Every marshalling box shall be provided with the following:

- Undrilled gland plate arranged for bottom entry
- Anti-condensation heater with thermostat and fuse
- Padlocking facility and padlock
- Earthing bar with terminal holes
- Door-switch operated internal light with fuse
- Labels for front door, fuses, terminal blocks, and terminals

- Transparent plastic covers on terminal blocks operating at greater than 24 V

12.27 Power Transformers

(A) General

Power transformers 25 kVA and above shall be of the outdoor, oil immersed, naturally cooled typed, classified ONAN. They shall be manufactured and tested to SSRN 051.

Transformers shall be sized for continuous operation at the maximum rating at the ambient conditions specified. Unless otherwise specified the rating shall allow for unshaded conditions.

The transformer load factor shall be taken as 80% for normal operation.

The core construction shall be built up of on-aging, low loss and high permeability, cold rolled, grain-oriented silicon steel. Lifting eyes or lugs shall be provided for removal of the core assembly. The cores shall be earthed at one point only with a readily accessible removable connection which may be conveniently opened to check the core insulation.

The windings shall be double wound connection Dy 11.

Transformers shall be supplied complete with oil level indicator with drain cock, sample cock, oil change valves, jacking pads, pulling lugs, Buchholz relay, thermometer pocket with thermometer, and earthing terminal.

Transformers rated above 150 kVA shall be fitted with separate oil and winding temperature gauges.

Transformers rated above 250 kVA shall be provided with offload tap changers manually operated by a lockable wheel or handle. The tappings shall be provided on the HV windings at ±2½% and 5% of the no load primary voltage.

Cable boxes with wiping or screwed glands shall be provided for the cables specified. A non-magnetic gland plate shall be fitted for single core cables and insulated glands provided for 400 sq mm cables and above. It shall be possible to remove the cable boxes without breaking the cable seal or draining the oil. Disconnecting link boxes shall be fitted on the high and low voltage sides of the transformer for cable pressure testing.

(B) Insulator and Bushings

Porcelain insulators and bushings shall comply with the requirements of SSRN 053 and SSRN 072 as appropriate.

Porcelain for insulating purposes shall comply with the relevant requirements of SSRN

072. Each porcelain insulator shall bear the manufacturer's mark and batch identification, which shall be applied before firing. The clamping surfaces of all porcelain insulators shall be accurately ground and shall be free of glaze.

(C) Insulating Oil

Insulating oil shall comply with the requirements of SSRN 054. Insulating oil shall be provided by the Contractor for all oil-filled apparatus and 10% excess shall be provided for topping up purposes in sealed drums.

If equipment is to be filled with oil at Site, the Contractor shall provide oil for filtration equipment of suitable capacity.

The Contractor shall supply a schedule of insulating oils and greases which the Contractor recommends for use with his equipment.

12.28 Overload relays

Overload relays shall be of the thermal type, with inherent ambient temperature compensation and single phasing protection. They shall be of the manual reset type, having mechanical indication of the tripped conditions, resettable without opening the compartment door.

Calibration shall be adjustable between 80 and 150% of the motor's full load current.

On motor drives, of 100 kW and above, overcurrent relays shall be of the definite minimum and inverse time limit pattern.

12.29 Voltage protection relays

Regulation at certain towns has proven to be a source of plant failure and damage. Adjustable protection relays suitable for providing both under voltage and over voltage protection shall be included within the starter units. Full details shall be submitted with the Tender. The relay units shall be suitable for voltages of +10% and -15% of the nominal voltage.

12.30 Phase failure relays

Phase failure relays shall be connected to all phases and neutral and shall de-energize at or below 90% of rated voltage on any one or more phases. The relays shall be separately fused with contacts wired down to outgoing terminals.

12.31 Push buttons

Push-buttons shall be at least 25mm in diameter with chromium plated or similar Bezels. Plastic Bezels will not be acceptable.

They shall generally match indicating lamps in style, start push buttons being recessed to prevent accidental operation. Stop push buttons shall not be recessed.

Emergency stop push buttons shall be of the "stayput" mushroom-headed type. Composite motor control panels shall include a door mounted emergency stop button that will automatically shut down all pumping plant when activated.

12.32 Relay units

Relays shall be either of the plugs in or block type.

Plug-in relays shall be fitted with transparent plastic dustproof covers, retaining clips a base into which the relay plugs and external connections, made using easily accessible screw clamp terminals. Bases and relays shall be keyed to prevent relays being plugged into incorrect bases.

Block type relays shall be totally encapsulated.

Relays shall have changeover contacts and a means of visually indicating that they are energized.

The pin configuration of each relay shall be printed on the casing and on the schematic diagrams.

Time delay relays shall be of the multi-pin plug-in type and adjustment for increasing and decreasing the timing period shall be clearly marked.

12.33 Residual current devices (RCD's)

Residual current devices shall be back connected (behind the door), current operated, with a sensitivity of 30mA, door mounted so that the test push-button and operating lever are readily accessible.

Operation of RCD's shall not be impaired by any dc component in the current.

12.34 Selector switches

Selector switches shall be of the rotary type spring loaded to ensure clean controlled operation having bezels at least 50mm square with all switch positions fully and clearly identified.

They shall be equipped with sufficient contacts of the correct rating and type, if necessary by means of auxiliary relays, to enable all control/indication/alarm requirements to be fulfilled.

Operating handles shall be interchangeable and securely fixed to the switch mechanism by a keyed shaft and recessed retaining screws.

Where lockable switches are provided it shall be possible to operate them without the key, but also possible to lock them in any position and withdraw the key.

12.35 Terminals

Removable DIN rail terminals shall be provided for all wiring, mounted at an angle to provide ease of access, with center-disconnecting link type terminals for analogue signal circuits, isolation or test purposes, sufficient, suitably sized earth terminals, and end and earthing end stops.

All terminal boards and terminal blocks shall be of a type providing a positive mechanical clamp on connection. Terminals for the connection of all external cabling shall be situated near their respective gland plate and at a minimum distance of 150mm from it.

All main phase terminals shall be suitably marked to ensure that the correct phase rotation is obtained when the plant is connected to the supply.

Separate terminals shall be provided for incoming and out-going connections and not more than two wires shall be connected to any one terminal.

Barriers shall be provided on all banks to group terminals into logical divisions and between power terminals of different phases.

Control terminals shall be separated from power terminals.

Outgoing terminals shall be grouped on a common rail in the termination section. Each group shall comprise terminals common to a motor starter reference or alternatively, for control circuit wiring, grouped or barriered with regard to the voltage levels.

In all cases care shall be taken to ensure that terminals are easily accessible after all wiring has been installed and terminated. All connections shall be made on the front of terminal blocks.

No more than two conductors shall be connected to one side of a terminal. Outgoing cables shall be wired so that all panel wiring is connected to one side only.

The terminal numbers, voltage grouping, and terminal block layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All terminals shall show the circuit wire number reference.

12.35.1 Thermostats

Thermostats shall be of the tamperproof adjustable type, with a range centered on the temperature at which they will normally be set and not close to one end. They shall not be mounted close to heat-generating plant.

12.35.2 Timers

Timers shall be of the electronic, synchronous or cam type only depending upon the application. They shall have linearly calibrated scales, in units of time, each scale division being a maximum of 5% of full scale. Repeat accuracy shall be within 0.5% of full scale.

Electronic and synchronous timers shall be of the plug-in or block type, provided with "energized" and "timed out" indicators. They shall be surface mounted when within cubicles but, where front mounted to give operator access, they shall be flush mounting and provided with a lockable cover to prevent unauthorized interference.

Plug-in units with retaining clips shall plug into bases to which external connections are made using screw clamp type terminals that are easily accessible. Timers and bases shall be keyed to prevent mismatching.

The pin configuration of each timer shall be printed on the casing.

12.36 Switchboard and cubicle wiring

Ample wiring space shall be provided within the switchboards and cubicles and all wiring shall be carried out in a neat and systematic manner with cable supported clear of the panels and other surfaces at all points to obtain free circulation of air.

In all cases, the sequence of the wiring terminals is to be such that the junction between multi-core cables and the terminals is effected without crossover. Insulated bushes are to be provided where necessary to prevent the chafing of wiring.

All panel wiring is to comply with the requirements of BS 6231:1998 Type A or B, as appropriate. Conductors are to be copper and have a minimum cross section equivalent to 7/0.67mm (2.5mm2) or 1/1.78mm (2.5mm2), but single stranded conductors should only be employed for rigid connections that are not subject to movement or vibration during shipment, operation or maintenance. Flexible conductor's equivalent to 30/0.25mm (1.5mm2) or smaller sizes generally shall only be employed with the written approval of the Engineer.

No wires may be teed or jointed between points.

Electrical wiring and instruments are to be located so that leakage of oil or water cannot affect them.

Bus wiring between control panels, etc., is to be fully insulated and to be completely segregated from the main panel wiring.

All metallic cases of instruments, control switches, relays, etc., mounted on control panels or in cubicles, steel or otherwise, are to be connected by means of copper conductors of not less than 2.5mm^2 section to the nearest earth bar. These conductors may be bare or have insulation colored green or green/yellow striped.

Color coding of the separate phases, neutral and earth, shall be provided and maintained throughout the installation. Where necessary, further identification of wiring shall be provided to the extent necessary to permit any conductor to be located and traced. Also color coding of remote control and local control wiring shall be provided. Voltages of control systems shall be clearly stated.

Color coding shall be:

red	-	red phase
yellow	-	yellow phase
blue	-	blue phase

black	-	neutral
green/yellow	-	earth
grey	-	110 V AC
white	-	Control circuits

Cable for specialist applications such as co-axial shall be of an approved type.

All wiring shall have crimped terminations, only one wire being held by any one crimp. Crimped lugs shall be of the insulated type without conductor exposure between the crimps and wire insulation.

The type of crimp used shall be appropriate for the type of terminals to which it connects.

Terminations shall be neatly arranged leaving adequate length for one additional termination.

Wiring shall be neatly laid in limit compression insulated cleats, insulated straps or, where more than ten wires follow the same route, in plastic slotted-sided trunking with clip-on cover. Where trunking is used, the ratio of effective overall cross-sectional area of cables shall not be greater than 40% of the trunking cross sectional area.

Holes in steelwork, etc., through which cables pass shall be protected using nylon grommets, or edging strip suitable for the size of hole.

Cables used for control, extra low voltage and instrument signal transmission likely to be affected by interference shall be screened and/or spaced from each other and from heavy current power cables, at a distance to ensure that resultant electrical "noise" is insufficient to cause any form of malfunction of associated plant.

All wiring shall be identified at each end by means of glossy plastic ferrules showing the wire number as on the schematic diagrams. Ferrules shall be color coded, “Z” type and indelibly marked.

12.37 Electric motors

12.37.1 General

All motors shall be of a make approved by the Engineer and shall be suitable for operating from the specified power supply. Motors shall comply in all respects with the relevant parts of BS 4999, BS EN 60034, BS 5000 and BS EN 50347:2001 and shall be designed to run at high power factor and efficiency at the prescribed plant duty.

Motors shall be three-phase, squirrel-cage, induction type, continuously rated for the heaviest specified duty, totally enclosed and suitable for operation on the electricity supply and determined by the Contractor in relation to the power requirements,

ambient temperature, altitude and normal working conditions of the mechanical plant offered.

The starting (locked rotor) current of any motor shall not exceed 6 times the full load operating current. Motor starting torque shall be at least 120% of the pump torque requirements throughout the starting sequence. Motors shall be capable of running backwards at rated speeds under backflow conditions without damage to the motor.

In addition to the requirements of BS 5000, the motors shall be capable of satisfactory operation with a frequency variation of ± 1% above or below the normal frequency of 50 Hz.

The design of the motors shall be adequate in all respects for the number of starts per hour required when the pumping plant is in normal operation.

Where an insulation Class is specified the requirements of BS 4999 and BS EN 60034 shall be met. The limit of temperature rise shall be for the appropriate Class of insulation quoted. Class G insulation shall be provided, but with Class B temperature rise limitations.

Motors shall be fitted with locating type bearings and/or heavy type thrust bearings at the non-drive end and roller type bearings at the drive and according to the type of motor offered. All bearings shall be of adequate proportions and design suitable for the particular application, and shall have ample capacity to allow the pump to operate for short periods with the discharge valve closed.

Details of the bearing types being proposed, grease, oil, shall be submitted for all vertical motors together with details of the grease lubricated bearings for horizontal split case motors.

The motors shall be built of high grade components and materials in accordance with the best practice for the type of plant offered.

Motors of 5 kW and above shall be fitted with temperature sensitive thermistors embedded in the motor to control a winding over-temperature relay mounted in the control cubicle. Each motor shall have at least three thermistors. The thermistors shall be suitable for connection to a monitoring unit in the motor control circuit to provide protection against winding failing due to overheating. The motor starters shall trip in the event of high winding temperature being experienced.

The motors shall be capable of delivering 10% more than the maximum power absorbed by the plant being driven. The motors, where practicable, are to be selected to provide an element of commonality and thus flexibility in use at each site.

Only ISO standard roller and/or ball grease lubricated bearings shall be fitted.

The grease lubrication shall be applied using hydraulic type nipples that are freely accessible, without any dismantling, or otherwise piped out to a readily accessible location.

"Sealed-for-life" bearings shall not be used.

Continuously rated anti-condensation heaters shall be installed in all motors above 5 kW that are to be installed or in damp or cold environments. They shall be sized by the Contractor to suit the motor frame size.

Heaters shall be located within the motor so that the heat dissipated does not damage the insulation of any of the windings or associated cables.

Terminal boxes shall be separated from the frame and shall be reversible to allow cable entry at the top, bottom or either side, suitable for cable glands required. Terminal mountings shall be arranged such that the motor supply wiring can be disconnected without disturbing its internal connections.

The end of each winding shall be brought out to a separate terminal, connecting links being provided to facilitate interconnection of individual terminals.

A diagram of connections shall be fixed inside the terminal box cover, which shall be provided with watertight, oil resisting gaskets.

Where motor anti-condensation heaters are fitted additional terminals and a separate cable gland entry shall be provided. A warning label on the terminal box cover shall be provided stating “WARNING, LIVE HEATER TERMINALS, and ISOLATE BEFORE REMOVING COVER”.

Plates shall be fixed on each motor, giving the following information:

BS (or IEC) No _____ No. of Phases _____

Manufacturer	_____	Motor kW	_____
Serial No	_____	Voltage	_____
Insulation Class	_____	Current at FL	_____
Frequency	_____	Speed	_____

All motors rated at more than 160 kW shall be fitted with suitable vibration control devices to automatically shut down the motor in the event of excessive vibration. The Contractor shall stipulate the vibration tolerances associated with each motor rating above 160 kW and shall recommend appropriate control devices, details of which shall be submitted for approval.

For motors larger than 160 kW, kilowatt-hour meters, with maximum demand indicators shall be provided.

Vertical spindle motor units rated in excess of 5 kW shall be fitted with a thermocouple at the upper thrust bearing to shut down the motor in the event of the bearing temperature exceeding a recommended value. Details shall be provided for approval

Motors that are water cooled shall include suitable protection to safeguard against the lack of water flow.

Where required by the specified operational system, motor circuits shall include suitably rated rotary off, manual or automatic switches.

The Contractor shall submit details of the painting standards and color range being proposed. The Employer will finally decide on the color, this being in accordance with the manufacturer's standard color charts.

All motors shall be provided with two earthing terminals.

The motors shall be commercially silent in operation and shall run free from vibration. They shall be of robust design with frames and covers constructed in cast iron. Fan covers and cowls shall be of a strong and durable material (plastic, PVC or GRP will not be acceptable). The rotors shall be fully keyed to the shafts and shall be balanced both statically and dynamically.

Motors shall be labeled to correspond to their respective starters. These shall be at least 40mm x 75mm x 2mm in stainless steel on non-ferrous metal. Details shall be agreed.

Air vents and other openings where provided will be screen protected.

12.37.2 Submersible motors

Submersible motors shall be capable of continuous operation under water at the conditions specified. Heater requirements do not apply to these units.

The motor shall be installed vertically and rigidly coupled to the submersible pump such that both the pump and motor are completely flooded. The windings of the motor shall be insulated with an approved waterproof plastic or other approved material as recommended by the manufacturer. The motor shall be squirrel cage rotor motor with the rotor suitably supported in lubricated plain bearings.

The cable from the motor shall be sealed at its exit by a water tight cable gland. Sufficient cable shall be provided to meet the installation requirements.

12.37.3 Surface mounted motors

Surface mounted motors shall be weatherproofed, fully trivialized, and suitable in all respects for external operational duties in the prevailing climatic conditions. The connections of the motors shall be brought out to terminals at the side of the frame and properly clamped and terminated within a cable box complete with correct glands to accept the size and type of cable specified. In general, the glands shall be downward pointing at an angle to pass the cables clear of the base frame and plinth.

12.37.4 Cables for submersible motors

Cables for submersible motors shall be a 600/1000 V grade multicore cable and consist of conductors of high conductivity tinned copper wire, EPR insulated and with super tough rubber sheath. The cable shall be suitable for suspension within a borehole approximately 60 meters deep and shall include all necessary internal supports (i.e. steel core or similar) to prevent undue strain being imposed on the cable conductors. Two clips shall be supplied for each length of riser.

Details of the cable proposed shall be provided with the tender.

12.37.5 Emergency stop/lock-off push buttons

Emergency stop/lock-off push buttons shall be provided adjacent to the pumping units specified. Each shall be of the surface mounted weatherproof push to break and mushroom type with latching device to resist the push button return movement so that contacts remain normally open until the latch is released by a counter clockwise direction.

The buttons shall be robust and watertight suitable for the environment at the various locations, with IP enclosure. Certain stop buttons will be wall-mounted, others will be mounted on frames 1,000mm above the floor level, as stated in the Particular Specifications. The frames, boxes, terminations, screws and fixings shall be supplied.

12.38 Safety devices and controls

The control requirements for the pumping plant have generally been specified elsewhere. The Contractor shall include for all requirements to meet both the manual and automatic control of the plant and pumpsets. In addition to the safety devices already specified, the Contractor shall provide for other protection devices that are necessary to protect against any operating conditions which would be liable to cause damage to the plant, for example, lack of water at the pump suction.

12.39 Variable-speed drives

12.39.1 General

The variable-speed drives shall be purposely designed and manufactured for pumping applications. The variable-speed drives shall be suitable for all loads with variable torque characteristics.

The variable-speed drives shall be capable of starting and running high inertia loads such as centrifugal pumps.

The variable-speed drive supplier shall carry a comprehensive range of spares, which shall continue to be available for at least 5 years after the production of the particular variable-speed drive model has been discontinued.

The variable-speed drives shall be compatible for use with the various asynchronous squirrel cage induction motors typically used to power pumping plant.

The variable-speed drives shall be of sufficient capacity and shall produce a quality low distortion output waveform so as to achieve full rated nameplate shaft power output of the motor. The variable-speed drives shall be capable of operating any standard squirrel cage induction motor of the specified variable-speed drive's power rating without any modifications to the motor or the variable-speed drive.

12.39.2 Design

The variable-speed drives shall be fully digitally controlled.

The variable-speed drives shall consist of the following major components:

- full-wave bridge 6 pulse rectifier;
- DC link capacitors;
- Inverter stage with Insulated Gate Bipolar Transistor (IGBT) or Integrated Gate Commutated Thyristor (IGCT) power modules across the entire range (GTO or BJT devices shall not be acceptable);
- Control and display panel.

The variable-speed drives shall have high efficiency and have low maintenance requirements. The variable-speed drives shall provide an adjustable output frequency and voltage utilizing the principles of Pulse Width Modulation (PWM) or Direct Torque Control designs. These techniques shall provide full nameplate motor voltage as well as distortion free sinusoidal currents at the terminals of the motor to obtain full motor rated torque at rated frequency. The operating characteristics shall not exceed those recommended by the motor manufacturer.

The mechanical design of variable-speed drives shall adhere to the following guidelines;

- the internal layout of the variable-speed drives shall maintain separation between the control signals and the power conductors in order to minimize EMC noise related problems;
- the variable-speed drives shall be assembled in such a way as to facilitate easy maintenance;
- the location of the nameplate or label of the variable-speed drives shall be easily accessible and contain all the necessary information in order to determine the variable-speed drives rating and to also assist with identification;
- all incoming and outgoing cables shall enter and exit from the top and/or the bottom of the variable-speed drives;

- gland plates shall be provided as standard for the correct fitting of cables with cable glands to ensure safety and reliable operation;
- The variable-speed drives shall be of compact design and have the ability to be mounted side-by-side without separation for greater space saving.

  The variable-speed drives enclosure shall be protected to IP20.

12.39.3 Standards

The variable-speed drives shall be designed and constructed in accordance with the requirements of the IEEE standards.

The variable-speed drives shall be UL and CUL listed for power conversion equipment for use in pollution degree 2 environments and labeled accordingly.

The variable-speed drives units shall be certified for compliance with the following standards:

BS EN 60146-1-:1993, IEC 60146-1-1:1991	Semiconductor converters. General requirements and line commutated converters. Specifications of basic requirements.
BS EN 60204-1:1998, IEC 60204-1:1997	Safety of machinery. Electrical equipment of machines. General requirements
BS EN 60204-11:2001, IEC 60204-11:2000	Safety of machinery. Electrical equipment of machines. Requirements for HV equipment for voltages above 1000 Vac. or 1500 V d.c. and not exceeding 36 kV

The variable-speed drives, when installed in accordance with the recommendations and guidelines of the variable-speed drives manufacturer, shall comply with the requirements of the EMC Directive as defined by the EMC product standard for power drive systems BS EN 61800-3:1997 “Adjustable speed electrical power drive systems. EMC product standard including specific test methods.”

The variable-speed drives shall be factory tested upon asynchronous induction motors using a variety of user parameters. The factory tests shall simulate operation within actual variable-speed drive installations. The variable-speed drive supplier shall provide copies of the Certificates of Type Test.

The variable-speed drives shall meet or exceed the following standards:

BS EN 61800-2:1998, IEC 61800-2:1998	Adjustable speed electrical power drive systems. General requirements. Rating specifications for low voltage adjustable frequency a.c. power drive.
BS EN 61800-4:2003	Adjustable speed electrical power drive systems. General requirements. Rating specifications for a.c. power drive systems above 1 000 V a.c. and not exceeding 35 kV.

BS EN 61800-5-1:2003 BS EN 61800-5-1:2003 Adjustable speed electrical power drive systems. Safety requirements. Electrical, thermal and energy.

12.39.4 Protection functions and features

The variable-speed drives shall include the following protective features in order to ensure the security and safe operation of the plant:

- ability to disable panel buttons whilst in remote control mode
- parameter protection with 2 levels of setting
- automatic restart after a fault, etc.
- expansion to serial communication network using RS485 and simple protocol (USS).
- closed loop internal PID control for regulation.
- ability to have selection between MANUAL and AUTO through use of selector via variable-speed drives digital input terminals.
- ability to provide optional AC line reactors for power factor improvement, harmonic control, prevention of zero voltage notching or surge protection from low impedance supplies.

12.39.5 Control signals

The variable-speed drives shall have two analogue inputs (0-10V or 0/4-20mA) and six fully programmable digital inputs.

The variable-speed drives shall accept any of the following speed setting input signals:

- 0-10V DC;
- 0-20 mA or 4-20 mA;
- Motorized potentiometer using up/down digital inputs;
- Fixed frequencies using digital inputs;
- RS485;
- Keypad display for local hand operation.

The variable-speed drives shall have at least one analogue output signal (0/4-20mA) which can be programmed to:

- output frequency;
- output current (load);
- DC-link voltage;
- motor torque;
- motor speed;
- set point frequency.

The variable-speed drives shall incorporate two volt-free outputs (240VAC, 1A) for remote indication of following:

- motor running;
- set point speed reached;
- fault indication (over-temperature, over-current, etc.);
- PID high and/or low speed limits reached.

The variable-speed drives shall have an RS485 interface as standard allowing the variable-speed drives to be used in conjunction with an external system within a multi-drop LAN configuration. The interface shall allow all the various parameter settings of the variable-speed drives to be programmed via BMS control. In addition, the variable-speed drives shall have the capability to retain these setting within the non-volatile EEPROM memory.

The variable-speed drives shall incorporate a clear and easy to operate user-interface panel. The preferred design is to have a 4 digit green LED display with a membrane keypad.

The information to be displayed in the variable-speed drives display mode shall be:

- output frequency;
- speed of motor;
- status of motor (running, stop, fault, etc);
- motor current
- motor torque
- fault status
- PID feedback signal
- DC-link voltage
- set point frequency
- motor output voltage
- serial link status

12.39.6 Harmonics on mains supply system

The variable-speed drives and their installation shall comply with the following reference standards:
IEEE 519 -"Guide for Harmonic Control and Reactive Compensation of Static Power Converters."
Engineering Recommendation G5/3 of the Electrical Council (UK).

12.39.7 Electromagnetic compatibility

When installed according to the recommendations of the manufacturer the variable-speed drives product range shall fulfill all requirements of the EMC Directive as defined by the EMC Product Standard for Power Drive Systems EN61800-3.

The variable-speed drives shall have a level of performance to allow the assembler to self- certify their apparatus for compliance with the EMC directive for the industrial

environment as regards the EMC performance characteristics of the power drive system. Performance limits are as specified in the Generic Industrial Emission and Immunity standards BS EN 61000-6-2:1999, IEC 61000-6-2:1999 and BS EN 61000-6-4:2001.

12.39.8 Output chokes

The variable-speed drives should be capable of operating normally (without the need for an output choke or reactor) when connected to the motor with a screened / unscreened motor cable length of up to 50m.

12.39.9 General services

- **Labels and notices**

Labels shall be provided to describe the duty of or otherwise identify all items of plant, mounted internally and externally, with clear, concise and unambiguous wording. Each label shall be permanently secured to the panel surface adjacent to the item to which it refers but not to trunking covers or other readily removable items, using plated screws.

All component labels shall have circuit designations that can be easily correlated with the drawings. Labels shall be provided on or adjacent to fuse carrier bases, where provided, to indicate the rating of the fuse to be employed. Labels shall be manufactured from laminated plastic or similar white/red/white for danger and warning labels, otherwise white/black/white. Edges shall be beveled and lettering at least 5mm high. In addition to component labels, each cubicle door shall bear a large identification label (minimum lettering size 8mm), whilst each panel shall bear a large overall identification label (minimum lettering size 12mm). In addition to individual terminal numbers each group of terminals shall be provided with a "Function Description" label.

Warning notices, in red lettering on white background, shall be provided on all automatic start-up plant.

Component "stick on" block diagram identification labels shall be fixed to the inside of each cubicle and starter panel. The diagrams shall match the component layouts so that easy identification of all components is possible.

Warning labels shall also be fitted to the capacitor and motor terminal boxes, inscribed as follows: "WARNING - EQUIPMENT CONNECTED TO STORED ELECTRICAL CHARGE. ISOLATE AND EARTH ALL TERMINALS BEFORE HANDLING".

- **Shrouding**

Shrouding shall be provided such that it is not possible to touch a live conductor, with or without a tool, unless a positive step has been taken (using a tool) to remove a cover, shroud, etc. All such covers and shrouds shall bear adequate labels identifying the potential danger.

- **Control circuits**

All circuits shall be designed as far as possible to fail to safety. Generally, control relays shall de-energize for the safe condition.

Safety interlocks, designed to prevent injury to personnel or damage to plant, shall be direct in operation.

Circuits shall be as simple as possible subject to necessary operational and safety constraints, involving a minimum number of components.

Where automatic control of several items of plant is provided by a PLC, then a simple back-up automatic control system, independent of the PLC, shall be provided to give rudimentary unmanned control in the event of PLC failure. Such a system needs not to be efficient or even provide 100% plant availability, but it shall come into operation automatically in the event of normal control system failure.

- **Steel conduit and fittings**

Steel conduits and fittings shall comply with BS 4568-1:1970 or BS EN 50086-1:1994. Distance type saddles shall be used for all surface exposed steel conduits.

Conduits shall be installed in such a manner that all cables can be drawn in after erection by means of a draw-in tape. Conduit joints shall be painted with approve metallic paint. Elbows and tees shall be avoided where practicable, and normal bends or sets used. Exposed outlet boxes shall be cast metal types, and flush boxes shall be cast or sheet metal. No knock-outs shall be removed unless used. Where conduits enter sheet metal boxes they shall be locked-nutted back and front. Burrs and obstructions shall be removed before installation of boxes and conduits.

No conduit shall be smaller than 20mm in diameter.

Boxes shall generally be galvanized steel, small, circular 60mm types with steel covers.

Adaptable boxes shall be galvanized steel with overlapping lids but without "knockouts".

Box covers shall be fixed by brass round or cheese head screws.

- **Plastic conduit and fittings**

Plastic conduit, where approved for use by the Engineer, shall comply with BS EN 50086-1:1994 and BS EN 50086-2-1:1996 and be heavy gauge, high impact. Fittings, fixings and accessories shall be of the same manufacture and color as the conduit.

All accessories shall be fitted with earthing terminals.

- **Trunking**

Trunking shall be heavy duty, galvanized, to BS 6946:1988 or BS EN 50085-1:1999.

- **Cable tray and accessories**

Cable trays shall be to BS EN 50085-1:1999 or BS EN 61537:2002, IEC 61537:2001.

Galvanized cable tray shall be perforated, heavy duty return flange type, hot dipped galvanized after manufacture.

Plastic coated cable tray shall be diamond pattern, heavy duty, black PVC covered.

Rigid PVC cable tray where approved for use by the Engineer, shall be manufactured from rigid unplasticised PVC having a thickness of not less than 3mm. It shall be perforated and have provision for a cover. The material of manufacture shall be self-extinguishing or non-flammable and suitable for use in ambient temperature of -20 oC to +80oC.

Fixings shall be carried out using manufacturer's recommended brackets and supports.

- **Low water level sensors**

Low water level electrode sensor units shall be provided within all boreholes and within certain storage tanks and water inlet chambers. The sensors shall be supplied complete with all required cabling, fixings and terminations. The units required for installation within the boreholes shall be complete with two clips for each length of riser.

- **Sump pump controls**

Submersible drainage pump units shall be supplied complete with suitable float operated on-off controls. The pump units shall be supplied with control panels/starter units as specified, cables, supports, and fixings as required.

- **Co-ordination**

The Contractor shall be fully responsible for the necessary liaison and co-ordination of all works on site.

Cable runs shall be to suit pipe work, drainage, cables, foundations and the like. The Contractor shall produce drawings for approval indicating the proposed routes of his cable. These shall in general follow an agreed service reserve.

- **Locks**

Sufficient padlocks with individual keys of a type approved by the Engineer shall be provided for locking the following items:

lockable, lock-off, isolating fuse switches and feeder pillars and the like, and inter-locks, lock-off, ACB's (and/or Castelle interlocks)

Each shall be provided with four keys and be individually identified.

- **Continuity**

All conduits, trunking, duct, cable tray, etc, shall be mechanically and electrically continuous thought. Where steel conduits cross expansion joints, flexible steel conduit sections, PVC served, shall be inserted, or other approved means used to provide the necessary continuity and flexibility.

- **Radiated interference**

The Contractor shall ensure that radiated interference from all items of Plant is suppressed to the limits specified in BS EN 55014.

12.40 Earthing

12.40.1 General

The system of earthing on the LV reticulation will generally be TN-S as defined in the IEE Wiring Regulations (16th Edition). Earthing systems shall comply with BS 7430:1998 and the current edition of the IEE Wiring Regulations. Separate earth protective conductors shall be employed throughout on mains, sub-mains and all final circuits.

As a minimum the metalwork of all items of electrical plant, electrical system neutral points, power and control cable armoring and screens, and extraneous metalwork including structural steelwork and pipe work, shall be connected to the earthing installation.

Earthing continuity in non-electrical plant shall normally be achieved via metal to metal faces, metal hinges, and metal fixings. Earth straps shall only be supplied where earth resistance is high or there is risk of corrosion or similar which could in the future increase resistance and affect earth continuity.

All structural steelwork within the site shall be bonded to the earthing system.

All pumping plant shall include an earth continuity conductor or tape which shall extend from the pump/motor frame/bed plate to the main station/switchboard earthing system.

The final arrangement of the earth electrode system shall be to the requirements of the supply authority and to the satisfaction of the Engineer.

The earth resistivity at the sites may vary and the Contractor shall include for taking earth resistance readings both before and at least once during construction, and one final reading, at every earth point to ensure the Specifications values are obtained.

Each system shall be varied according to the immediate location. Each local earth system shall be installed progressively until the value of earth resistance is obtained to the satisfaction of the Engineer.

At the various sites an earth busbar system shall be supplied, connected to earth electrodes, to which the following shall be connected:

- star points of all transformers on the medium voltage side.
- sheathing of cables.
- metalwork at the sites, other than carrying cables.
- earth wires from plant, external to main pump stations, that is fed only from that pump station.
- main incoming water pipes.
- the building metallic structure.
- the lightning protection system where provided.

The earthing continuity of each metal sheathed cable shall be maintained by efficient bonding between the cable sheath, the gland, and the metal case of the switchgear or other metal clad accessory or appliance at which the cable terminates. In addition, ICEW's or BCEW's shall be run with all cables.

Three-core cables may be used to single phase items of plant, the third conductor being used as the insulated copper earthwire.

The size of all earth wires bonding plant to a main earthing system shall be such that a current of three times the fuse rating of the circuit or one and one half times the overload setting of the circuit breaker can flow without adverse effects.

All joints between wires and other earthing metalwork shall be mechanically sound and soldered.

The earth leads shall be insulated until the connection is made to the electrode system. A bolted test link shall be installed to facilitate regular testing of the earth electrode system resistance.

The insulation of the earth lead shall be insect and rodent resistant.

All materials used in any earthing installation shall be adequately protected against corrosion and earth leads shall be protected against any mechanical damage.

12.40.2 HV Earthing systems

Where pole mounted high voltage load/air-break isolators and fused-cuts are installed, the operating handle of the isolator shall be separately and effectively

bonded to a potential earth mat suitably placed for the Operator to stand upon. In addition, a standard earth electrode system shall be installed at the bottom of the relevant pole. The earth tape of all the high voltage hardware steelwork and to the transformer tank shall be connected to a separate earth electrode system outside the influence of other earth mats.

Copper earth conductors, for the overhead line structures, shall be 70mm2 in cross sectional area. They shall be protected from pilfering by a length of 50mm2 diameter galvanized water pipe sunk into the ground and terminating 2,500mm up the supporting structure and securely clamped to the supporting structure. The ends shall be sealed by suitable means after installation of the cables.

Where outdoor plinth mounted transformers are installed, all boundary fencing fabricated of current carrying materials shall be effectively connected to the low voltage earthing system along the peripheral length. The fence shall be bonded to the electrodes and shall be provided with protective bonding across all gates, these bondings being flexible and protected.

12.40.3 Installation

The earthing installation shall comprise an earth terminal, earth busbars, circuit, earthing conductors, equipotential bonding conductors, and main earthing conductor and earth electrodes. The circuit earthing and equipotential bonding conductors shall be of the radial, grid or ring form as dictated by the plant layout.

The earthing installation shall be protected from mechanical damage and corrosion.

Joints in tape conductors shall be riveted and soldered, brazed, clamped, bolted or exothermically welded. Non-corrosive flux shall be used for soldered joints. Clamped and bolted type joints shall be tinned and shall only be used above ground.

The interconnection of conductors below ground shall be by means of exothermic welding or brazing. Compression type lugs shall be provided for the termination of cables.

Earthing conductors shall be buried directly in the ground or secured to building structures, cable racks and trays using proprietary fixings.

Where the soil is aggressive to copper, buried earthing conductors shall be protected by an approved sleeving.

An equipotential bond shall be provided to all buried metal pipe work at the point of entry into a building or chamber where electrical apparatus is installed. Electrical continuity across all pipe joints within the structure shall be ensured. Where pipe work incorporates a compression coupling (e.g. Viking-Johnson coupling), a bond shall be provided to any isolated section.

Cable armoring and screens shall be bonded to earth at both ends unless otherwise specified. Cable amour shall not be used as the sole earth protective conductor.

12.40.4 Conductors

Circuit and main earthing and equipotential bonding conductors shall be high conductivity copper tape or 1000 V grade PVC insulated multi-stranded cable. PVC cable insulation shall be striped green/yellow. Cable lengths shall be continuous and intermediate jointing is not permitted.

The main bonding conductor shall be not less than 16mm2 and supplementary bonding of non-electrical plant not less than 10mm2. All connections shall be made using compression type cable lugs, taped on completion to completely seal the lug and any bare copper from the atmosphere. The surface to which earthing bonds are fixed shall be cleaned free from paint and other non-conducting material and coated with petroleum jelly.

The Contractor shall provide the following supplementary bonding conductors which shall be made in 2.5mm^2 cable if mechanically protected, or 4mm^2 if not mechanically protected:

- all sink and shower units to pipe work
- all small power outlets and sink units within a 2.5 m radius of each other
- all metallic tanks

12.40.5 Earth electrodes

Earth electrodes where used shall be copper or copper clad high tensile steel rods having minimum copper thickness of 0.25mm and outer diameter not less than 16mm. The rod shall penetrate a minimum of 2,400mm below ground level. Where multi-rods are used a distance of not less than the driven length shall separate them.

Earth rods shall have hardened tips and caps and be extendable. Bare copper tape buried at a minimum depth of 600mm shall be used for interconnection of rods.

Where soil conditions make the use of rods type electrodes impracticable a grid configuration may be used comprising horizontally buried bare high conductivity copper tape of dimensions 15mm x 4mm minimum. Tape shall be buried at a minimum depth of 600mm.

All earth electrodes shall be buried in a mixture of well ground charcoal and common salt in a ratio of 2:1.

Earth rods shall be provided with a non-ferrous clamp for the connection of the earthing conductor. Each connection between conductor and earth electrode shall be suitably protected against corroding elements in the soil with bituminous tape.

The connection shall be made in a concrete inspection chamber set flush with the finished ground level. The inspection chamber shall be permanently marked “ELECTRICAL EARTH”.

Marker posts and plates shall be provided to mark the position of the electrodes and buried connections. The markers shall be similar to those provided for cable routes.

12.40.6 Main earthing terminal

Where specified, a main earth terminal shall be installed in a convenient location. This shall comprise a high conductivity copper bar of sectional area at least that of the main earthing conductor. The terminal shall be supported on porcelain barrel type insulators and wall-mounted.

The terminal shall be of sufficient length to accommodate, with 25% spare capacity, bolted copper tape connections to:

- the earthing conductor(s) between the earth terminal and earth electrodes
- circuit protective conductors between the earthing terminal and exposed conductive parts
- the main equipotential bonding conductors between exposed and extraneous conductive parts
- the system neutral earthing conductor (where specified)

Facilities (i) and (iv) shall be removable with a tool to permit measurement and testing.

Earth studs shall have a minimum size of M8.

12.40.7 Earthing of buildings

Earthing of all electrical apparatus, circuits and outlets shall be carried out in accordance with the requirements of the local supply authority and the relevant wiring regulations. All metal conduit and metal sheaths of cables shall be bonded to the metal work of their termination gear.

Each building shall have an associated terminal to which all metal bodies requiring to be earthed shall be connected. The earth terminal shall be connected by an earthing lead to an effective earth electrode situated as near as practicably possible to the building earth terminal.

The earth lead shall not be smaller than 25mm2 insulated stranded copper conductors.

The resistance from the earthed end of the earthing lead to any earth continuity conductor in a building installation shall not exceed 0.2 ς.

The measured resistance of the earth electrode shall not exceed 1 ς

All metal external water pipes, drainpipes, down pipes, conduit and guttering shall be securely earthed, contact surfaces being thoroughly cleaned and connections made by soldering on by means of copper clamping bands with non-corroding bolts in accordance with the relevant standards. Wire used shall be stranded copper of not less than 4mm^2.

12.40.8 Tests on site

On completion of the earthing installation the Contractor shall measure the resistance of each electrode installation and of each complete earthing system to the general body of the ground. All other tests stipulated in the Reference Standards shall also be carried out.

The Contractor shall carry out tests to verify that exposed metalwork within the buildings is effectively bonded and install supplementary bonding connections as necessary to ensure proper continuity. In particular supplementary bonding shall be provided to individual suspended systems throughout the buildings.

The resistance to earth of each complete network shall not exceed 5 ς.

12.40.9 Lightning protection

Where buildings, structures or sections of the plant are to be protected against lightning or static charges, an earthing system shall be provided. The installation shall be carried out in accordance with BS 6651:1999.

The down run conductor shall be of hard drawn high conductivity copper of 25mm x 3mm section. The tape shall be fixed to the outside of the structure by means of stand off saddles. Where indicated, connections shall be made to the concrete reinforcing. The route of the tapes and the fixings shall be discussed with the Engineer before installation.

Where the conductors specified shall be PVC insulated to prevent corrosion and to blend with the building fabric.

A test link shall be installed in each down conductor adjacent to the earth rod at a height of 1,200mm above ground level. The overall resistance of the earth termination system to earth shall not exceed 10 ς. If this requirement is not met the number of earth electrodes shall be increased or they shall be interconnected until a value of 10 ς is attained.

Earth rods shall be not less than 16mm diameter copper or copper-clad steel, provided with hardened tips and driving caps. Each rod shall be provided with a

non-ferrous clamp for connections of the copper strip. Each connection shall be housed in an inspection chamber set at ground level.

Where feasible, the lightning protection grounding system may be inter-connected with the system earth to ensure equipotential under all conditions.

12.41 Small Power and Lighting Distribution System

12.41.1 General

The complete internal and external lighting and small power requirements shall be provided for all buildings, pumping stations, booster stations and sites.

Each installation shall include the distribution board, wiring, lighting fittings, socket outlets, earthing and lightning protection and external floodlighting as required together with all conduits, trays and accessories as necessary to complete the whole of the installations.

In general, fluorescent fittings shall be used for internal lighting with weatherproof fittings for exterior fittings mounted on building structures above and adjacent to the door openings.

External wall mounted luminaries shall be installed using a back entry conduit system terminating behind the respective fitting with an end box mounted on the building fabric. Appropriate neoprene seals shall be used to prevent ingress of moisture. The final connections of each fitting shall be sleeved with silicon glass over sleeving.

The final circuit arrangements and phasing shall be agreed for all sites and buildings to suit the requirements of the IEE Regulations and the Contractor's working drawings.

12.41.2 Wiring

The installation shall in general be surface within pump houses, etc. but concealed in offices, dwellings and similar structures. The circuit wiring being continuous on a loop-in, loop-out system. The final connections to the fittings shall be by lid and cord grip, the circuit wiring terminating within the conduit box at a suitably rated terminal block. The final connection from the block (via the cord grip) to the fitting shall be carried out in heat resisting three-core PVC/PVC (or similar) cable, white in color.

12.41.3 Internal lighting

Luminaries shall be complete with all supports, suspensions, flexible cables, pendants and plugs. They shall be connected to the main circuit wiring with heat resisting flexible cables of a minimum core size of 24/0.20mm.

Protective classification shall be IP42.

The earthing of all luminaries shall be by a separate core in the connecting flex cable or cable system, securely bonding the earth terminal on the fitting to that of the interconnecting cables.

Where adjacent luminaries are connected to different phases of the supply, a label shall be fitted internally warning of the presence of the phase to phase voltage.

Luminaries shall not transmit load to suspended ceilings unless the ceiling and lighting is of integrated design with the appropriate supports.

Lamp holders for flexible pendants shall be of the all-insulated skirted pattern with cord grips.

The fixings, connection boxes and other parts of the luminaries shall be erected at times to suit the building program. The glassware, diffusers, shades, lamps and tubes shall not be fitted until all building works are complete. Fittings shall be left clean inside and outside and ready for use.

12.41.4 Incandescent fittings

Incandescent fittings shall be supplied complete with their lamps. Lamp holders in totally enclosed fittings shall be of a heat resistant type and shall be connected with heat resistant cable. Generally, Bayonet Cap lamp holders and lamps shall be used.

12.41.5 Fluorescent fittings

Fluorescent fittings shall be supplied complete with their lamps. They shall be complete with tubes, auxiliaries and all other items required for their complete installation. The fittings shall have a completely enclosed wiring channel for accommodating wiring and auxiliaries, and supporting the lamp holders, reflector and diffuser as applicable.

In general fluorescent fittings complete with reflectors shall be used for lighting within the buildings and weatherproof fluorescent fittings with IP65 enclosure shall be used for exterior fittings mounted on building structures above or adjacent to the door openings.

Diffusers where specified shall be of flame retardant extruded acrylic or GRP material. They shall be either opal or prismatic pattern as specified.

A gasket shall be fitted between the diffuser and the body to form an effective seal.

The luminaries shall comply with BS 4533 and EN 60598 for Class 1 ordinary, indoor normal atmospheres and Class 11 A for chemically corrosive atmospheres, where appropriate.

Fluorescent luminaries shall have two suspension or fixing points and shall be complete with lamps.

Fluorescent lamps shall comply with BS 1853-2:1995, BS EN 60081:1998, IEC 60081:1997, , BS EN 60901:1996, BS EN 61195:2000, IEC 61195:1999 and/or BS EN 61199:2000, IEC 61199:1999 as appropriate.

Unless otherwise specified, lamps shall be colored “white” for industrial use and “warm white” for commercial and domestic lighting. Lamp caps shall be of the bi-pin type.

12.41.6 Lighting switches

All lighting switches shall generally be metal clad surface mounted in pump houses and similar areas and flush in domestic and office buildings. They shall be fitted into approved surface or flush conduit boxes. Lighting switches shall be minimum 6 A rating of the type specially designed for ac circuits. Exterior switches shall be of IP65 enclosure pattern. All switch boxes shall be provided with earthing terminals. Mounting height shall generally be centered at 1.375 m above finished floor level subject to site and building details. Metal clad switches shall be to BS EN 60669-1:2000, BS 3676-1:2000.

Internal lighting switches shall have white molded plates and shall comply with BS EN 60669-1:2000, BS 3676-1:2000. They shall be supplied complete with box, cover plate and fixing screws. External lighting switches shall be of the metal clad, galvanized and weatherproof pattern with rotary action. They shall be surface mounted. Alternatively, the sealed splash proof pattern with enclosures to IP54.

At multi-switch positions, the switches shall be contained in multi-gang boxes. Where operation of a lamp or group of lamps is required from two separate locations, two-way switches shall be fitted with intermediate switching where shown.

12.41.7 Socket outlets and spur outlets

The socket outlets in pump houses and similar shall be generally metal clad. The socket outlets shall be surface mounted, fitted into approved surface conduit boxes. All boxes shall be supplied with adjustable steel grids and earthing terminals. They shall be three pin shuttered and switched where specified. Earthing pins and shutters shall be provided throughout.

Domestic pattern socket outlets shall be flush mounted, three pin (with earth) and shuttered complying with BS 1363-2:1995. Industrial pattern socket outlets shall comply with BS EN 60309-1:1999, IEC 60309-1:1999. Spur outlets shall comply with BS 5733:1995 and shall include a switch and neon light.

Plugs tops shall be provided with all outlets complete with fuses and 100% spare fuses.

Industrial sockets shall be to IP44 protection for surface mounted switch socket outlets used internally and IP67 where used externally. A corresponding plug top shall be issued with each socket.

The light switches and socket outlets shall be of the same range and pattern where located in one room, structure or building.

The mounting height to the bottom line of the outlet shall be:

- 250mm above the worktop surface
- 450mm above the finished floor level in office areas
- 1,200mm above the finished floor level in workshop and storage areas (excepting over workbenches)
- 1,200mm above the finished floor level in pump stations

The above requirements are intended as a general guide. Final details shall be agreed with the Engineer on site to suit the particular facility, plant layout etc.

12.41.8 Three phase power outlets

Three phase power outlets shall be shall be surface mounted, switched, and complete with plug top.

12.42 Distribution Boards and Consumer Units

The distribution boards shall be a molded case and miniature circuit breaker type and shall be of the totally enclosed metal clad, cubicle type of surface pattern as indicated. They shall be complete with hinged lid and so constructed that the circuit breaker toggles are concealed when the lid is closed. The distribution board shall be controlled by an isolating switch integral with the board.

Distribution boards shall be equipped with RCD's, HRC fuses or miniature circuit breakers, arranged for triple pole and neutral or single pole and neutral outgoing circuits from a three or single phase and neutral incoming supply.

The circuit breakers shall be provided with thermal overloaded and magnetic short circuit tripping and a quick trip-free mechanism. The Contractor shall ensure that the necessary discrimination between each main panel and final sub-circuit is provided. Circuit breaker distribution boards used throughout the installation shall be of the same pattern, range and manufacture. All MCB’s shall have a short circuit capacity not less than 5 kA.

Doors shall be lockable, hinged and casketed to give a damp and dustproof enclosure. The degree of protection shall be IP43 (indoors) and IP55 (outdoors).

The boards shall conform to BS EN 60439 and shall be provided with conduit and cable gland entry plates.

The busbars shall be mounted on non-hygroscopic insulators, completely shrouded or PVC insulated, colored to denote the appropriate phase. The current rating of the busbars shall not be less than the current rating of the incoming circuit. A neutral bar shall be provided with a separate terminal for each circuit.

Fuse carriers used in distributions boards shall be of the fully shrouded pattern and shall employ HRC fuses only. They shall be mounted on the back plates using spacers so that outgoing wiring can pass behind the carriers.

Distribution boards employing miniature circuit breakers shall be capable of accepting breakers of mixed ratings of standard or residual current detection type.

Distribution boards shall be provided with an earth bar to allow connection of circuit protective conductors. The number of connections shall be equal to the number of single ways. A main earth terminal shall be provided to allow bonding of the enclosure in accordance with the requirements of the IEE Regulations. All earth, neutral and phase connections within distribution boards shall be numbered correspondingly by tagging the wires.

Such an earth terminal shall also be provided on the local isolator enclosure where this forms a separate unit to the distribution board.

A fully detailed and comprehensive circuit list approved by the Engineer shall be fixed inside each distribution board, enclosed in a transparent incombustible envelope.

Consumer units shall be of the flush or surface mounted metal enclosure type complete with all MCB's and isolating switches, basically as specified for the distribution boards. Details shall be submitted for approval.
The Contractor shall supply and install all fused connection units feeding electrical appliances mounted adjacent to the electrical appliance. For floor mounted appliances the mounting height to the bottom line of the outlet shall be 450mm above finished floor level.

Fused connection units shall be installed such that, where applicable, the connecting flexible cable is no longer than 300mm.

Fused connection units shall be mounted in enclosures with white molded cover plates in offices etc and metal clad type in plant rooms, pump stations or similar locations. Isolators shall be mounted in enclosures with white plastic or metal cover plates.

12.43 Emergency battery lighting unit

Portable emergency lighting units shall be supplied and installed. Emergency self-constrained light fittings shall be positioned as indicated to provide lighting in the

event of a power failure. The lighting units shall have between one to three hours autonomy.

The units shall be double spot light or multi-spot type complete with mounting bracket and charging facilities operated from a 220 V ac supply. The battery light shall be arranged to switch on in event of failure of the ac supply to the fittings and shall operate for minimum of three hours from the battery without re-charging.

Recharging shall be automatic on the restoration of the main supply and the period of the recharging shall be approximately twelve hours. The fitting shall generally be provided with an earthed metal case housing the battery and switching plant.

The lamps shall be 12 W tungsten halogen operated by a sealed type lead acid battery. A solid state constant voltage charger shall be provided together with low voltage cutout protection to protect the battery against over-discharge. The units shall be suitable for the environments in which they are to operate.

12.44 Portable hand held fire extinguishers

Portable hand held fire extinguishers shall be in accordance with BS 5306-8:2000, BS EN 3 and local CFO requirements.

Each extinguisher shall be complete with a suitable wall-fixing bracket. The final mounting/fixing shall be agreed on site.

12.44.1 Portable carbon dioxide fire extinguishers

The 5 kg portable carbon dioxide fire extinguishers shall comply with BS EN 3-3:1996.

12.44.2 Dry powder fire extinguishers

The 12kg portable dry powder fire extinguishers shall comply with BS EN 3.

12.44.3 Wiring

All cables and small wiring shall be coded and terminated with lugs or eyes or be soldered; the terminations shall be clearly marked with the numbers and letters of terminations to which they are connected. Terminals shall be numbered or lettered, easily accessible and fitted with individual insulating barriers or be adequately spaced. Barriers shall be fitted to separate control terminals from power wiring terminals.

12.44.4 Earthing

All metalwork housing electrical equipment shall be bonded to suitable earthing terminals and be generally in accordance with BSCP1013.

12.45 Enclosures for Electrical and Control Equipment

Enclosures for electrical and control equipment shall be drip proof and dust protected with adequate front and rear access as necessary for maintenance and repair. Special attention shall be given to the method effect of vibration where it is intended to mount the control cubicle as an integral part of the generator. Where a remote mounted panel is to be provided full consideration shall be given to the fixing/supports and the running/connection of all cables. Full details shall be submitted for Engineer's approval.

12.45.1 Guarding

All live and moving parts shall be adequately guarded to prevent injury to personnel.

12.45.2 Floodlights

Floodlighting units shall be of a type designed and constructed for the application. They shall be complete with 500 W tungsten halogen lamp, enclosure, reflectors, etc, and all items necessary for their installation.

They shall be of corrosion resistant light alloy with clear toughened glass front, the whole assembled to provide a weatherproof unit with IP65 enclosure.

Galvanized steel poles, complete with horizontal mounting brackets, shall be provided complete with a service door which shall provide access to the back-board, fused cut-out, gland plate. Sufficient space shall be provided to permit a maximum of three cable terminations.

Wiring between the MCB, fitting and lamp, via the control gear, shall be 20 A rating butyl rubber insulated, PVC sheathed cables or equal approved.

A separate earth wire shall be run between each lighting fitting and the earth termination situated at the supply point.

Foundation details shall be provided for approval. All cable glands, fixings and terminations shall be provided.

The mounting of the floodlights and associated brackets shall be such that both horizontal and vertical alignment can be carried out at site after installation.

The holes for the planted root columns shall be excavated to a depth as recommended by the column manufacturer and the whole diameter shall not be more than twice the diameter of the column base, and shall be to the satisfaction of the Engineer.

The column with bracket affixed shall be placed centrally in the hole in a vertical position on a pad of concrete and the hole filled with concrete in 150mm layers of 200mm radial thickness around the column up to a depth of 150mm below ground level. The excavation shall be backfilled and evenly rammed. A flexible PVC duct not less than 50mm diameter shall be installed through the concrete surround into the column via the cable entry slot to provide a clear route for the electricity supply cable complete with draw cord.

12.46 Control and Monitoring Systems

12.46.1 General

The Contractor shall design, supply and install all plant for the automatic or semi-automatic control and monitoring of the boreholes being supplied under this contract and to achieve the operating sequences specified. The plant shall be complete in all respects and shall be suitable for use with the plant offered.

All instrumentation shall be designed and selected in accordance with good engineering practice and to the relevant standards. Plant shall be robust and reliable and require minimum maintenance. Instrumentation including transmitters shall be of the solid-state electronic type, unless otherwise specified elsewhere. Flow and water level indicating instruments shall be fitted with linear scales and shall have a circular dial not less than 200mm diameter, unless specified.
Panel mounted instruments shall be flush mounted. The maximum range of indicating and recording instruments shall be at least 25% more than the normal maximum indication. For flow measuring instruments where allowance for future flow increase is specified, the instrument shall be rated for the future flow.
The control and monitoring is subject to further consideration, to suit the system offered. However, the Contractor shall include and price for a system that is flexible and can be readily expanded to accommodate further operational functions and requirements.

12.46.2 Standards

The following Specifications shall be used and complied with in the design and installation of the control system and instrumentation:

- IEE - Guidelines for the Documentation of Software in Industrial Computer Software for Real Time and Interactive Systems;
- BS 6739:1986 Code of practice for instrumentation in process control systems: installation design and practice;
- The relevant British Standard shall be used for any item, installation or application not covered by (i) or (ii) above, e.g. BS EN ISO 6817:1997 for electromagnetic flow meters.

12.46.3 System Control and Data Acquisition (SCADA)

A system control and data acquisition (SCADA), where required, shall be set-up within the monitoring room. The SCADA system comprising industrial hardware will run on a Windows XP or approved operating system and will have a UPS backup of a minimum of 30 minute duration. Minimum of 2 workstations are to be supplied with adequate data backup facilities.

The SCADA shall process and record and display the following graphically (mimic screens) in real time:

- Flows;
- Pressures;

- Liquid levels;
- Status of equipment (running or idle);
- Alarms.

Data is also to be graphically displayed in hourly intervals and cumulative hourly, daily, weekly and monthly figures must be presented such that it can easily be extracted to word processing files or spreadsheets.

All data shall be stored as back-ups on CD-ROMs before any erasure or overwriting takes place.

13. MECHANICAL INSTALLATIONS

13.1 Pumps

13.1.1 Pump Selection

In selecting pumps the following factors shall be considered:

- Quality of water (corrosivity, abrasiveness);
- Suction head and draw-down (in boreholes);
- Borehole casing diameters and positions of screens;
- Power supply characteristics;
- Hydraulic characteristics of the supply system;
- Pump cost and operating costs;
- Hydraulic efficiency;
- Availability of operation and maintenance services;
- -Standardisation of equipment

Large pumps in low lift stations shall preferably be of the vertical turbine type. Smaller low lift pumps may be either horizontal or vertical.
High lift pumps shall preferably be horizontal, for ease of maintenance and longer life. Wherever possible a single-stage pump shall be preferred to a multi-stage, and lower speed motors are preferable to high-speed motors. It is not considered advisable to use multi-stage high speed pumps due to increased wear despite possible initial costs savings.
Every pump shall be provided with a non-return valve, gate valve, air release valve, pressure gauge and flow detection switch.

Borehole pumps shall in addition be equipped with a level measurement instrument and an automatic low-level protection switch. Provision shall be made for metering the production of each system, and for flow-recording at larger stations.

13.1.2 General Pump Design

Pumps shall be arranged for priming by means of an adequate positive suction head in all possible operating conditions and be driven by electric motors, unless otherwise specified.
Pump shafts shall be forged from a material compatible with the impellers. If the pumps are fitted with packed glands, the shafts shall be provided with replaceable sleeves where they pass through the gland.
Pumps may be fitted with mechanical seals in place of packed glands only if they have proved satisfactory over a long period when fitted to the design pump in question and with prior approval. They shall be designed for easy adjustment and seal removal.
Effective means shall be provided for the collection of gland leakage water and piping it to a suitable floor drain.
Intake pumps for surface water duty shall be designed for pumping raw water with a high silt content, to be capable of passing 75 mm diameter solids and to avoid possible choking by weeds or other tough sinuous material.

Lubrication arrangements shall be designed to avoid any contamination of the pumped fluid. Unless otherwise specified, all pump bearings shall have a design running life of not less than 100,000 hours.
Bearings shall be designed for loadings 20% in excess of calculated maximum loading and shall be suitable for reverse rotation at 150% rated speed or the maximum reverse speed the pump can reach in installed conditions when driven backwards by reverse flow, if this is greater.
Bearing cooling arrangements if used shall be designed on the closed-circuit principle. Open discharge of cooling water into the pumping station drainage system is not permissible.
The rotating assemblies shall be statically and dynamically balanced and designed so that the first critical speed of the pump and its drive is at least 50% higher than the maximum operating speed. Where the rotating assemblies are small and any out of balance forces are negligible this requirement will not be necessary. The manufacturer is required to state whether balancing has been completed.
The speed of any main pump shall not exceed 1500 rpm without approval of the Engineer.
The head/quantity characteristic of any pump shall be stable at all rates of flow between close and open valve and shall be steep enough to permit satisfactory operation in parallel with other pumps under all conditions specified.
The pump efficiency shall be well maintained over the whole of the specified duty range, even if this necessitates the use of a larger motor to provide the peak power demand. For vertical spindle suspended pumps the pump efficiencies quoted shall take into account shaft and rising main losses up to and including pump discharge bend and pump coupling.
The NPSH requirements of the pumps, based on the 2% output drop criterion shall be at least 1 m less than the NPSH available at every working condition.
Water velocities in the suction or delivery branches of a pump shall not exceed 3.5 m/s when the pump is operating within its specified duty range and within this working range there shall be no discernible noise due to hydraulic turbulence or cavitations within either the pump or its associated pipe-work and valves.
Each pump shall be complete with all necessary ancillary equipment and fittings to render the unit complete and ready for service. This shall include isolating valves, non-return valves, air-valves, cooling water pipe-work, gland leakage pipe-work, air release pipe-work, pressure gauges, gauge pipe-work, holding down bolts, access platforms and other items as appropriate.

13.1.3 Pump Performance Guarantee

The pump performance guarantee shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's works.
The pump shall operate at its design point within the acceptance tolerances for flow rate and total head laid down in SSRN 016.

13.1.4 Materials of Construction

The pump impeller, shafting, sleeves, wear rings, casing, etc. shall be of suitable material to cope with the pumped medium and the Tenderer shall have satisfied himself that sufficient detail has been provided to make this assessment.
Typical materials of pump construction have been given in the following Clauses and are intended only as a general guide.

13.1.5 End Suction Pumps

Pumps shall be horizontally mounted complete with drive motor on a common base plate. The pump/drive coupling shall be of the spacer type to facilitate removal of the pump rotating element and bearing housing without dismantling the pump casing, adjoining pipe-work or drive motor.
The dimensions of the pump shall be metric conforming to SSRN 088 or its equivalent. Flanges shall conform to SSRN 207. The bed-plate shall be of substantial fabricated steel construction with floor fixing bolt holes ready drilled. All holding down bolts, etc. shall be supplied with the units.

The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.
Impellers shall be provided with means to prevent abrasive matter reaching the glands and with fully shrounded impellers, to prevent the trapping of matter between the impeller vanes and the casing.
Glands may be fitted with suitable mechanical seals or conventional soft packing. The gland arrangement shall be designed for ease of adjustment or removal of the seal or packing material. Shafts shall be sleeved around the area of the gland when soft pack glands are used.
Flushing facilities shall be provided for mechanical seals or packed glands where pump fluid may be contaminated with abrasive material. Where soft packed glands are used, means shall be provided for collection of the gland leakage water which shall be piped into the drainage system through adequately sized ports.
Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.
The pumps and associated pipework shall be, wherever possible, arranged so that air can be completely expelled during priming. Where this is not possible, facilities shall be provided for the removal of the trapped air. Adequate facilities shall be provided for drainage of the pumps for inspection purposes.
Tappings shall be provided at both the suction and discharge flanges for pressure gauge equipment.

13.1.6 Construction of Surface Mounted Pumps

The pumps shall be of horizontal fixed speed centrifugal flow type operating at a preferable speed not exceeding 1500 RPM. Where low speed pumps have low efficiencies at a given duty, pumps with speeds not exceeding 3000 RPM may be offered. The pump, 415 V, 3 Phase motor, flexible coupling and guard shall all be mounted on a single baseframe.
Pump impellers for raw water may be of cast iron (GG 25) and for high lift duties, shall be of zinc free bronze. Impellers shall be cast in zinc free bronze, leaded gunmetal, stainless steel (or equivalent) of a composition chosen with regard to the specified pump duty.

The impellers shall be keyed to shafts of high tensile steel adequately protected against corrosion with renewable bronze sleeves. Alternatively shafts may be of stainless steel fitted with renewable sleeves where wear is likely to occur. The seal shall be gland packing in a stuffing box.
All revolving parts shall be correctly balanced both statically and dynamically.

Renewable bronze or stainless steel wear rings shall be provided, with adequate clearance for water to be pumped, at all points where wear may impair the efficiency of the pump.
Oil or grease lubrication of the bearings shall be such as to prevent leakage and contamination of the water.
Correctly designed tapers and joints for the suction and delivery pipework shall be provided.
Provision shall be made of all necessary foundation bolts, ragbolts etc. required for the plant and these shall be complete with plates, nuts and bolts and made of corrosion resistant material.
A coupling shall be provided between the motor and the drive shaft. The coupling shall be of non-rigid rubber bushed pin type and have easily removable coupling guards.
The acceptance tests for pump sets shall conform to the relevant sections of SSRN 016 and SSRN 017.
The pumps' suction and delivery connections shall be flanged. The pumps shall be equipped with suction and delivery pressure gauges as specified.
Each pump casing shall be of close-grain grey cast iron, modular cast iron or similar approved material. All working surfaces shall be accurately machined and where necessary, they shall be provided with a register of adequate depth to ensure accurate and true alignment.
Unless specified otherwise, the sealing for all the pumps shall be of gland packing type.
The Contractor shall provide all bolts, nuts, plates, guards, etc. necessary for rendering the installation complete.

13.2 Electro Submersible Borehole Pumps

Borehole pumps shall be of the totally submersible radial or mixed flow borehole type, having zinc free bronze casings and impellers and high tensile steel shafts and fittings. The pumping units shall be suitable for continuous operation.
The pump body shall have separate sections for each stage, which shall have matching faces machined and spigotted, to allow accurate location and alignment of the sections during assembly. The fixing nuts, bolts, washers and studs or bolts shall be manufactured in stainless steel material.
The pump shall be fitted with removable shaft bearing sleeves, bearing brushes, casing wear rings and impeller wear rings. Each impeller shall be located on the shaft by identifiable distance sleeves or similar, such that reassembly of the rotating element can be carried out without the necessity of accurate measurement. The rotating assembly shall be statically and dynamically balanced after which each part of the assembly shall be identified and marked to ensure identical reassembly after maintenance, etc.
Bearings shall be water lubricated and where rubber type bearings are used the bearing material shall be securely bonded to a metal housing. Rubber bearings shall only be used where there is sufficient pressure difference through the bearing to afford adequate lubrication and cooling of the bearing, and where the bearing is submerged under all operating and starting conditions. Natural rubber shall not be used under any circumstances.

Bearings shall be positively retained within the pump body to prevent the possibility of the bearing rotating; a press fit alone is not acceptable.
The pump shall be directly coupled to its drive motor and shall be fitted with a lifting disc type check valve. The check valve shall be designed for a minimum friction loss and shall have its disk drilled with a suitably sized hole, to allow the water column to fall on cessation of pumping, without excessive reverse rotation of the pump.
The pump shall be fitted with a suction case of a material suitable for the liquid being pumped and shall be provided with long bearings to stabilise the shaft and motor shaft and to avoid radial thrust on the motor bearing. A screen shall be incorporated having a minimum open area of 4 times the eye of the impeller.
The submersible motor shall be of the completely enclosed type for continuous duty under water operation on 415V, 50 Hz, 3 phase ac. The motor shall be equipped with an approved seal, located in the top of the motor where its shaft extends through the motor housing, to isolate the well water from the liquid filled motor. The liquid shall be either water or a high dielectric strength mineral oil and it shall be circulated throughout the motor for cooling the motor, stator winding and bearings. Motor performance shall be in accordance with the relevant section of SSRN 011 and SSRN 022.
Motor thrust bearing ratings must be ample to carry the thrust load imposed by the pump when operating under the maximum anticipated pumping head. Motor thrust bearings shall be capable of operating with rotation in either direction, and the thrust capacity when operating in reverse shall not be less than the rated capacity.

An expansion chamber or diaphragm shall be provided to relieve thermal expansion of internal motor fluid due to temperature and shall provide motor internal and external pressure balance under all conditions of temperature and pressure.
The drive shaft shall be a 13% chromium steel or equivalent corrosion resistant material. Outer shell shall not be less than 0.012 m thickness and shall be of material to resist corrosion.
The borehole pump column pipe shall be manufactured from steel pipe coated with an epoxy bituminous solution or similar approved.
The column pipe shall comprise a number of sections at the option of the Contractor such that for each well the total length may be adjusted by plus or minus 2 m. A maximum of three different lengths shall be supplied. Column pipes and fittings supplied in accordance with this requirement in excess of that installed shall become the property of the Purchaser which shall be in addition to those ordered as specified for spare parts.
The sections shall be connected by either welded neck flanges or screwed couplings. Welded neck flanges shall be suitably notched or similar to facilitate installation of the motor power cable and level sensing equipment. Where screwed couplings are used the couplings shall be coated with a PTFRE anti-galling compound.
The borehole pump surface plate assembly shall consist of a steel base plate of the required strength to carry the weight of the complete pumping unit. The surface plant shall be supplied with a flanged sleeve to fit over the well casing. The sleeve shall be fitted with a puddle flange for building in. The couplings shall be screwed on to the upper end of the column pipe and shall have a long radius flanged bend.
The plate shall be provided with suitable openings for the power cable, well vent and water level indicator, as required.

13.3 Chemical/Chlorination Facilities

13.3.1 General

This specification covers the minimum requirements for design, manufacture, testing at manufacturer's works, supply, site testing and commissioning of the chlorination system. This specification shall be read in conjunction with the relevant data sheets, drawings and other relevant sections of the Tender Documents.

The Contractor shall notify the Engineer of any conflict between this specification, the codes and standards and any other specification included as part of the contract documents applicable.

13.3.2 General Dosing Arrangement

Plant for the handling, stock preparation and dosing of the necessary water treatment chemicals shall be provided.
Dosing shall be by gravity feeders or chemical metering pumps, supplied with one unit being provided as a standby dosing facility.
Batch mixing of chemical solutions and slurries shall be carried out manually including changeover from empty to full stock tanks.
In preparing his designs the Contractor shall pay particular attention to maintaining continuity of dosing from any existing chemical dosing facilities during installation of new plant.
The layout, design and materials of construction of chemical plant shall conform to the latest relevant technical information data sheets and literature published by potential chemical suppliers and equipment manufacturers.

13.3.3 Scope

These specifications refer to the supply, delivery, offloading, transport, handling, storage, erection, installation, testing and commissioning, of the following chlorination parts:

- Solution mixers
- Solution tanks
- Dosing pumps
- Pipework, valves and fittings

13.3.4 Materials

As far as possible, materials resistant against the chlorinate solution to be handled shall be used. Where this is impractical, suitable corrosion-resistant coatings shall be applied. Moving parts, chains, electric motors and electrical switchgear shall be suitably enclosed or sealed against the ingress of chlorinate solution dust or liquids as appropriate to the working environment.

Moving parts in contact with the chlorinate solution must also be wear resistant. Assembly of the unit must be such as to facilitate repairs and the replacement of all parts.

1. Standards and Codes

- BS 970 (ISO683) Wrought steel for mechanical and allied engineering purposes
- PWA – Chlorine safety Guidelines

13.3.5 Chlorination Plant

- **Solution Mixers**

The dissolution of coagulant chemicals and suspension of lime shall be achieved by hydraulic means wherever possible. Where this is impractical, electrically driven mixers shall be provided and shall be sized such as to provide adequate mixing. Mixers shall be mounted in such a way as to minimize possible contact of the solution being mixed with the motor, gearbox (if any) and electric controls. The unit should be such as to be easily removed or repositioned during cleaning operations.

Chlorinate solution mixers shall be designed to give a turnover rate of at least four times per hour. Control shall be manual.

All components of the mixer shall be of rigid design. Particular care in the design to provide hydraulically balanced operation. Stresses in all members shall be limited to ensure 100,000 working hours without danger of fatigue failure due to the cyclic nature of the loads.

The mixer blades shall be self-cleaning as far as possible.

- **Solution Tanks**

Corrosion resistant materials shall be used. Pipework connections to the tank shall be such as to avoid excessive stress in the wall of the tank or fatigue failure. Where it is intended that a mixer be mounted on the tank, the mounting points must be designed for the purpose. All tanks shall be fitted with a drain to facilitate cleaning of the tanks. Solution tanks shall be securely fixed to the working platform.

- **Gravity Chemical Dosers**

Gravity feeders shall be designed to give constant discharge of chemical solution at the selected rate and maintain this over the drain down range of the stock preparation tank. Flow setting shall be adjustable by means of a clearly calibrated regulator. The discharge orifice shall be submerged under all operating conditions.

Gravity chemical feeders shall be of robust construction and all parts in contact with chemical solutions (including external surfaces, supporting feel, etc. likely to be affected by spillage or overflow) shall be of suitable non-corrodible materials appropriate to the chemical being handled.

- **Chemical Dosing Pumps**

Chemical dosing pumps shall be selected taking into account the chemical being dosed, wear, leakage, resistance to corrosion and accuracy.

Chemical dosing pumps shall be of the diaphragm type driven by electric motors. Pump, motor and driving arrangement shall be mounted on a robust combined base plate incorporating a drain connection.

The operating range of dosing pumps shall be not less than 6:1 under manual control with an overall repeatable accuracy within ±3% of the set rate within the full operating range.

Diaphragm pumps shall have thermoplastic diaphragms faced with polypropylene, butyl rubber or PTFE. Pump heads shall be either stainless steel or polypropylene. Mechanical glands shall not be used.

Variable stroke mechanisms shall be incorporated which enable pump output to be varied manually locally, while the pump is running by means of a micrometer hand wheel or similar device. Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gearbox shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.

Each pump shall be provided with inlet and outlet isolating valves and, where necessary, with pressure relief and non-return valves. Dosing pumps shall be provided with backpressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.

A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely and shall be located in the discharge line between the pump and the backpressure-loading valve. Relief valves when used on pumps handling non-hazardous chemicals, shall discharge the vented liquid to waste. When used on hazardous chemicals, the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.

Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifold and delivery lines to point of application.

13.3.6 Pipework, Valves and Fittings

All pipework, valves and fittings shall be of corrosion resistant materials. Wherever possible, readily available domestic pipe and fittings shall be used. Facilities for routine cleaning of all pipe runs shall be provided. Where flexible hosing is required, such as lime delivery lines, natural rubber shall be used.

- **Chemical valves**

Valves shall be of the suitable type with bodies and linings suitable for the chemicals handled. On-return valves on slurry lines shall be of the ball type and shall be mounted on the vertical leg of the pipe.

Guard valves shall be provided for all non-return, pressure reducing, electrically actuated, loading and pressure relief valves.

- **Chemical mixers**

High speed or low speed motor driven mixers for chemical mixing shall have a stainless-steel drive shaft and stirrer driven by a totally enclosed fan ventilated, three phase, electric motor, with rotational speed not exceeding 1000rpm.

The gearbox and drive arrangement shall be designed so forces due to flexure of the mixer shaft shall not be transmitted to the gears. Drive coupling shall be of the flexible dog type, or similar requiring no unbolting for removal.

14. INSTRUMENTATION AND MONITORING FOR TIWI BOREHOLES

14.1 Brief Description of Scope of Tiwi Boreholes System

The Tiwi well field is divided on two parts, North Well Field and South Well Field. Each borehole has its own operator building with Motor Control Room. There is one local central head office for all boreholes located at borehole no. 3 and 6.
The new Local Control Station as part of Tiwi remote control system will be installed in this Tiwi Manager's office. All data collected from all boreholes will be stored and monitored from this office. The daily, weekly and monthly reports will be sent by wireless GPRS/GSM module to this office.

14.2 Proposed Well field Upgrading Equipment

The South well field consists of boreholes 1, 2, 3&6, D, E, and G. The boreholes pump the water to Magonzoni reservoir. The water is then supplied by gravity to Ukunda and nearby consumers.
The north well field consists of boreholes 4&7, 8, 9, A and C. The boreholes pump the water to Kaya Bombo reservoir. Then the water is supplied by gravity to Likoni and nearby villages.

From a field assessment of the boreholes in the period July 2018 until March 2019, the following rehabilitation/upgrading works are proposed to bring the boreholes operation into an efficient level.

The rehabilitation/upgrading will include the following:

- pressure transmitters
- flow meters
- complete set of valves,
- strainers,
- non-return valves ,

The new Motor Control Starter Panels will be upgraded with new remote control unit (RTUs) equipment as part of monitoring system of Tiwi well field.

- Motor Protection Units,
- I/O module and
- GPRS/GSM communication modules.

14.3 Amplified Pressure Transmitter

A total of 16 Amplified Pressure Transmitters have will be provided. As part of upgrading works the diaphragm pressure gauge with snabber and stop cack 160mWC , G1/2" B pressure connection will be installed on discharging pipe . On the measuring point where the pressure transmitter 16bar which will convert the pipe pressure to 4-20mA instrument signal. This signal will be used to show the actual pumping pressure at remote monitoring system. The specifications of the APT are as follows

Pressure transmitter

Pressure range	16 bar
Over pressure safety	50 bar
Burst pressure	250 bar
Pressure reference	Relative pressure
Pressure connection	G1/2 B
Material	Stainless steel
Internal transmition fluid	Silicon oil
Power supply	10<Ucb<30 VDC
Signal output	4-20 mA 2-wire system
Maximum load	$R_A \leq (U_R\text{-}10V)/0.02A$
Adjustability zero/span	$\pm$10
Response time (10-90%)	<1 ms
Accuracy	$\leq$0.5 % of span
Hysteresis	$\leq$0.1% of span
Repeatability	$\leq$0.05 % of span
Permissible temperature	$-20^0C + 80^0C$
Electrical connection	4-pin L-pug
Wiring protection	Protect against polarity crossing, overvoltage and short circuiting
Degree of protection	IP65

14.4 Gate Valves

The existing valves are all in bad condition or not working properly. A total of 16 gate valves have been identified for replacement. The specifications are as follows:

Valve No.	
Location	Flow meter chambers
Number Required	Two (2)

Size	100 mm
Fluid Handled	raw water
Steam	Brass ASTM B16
Handwheel Nut	Cast Bronze ASTM B 584
Handwheel	Cast Iron ASTM A 126
Body Nut	Steel ASTM A307
Body	Cast Iron ASTM A 126
Service	Isolate flow meter pipe
Operator	Manual
Working Pressure	PN 10
Length of headstock	Hand wheel direct assembled
Connection	Flanged

14.5 Check (Non-return) Valves

With upgrading work each on borehole discharge pipeline new Non-return valves will be installed. The existing valves are all in bad condition or not working properly. A total of 16Nos will be installed. The specifications are as follows:

Valve No.	
Location	Flow meter chambers
Number Required	One (1)
Size	100 mm
Fluid Handled	raw water
Body Bolt	Steel ASTM A 307
Bonnet	Cast Iron ASTM a126
Body Gasket	Synthetic Fibber
Body Nut	Steel ASTM A307
Body	Cast Iron ASTM A 126

Service	Isolate flow meter pipe
Working Pressure	PN 10
Connection	Flanged

14.6 Iron Y-strainer

The existing strainers are observed to be all in bad condition. With upgrading work on borehole discharge pipeline new Y-Strainers will be installed on the places where there are not or where there are old horizontal strainers before flow meter. This type is considered better from an operation point of view. The detailed specifications are as follows:

Strainer No.	
Location	Flow meter chambers
Number Required	One (1)
Size	100 mm
Fluid Handled	raw water
Body	Cast Iron ASTM A 126
Bonnet	Cast Iron ASTM A126
Gasket	Metal Field Graphite
Plug	Cast Iron ASTM A 126
Service	Clear flow meter pipe
Working Pressure	PN 10
Connection	Flanged

14.7 Electromagnetic Flow meters

The existing flow meters are installed in a flow meter chamber but during the field assessments most of the meters were not working. With the proposed rehabilitation/upgrading work on each borehole discharge pipeline a new electromagnetic flow meter will be installed. Before the flow meter there should be 5D long straight piece of pipe and after 2D long straight piece of pipe (D diameter of discharge pipe). The Transmitter will be separate from sensor for remount mounting. The detailed specifications are as follows: A total of 16 Nos will be installed.

	Electro Magnetic Flow Meter
Standard	ISO 4064 Class B

Size	DN80
Flow	Qmax=80 m^3/h, Qnom=40 m^3/h, Qt=8 m^3/h, Qmin=1,2m^3/h
Accuracy	± 2%
Wetted Material	Lining-Suitable for portable water Electrodes-stainless steel 316L
Pressure Limitation	As flange rating
Pressure equipment directive	Applicable for supply, distribution and discharge of drinking water
Conductivity	>50 µS/cm
End Connection	80mm flanged BS4504/ISO 7005 –PN16
Transmitter	Remote up to 10m Analog Output: 4-20mA Pulse Output-forward only pulses
Housing	IP68
Power Supply	External, 0-24VDC or internal with 2 butteries -typically
Serial Communication Interface	RS232 RS 485

14.8 Borehole Level Transmitter

Hydrostatic borehole level transmitter with built-in Pt100 sensor will be installed in the proposed rehabilitation/upgrading work. The transmitter will be separate from sensor for remount mounting. A total of 16Nos will be installed. The specifications are as follows:

	Hydrostatic Level Transmitter with integrated Pt 100 temperature sensor
Function	Continues level measurement
Hydrostatic Level range	From 1 up to 100 mH2Og

Accuracy	± 0.175% FS BSL NLHR>4mH2O, ±o.25%<4mH2O
Output signal	4-20mA current loop
Electrical connection	PUR, PVC or FEP vented cable sealed to IP 68
Pressure connection	Removable protection cone
Media Compatibility	Stainless steel 316 Ti housing, stainless steel 316L diahragm
Terminal box	-Robust Aluminium case -Ingress protection IP 66 -For connection 2 wire submersible transmitters with integrated Pt 100 temperature sensor -Integrated atmospheric pressure compensation with PTF filter
Temperature measurement	Integrated Pt100 -temperature range 0-70^{0}C -3-wire connection of temperature sensor -Output signal /Supply 4-20mA/Vs=12..34VDC -Accuracy <0.15% -Linearity <0.1% -Thermal effects <0.01%/K

14.9 Motor Starter Panel for Tiwi Well Field- Remote Terminal Units (RTU)

For new boreholes or those where rehabilitation is to be carried out a completely new Panel will be supplied and installed. Each motor starter will be equipped with new ACB, Soft Starter, Temperature monitor device, timer relay and power factor correction. In order to implement Monitoring System and Energy Management System (Energy Saving) additional equipment has to be installed in this panel as part of rehabilitation/upgrading works. These are Remote Transmiter Units (RTUs) responsible for control of the pump at the site. These RTUs will communicate, via fiber optical cables with a Local Server located in Tiwi Water Office Manager's room. A total of 16Nos are proposed.

14.10 Motor Protection Unit -MPU

Each borehole pump motor starter compartment will be upgraded with electronic motor protection unit for the protection of asynchronous motor and pump. The unit consists of incorporated current transformers and electronics and incorporated buttons and digital display for reading and programming of data through opening on the motor compartment door.
There will be two sets of limits:

- a set of warning limits which will allow the motor continues to run when alarm will be on
- a set of trip limits which will stop the motor.

The same time the limit which will be exceeded will be indicated.
A total of 16 Units will be provided.

	Electronic motor protection unit
Monitoring function	Insulation resistance before start up
	Temperature
	Overload/underload
	Overvoltage/undervoltage
	Phase sequence
	Phase failure
	Power factor-cosϕ
	Power consumption
	Harmonic distortion
	Operating hours and number of starts
Technical data	Enclosure class IP20
	Ambient temperature 20^0C to 60^0C
	Relative air humidity 99%
	Voltage range 100-480 VAC
	Current range 3-999A
	IEC trip class 1-45s
	Voltage variation -25%/+15%
Measuring range	Current with external transformer 120-999A $\pm$1%
	Phase to phase voltage 80-610VAC $\pm$1%
	Frequency 47-63 Hz $\pm$1%
	Power factor 0-0.99 $\pm$2%
	Energy consumption 0-4x109 kWh $\pm$5%

Bus Communication	Monitoring and communication via open and interoperable network such as Profibus , Modbus, LONWorks, Ethernet.

14.11 Input / Output interface module (I/O)

Each Motor starter compartment has to be equipped with I/O module as additional protection module or as a control module that can start and stop the pump according to an analog 4-20 mA signals (second analog output from current splitter) from borehole level transmitter and pressure transmitter. The I/O module will have the following functions:

- dry run protection with low water level alarm in borehole
- stop the pump if outlet pump pressure is too low

A total of 16Nos will be installed. The detailed specifications are as follows:

Technical data	I/O module
Supply voltage	24VDC $\pm$ 10%
Analog Inputs	Min. 4 inputs 0-10V, 0-20mA, 4-20mA programmable
	Tolerance $\pm$ 3% of full scale
	Input resistance <250Ω
	Input resistance voltage >50 kΩ $\pm$ 10%
	Supply to sensor 24V $\pm$ 10% maximum 30 mA
Analog Output	Min.4outputs 0-10VDC $\pm$ 2% of full scale
	Relative accuracy $\pm$ 1% of full scale
	Max output current 1mA
Digital inputs	Min. 2 inputs
	Open –circuit voltage 5VDC
	Closed-circuit current 10mA
	Frequency range 0-16 Hz
	Logic “0” <1.5V
	Logic “1” > 4.0V

Relay output	Min. 4 outputs programmable Normally open NO or Normally close NC Maximum contact load 240VAC , 2A Minimum contact load 5 VDC, 10 mA
Communication ports	RS232 RS485

14.12 24V DC Power Supply Unit

Compact primary switched-mode power supply unit approved for industrial use and suitable for supplying power to electrical and electronic components will be provided and operated. A total of 16Nos will be required. The detailed specifications are as follows:

Installation	on 35mm mounting rail inside of enclosures and switchboards
Input voltage:	500VAC Equipped with one input fuse
Permitted voltage operation range:	187 – 264V AC
Frequency range:	47 to 63 Hz
Input and output equipped with	surge voltage protection (e.g. varistor)
Nominal output voltage:	24V DC Tolerance: +/- 3%
Nominal output current:	according to connected load including reserve capacity of 30%
Function display	via LED
Efficiency	>85%
Ambient operation temperature:	0°C….+45°C
Permitted humidity:	up to 95% at 25°C
Type of protection	≥ IP20
Class of protection:	I

14.13 Class 10 GPRS Modem

Motor starter device shall have in-built GPRS modem with the following features

- Dual-Band E-GSM/GPRS 900/ 1800 MHz
- Plug-in modules for direct interfacing with micro-controllers

- GPRS multi-slot class 10
- Compliant to GSM phase 2 specifications
- Maximum power output
- 1W@900 MHz
- 1W@ 1800 MHz
- Control via AT commands
- Normal operation temperature -20^0 C to +55^{0}C
- RS 232 interface for direct communication with computer or microcontroller unit.
- Push type SIM-Card Holder
- SMA connector for GSM Antenna
- Network LED on module for indicating module state- power on/network registration
- Powerful TCP/IP protocol stack for M2M applications and bi-directional data
- transfer over GPRS.

A total of 16Nos will be required.

14.14 Ultrasonic Level Meter for Kaya Bombo and Magodzoni Reservoir

The reservoirs will be upgraded with new ultrasonic level meters. In the level transmitter has to be incorporated wireless GPRS modem to transmit the level data to Tiwi Local Server. 2No units will be provided. The specifications are as follows.

	Wireless Ultrasonic Level Meter
Description	Mono-block, ultrasonic level meter with embedded GPRS modem
Range	for liquids targets 8 meters (max)
Dead zone	15 cm
Accuracy	+/-0.5 cm
Measured values	Distance, level, (absolute and %), temperature, embedded and an external temperature sensors for accurate readings in rapid temperature variations Temperature compensation
Transmission of measured data	GPRS/GSM link
	USB for quick set up and for local monitoring
One multifunctional port	for one RS485 communication link or for one
Operating temperature	-30°C to +70°C (-20°C to +70°C with display option)
Installation threads	1.5” NPT or 1.5” BSP
Power supply	8 to 33 VDC Or 2 butteries -typically 3 years -3.6V Lithium
	Or Solar Cells

14.15 Surge Protection

The lightning and switching transients and the regulation of the available 230VAC supplies will be as for a normal industrial supply.

Equipment which is connected to signal lines of any type which run for any distance outside a building, shall, if technically possible, be surge protected to survive twenty 8/20 microsecond current impulses with maximum amplitude of 10 kA when applied in common mode between the signal lines connected together and earth. Ten of the test pulses shall be applied as positive pulses with respect to earth and the other ten as negative pulses.

In addition, the protected equipment shall be able to survive 20 8/20 microsecond current impulses with maximum amplitude of 2 kA when applied in differential mode. Ten of the test pulses shall be applied with any particular polarity and the other ten with the polarity reversed.

The test pulses shall be applied at intervals of not less than one minute.

The surge protection equipment may be built into the equipment being protected. If the provided internal protection is inadequate to meet this specification, then additional external protection has to be provided.

Equipment which is connected to signal lines of any type of which the entire length of the run is within the same building and for which the signal cable is longer than 30 m, shall be protected as in 24.2, except that the maximum amplitude for the common mode test shall be 2 kA and the maximum amplitude for the differential mode test shall be 500 A.

Surge protection devices shall be chosen in such a way that the protected circuit shall still function to specification in spite of the introduction of series and/or shunt impedances by the protecting devices

14.16 Tiwi Control Room

14.16.1 Scope

The Local Control Station will be installed to allow permanently monitoring of individual functionality and parameters of each Tiwi Borehole Pump Station.
The system should be flexible system and should consist of Local Server (LS) and 15.6” digital display (monitor) which shall log the data in one location where is the main Tiwi Station. The Local Server shall be used to log the data locally and also to generate basic reports.
As proposed with rehabilitatiom/upgrading works, the all borehole pumps start panels will be equiped with RTUs (Remote Terminal Units) at the each borehole pump sites. The RTUs shall be responsible for control of the pump at the site. These RTUs will communicate, via wireless system with a Local Server.

The Proposed scheme would offer the following advantages: better and more control and monitoring options, improvement in system efficiency/ performance, safety of equipment/ people, and reduction in downtime by way of timely maintenance attention.

14.16.2 Parameter Monitoring

The borehole monitoring system should bifurcate the monitoring parameters into three basic types:

a) Analog Parameters

An analog parameter should provide output at regular interval of 15 minutes which should be remotely configurable via web based CS software. For a typical water system, it can be (say):

- Flow
- Temperature
- Pressure
- Chlorine content
- Water level
- Subsoil water level

b) Digital Parameters

- A digital parameter should provide status or alarm situation for the monitored equipment; for a typical pumping system, it can be:
- Pump status
- Sequential Packet Protocol (SPP) failure
- Overload failure
- Level switch
- Valve open/close.

c) Electrical Parameters

The typical list of Electrical parameters to be captured are as follows:

- Voltage of each phase
- Current in each phase
- Neutral Current
- Power Factor(PF)
- kW each phase and total
- kVA each phase and total
- kVAR each phase and total
- Metering kWH cumulative
- Metering kVAH cumulative

14.16.3 Technical Requirements

a) Technical details

Technical details in respect of the system required for monitoring system of the borehole pump stations will be furnished as follows.

Scope of work

The scope of work shall include the following activities and any other activity which may be required to run the system successfully:

- The instument field device like level, flow, pressure and temperature should be able to send data to the RTU
- The integrated energy meters should be based on open protocol and should not be proprietary protocol of meter manufacturer.
- Control wiring in the Motor starter should be designed in a way that the Motor can be operated manually by pressing Start and Stop buttons on Starter Panel and give digital signals to LS for status of the pump shown on LCD display : green-pumping, red pump stop.
- The proposed Local Server (LS) application system should be hosted at a Data Centre and the system must be web based. The LS application software should be controllable through a web browser via Internet. There should not be any requirement of paid client license on the User workstation.
- The LS field device should log the following electrical parameters at 15 minutes interval:
    - Voltage and Current for all 3 phases
    - Frequency
    - Energy (Active, Apparent, Reactive)
    - Power Factor phase wise
    - Total Power Factor (calculated and displayed for each interval)
    - Power (Active, Apparent, Reactive)
- Hardware I/O unit should have min 6 nos. 4-20 mA inputs with capability to integrate with sensors like Flow, Pressure and Level, etc.
- There should be facility to view reports for:

a) KWh reporting between a start date & time and end date & time with bar graphs on hourly and daily basis for:
    - -each well pump, group of borehole pumps (North/South),
    - -each Mombasa/Mailindi pump, group of Mombasa/Malindi pumps

b) Total cumulative consumption between a start and end date for water pump also daily, weekly and mountly

c) Flow(m^3/h) of water supply from each borehole flowmeter, total supply from group boreholeles flowmeters,

d) Level(m) of water levle separately from Magonzoni and Kaya Bombo reservoirs

- There should be provision to define schedules with the conditions like:
    - Pump operations for fixed hours despite power outage, as per defined schedule
    - Operational hours reset on daily basis
- There should be provision for online display of graphical charts for:
    - Active Power
    - Apparent Power
    - Reactive power
- There should be provision to define group of pumps and define the reports on group basis like cumulative kWh and running hours, etc.
- Markings: All markings/indications shall be placed in the vicinity of the components to which they refer and shall not be placed on removable parts.

- The software application should generate Alarms and send audio and rotary light messages to oerator incharge for the following conditions:
  - Electricity Supply failure to the motor.
  - Pump overdue POH. (Date, Month, Year) of POH due date to be entered in the system.
- Pump Failure History:
  - The system should be capable of keeping the history of pump failure data for the last 3 years.
  - History of replacement of different pumps with makes.
- The system should have the facility to view reports for pumps stopped due to the following reasons :
  - Single phasing.
  - Reverse phase sequence.
  - Unbalance in phase voltages.
  - Overloading of pump motor.
  - Dry run.
  - Earth leakage in pump motor.

14.16.4 Tiwi Office Server Specifications

Architecture of Tiwi Water Office server located in Manager's room should have all futures to fulfull the requirements of the Tiwi Well Field

	Local Server
Server microcontroller platform	minimum 32 Bit Microcontroller platform
Connectivity	GPRS Connectivity
Clock	RTC Inbuilt Real time Clock
Memory	Internal storage memory
Analog Input	ADC Analog Input Channels with 16 Bit Resolution
Digital Input	Opto- isolated Digital Inputs
Digital Output	Opto-isolated Digital Outputs
Display	Min. 21"LCD display showing status of the pumping process parameters and errors
LED Display	for TCP/IP Connection Status
Keypad	Keypad for user interaction
Status	Status Indication Buzzer
Battery Status	Battery Charge Monitoring
Communication	RS485 interface to read meters -GPRS (RSSI >22,BER=0) -GSM RS232 Serial Communication -TCP/IP Port for Ethernet Connectivity -GPIB Port Optional
SMPS	Inbuilt SMPS
Fuse	Inbuilt Fuse for Short Circuit protection

Tamper	Proof Inbuilt tampering alarm detection
Power Supply	Operating voltage: 140VAC – 315VAC Phase to Neutral, 240VAC-550VAC phase to phase.

14.17 Field Data Acquisition

14.17.1 Process data

The LS unit should be able to read the data from Single or Multiple Energy Meters and Water Flow meters at fixed intervals (typically 15 minutes) and should send the data to Data Center Server. Meter data should be stored in non-volatile memory of the LS device and should be cleared only after successful data transfer to the Data center. The LS device should be able to keep minimum 7 days of Meter data in its non-volatile memory during communication failure with the Data center. The data should be sent over GPRS in push mode by the devices to the Data Centre.

14.17.2 Protection

Protection against overloading of the pump motor & dry run protection. The system should be capable of stoping the motor in case of over load / dry run.

14.17.3 Display System

The LS device shall have LED or LCD display for showing the status / error for the following conditions:

- Status of Connection / Disconnection from Data Center
- Error in communication with Energy Meters
- Error in time Synchronization with Data Center.

14.17.4 Power Supply for LCS

The Power Supply for LCS device should meet the following minimum requirements

- Power supply should work with neutral missing with any two live phases
- and single phase with neutral.
- Filter circuit with fuses to protect the system against Surge up to 6KV.
- Protection against faults like neutral missing/weak, phase to phase shorting
- Battery back-up for minimum 8 Hrs. Power Supply status indications for
- Mains fail, Battery charging and low battery.
- In-built short circuit protection for each DC output using resettable fuses.

14.17.5 External Switchgear

Local Server device shall have support to control any external switching device (Contactor). These switchgears shall be placed out of the enclosure but shall have control communication through LS device.

14.17.6 Sensor Integration

Local Server device shall support up to 14 Channel Analog inputs with minimum 10-Bit
resolution Sensor integration capabilities. The Analog Inputs should accept 4-20mA current inputs to interface with Standard sensors.

14.17.7 Inbuilt class 10 GPRS Modem -General Features

Local Server device shall have in-built GPRS modem with the following features

- Dual-Band E-GSM/GPRS 900/ 1800 MHz
- Plug-in modules for direct interfacing with micro-controllers
- GPRS multi-slot class 10
- Compliant to GSM phase 2 specifications
- Maximum power output
- W@900 MHz
- 1W@ 1800 MHz
- Control via AT commands
- Normal operation temperature -20^0 C to $+55^0$C
- RS485, RS 232 interface for direct communication with computer or microcontroller unit.
- Push type SIM-Card Holder
- SMA connector for GSM Antenna
- Network LED on module for indicating module state- power on/network registration
- Powerful TCP/IP protocol stack for M2M applications and bi-directional data transfer over GPRS.

14.17.8 Battery Backup for Local Server Device -UPS

LS device should have in-built battery backup of at least 8 hours. LS device should be able to perform regular operations of monitoring, scheduled on/off and communication with Data Center. Device should also be able to accept the data from data center when on battery backup.
LS device should have capability to sense the status of the battery and, it should send the battery health status to the data center while running on battery.

14.18 LS Hardware Functionality

Futures	Description
Connection Management	Automatic GPRS Connection Management to establish connection to the Server
Time Management	Automatic time synchronization with server Servers should be able to request device time Server should be able to set time of device remotely

Device Data Validation	Command verification Error Logging
Data Acquisition error Diagnostic Message for Meter Not Responding	On Demand Device Reading Configurable Device data sampling time (1-60 Minutes) Deletion of device data logs from WPAS Data publish to Data Center using push/assured delivery mechanism within 5 minutes of configured time from all devices and sites Diagnostic Message for Timing error Diagnostic Message for Memory
Remote Management	Support receiving command from Data Center Acknowledgement or Not acknowledged sent for every remote operation command
Scheduler	Support up to 32 schedules at minimum Reset all Schedules Schedule performed acknowledgements sent by device to servers Fixed running hour operation support Schedule resume support in case of power failure during scheduled period
Reset of WPAS device	Remote restart of LS shall be supported
Alerts	Tamper switch shall detect attempt to open enclosure Power Fail and Power Restoration alerts shall be sent to server;; during this mode device shall operate on battery powered mode Disconnection Intimation generated by server when device gets disconnected from server
Remote Configuration	Device connectivity settings like public IP, username, password etc Configuring Device data sampling time for publishing the data Adding new sensor , digital input or digital output in system remotely Resetting all provisioned information
Diagnostic Commands	Device Ping Firmware Version Request On Demand Diagnostic which checks complete unit
Additional Features	Remote Over The Air Firmware (OTAF) Updates of the complete unit for future proof deployment
RSSI	Minimum value of 22 should be shown by an approved and calibrated metering device, used to calculate GSM signal strength

BER	The Bit Error Rate reading should be 0. That is, there should be no error in transmission.
Sensors	Calibration Certificates should be provided from a recognized government lab or equivalent international lab

14.19 Tiwi Server Application Software Features

The LS application must be modular and scalable so that it can at a later date be integrated into an Integrated Energy Management System. LS Application software should have the following functionalities for Users

Feature	Description
Group Management	The web application should have provision to define Groups based on various parameters like area, rating, etc. There should be provision to take collective action or define reports on defined groups.
Reporting	The software should provide tabular as well as graphical reports on following intervals: - 15 minutes - Hourly - Daily - Weekly - Monthly - Yearly There should be provision to export reports in Excel format. There should be provision to define reports on the quality of power supply like Voltage imbalance, Current imbalance, Voltage fluctuations, etc.
Alarms and Events	There should be provision to display Alarms / Events in near real time and also maintain the history of Alarms / Events.
Remote Management	There should be provision to remotely send On/Off command to a pump or a group of pumps.
Schedule Definition	There should be provision to define unlimited schedules and apply upto 32 schedules to WPAS device or to a group of devices. Application should have capability to identify conflicting schedules and should not allow Users to define conflicting schedules.
Rule Definition	There should be provision to define various rules for Alarms /Events reporting. The rule engine at Data Centre should work on real time basis.

System Monitoring	The application should be able to indicate the following conditions: - Phase failure - Power Outage - Communication failure

14.20 Construction Ingress Protection:

The Local Station device should have a Metal Enclosure suitable for indoor installations. Ingress Protection Rating of LS device enclosure should be IP30 compliant at minimum. The Enclosure should have provision for Wall mounting. Antennas or communication cables should be terminated inside the Enclosure to avoid tampering. Electrical cables and control cables should also have termination inside the unit and the enclosure should have Glands to reduce the stress on cables. The system should be certified for the following:

- Operating Temperature: 0 – 55 degrees Celsius
- Storage Temperature: -20 to 80 degrees Celsius
- Humidity: 95 % condensing

14.21 Meters and Indication

a) Energy Meters

The equipment should be capable of communicating with energy meters which will be install as part of ongoing works. There should be provision to show the power consumtion rate of pumps at various intervals. Calibration Certificates are to be provided for all the meters.

b) Water Flow Meter

To be installed along with the system:

- The equipment should be capable of communicating with the flow meter.
- There should be provision to show the flow rate of water at various intervals.

Calibration Certificates are to be provided for all the meters.

14.22 Test Scheme

a) *For Software*:

- The software shall fully comply the requirements entailed by this specification. If
- required, the software should be customized, taking into consideration the specific
- needs of the Bulk Water Company
- All functionalities should be tested on site in front of the customer.

b) For Hardware:

- Using standardized equipment, the GSM signal strength on site has to be
- determined to be a minimum of 22 as defined by GSM 05.08 [20] sub clause 8.2.4
- The mobile communication has to be approved for IEC 61149 or equivalent IS

- standard or other acceptable standard by neutral and recognized agency (safety of
- Mobile Radios)
- The enclosures shall be type tested according to the test standards defined in
- Section 3.
- The BER or Bit Error Rate has to be 0 as defined by GSM 05.08 [20] sub clause
- 8.2.4. This has to be tested using standardized equipment
- Only if the GSM/GPRS link is not strong enough as specified above, other options
- like RF linkage, laying of a permanent optical fiber link etc. can be considered.

14.23 Documentation and Log Books

The supplier shall provide easy-to-use illustrated installation and operation manual in English and local language for easy installation and trouble-free usage. The manual shall contain complete system details such as schematic of the system, working principle, clear instruction on regular maintenance, trouble shooting, etc.
The Tiwi Water Officer-in-Charge shall maintain a logbook detailing inspection and operating activities. This logbook must be kept in a secure place and shall be made available, whenever required for inspection. Testing of all protection devices shall be carried out at regular intervals (no longer than six months) by the customer and recorded in the logbook.

14.24 Cabling

a) Power Cables

LV multicore cables for use on 240 V power supply systems shall be XLPE or type with aluminium conductors. Single core cables shall have aluminium armouring and conductors.
Single core cables for used in trunking and conduit shall be PVC insulated.

b) Control and Instrumentation Cables

Multicore control and instrumentation cables shall have copper conductors of minimum size 1.5 sq. mm for control and 1.0 mm^2 for instrumentation. These cables shall be PVC insulated, sheathed and armoured. The conductor cores shall be arranged within the cable as twisted pairs. Control cables shall have an overall earth screen below the armouring layer. Instrumentation cables shall have a similar overall earth screen and a separate screen around each pair of cores.

c) Cable Installations

Cables between buildings will be installed underground in 1.0 m deep trenches. Heavy duty galvanised iron cable tray and ladder racking shall be used in buildings for cable support systems. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cable.

d) Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three-digit number.

- LV power P_ _ _
- Control C_ _ _
- Instrumentation I_ _ _
- Protection PR_ _ _
- Telecommunication T_ _ _
-

14.25 Solar Photo Voltaic Installation

14.25.1 General

The Employer intends to install a complementary solar power system at the boreholes in order to alleviate the cost of grid power for borehole pumping. In order to actualize this system, a pilot system will be installed at first at boreholes A, 4/7 and 9. A detailed design of the photo voltaic system will be implemented after the final sizing of the pumps following site investigations. The Bills of Quantities offer a rough guide on the size and materials required. It is proposed to implement a hybrid system in which the Solar PV will operate between the hours of 8.3am – 3.30pm and offer at least 7 hours of power supply. The following sections describe the minimum requirements for the solar PV.

a) PV Generator (Solar PV Modules):

The Photovoltaic Generator shall consist of silicon crystalline Photovoltaic modules of capacity at STC 240Wp or more. The PV module shall comply with IEC61215 and IEC61730 standards. An aluminum frame is applied around each module to protect the module from any damage during transport, installation and operation.

The junction box behind the module with their positive and negative terminals has to be equipped with bypass diodes and shall be at least with IP 65 protection and UV resistant.

Cables used within the PV generator shall have a voltage rating of at least 1.2 VOC of the solar array; have a temperature rating higher than 40 °C above ambient temperature; be UV-resistant; water resistant and it is recommended that they be flexible (multithreaded) to allow for to allow for easy installation and maintenance.

The module support structure shall be ground-mounted. It shall have a tilt angle in the range of 100-150 from the horizontal plane/ground. The support frame shall be of

either light-weight aluminum or galvanized steel and it shall be easy for installation, maintenance and disassembly at the end of the life cycle.

b) PV Grid-Tied Inverter:

The grid-tied inverter converts the DC direct current from the solar generator into alternating AC current.

The string inverters shall be installed indoors or outdoors with a cover to offer protection against high ambient temperatures and dust.

A 3-phase, transformer-less inverters with maximum European efficiency of 95% or higher is recommended.

c) Equipment Housing:

Power House or Container System:

The data monitoring equipment, and all monitoring equipment shall be installed indoors with natural air ventilation accordingly to the equipment manufacturer's recommendations. All electrical boards and LV protections will also be installed indoors. The Diesel Generator shall be installed outdoors. The PV grid tied Inverter can either be installed indoors or outdoors.

The Power House shall also be equipped with safety and protective elements required for operations, maintenance and emergencies. Natural ventilation is must for all rooms / compartments within the Power House.

In case a container solution is used, the battery inverter-charger, PV grid tied inverter, and all monitoring equipment shall be installed with natural air ventilation according to the equipment manufacturer's recommendations.

The container has to be placed on reinforced concrete blocks in a location where no heavy rain or seasonal flooding can enter the container. Therefore depending on chosen location, the foundation should be elevated to appropriate heights. Protection from direct sunlight falling on the container's roof should be provided.

d) Electrical Installation:

In the case of a power outage of the core component - the battery inverter, the loads have to be bypassed to the diesel generator and manually switched. Corresponding electrical installation equipment has to be installed.

e) Electrical Protection:

The solar PV hybrid system shall contain all necessary electrical protection to ensure the safety of people and equipment. At the LV distribution boards, thermomagnetic circuit breakers and Residual circuit Breakers shall be included.

A lighting protection system shall also be erected, ensuring the coverage of the whole PV plant, Power House, Container and Diesel Generator.

f) Distribution Line:

The electricity distribution from the generation plant to the water pump and site offices will be done by means of a distribution line formed by low voltages (LV) lines at 3-phase 415 V/ 50 Hz or 1 phase 230V towards the consumers. All these lines shall run underground.

The distribution lines sizing and protection shall be designed according to the ERA and the Kenyan Grid Code Regulations.

The LV lines for these projects can initially be limited to distances of about 20m-50m (This can, however, change depending on the location of the generation plant and the main load centres (water pump). Extensions can be done later on application/demand basis.

Energy Meters shall be installed (optional) complete with current transformers (CTs) for measuring energy generated by the solar PV hybrid power plant.

g) Balance of System:

The Balance of System (BOS) encompasses all components of a solar PV hybrid power plant that includes wiring, switches, a mounting system, enclosures, fuses, ground fault detectors, data monitoring accessories etc.

h) Module Mounting Structure:

The solar power plant including the solar modules shall be installed in the parcel of land that already exists. The modules shall be fixed about 1m above the ground and maintain a tilt angle of not more than 15o from the horizontal. They should rest on aluminium frames or standard hot dipped galvanized steel using stainless steel bolts. The frames shall rest on aluminium fixtures or racks that are firmly anchored to the ground with a layer of ballast aggregate.

The module-mounting frame will be earth grounded.

15. SEQUENCING OF WORKS

15.1 Tiwi Wellfield - Geophysical Investigations

Before carrying out any rehabilitation or new drilling works of boreholes, the Contractor will be required to undertake investigations of the groundwater conditions including geophysical investigations.

The exact investigation areas will be defined and shown by the Employer on site and shall only be changed in consent with the Employer or his Representatives.

15.2 Tiwi Wellfield – Rehabilitation of existing wells and new wells

The Contractor shall sequence the works at Tiwi wellfield as follows:

- Rehabilitation works on the existing well fields starting with those wells that are presently not supplying water to the network, as instructed on site by the Employer and Engineer.
- Only once sufficient wells are rehabilitated to secure water supply, the wells that are presently operating can be taken out of operation and be rehabilitated. Explicit approval by the Engineer and Employer is required prior to starting rehabilitation works of operating wells.
- Drilling of new wells can start in parallel to the rehabilitation of the existing wells that are presently not supplying water to the network.

The optimal sizes of the well pumps will only be known following completion of test pumping. The present Bill of Quantities only define an indicative pump size. Following successful test pumping, assessment and evaluation of the results being provided by the Contractor to the Engineer and request by the Contractor, the Engineer will determine the optimal pump size. The Contractor need to consider in his work program these time periods for ordering and delivery of the respective pumps to the site, prior to the completion of works on any one well.

15.3 Tiwi Wellfield – Connecting pipes

Work on the new connecting pipelines shall start early in the project so that they can be taken into use as soon as the respective wells have been rehabilitated / newly developed. This is required to increase flow to Likoni as soon as possible.

15.4 Marere Parallel Pipeline

The existing Marere pipeline is an important source of supply. Interruption of its operation should be limited to an absolute minimum.
The section of the Marere pipeline following Kaya Bombo off-take (the flow to the Moi International Airport) can be taken out of operation for a maximum of 3 consecutive days per week. The Employer will inform on the practiced regime on request by the Contractor.

The new, parallel pipeline needs to connect to Marere Headworks and two off-takes (Madabara and Kibaoni) need to be reconnected to the new, parallel pipeline.

Interruption of supply at the two off-takes shall be limited to a maximum of 24 consecutive hours and need to be agreed with the Employer a minimum of 3 working days in advance.
Interruption of supply on the main Marere pipeline shall be limited to a maximum of 24 consecutive hours and need to be agreed with the Employer a minimum of 3 working days in advance.

15.5 Rehabilitation of Kaya Bombo RC Reservoir

The Contractor shall rehabilitate the existing 1140 m^3 capacity concrete tank at the same time when construction of the parallel pipeline is ongoing and the borehole rehabilitation and improvement is on-going.

15.6 Bulk Meter Installations at Borehole Sites

The Contractor shall execute works for new electromagnetic bulk flow meter installations in the Tiwi borehole system and associated pipe work to allow routine maintenance, according to the Drawings of the Contract:

The following boreholes are identified for installation of new bulk flow meters: C, D1, D2, D3, E,G1, 1, 2, 4, 6.1, 6.2, 7, 8.1 and 8.2 , A and 9.

15.7 Water Meter Installations on Marere pipeline

The bulk meter installation works shall be executed by the Contractor to minimize shut-down of the transmission Pipelines Marere to Changamwe and shall conform to the Method Statements submitted by the Contractor in his Bid and forming part of the Contract.

16. PARTICULAR SPECIFICATIONS FOR MARERE PIPELINE

16.1 General Provisions

The Contractor shall provide all labor, materials, equipment and incidentals required to supply, install, test and clean, and all other activities required for the construction works of the parallel Marere Pipeline, as specified.

There is an existing DN500 steel pipeline connecting the springs of Marere with Mombasa / Changamwe. Due to operational difficulties, a parallel pipeline shall be constructed along the first approximately 6.4 km of the pipeline. Two off-takes, namely Madabarra and Kibaoni, that are presently connected to the DN500 pipeline shall be disconnected from the main line and be connected to this new, parallel line. The new, parallel line shall be fed from Marere Headworks following modifications to the existing Marere headworks chamber.

16.2 Construction of Flow Division Chamber at Marere Headworks

The existing chamber at Marere Headworks is of size 2000mm x 2000 mm. Post-Chlorination of the water is done through this chamber. The existing DN500 steel pipe to Changamwe originates at this chamber. The chamber has an overflow weir and a DN50 scour pipe and valve. The scour pipe discharges into a masonry chamber of size 1200 mm x 1200 mm. The DN160 uPVC drain pipe discharges the scour into the river.

It is proposed to expand the RC dosing chamber to accommodate the existing DN500 pipe to Changamwe as well as the proposed parallel pipe of DN250 HDPE to Madabarra and Kibaoni. It is proposed to modify and extend the dosing chamber by 500 mm lengthwise to make it a proportional flow division chamber for the flows into the DN500 and the DN250 pipes. This will also necessitate demolition of the scour chamber and reconstruction after the extension of the flow division chamber. It will also be necessary to install sluice valves on each of the pipelines or appropriate modifications on the inlet structure to the chamber to allow for continuous operation when one pipeline is taken out of service for maintenance. The Contractor should note that this system is live and supplies water to the Moi International Airport which is a sensitive installation and may only be interrupted with minimal downtimes. The Contractor will be required to provide a Method Statement for this work as part of evaluation of the tender.

16.3 Pipeline Off-Takes for Madabarra, Kibaoni and Kaya Bombo

The existing off-takes are constructed on the main DN500 Marere –Changamwe pipeline. The pipeline is of pressure rating PIN25.

16.3.1 The Madabarra Off-take

The first off-take located at CH 2+844 diverts a proportion of the flow to Madabarra reservoir and pumping station. The off-take is located at elevation 153.58 masl and the pipe is set at invert level 152.88 masl. The off-take details are set on drawing No. 1220/K/010A. The off-take is housed in a concrete chamber.

16.3.2 The Kinango Off-Take (Kibaoni)

This off-take is located at CH6+375 and diverts a proportion of the flow to Kinango Town through a reservoir and pumping station. The off-take details are provided on drawing No. 1220/K/010A.The off-take is housed in a concrete chamber.

16.3.3 The Kaya Bombo Off-take

This off-take is located at CH21+900 and diverts flow to the new Kaya Bombo 1250 m^3 capacity reservoir through a DN200 pipeline of 12.4 km. The elevation at off-take is 80.39 masl and the pipeline is set at invert level of 78.89 masl. The off-take details are provided on drawing No. 1220/K/010A

16.3.4 Proposed Construction Works of Madabarra and Kibaoni Off-takes

The existing off-takes to Madabarra and Kibaoni reservoirs are of DN150 GI mains. The Contractor shall execute works for new off-takes assembly, according to the Drawings of the Contract, including the supply and installation of new DN250 PIN25 sluice valves, 250 x 150 Flanged tee and bulk meters and associated fittings for a maximum working pressure of 25 bars.

It is proposed that once the construction of the parallel DN250 pipeline is complete and tested, the 2 off-takes at Madabarra and Kibaoni will be moved from the DN500 pipeline and connected to the new line. This will be done one at a time. The contractor will be responsible for the construction of the off-takes in appropriate fittings for the new DN250 steel pipe and when ready will apply to the Engineer for arrangements for the connection of the respective off-take to the branch line taking water to the reservoirs. One off-take will be done at a time to reduce risks. The fittings and valves on the DN500 main will be removed and handed over to the Engineer. The resultant space will be replaced with a straight pipe piece. The Contractor will be responsible for the preparation of the required flanged pieces. The details of the new construction of the off-takes are provided in Drawing No No. 1220/K/010A

16.4 Supply and Installation of Flow Control Valve Works at Kaya Bombo Off-take

It is proposed to install a constant flow control valve on the downstream of this intake on DN500 steel pipe. The flow control valve will ensure a pre-set constant flow to Changamwe reservoirs and the rest of the flow to Kaya Bombo reservoir.

The details of the installation are provided in Drawing No No. 1220/K/010A.

16.5 Construction of DN250 Parallel Marere Pipeline

The Contractor shall execute works for new DN250 PIN25 pipeline and associated pipe fittings to allow routine maintenance, according to the Drawings of the Contract, including the supply and installation of new DN250 sluice valves, Non-slam air valves and washouts where indicated on the drawings, for a maximum working pressure of 25 bars, some of which are included. The total length of the pipeline is 6.4km

New valves installations shall be installed in new water-proofed and well-ventilated chambers with lockable composite chamber covers.

All pipe works shall be disinfected prior to final assembly and installation, by either spraying or flooding the fittings and equipment with a solution of sodium hypochlorite of concentration not less than 1%, or with a solution of 80/20 ethanol/water solution, with a contact time of at least one minute, to the full satisfaction of the Engineer.

All costs to execute the works, including any works associated with existing installations, and including any removal or modification of existing installations as required by the Engineer, shall be deemed to be covered in the rates and prices of the Contract.

16.6 Bulk Meter Installations on Parallel Marere Pipeline

The Contractor shall execute works for new electromagnetic bulk flow meter installations in the Marere system and associated pipe work to allow routine maintenance, according to the Drawings of the Contract: The bulk meters shall be installed at Madabarra off-take and Kibaoni off-take.

The bulk meter installation works shall be executed by the Contractor to minimize shut-down of the transmission Pipelines Marere to Changamwe and shall conform to the Method Statements submitted by the Contractor in his Bid and forming part of the Contract.

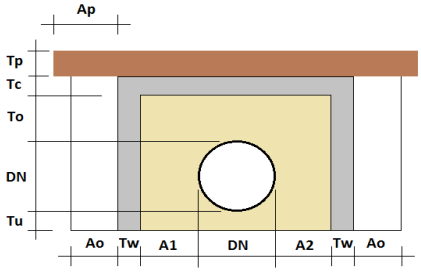
New bulk meter installations shall be installed in new water-proofed and well-ventilated meter chambers with lockable composite chamber covers.

All meter and pipe works shall be disinfected prior to final assembly and installation, by either spraying or flooding the fittings and equipment with a solution of sodium hypochlorite of concentration not less than 1%, or with a solution of 80/20 ethanol/water solution, with a contact time of at least one minute, to the full satisfaction of the Engineer.

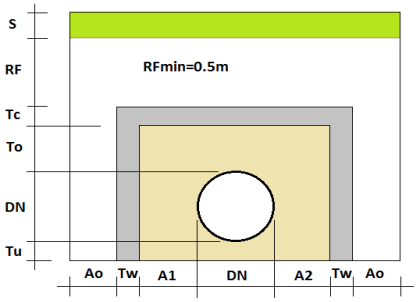
All costs to execute the works, including any works associated with existing installations, and including any removal or modification of existing installations as required by the Engineer, shall be deemed to be covered in the rates and prices of the Contract.

16.7 Creek / river undercrossing

Where the line of trench excavation crosses streams, ditches, culverts and other watercourses the Contractor shall be deemed to have allowed for all the additional measures necessary for the proper construction of the works at these crossings including maintaining the full flow of water. The works shall be done according to the drawings, check the following sketch. The following sketch has two cases: if the RF+S<0.5 then case one is used and if RF+S=>0.5 case two is used.



Case 1



Case 2

17. PARTICULAR SPECIFICATIONS FOR TIWI BOREHOLES

17.1 General Provisions

The Contractor shall provide all labor, materials, equipment and incidentals required to supply, install, test and clean, and all other activities required for the construction works of the parallel Marere Pipeline, as specified.

17.2 Identified Boreholes

The table below shows the required works at each borehole. The works are detailed in the Bills of Quantities. Currently, various pumps have been installed in the boreholes at various times and the status of working varies from time to time. The exact data of the existing boreholes and the pump installation information e.g. actual test pumping, water rest level, drilled depth, sand ingress levels are not accurately know. This will be determined following investigations phase of the works.

In this case, the Contractor is further notified that sizes given in the Bills of Quantities are assumed pump capacity and the final specifications (e.g. cable thickness) will depend on the type of pump and pumping depths which will be determined by the contractor after test pumping

S/No.	BH ID	Cluster served	Status	Remark	Proposed Action	Estimated Pump size Range
1	A	N	BH abandoned	collapsed	**drill new replac.**	20-60 m3/hr
2	C	N	BH stopped working 1 year back	pump removed	emergency repair	20-60 m3/hr
3	E	S	Not working	pump stuck at depth	emergency repair	20-60 m3/hr
4	D1	S	Not working	backfilled	emergency repair	20-60 m3/hr
	D2	S	Not working	pump removed	emergency repair	20-60 m3/hr
	D3	S	Reported yield was 1,200 m3/day	No pump	emergency repair	20-60 m3/hr
5	G1	S	Reported no longer working	motor broke down	emergency repair	20-60 m3/hr
	G2	S	Not working	collapsed	Abandon	20-60 m3/hr
6	1	S	Not working	electrical problems	emergency repair	20-60 m3/hr
7	2	S	Reported no longer working	motor broke down	emergency repair	20-60 m3/hr
8	3	S	Not working. Abandoned.	abandoned	abandon	20-60 m3/hr
9	4	N	Was working, 1,150 m3/day	disconnected	emergency repair	20-60 m3/hr

S/No.	BH ID	Cluster served	Status	Remark	Proposed Action	Estimated Pump size Range
10	6.1	S	Working			20-60 m3/hr
	6.2	S	Drastic reduction of yield	motor broke down	emergency repair	20-60 m3/hr
11	7	N	Was working, 900 m^3/day	disconnected	emergency repair	20-60 m3/hr
12	8.1	N	Working	minor electrical issues	emergency repair	20-60 m3/hr
	8.2	N	Working. Next to BH 8.1	minor electrical issues	emergency repair	20-60 m3/hr
	8.3	N	Abandoned	backfilled	abandon	20-60 m3/hr
13	9	N	Not working	Poor construction	**Drill new replac.**	20-60 m3/hr

18. Completion of Works

18.1 Notices of Approval

For each section of Works, the Contractor shall submit two draft copies of Technical Particulars for goods to be supplied under the Contract to the Engineer for his approval, prior to placing any order for purchasing the goods.

The Engineer will, within 14 days after receipt of the documents, either issue a Notice of Approval, or return a draft copy to the Contractor with noted objections.

If the draft copy is returned to the Contractor with noted objections, then the Contractor shall address the noted objections at his own cost. Thereafter, the Contractor shall resubmit the Technical Particulars at his own cost, and the procedures above shall be repeated.

If the Engineer fails to issue a Notice of Approval or fails to provide the Contractor of the draft copy with noted objections within 14 days after receipt of the documents, then the Contractor has the right to notify the Employer in writing that he deems the Technical Particulars to be approved, by Notice of Deemed Approved, as of the date of his notice.

Upon approval, whether by the Engineer or as deemed by the Contractor, the Technical Particulars for each section of Works shall be submitted as five copies to the Engineer as final version.

18.2 Notices of Acceptance

As soon as the goods for works under the Contract have been delivered to the Project Area for the eventual installation by the Contractor, to a site agreed with the Engineer prior to shipment, then the Contractor may notify the Engineer in writing.

The Engineer will, within 14 days after receipt of the Contractor's notice, perform final inspections of the delivered goods and either issue a Notice of Acceptance or notify the Contractor in writing of any defects and/or deficiencies.

If the Engineer notifies the Contractor in writing of any defects and/or deficiencies, then the Contractor shall correct such defects and/or deficiencies at his cost, and the procedures above shall be repeated.

If the Engineer fails to issue the Notice of Acceptance or fails to inform the Contractor in writing of any defects and/or deficiencies within 14 days after receipt of the Contractor’s notice, or if the Employer makes use of the delivered goods, then the Contractor has the right to notify the Employer in writing that he deems the supply of goods to be accepted, by Notice of Deemed Acceptance, as of the date of his notice.

18.3 Notices of Completion

The works shall not be considered complete, until the whole of the works have been completed as represented in the drawings approved by the Engineer. If the Employer makes use of the installation, to minimize shut-down of the system before the installation is wholly completed, then the Contractor shall provide complete and adequate protection of the installation to prevent any defects or vandalism of installed goods, until the moment when the whole of the installation is considered complete.

As soon as the Contractor considers each section of work to be completed, then the Contractor shall so notify the Engineer in writing.

The Engineer will, within 14 days after receipt of the Contractor's notice, either issue a Notice of Completion or notify the Contractor in writing of any defects and/or deficiencies.

If the Engineer notifies the Contractor in writing of any defects and/or deficiencies, then the Contractor shall correct the defects and/or deficiencies at his own cost, and the procedures above shall be repeated.

If the Engineer fails to issue the Notice of Completion or fails to inform the Contractor in writing of any defects and/or deficiencies within 14 days after receipt of the Contractor's notice, then the Contractor has the right to notify the Employer in writing that he deems the Works to be completed according to the requirements of the Contract, by Notice of Deemed Completion, as of the date of his notice.

19. Terms of Payment

19.1 General Provisions

The work under the Contract shall be paid according to the value of work executed by the Contractor, as determined by the Engineer and according to the Terms of Payment stipulated below, and according to the items, quantities and prices inserted in the Bill of Quantities for works under the Contract.

No payment made by the Employer shall be deemed as the completion of any performance of the Contractor's obligations.

19.2 Payment for Technical Particulars

The value of work executed by the Contractor shall be a proportion of the Lump Sum price of the Bill of Quantities, according to the ratio of the total value of the work executed for works under the Contract to the total value of the Bill for works under the Contract; excluding the value of any Dayworks to be executed for works under the Contract.

19.3 Payment for Working Drawings

The value of work executed by the Contractor shall be a proportion of the Lump Sum price of the Bill of Quantities, according to the ratio of the total value of the work executed for works under the Contract to the total value of the Bill for works under the Contract; excluding the value of any Dayworks to be executed for works under the Contract.

19.4 Payment for Method Statements

The value of work executed by the Contractor shall be a proportion of the Lump Sum price of the Bill of Quantities, according to the ratio of the total value of the work executed for works under the Contract to the total value of the Bill for works under the Contract; excluding the value of any Dayworks to be executed for works under the Contract.

19.5 Payment for Works

The value of work executed by the Contractor shall be sixty percent (60%) of the rates of the Bill of Quantities for the items of works for which delivery of goods have been accepted.

Acceptance of delivery of goods shall be determined either by the Notice of Acceptance of the Engineer or by the Notice of Deemed Acceptance of the Contractor. Such documents shall be attached to the Contractor's statement as a condition for the Engineer certifying the amount to be paid to the Contractor.

Any advance payment to the manufacturer for the supply of the goods shall be paid directly by the Employer to the manufacturer, against provision by the Contractor of an Unconditional Bank Guarantee in a form and by a bank acceptable to the Employer in amounts and currencies equal to the advance payment. The advance payment shall be repaid by deducting proportionate amounts from payments otherwise due to the Contractor.

The value of work executed by the Contractor shall be forty percent (40%) of the rates of the Bill of Quantities for the items of works which have been completed.

Completion of works shall be determined either by the Notice of Completion of the Engineer or by the Notice of Deemed Completion of the Contractor. Such documents shall be attached to the Contractor's statement as a condition for the Engineer certifying the amount to be paid to the Contractor.

19.6 Payment for Rehabilitation Works

The value of work executed by the Contractor shall be forty percent (40%) of the rates of the Bill of Quantities for the items of works for which delivery of goods have been accepted.

Acceptance of delivery of goods shall be determined either by the Notice of Acceptance of the Engineer or by the Notice of Deemed Acceptance of the Contractor. Such documents shall be attached to the Contractor's statement as a condition for the Engineer certifying the amount to be paid to the Contractor.

Any advance payment to the manufacturer for the supply of the goods shall be paid directly by the Employer to the manufacturer, against provision by the Contractor of an Unconditional Bank Guarantee in a form and by a bank acceptable to the Employer in amounts and currencies equal to the advance payment. The advance payment shall be repaid by deducting proportionate amounts from payments otherwise due to the Contractor.

The value of work executed by the Contractor shall be sixty percent (60%) of the rates of the Bill of Quantities for the items of works which have been completed.

The items of the Bill of Quantities for Rehabilitation of Meter and Valve Chambers shall be determined by the measurement of the surface area dimensions of the outer edges of the chamber top and of the depth from the outside top surface of the chamber to the inside floor bottom of the chamber, as determined by the Engineer.

Completion of works shall be determined either by the Notice of Completion of the Engineer or by the Notice of Deemed Completion of the Contractor. Such documents shall be attached to the Contractor's statement as a condition for the Engineer certifying the amount to be paid to the Contractor.

19.7 Payment for New Works

The value of work executed by the Contractor shall be the rates of the Bill of Quantities for the items and quantities of works which have been completed.

Completion of works shall be determined either by the Notice of Acceptance of the Engineer or by the Notice of Deemed Completion of the Contractor. Such documents

shall be attached to the Contractor's statement as a condition for the Engineer certifying the amount to be paid to the Contractor.

19.8 Payment for As-Built Drawings

The value of work executed by the Contractor for the provision of As-Built Drawings for works under the Contract shall be the Lump Sum price of the Bill of Quantities for As-Built Drawings when the As-Built Drawings have been approved.

Approval of As-Built Drawings shall be determined either by the Notice of Approval of the Engineer or by the Notice of Deemed Approval of the Contractor. Such documents shall be attached to the Contractor's statement as a condition for the Engineer certifying the amount to be paid to the Contractor.

20. STANDARD SPECIFICATION REFERENCE NUMBERS

(SSRN) INDEX

NUMBERS SUBJECT PAGE