



The Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT

Directorate of Water Development

EMPLOYER:	MINISTRY OF WATER AND ENVIRONMENT
PROJECT:	INTEGRATED WATER MANAGEMENT AND DEVELOPMENT PROJECT (IWMDP)
CONTRACT TITLE:	CONSTRUCTION OF THE ALA-ORA WATER SUPPLY AND SANITATION SYSTEM IN FOUR LOTS (4) LOT 3: ENYAU (Intake, Water Treatment Plant, Otumbari, Ndaapi and Mvepi 3) WATER SUPPLY AND SANITATION SYSTEM
COUNTRY:	UGANDA
PROJECT ID NO.	P163782
RFB NO.	LOT 1: MWE/WRKS/22-23/xxxx

BIDDING DOCUMENTS

VOLUME 3 – 3 TECHNICAL SPECIFICATIONS

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1 DESCRIPTION OF THE WORKS

1.1 LOCATION AND BACKGROUND OF THE PROJECT

The Ministry of Water and Environment has received financing from the World Bank toward the cost of the Ala-Ora Water Supply and Sanitation System and intends to apply part of the proceeds toward payments under the contract for the Construction of Enyau Water Supply and Sanitation System.

The construction works of Enyau Water Supply System in Ariwa and Uriama Sub-counties in **Yumbe and Terego District** in Northern Uganda.

1.2 THE SCOPE OF WORKS

The scope of work for the 2,977m³/ day water supply system is described below.

- **Intake works** comprising of a diversion weir across River Enyau, Intake channel, Intake sump and the raw water gravity main 6.9km with a flow rate of 237m³/hour with head difference of 15m.
- **Water Treatment Works** of 2,977m³/day output capacity comprising of reinforced concrete units including:
 - Twin chamber coagulation/Flocculation,
 - 2 No. Sedimentation Tank unit,
 - 2 No. Rapid gravity sand filtration unit,
 - Chlorination unit,
 - 60m³ underground treated water storage tank,
 - Coagulation and disinfection chemicals dosing units,
 - Sludge drying bed, and
 - 100
 - 50m³ hot pressed steel section panel backwash tank elevated 6m above ground level on structural steel support tower,
 - Air blowers for backwash system,
 - Buildings including:
 - 10.1 x 4.9m Generator and pump house for the backwash pumps and air blower
 - Office / Laboratory building
 - Site drainage works
 - External works including:
 - Access road and parking
 - Landscaping
 - Chain-link fencing on concrete posts,
 - Metallic frame gate and guard house
 - Walkways paved with 80mm thick pre-cast concrete pavers laid on well compacted gravel earth material and sand base material.
 - Stone masonry retaining walls
- **Power supply including:**
 - Generator set for emergency during backwash
- **Water tanks**
 - Hot pressed section steel panel water storage elevated tanks installed on metallic structures at the following location:

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Tank Name	Capacities m ³	Height from Ground m)
Tank 1	15	18m
Tank 2	222	15m
Ndaapi Tank 5	69	18m

- Transmission Pipelines**

Gravity mains	Nominal Diameter (mm)	Pressure Rating	Pipe Material	Length(m)	
Transmission line 1 (WTP to T-Jctn)	DN300	PN10	Steel	3,301	3,301
Transmission line 2 (T-Jctn to Tank 2)	DN100	PN10	Steel	144	144
Total Length of gravity transmission lines					3,445
PUMPING MAINS					
Pumping Main 1 (WTP to Tank 1)	OD50	PN16	HDPE	8,110	8,110
Pumping Main 2 (WTP to Existing Tank)	OD90	PN10	HDPE	408	408
Pumping Main 3 (WTP to Ndaapi Tank)	OD110	PN10	uPVC	8,670	8,670
Total Length of pumping transmission lines					17,188

- Distribution Pipelines**

The distribution pipelines are summarized below.

Supply Tank	Pipe Details	Length (m)	Length (m)	
Tank 1 Supply Area	OD 63/PN10	HDPE	100	900
	OD 50/PN10	HDPE	200	
	OD 40/PN10	HDPE	300	
	OD 32/PN10	HDPE	300	
Tank 2 Supply Area	OD 160/PN10	uPVC	4,176	18,498
	OD 125/PN10	uPVC	3,908	
	OD 110/PN10	uPVC	10,414	
Ndaapi Tank Supply Area	OD 90/PN10	HDPE	300	1,500
	OD 75/PN10	HDPE	200	
	OD 63/PN10	HDPE	500	
	OD 50/PN10	HDPE	500	
Existing tank Supply Area	OD 63/PN10	HDPE	1,000	2,000
	OD 50/PN10	HDPE	1,000	
Total length of distribution lines				22,898

- Service Connections**

- 760 service connections.
- 21 Public stand posts
- **Sanitation**
 - 1 No. Blocks of water borne toilets with septic tanks in public places. Each block consists of 2 stances with a bathroom and urinal for males 5 stances for females with a bathroom including 1 stance for persons with disabilities and a store.
 - 2 No. Blocks of lined VIP toilets in schools. The Girls block consists of 5 stances including 1 stance for persons with disabilities. The Boys block consists of 4 stances including 1 stance for persons with disabilities.
- **Water Offices**
 - 1 No. Water Offices Type 1

2 PARTICULAR SPECIFICATIONS

2.1 General Description of the Works

The Enyau Water Supply and Sanitation Project is located in Northwest of Kampala city, approximately 460 Km respectively from Kampala City for the supply area, in West Nile Region.

The Works include for the provision of all permanent and temporary material, equipment, tools, consumables, labour and supervision and all other resources necessary for the complete and proper execution of the Works as specified and in accordance with the Contract.

All goods and materials to be incorporated in the Works shall be new, unused, of the most recent or current models, and incorporate all recent improvements in design and materials unless provided otherwise in the Contract.

The Works comprise:

- **River Abstraction and Intake Chamber**
 - 40m long reinforced concrete Flow Diversion Weir.
 - Intake Chamber consisting of 2No. chambers of 1.0x1.0x2.4m (LxWxH) including 30 and 10mm aperture stainless steel Coarse and Fine Screens respectively.888
 - 6.9km DN300mm steel raw water gravity main
- **Construction of 2,977m³/d Water Treatment Plant**
 - 915m³ concrete in water retaining structures
 - 50m³ elevated pressed steel tank
 - 301m² single-storey buildings (5no)
 - Pumping plant; 2 x 1.79kW, 2 x 0.56kW, 2 x 6.84kW, 2 x 1.60kW and 2 x 11kW blower.
 - 2 x 65L/hr, 2 x 69L/hr and 2 x 125L/hr. gravity dosers.
 - Solar PV System
 - Array size – kWp
 - Panels - 69 Nr.
 - Array size (series x parallel) Varies with different demand.

	Array Size	
	Series	Parallel
High lift pumps (Existing Tank)	17	1
High lift pumps (Tank 1)	5	1
High lift pumps (Omugo)	17	3
Backwash pumps	15	1
Air blowers	4	1
Pumphouse (general purpose)	1	1
Administration block	6	1
Guard house	1	1
Superintendent's house	2	1
Attendant's Quarters	1	1

- **Laying of primary Transmission pipelines**
 - 3.301km DN300 PN10 Steel pipe gravity main.
 - 0.14km DN100 PN10 Steel pipe gravity main.
 - 8.67km OD110 PN10 uPVC pipe pumping main
 - 0.41km OD90 PN10 HDPE pipe pumping main
 - 8.13km OD50 PN16 HDPE pipe pumping main
- **Installation of Storage Reservoir Tanks**
 - 15m³ pressed steel reservoir on 18m steel tower.
 - 222m³ pressed steel reservoir on 15m steel tower
 - 69m³ pressed steel reservoir on 18m steel tower
- **Laying of primary distribution pipelines**
 - 4.2km OD160 PN10 uPVC pipe gravity main
 - 3.91km OD125 PN10 uPVC pipe gravity main
 - 10.4km OD110 PN10 uPVC pipe gravity main
- **Laying of secondary water distribution pipelines, service lines and consumer connections (Provisional Quantities)**
 - 5.3km HDPE PN10 (OD90 – OD32)
 - 47.5km HDPE PN16 service lines (OD25 – OD20)
 - 760 On-site Yard Tap water connections
 - 21 public multi-tap standpost
 - Supply of pipe fittings
- **Town Water Office**
 - 1nr building and ancillary structures
 - Supply of office furniture and equipment
- **Public Sanitation:**
 - 1nr public waterborne toilet block with ancillary services.
 - 2nr lined VIP Ventilated Improved Pit Latrines (VIPs) .

2.2 Setting out and Surveys of Properties, Lands and Crops

The Contractor shall be responsible for setting out the Works. The Contractor shall provide the Project Manager with the details of all the property that may be destroyed in the course of the execution of the works, four weeks prior to commencing works in the affected areas. The Employer shall not be held liable for any delays in the works arising from late presentation of this information to the Project Manager or delays arising out of inaccuracies of the information presented by the Contractor to the Project Manager.

2.3 River Flow Diversion Weir

The river flow diversion weir works are shown on drawings **ENY/INT-001**. The works comprise excavation to a level 1.5m below the current river bed level. It is envisaged that a cofferdam will be constructed for this work. The weir is of insitu reinforced concrete construction rising to elevation 0.1m above the weir in the intake chamber.

2.4 Raw Water Intake Structure

The raw water intake chamber works are shown on drawings **ENY/INT-002**.

The works comprise excavation to elevation 0.5m below current river level. It is envisaged that a cofferdam will be constructed for this work. The chamber is of insitu concrete construction rising to elevation 1.5m above highest recorded flood level.

The intake structure comprise of a 4.8m long x 1.0m wide rectangular training channel to direct flow into the 2nr. x 1.0 x 1.0m x 2.9m screening chambers (1nr. coarse + 1nr, fine). The training channel base is of two profile i.e a 1.5m long flat section at the beginning that flashed with the river weir upstream apron. The second section of the profile slants away from the intake chamber weir. The coarse screen chamber empties into the fine screen chamber through a DN300 penstock. The fine screen is to be fitted with a DN300 penstock for flushing/ cleaning and a DN300 steel raw water pipe with a corresponding strainer.

2.5 Raw Main

The details of the raw water gravity mains are given in the Drawing **ENY/RWM-001**.

The works comprise laying and testing 6.9km DN300mm pipeline from intake to the treatment plant. Majority of the works proceed through the wilderness with dense to light vegetation, rocky grounds and varying terrain which will require the Bidder to acquaint her/himself with the nature/ conditions of the route so as to come up with the competitive pipe laying rate. The Designer has carried out limited geotechnical investigation to guide the bidder on the nature of the ground.

The main is installed with DN50 double acting anti-shock air valves and washouts in DN80mm as appropriate.

2.6 Water Treatment Plant

The water treatment plant is drawings **ENY/WTP-001 to ENY/WTP-016**.

The plant is designed for 2,977m³/d operating on 24-hour basis to meet the maximum day demand and treatment plant use.

The system components are as follows:

- Raw water inlet
- Alum dosing
- Coagulation and Flocculation
- Sedimentation,
- Filtration and backwash,
- Disinfection, PH correction and contact tank,
- Wastewater clarification chamber.

- Sand storage
- Ancillary buildings and site works

2.6.1 Site Works

The site works are shown on the General Arrangement Drawing **ENY/WTP-001** series and include the following:

- The earthworks necessary for construction of the works.
- The inter-connecting pipework and channels
- Sampling points.
- Drainage.
- Road works.

Earthworks

The Contractor shall strip the topsoil from the site and set aside for re-use when landscaping on completion of the construction works. The Contractor shall excavate for the structures from the stripped surface level to the extent of the formation levels given in the drawings.

Inter-connecting pipework

The inter-connecting pipework shall be in Ductile Iron, uPVC or HDPE or PPR to the sizes given in the layout drawings.

A DN150 bulk water meter and butterfly valve shall be installed on the backwash water supply main to set the flow to the required rate. The meter shall accurately register within + 0.5% of the flow range.

All pipelines connecting to structures shall have flexible couplings outside the structures to take movements in the structures. This shall be of the Viking Johnson maxi type or similar.

Inlet Stilling Chamber

The raw water enters the treatment works through the Inlet Stilling Chamber. The chamber shall break the pressure of the raw water leading to the chamber for alum dosing.

Sampling taps

The Contractor shall install 4-nr standpipes of DN25 GI pipes (complete with fittings), to enable sampling through the treatment process. The standpipes shall rise to a height not exceeding 0.9m above the ground. The sampling points are on the following mains:

- Raw water main - 1nr.
- Clarified water line – 1nr.
- Filtered water line – 1nr.
- Treated water main – 1nr.

Drainage

Drainage pipework shall be provided to take all the overflows, washwater and drains from the structures. The drains shall be laid to even fall, and shall ensure a velocity of at least 1m/s. The manholes shall be finished at least 0.3m above the general ground.

The Contractor shall construct a 2nr. septic tank with soak pit to take the wastewater from the Office block and Staff Housing and Chlorine House respectively.

Sludge drying beds

The Contractor shall construct 2nr. 3.0 x 3.0 x 1.8m dewatering and sludge drying beds to handle the chemical wastewater and overflows from treatment works. Details are shown in Drawing **ENY/WTP-011**.

Roads and parking areas

The Contractor shall construct the road and parking areas within the Treatment Plant as shown on drawings to give a final surface of concrete pavers and lined with precast concrete road kerb at the edges. The roads and parking areas shall be constructed on firm ground base. Where an imported sub-base is required, this shall be compacted as provided for in the general specifications. The works shall be laid out to enable rapid drainage of run-off, and at the appropriate location, drainage channels and culverts shall be provided.

Site security

The site shall be fenced and provided with a vehicular and pedestrian access gate, as shown in the general drawings **ENY/WTP-001**.

2.6.2 Alum Dosing Platform, Flocculator and Sedimentation Tanks

Details of the Alum Dosing Platform, Flocculator and Sedimentation tank are shown on drawings **ENY/WTP/003 to ENY/WTP-005**.

The alum dosing platform is a reinforced structure with timber roof structure and clay roofing tiles. The floor is to be treated with a floor sealer as *Sikafloor® Proseal* installed as per manufacturer's instructions. The platform houses the mixing tanks and doser.

Chemical storage will be in two separate buildings of the following storage areas:-

- Alum – 10m², single room.
- Chlorine – 15.4m² and Soda ash – 15.4m² on one building with separate rooms for each chemical.

Chemical mixing will be carried out every 24 hours. Both alum and chlorine stock solutions will have a strength of 10%, whereas soda ash will have a strength of 1%

Each chemical shall be provided with two mixing tanks and two dosers on a duty/ standby basis. The tanks will be of reinforced concrete and lined with acid resistant ceramic tiles. Alum tanks area 1.3 square x 1.2m deep and Soda ash as well. The jointing material shall be similarly acid resistant, and the concrete and mortar shall be made from sulphate resistant cement. The mixing tanks will be provided with:

- Level indicator in each tank

- dissolving tray with stainless steel mesh suitable for chemicals
- manual paddle mixers to suit the mixing tank size.

The dosers for each chemical will be gravity solution-feeders constructed in chemical resistant plastic and interconnected to operate on a duty/ standby principle. Preliminary settings for the dosers are 65l/h for alum, 69l/h for chlorine and 125l/h for soda ash.

The alum dosing shall be carried out into the channel at the weir plate where maximum turbulence occurs.

The following equipment and chemicals shall be supplied in the Alum store.

Equipment and chemicals to be supplied

Item	Description	Unit	Quantity
1	Equipment		
1.1	Platform/beam type weighing machine as made by AVERY® or approved equivalent to weigh up to 200 kg with a resolution of 100 gm with a chemical resistant finish complete with all accessories	Nr.	1
1.2	Stainless steel graduated (metric) buckets (10 litres)	Nr.	2
1.3	Stainless steel scoops for scooping chemicals - 1 kg capacity	Nr.	2
1.4	Steel wheelbarrow for transporting chemicals	Nr.	1
2	Chemicals		
2.1	Aluminum sulphate in 50 kg bags	No.	210

Flocculator

The flocculator will have two tanks (duty/ standby comprising 5nr. compartments each 1.1m, effective depth 2.7m and length of 2.68m

The Flocculator is a four -stage vertical-flow baffled chamber designed with the following parameters:

Parameter	Section 1	Section 2	Section 3	Section 4
Velocity gradient (s ⁻¹)	0.326	0.247	0.197	0.163
Number of ports in baffle walls	6	8	10	12
Headloss (m)	0.011	0.0064	0.004	0.0028

Sedimentation Tanks

The sedimentation tanks consist of horizontal-flow rectangular chambers designed with the following parameters:

Parameter	Values
Dimensions (m)	L = 14.4. W = 4.8, D _e = 2.6
Number of tanks	2 nr
Detention time	2.9 h

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Surface loading rate	1.8 m ³ /m ² h
Weir overflow rate	3.6 m ³ /m h
Sludge withdraw	8min/day, manual through a DN150

De = Effective depth

2.6.3 Filters

Filtration is by rapid gravity filters. Details are given in drawings **ENY/WTP-006**.

The design is based on the following parameters:

Parameter	
Dimensions (m)	L = 3.1, W = 3.1, D _w = 3.3
Number of filters	2 nr
Filtration rate	6.5 m ³ /m ² .h
Filter sand size	0.5 – 1.0 mm
Filter sand uniformity coefficient	1.3
Thickness of filter sand	0.8 m
Thickness of filter support gravel layers	1.0 m
Underdrain system <ul style="list-style-type: none"> • Nozzles • Laterals • Manfold 	12mm dia @ 150 centres OD50mm dia @ 300mm centres DN315
Backwash <ul style="list-style-type: none"> • method • air scour rate • washwater rate 	3min air scour then 8min water 4.8 m ³ /min 0.05 m ³ /s

Dw = Water depth

Prior to commissioning each filter shall be backwashed and the media skimmed, if necessary, such that the proportion of fines in the top 150 mm does not exceed 5%. The depth of media lost by skimming and any media lost during commissioning shall be replaced by the Contractor at his own expense.

The Contractor shall provide filter support bed of grading compatible with the filter. The quality criteria for the support bed shall be similar to that of the filter bed.

Cleaning will be by air scour followed by wash water. Air will be provided by air blowers in the pumphouse. The wash water will be taken from a backwash tank. The pressure and flow will be regulated by a butterfly valve. A flow meter will be fitted on the backwash line. The operation of the filters will be entirely manual.

Backwash Tank

The Contractor shall install a 50 m³ elevated tank to provide filter washwater and service water adequate for 3nr. filter washes per day. Details of the tank are given in Drawing **ENY/WTP-010**.

The tank shall be made from hot pressed galvanized steel panels to BS 1564 Part 1 or similar. This shall be on an elevated steel tower 6 m tall. The Contractor shall submit the design of the support structure to the Project Manager for review.

Filling of the tank will be within 3 hours using pumps drawing from the Clear Water Tank. Two backwash pumps (duty and standby) will be provided, each with an output of 17 m³/h.

2.6.4 Clear Water Tank and Chlorine/ Soda Ash mixing and Dosing Platform

The Clear Water Tank shall have one compartment provided with baffle walls as shown on Drawings **ENY/WTP-008**.

The tank shall be provided with internal access ladders at each of the access/ inspection covers. These shall be galvanised to protect them from rusting. Roof vents of diameter not less than DN 150 shall be provided as shown in the drawings. These shall be vermin proofed and fitted with corrosion resistant mosquito proof fabric. They shall be of such design as not to allow surface run-off to gain access to the tank.

A roof-mounted level indicator shall be provided for each tank compartment and shall have metric graduations. All the components of the level indicator shall be rust proof and be made from durable materials.

2nr. access covers shall be provided at roof level for the tank compartments as shown in the drawings. These shall be raised against the general level of the roof to stop roof run-off from entering the tank.

The Chlorine and Soda Ash platform contains the mixing tanks and dosers as shown on Drawings **ENY/WTP-007**. The platform is reinforced concrete and roof structure overlain with clay roofing tiles. The floor is to be treated with a floor sealer as *Sikafloor® Proseal* installed as per manufacturer's instructions.

Chlorination and PH correction shall be separately carried out by calcium hypochlorite and soda ash solutions. The chlorine and soda ash solutions shall each be prepared in two mixing tanks for which shall be of reinforced concrete and lined with acid resistant ceramic tiles jointed in sulphate resistant cement. Each mixing tank will be provided with level indicator, glass reinforced plastic (GRP) dissolving tray with stainless steel mesh suitable for chemicals.

The gravity chlorine and soda ash dosers, operating on duty/ standby basis, as *Grundfos® DDI* or approved equal will be set to a preliminary dosage of 69l/h and 125l/h respectively. Chemical resistant plastic pipework, interconnected to allow duty/standby operation, shall be installed to the clear water tank points of entry of filtered water.

The following equipment and chemicals shall be supplied in the Chlorine/ Soda Ash store.

Equipment and chemicals to be supplied

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Item	Description	Unit	Quantity
1	Equipment		
1.1	Platform/beam type weighing machine as made by <i>AVERY®</i> or approved equivalent to weigh up to 200 kg with a resolution of 100 gm with a chemical resistant finish complete with all accessories	Nr.	1
1.2	Stainless steel graduated (metric) buckets (10 litres)	Nr.	2
1.3	Stainless steel scoops for scooping chemicals - 1 kg capacity	Nr.	2
1.4	Stainless steel wheelbarrow for transporting chemicals	Nr.	1
2	Chemicals		
2.1	Calcium hypochlorite (HTH) 60-70% content of chlorine in 50 kg barrels	Nr.	30
2.2	Soda ash in 50kg bags	Nr	90

2.6.5 High Lift Pumphouse

The Pumphouse shall house the high lift pumps, backwash pumps and air scour blowers and motor control centre. Details are given in drawing **ENY/WTP-009**.

The building is a blockwork construction. Roof is roof timber structure overlain with clay roofing tiles. The floor are to be treated with a floor sealer as *Sikafloor® Proseal* installed as per manufacturer's instructions.

8 high lift pumps will be installed in the pump house to operate on 4 duty/ 4 standby basis. The pumps are rated as follows:-

- 2nr. x 13m³/h, 29m Head and 1.5kW motor
- 2nr. x 17m³/h, 20m Head and 2.2kW motor

Pumping is designed on 22-h basis. The suction and delivery pipework are ductile iron fitting with pressure gauges and gate valves.

The main are each fitted with recoil non-return valve, electromagnetic flow recorder, air valve and surge relief valve with blow off.

Suctions pipework are a common DN100 to each set of pumps that split to connect to the duty and standby. Delivery pipework to each pump are:-

- DN50 delivery main to the Existing 90m³ Tank.
- DN150 delivery main to the 15m³ Tank 1.
- DN100 delivery main to the 202m³ Tank 2.
- DN300 delivery main to the 380m³ Tank 3.
- DN150 delivery main to the 296m³ Tank 4.
- DN100 delivery main to the 69m³ Ndaapi Tank 5

2nr. blowers will be installed in the pump house to operate on 1 duty/ 1 standby basis. The blowers are rated 11.0kW each.

2.6.6 Treatment Plant Power Source

Power is to be provided from solar PV system of the following details

- Array size – 38.59kWp
- Panels - 69Nr. x 270Wp
- Array size (series x parallel) – Varies with different demand.

	Array Size	
	Series	Parallel
High lift pumps (Existing Tank)	17	1
High lift pumps (Tank 1)	5	1
High lift pumps (Omugo) Ndaapi	17	3
Backwash pumps	15	1
Air blowers	4	1
Pumphouse (general purpose)	1	1
Administration block	6	1
Guard house	1	1
Superintendent's house	2	1
Attendant's Quarters	1	1

2.6.7 Office, Laboratory and Workshop Building

The Office block is detailed in Drawing **ENY/WTP-013**.

The Office block shall house the general purpose office, laboratory and workshop. The building is rendered blockwork construction with steel casement doors and windows, timber roof structure with clay roofing tiles and floors sealed with *Sikafloor® Proseal* to manufacturer's recommendation. The building finishes shall conform to the requirements of the General Specifications with the following additional requirements for the Laboratory and Workshop

- Terrazzo floor finish
- Workbenches shall be concrete slab finished in terrazzo with solid timber cabinets provided below the worktop
- The Laboratory workbench shall have a deep ceramic sink with a single drainer; 1nr. 13 mm swan neck stainless steel taps and glazed white ceramic wall tiles to a height of 0.5 m above the worktop.
- Water supply connections to sink unit and separate cold water supply to water still located near the sink, reachable by tubing and power supply socket.
- Wooden stool seat compatible with height of the workbench.
- Wall mounted shelving units in hardwood timbers fixed to the wall with brackets
- Floor drains with trap and cast iron grating/ plastic floor trap flush with the floor, draining to the site main drainage system.
- Soft board notice board fixed to the wall, area 0.5 m².

- Three coats of clear polyurethane varnish to exposed hardwood timbers and surfaces of shelves and bench supports.
- Emergency equipment to be installed – fire extinguishers of water and carbon dioxide

Office Equipment, Laboratory Equipment and Tools to be supplied

The Office, Workshop and Laboratory shall be provided with new equipment and tools of approved quality and finish. according to the following technical requirements. Items to be supplied shall be of approved quality and finish.

Furniture and Equipment for the Treatment Plant Office

Item	Description	Unit	Quantity
1	TOWN OFFICE FURNITURE AND EQUIPMENT		
1.1	Writing desk 1,560 x 780 x 750 mm (L x W x H) with 4 lockable drawers	No.	2
1.2	Steel office chairs with padded seat and back in black rexine	No.	2
1.3	Steel cabinet 1,950 x 950 x 420 mm (L x W x H) with 4 shelves; colour: grey double lockable doors,	No.	1
1.4	Lockable steel filing cabinet with 4 drawers	No.	1
1.5	Hardwood bookshelf 1.5 x 1.5 x 0.35m	No.	1
1.6	Computer Workstation as HP Pavilion All-in-one 24 Core i7, 8 GB RAM, 1 TB hard disk	No.	2
1.7	LaserJet Printer as HP Laserjet Pro P1102 or approved equal	No.	1
1.8	Office Safe 700 x 500 x 500mm (H x W x Depth)	No	1

2.6.8 Mechanical and Electrical Works

Equipment to be supplied - The bidder must submit with its bid the completed_Technical Schedules TS-1 stating details of the equipment to be supplied together with a priced schedule TS-2 itemizing the manufacturers’ recommended spare parts for two years operation.

2.6.9 Treatment Plant Attendants’ Housing

The Contractor shall construct a 3nr. Houses i.e., Superintendent’s house, Attendants Houses and Guardhouse as shown on Drawings **ENY/WTP/014 to ENY/WTP/016**.

Buildings shall be rendered blockwork on concrete slab with steel casement windows and doors, timber roof structures and clay roofing tiles. Building finishes shall be as detailed in the General Specifications.

2.7 Access Road to Treatment Plant Site

The access is an extension of an existing road. The existing road measuring some 4km from main access road and this shall be shaped as directed by the Project Manager and culverts installed as appropriate with additional gravel layers installed and compacted.

2.8 Pumping Main to Existing 90m³ Tank.

The details of the pumping mains are given in the Drawing **ENY/PM-001**

The works comprise laying and testing 0.4km OD90 HDPE PN10 pipe from treatment plant to the existing 90m³ reservoir site. All works to proceed through subsistence farmlands which will require the Contractor to make provision access properties along the route.

The main is installed with DN50 double acting anti-shock air valves and washouts in DN80mm as appropriate.

2.9 Pumping Main to Ndaapi

The details of the pumping mains are given in the Drawing **ENY/PM-002**

The works comprise laying and testing 8.13km OD50 HDPE PN16 pipe from treatment plant to Tank 1 reservoir site. All works proceed along existing roads which will require the Contractor to make provision for traffic control and access properties along the route.

The main is installed with DN80 double acting anti-shock air valves and washouts in DN100mm as appropriate.

2.10 Pumping Main to Tank 1

The details of the pumping mains are given in the Drawing **ENY/PM-003**

The works comprise laying and testing 8.67km uPVC OD110 PN10 pipe from treatment plant to Ndaapi reservoir site. All works proceed along existing roads which will require the Contractor to make provision for traffic control and access properties along the route.

2.11 Gravity Transmission

Section	Pipe details	Length, m
WTP to tee	DN300	3,301
Tank 2 supply line	DN100	144

Details are shown in drawings **ENY/GTM-001**

The pipeline is installed with DN50 double acting anti-shock air valves and DN100 washouts as appropriate.

2.12 Reservoirs

Details of the reservoirs are given in Drawings **ENY-RES-MVP-001, ENY-RES-MVP-002 and ENY-RES-MVP-005.**

The site works at the reservoir site shall consist of general earthworks, pipework, site drainage and

fencing.

The reservoirs are elevated hot pressed steel plate tank of capacities and elevations indicated below. The Contractor shall excavate the site to the extent of the formation level of the tank foundations. The excavated topsoil shall be reserved for filling within the site, landscaping, and the balance disposed of. The Contractor shall identify his own disposal sites. The site shall be dug up, raked level and grassed.

The tank shall be provided with internal and external access ladders, vermin-proof vents and access manholes. Pipework to and from the reservoir shall be in steel in sizes given in the table below.

Reservoir pipework sizes to each compartment

Item		Tank 1	Tank 2	Ndaapi Tank 5
Capacity	(m ³)	15	222	69
	1.22m Plates	3 x 3 x 1	7 x 6 x 3	5 x 4 x 2
Elevation		18	15	18
Inlet		DN150	DN100	DN100
Outlets		DN200	DN100	DN100
Overflow		DN150	DN100	DN100
Washout		DN150	DN100	DN100
Bulk Water Meters	Nr.	1	1	1

The pipework shall be provided with altitude valves on the inlet and gate valves on each outlet pipe.

The outlet pipe shall be connected into transmission main that will be installed with Woltman type bulk water meter complete with strainer. Meters are to be housed in in-situ concrete chambers. The meters shall registrar accurately to within +5%.

All the drains and overflows from the reservoir shall be directed to natural drainage courses and away from properties. All above ground pipework shall be in steel.

The site shall be fenced and provided with a vehicular and pedestrian access gate, as shown in the general drawings **ALA-ORA/SD-012**

2.13 Water Distribution System

2.13.1 Primary Distribution System

Details of the primary distribution systems are given in Drawings **ENY/DIST-001 SERIES**. The pipe sizes and lengths are summarized in the table below.

Primary distribution pipelines

Supply Tank	Pipe Details	Length (m)	Length (m)	
Tank 1 Supply Area	OD 63/PN10	HDPE	100	900
	OD 50/PN10	HDPE	200	
	OD 40/PN10	HDPE	300	
	OD 32/PN10	HDPE	300	
Tank 2 Supply Area	OD 160/PN10	uPVC	4,176	18,498
	OD 125/PN10	uPVC	3,908	
	OD 110/PN10	uPVC	10,414	
Ndaapi Tank Supply Area	OD 90/PN10	HDPE	300	1,500
	OD 75/PN10	HDPE	200	
	OD 63/PN10	HDPE	500	
	OD 50/PN10	HDPE	500	
Existing tank Supply Area	OD 63/PN10	HDPE	1,000	2,000
	OD 50/PN10	HDPE	1,000	
Total length of distribution lines				22,898

The Contractor must give at least a week's notice before commencing work on any road crossings and the roads shall be reinstated to the satisfaction of the Local Authority responsible for the roads.

2.13.2 Secondary Distribution and Service Connections

Provisional quantities of materials for secondary distribution pipework and service connections.

Secondary Distributions	Length (m)
OD90 PN 10	500
OD75 PN 10	400
OD63 PN 10	1,800
OD50 PN 10	2,000
OD40 PN 10	600
OD32 PN 10	1,000
Total	6,300
Service Lines	
OD25 PN 16	3,100
OD20 PN16	44,400
Total	47,500
Yard Tap connections	760
PSPs	21

The decision to lay this pipework is demand driven as determined by applications for the water supply connections. This process will commence after construction commences.

The Project Manager will determine the final quantities required and direct the Contractor to order them. The Contractor shall not place orders for the materials for secondary distribution pipework and service pipes until the layouts have been determined by the Project Manager and he receives an instruction from the Project Manager to that effect.

The Project Manager will issue a list of properties requiring consumer water connections to be made. The Contractor shall install these consumer connections complete with consumer meter and tapping the primary lines and laying of the service pipes, to the identified properties. The details of the consumer connections shall be as shown on drawings **ALA-ORA/SD-014**. Public Standpost (PSP) details are shown on drawing **ALA-ORA/SD-015**.

2.13.3 Supply only of Pipe Fittings

Bills also contain items for supply only of pipe fittings for mains repairs and consumer connections. These items are to be delivered and stored at the Town Office at completion of the Works.

2.14 Town Water Office

The Contractor shall construct 1No. Town Water Office (Type 1) at locations shown by the Employer and as detailed in Drawings **ALA-ORA/SD-016A**

The building shall be provided with solar based electricity, water supply and on-site sewage facilities (septic tank and soak pit).

The office shall be equipped with furniture and equipment of approved quality and finish.

Furniture and Equipment for the Town Water Office

Item	Description	Unit	Quantity
1	TOWN OFFICE FURNITURE AND EQUIPMENT		
1.1	Writing desk 1,560 x 780 x 750 mm (L x W x H) with 4 lockable drawers	No.	2
1.2	Steel office chairs with padded seat and back in black rexine	No.	2
1.3	Steel cabinet 1,950 x 950 x 420 mm (L x W x H) with 4 shelves; colour: grey double lockable doors,	No.	1
1.4	Lockable steel filing cabinet with 4 drawers	No.	1
1.5	Hardwood bookshelf 1.5 x 1.5 x 0.35m	No.	1
1.6	Computer Workstation as HP Pavilion All-in-one 24 Core i7, 8 GB RAM, 1 TB hard disk	No.	2
1.7	LaserJet Printer as HP Laserjet Pro P1102 or approved equal	No.	1
1.8	Office Safe 700 x 500 x 500mm (H x W x Depth)	No	1

In addition to details shown on drawings, buildings shall have:

- toilets and washroom walls and floors tiled with ceramic tiles of approved colour
- the ceilings shall be in approved expanded metal lathe plaster sand ceiling
- all the external windows and doors shall be burglar proofed minimum 16mm bars at 150mm centres to the Project Manager's satisfaction
- the whole building shall be painted and decorated
- installed electricity, water supply and on-site sewerage systems

2.15 Public Sanitation

The Contractor shall construct 1nr. waterborne toilet block and 2nr VIP latrines at locations designated by the Employer. The buildings will be complete with solar based electricity, water supply and on-site sewerage.

The structures are shown in drawings **ALA-ORA/SAN-001 series**.

2.16 Drawings, Documents and Maintenance Scheme

2.16.1 Contract Drawings

- (1) The Contractor shall submit to the Project Manager in triplicate the following drawings for approval:
 - (a) Electrical Drawings: On the basis of the simplified documents, the Contractor shall prepare the following planning records as supplements to the VOB DIN 18382 Standards:

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

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

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

- (b) Copies of proposed panel layouts other than specified.
- (2) Two copies will be retained for record purposes while one copy will be returned to the Contractor stamped "APPROVED" and/or supplement with any necessary modifications or revisions. The Contractor shall provide four further copies of finally approved drawings.

2.16.2 Record Drawings

- (1) Within a period stated in the Contract following the issue of the "Take-over" Certificate the as-built drawings shall be provided. Three sets shall be prints of:

- (a) Works and general site layout,
- (b) As-constructed drawings,
- (c) Comprehensive diagrams for the control panel showing scheduled functions and diagram of connection,
- (d) Overall mechanical/electrical and control schedules for the Works with details of interconnections between the various units of the plant,
- (e) Actual (not typical) section drawings where applicable,

2.16.3 Operating and Maintenance Manuals

- (1) Comprehensive operating and maintenance manuals in English language covering all items of Plant and including all manufacturers' instruction, references, lists, etc. shall be compiled. The manuals have to cover the pumping station and the treatment plant.
- (2) The manuals shall be submitted in five copies and shall cover the testing, operation, control, maintenance, dismantling and repair of all the Plant provided in the Works.

All information shall be supported by:

- Catalogues and brochures,
- Dimension drawings,
- Data sheets,
- Descriptive text,
- Comprehensive drawings, sketches, plans, sections as required.

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

- (3) It is emphasized that a collection of standard pamphlets of general nature unaccompanied by drawings and descriptive matter will not be acceptable. In particular, information supplied by Sub-Contractors and manufacturers employed by a Contractor shall be coordinated in the comprehensive manual. Cross-references of descriptive texts, drawings and spare part lists must be complete.
- (4) The Contractor shall deliver to the Project Manager in duplicate loose leaf copies of draft operational and maintenance manuals for the Plant two months before commissioning of the works. The manuals shall be divided into several volumes (e.g. function, operation, maintenance, overhaul) and shall fully and clearly set out the Contractor's own recommendations and instructions for the satisfactory operation, maintenance and overhaul of the Plant as applicable to each of the installations and devices supplied.
- (5) Draft manuals shall, during the testing and commissioning of the Works, be carefully checked by the Contractor and updated and modified to ensure that they are fully descriptive and applicable to the final lay-out of plant and process under operational conditions.

- (6) The draft manuals may include manufacturer's standard literature, but the Contractor shall fully supplement the literature by his own descriptive text, drawings, tables, figures, characteristic curves and the like.
- (7) The final approved manuals for the Works shall be submitted prior to the commencement of the Period of Maintenance. They shall be securely bound in A4 sized loose-leaf binders, clearly titled, index linked and cross-referenced.
- (8) If during the Period of Maintenance, the Contractor or the Project Manager has found that the manual should require modification or enlargement as a result of subsequent operational and maintenance experience in the Works, the Contractor shall provide the approved modification for each manual.

- The manuals shall include explanations of the function and purpose of each it

3 GENERAL CLAUSES & MATERIALS AND WORKMANSHIP

3.1 GENERAL CLAUSES

3.1.1 Definitions

In the Specifications (as hereinafter defined) the following words and expressions shall have the meanings hereby assigned to them.

- (a) "Specification" means this Specification together with the technical details given in the Bill of Quantities and, subject to the Engineer's approval, the Contract Drawings, Specifications, and technical details.
- (b) "Provided" and its derivatives means the complete design, manufacture, delivery, installation, testing and commissioning of the works, inclusive of such ancillary services as inspection and witnessed testing at the places of manufacture, workshop and site painting, handling on site, site trials and all such other services as are noted in the Specification or reasonably necessary for the safe, reliable and efficient completion of the Contract.
- (c) All references to the "Supervisor's Representative" in the Conditions of Contract and "Engineer" in the Specifications are synonymous and refer to the same designated person.

3.1.2 Climatic Conditions

The climate of the district is modified by the swamps surrounding the district. The rainfall is bi-modal with one peak during April - May and the other in August - October. The average annual rainfall in the district varies between 1,200 - 1,600 mm. The average minimum and maximum temperatures are 22.5°C and 33.6°C, respectively. The rain is usually convectional. Wind speed is lower during the rainy season with 1-4m/sec, compared to 4-8 m/sec in the dry season. With evaporation of more than 1800mm/year, soils retain moisture for short periods during the rainy season.

More detail information and meteorological data can be obtained from the concerned Department of Meteorological Services.

3.1.3 Extent of Contract

The works include civil works, procurement of pipes, pipework fittings and other materials and accessories, delivery to site, storage, installation/incorporation into the works, testing, commissioning, defects liability period 6 months of the works described and instruction of the staff in operation and maintenance procedures.

3.1.4 Schedule of Works

The scheduling of the works is to ensure that the works are executed timely and existing water supply is not allowed to drop below normal operating capacity at any time.

3.1.5 Work to be done

The work to be done under this Contract shall consist of the supply of all materials, plant, equipment and labour necessary for the complete construction and placing in operation

of all related work as shown on the Contract Drawings, specified herein or both and in accordance with the terms of this Contract and the requirements of the Employer and as instructed by the Engineer.

Without in any way limiting the scope of the forgoing, the work to be done shall, in general, include: the supply of all materials, the delivery, off-loading, transporting, hauling, stocking and installing of all materials and equipment, the constructing and maintaining of temporary structures, maintaining of all means of access, doing all clearing, grubbing, excavation, pumping, hailing, ditching, draining, sheeting, shoring, bracing and supporting, pipe bedding, backfilling, compacting, grading, ditching and disposal of excess excavated material; all pipe laying, jointing, testing and repairs, all formwork, false work and carpentry work, steel work, concrete and miscellaneous metal work, building, mechanical, electrical and control, and all clearing away and disposal of wastes, rubbish and surplus material, site cleanup and restoration work, and doing all other things necessary to complete the work to put into satisfactory operation all as specified herein and/or as shown on the Drawings.

3.1.6 Documentation and Submission to be provided

During the course of the Contract the Contractor shall furnish three copies of each of the following contract records to the Engineer for his review and approval:

- Technical information and specifications of all Mechanical and Electrical Equipment;
- Samples, test results, specifications, grading, etc. of all construction materials and equipment, concrete mixes, and reinforcement;
- Proposals for any temporary works, drainage, de-watering and non-permanent support to structures;
- Sub-orders for plant, materials and services. Where specialist manufacturers or sub contractors are declared in the Tender, the Contractor shall be confined to those for materials, plant and services in respect of which the Engineer's approval has been given. Three copies of each suborder, (inclusive of supporting documents to which it may refer) and of any amendments thereto shall be furnished to the Engineer immediately upon issue and each shall state clearly the contract title and the item or drawing reference, or other means of identification;
- Monthly progress reports of work in hand under the Contract, at manufacturer's work and elsewhere. The reports shall be in an agreed format, shall be issued before the 14th of each month and shall give details of progress with the Contract during the preceding month, including production status of drawings, manufacture, order, stocks of materials, shipping, delivery, erection, testing and commissioning;
- Progress schedules, to the Engineer's requirements indicating the planned dates of commencement and completion of installation for each portion of the work. These schedules, submitted at the Engineer's instructions shall be furnished in accordance with the conditions of Contract and as instructed by the Engineer.
- Day to day diary sheet recording Contractor's labour, equipment, plant, deliveries to, and work executed on Site, weather conditions, etc; and
- Other items as specified or required by the Engineer.

The Contractor shall furnish the programmes required by the Contract in triplicate.

The programme shall be in the form of a critical path network and Bar Charts capable of being monitored and updated continuously during the progress of the Contract. The programme shall show inter alia:

1. The dates by which the Contractor requires information from the Engineer in respect of further detailed Drawings.
2. The dates on which the Contractor will require access to the various works Areas and the period of time during which he will require occupation and all other similar constraints which will affect his activities.
3. The dates by which the Contractor intends to complete the Works.

The network and Bar Charts or another similar network shall describe major plant allocations and requirements.

Each month throughout the construction period the Contractor shall submit to the Engineer further copies of the programme marked to show the progress to date together with any revisions to the programme which he proposes to make. These marked programmes shall be submitted one week before the site progress meetings.

Method Statements

Before any particular, major or critical activity is commenced the Contractor shall provide the Engineer with triplicate copies of his proposals for execution of the activity including details of the major items of plant and operatives which it is intended to utilise for the Engineer's consent.

This information shall be supplied sufficiently in advance of the activity commencing that the Engineer may study, discuss and comment on the proposals and the Contractor may thereafter amend his proposals accordingly.

No work shall be put in hand without the prior written consent of the Engineer which consent shall not relieve the Contractor of any of his obligations and liabilities under the Contract.

Daily Returns

The Contractor shall supply by 12 noon on every working day, the following daily Returns as may be required by the Engineer.

1. A list of the labour employed on the previous day specifying the number employed in each trade and subcontract labour.
2. Total daily output of main production centres for the previous day.
3. Labour, plant and materials used on day work.

Weekly Progress Summary and Programme

The Contractor shall supply to the Engineer on the first day of the week:

1. A schedule of the main work items in each section of the Works showing quantitative progress during the previous week and cumulative progress to date.

2. (By 12 noon) his detailed intended programme of work for the current week.
3. Summary of Plant and Labour.

Monthly Progress Report

The Contractor shall submit to the Engineer, not later than the first week in every month, a progress report for the previous month which shall include the following items and information:

1. The marked-up programme submitted at the progress site meeting amended, (if necessary) to indicate agreed revisions.
2. Weather conditions (daily temperature range and rainfall).
3. Summary of staff and labour employed on Site.
4. Schedule of constructional plant on site including dates of arrival and departure of items.
5. Summary of principal materials and manufactured items:
 - ◆ placed on order, and
 - ◆ delivered to site.
6. Record of site safety.
7. Record of site security.

3.1.7 Drawings and Documents - Format

All drawings, dimensions, calculations and information furnished in connection with the Contract shall be expressed in SI units.

The drawings shall be sized to designations A1, A2, A3, and A4 of Section 2 BS 3429: Sizes A0 and above shall not be used. Each drawing shall carry the project title, the name of the Employer, the name of the Engineer, the Contractor together with the drawing title and number and other relevant data, in the lower right-hand corner.

3.1.8 Contractors Staff

The Contractor and any Sub-Contractor engaged upon the execution of the Works shall be deemed to employ, or to procure the employment of, staff skilled and experienced in works of a similar nature to the Works and jointly and severally they shall be responsible for the provision of safe, reliable and efficient Plant such as will ensure its precise and safe operation under all conditions, and shall provide all plant and services reasonably necessary for the complete setting to work and performance of the works whether or not specifically mentioned in the specification, Bill of Quantities or indicated on the Drawings.

3.1.9 Protection and Repair of Construction

All works shall be protected and should the Contractor fail to adequately protect any parts of the works and they become heaved, cracked or otherwise damaged, all such damaged portions of the work shall be completely repaired and made good by the Contractor at his own expense.

3.1.10 Protection of Utilities and Adjacent Structures

The Contractor shall, as part of his unit costs and in a manner approved by the Engineer, sustain in their place and protect from injury any and all water mains, public or private sewers or drains, conduits, service pipe, pavement, power lines, telephone lines, fences, sidewalks, kerbs and all other structures or property in the vicinity of his work, whether

over or under ground, or which appear in the excavation, and he shall assume all costs and expenses for such support and for damage which may be occasioned by injury of any of them.

It is the Contractor's responsibility to verify the location of all underground and overhead services with the various companies, Corporations or Utilities controlling these services and to determine the exact location, size and number of such services prior to start of trenching operations.

Should any drains, connections, sewers, culverts or any other utility, within the limits of this Contract be unexpectedly encountered, the Contractor shall immediately notify the Engineer, in writing, if the drains etc. are in the line of the water main, sewer or structure and thus prevent construction.

If, in the opinion of the Engineer, such services in the line prevent the laying or construction of the structure, realignment and/or replacement shall be made and the cost of such shall be born by the Employer.

3.1.11 Working Areas

The Contractor shall confine his operations to the working areas within the boundaries of the site as shown on the Drawings. The Site shall mean the extent of such public and private lands as is in the opinion of the Engineer necessary or practicable for the construction of the works. The Contractor shall not use the Site for any purpose not required by the Contract.

In no case shall the Contractor occupy private property without the approval of the Engineer.

The Contractor shall acquaint himself with the position of all existing services such as sewers, surface water drains, and cables for electricity and telephone, telephone and lighting poles, water mains and the like before commencing any excavation.

If any privately-owned service or supply for water, electricity, gas, drainage, cabling, etc. is affected by the Works, then the Contractor shall locate it and provide satisfactory alternative before cutting the existing service or supply.

The position of Statutory Undertakers, publicly owned and privately-owned services shall be verified by the Contractor who must satisfy himself as to the exact position of such apparatus.

The Contractor shall, during the progress of the Works take all measures required by any Statutory Undertaker, the Management of other Publicly owned service, or owners of privately-owned services and supplies during the progress of the Works and shall ensure that no such services or supplies are interrupted without the written consent of the appropriate authority or owner.

For an area that is restricted, and requiring permission for access, the Contractor shall take this into account in preparing his programme and in carrying out the Works in this area.

3.1.12 Setting out

The contractor shall be responsible for setting out the Works in accordance with the details given by the Engineer, and for all construction levels being correctly related to the benchmark level or existing structure given for reference at the particular site.

The Contractor shall give the Engineer not less than 24 hours notice in writing of his intention to set out or give levels for any part of the Works so that arrangements may be made for checking the work. The Contractor shall provide all assistance which the Engineer may require for checking the setting out.

All beacons and markers for setting out the Works or for defining the limits of the permitted working areas shall be of such size as shall be clearly visible at all times and lights shall be fitted where necessary or required by the Engineer. Any marks made or beacons installed by or for the Engineer shall be carefully preserved.

Working shall be suspended for such times as necessary for checking lines and levels on any part of the Works. All principal setting out lines shall be referred to the defined Site Grid and all levels shall be referred to the National Datum or other agreed system approved by the Engineer.

3.1.13 Measurement of Quantities

Measurement of quantities shall be in accordance with the preamble to the Bill of Quantities.

3.1.14 Tender and Contract Drawings and Specifications

The works are to be built of the materials and to the sizes, dimensions and grades as called for in the Specification and as shown on the Drawings forming part of these Specifications and Contract or such other Drawings as may be added by the Engineer from time to time during the progress of the work.

The Drawings as listed in the Volume 4 Book of Drawings of the Tender accompany this document and form part of the contract.

The Contractor shall note that the Specifications shall be read in conjunction with the Drawings as a whole to obtain exact details of the work to be done. No claim resulting from the Contractor's failure to do so will be entertained.

Additional Drawings showing details in accordance with which the work is to be constructed will be furnished from time to time by the Engineer, if found necessary, and will then become a part hereof. The Contractor shall be governed by figured dimensions as given on the Drawings. Where required dimensions are not shown in figures, the Contractor shall obtain such dimensions from the Engineer before proceeding with the construction of the portion of the work which they refer.

The Contractor shall not consider the provision of such information as cause of delay and shall not endeavour to claim any additional compensation therefore. In every case, detailed drawings shall take precedence over general drawings.

3.1.15 Working Drawings by Contractor

Working drawings shall be prepared by the Contractor for all new works for the Engineer's approval before work commences, in particular mechanical and electrical works. A total of three (3) prints of all working drawings with specifications shall be submitted to the Engineer for review. The Contractor or his Sub-Contractor shall check and initial all Shop drawings before submission to the Engineer so as to intercept any major errors or omissions. Shop drawings will not be checked by the Engineer unless they have been previously checked by the Contractor.

The Contractor shall identify each drawing, giving such reference as clause of Specifications where specified, location where equipment or material is intended to be installed, name of subcontractor or supplier, etc.

Review of the Contractor's drawings by the Engineer shall not relieve the Contractor of the responsibility for the correctness thereof, nor responsibility for the results arising from any error or omission of details of design. Review of drawings and specifications shall, in every case, be subject to final approval of the equipment and materials after they have been put in commission, all guarantees have been fulfilled and the general operation of the equipment and materials has been found satisfactory to the Engineer.

There shall be furnished to the Engineer six (6) sets of prints of the final amended drawings and specifications at the Contractors expense.

After drawings and specifications have been reviewed by the Engineer, no general change shall be made in them without his written permission. In the event of any such alterations or changes being authorised by the Engineer, further five (5) prints of each of the revised drawings and specifications, indicating these changes, shall be immediately furnished to him at the Contractors expense.

3.1.16 Record Drawings

Concurrently with the progress of work on Site the Contractor shall prepare all necessary drawings and diagrams of the 'as-built' Works as may be required for record and for care, maintenance, repair, etc., purposes and these shall include:

- (a) Arrangement drawings of each complete installation to a scale of not less than 1:50 and showing all changes, modifications, and new works;
- (b) Outline dimension drawings of each of the principal items of plant, new structure and modifications. Each shall carry or be accompanied by a schedule of fittings instruments and components which shall include the makes' names, reference numbers, ratings and full particulars of all the component parts;
- (c) Sectional drawings of each of the major items of plant with the parts named and numbered to facilitate maintenance and overhaul. These drawings shall also show the type of fit and running clearance for fitted and running parts and with them shall be included such detailed workshop drawings as may be necessary for the manufacture of replacement components during the working lifetime of the Plant;
- (d) Such electrical, hydraulic mid operational diagrams as may be necessary;
- (e) Cable schedules, diagram and route sections for cable installations; and

- (f) Cable route plan of the Site and of each of the principal installations showing sections through the cable group and trenches so that each cable, etc., in a group or trench may be readily identified. This information shall be shown on a number of working drawings which shall be correlated by means of a small scale master plan.

The foregoing drawings may include those submitted and approved as Working Drawings and all shall be sized and set out according to the requirements for the Working Drawings.

- ◆ submit 2 draft copies of 'as-built' documents for review by the Engineer; and
- ◆ submit 6 final copies of 'as-built' documents
- ◆ The final submission of 'as-built' drawings should also comprise a soft copy in AutoCAD .dwg file of AutoCAD version 2000 or later one.

The Plant shall not be deemed to be ready for item of the Completion Certificate until the Record Drawings have been furnished.

3.1.17 Operation and Maintenance Manuals

Concurrently with the progress of work on Site the Contractor shall prepare the operating and Maintenance Instruction Manuals which shall include, where applicable:

- (i) Schedule of approved Record Drawings and documents;
- (ii) Detailed description of the Plant and its method of operation control and protection;
- (iii) Recommended operation and routine check procedures;
- (iv) Recommended maintenance routines together with the procedures for the commissioning of major items of plant;
- (v) Recommended emergency control procedures;
- (vi) Maker's descriptive literature and technical data sheets in respect of each item of the Plant including the recommended installation, care, maintenance and overall instructions, parts lists etc., whereby the Plant may be maintained correctly and whereby replacement spare parts may be ordered without difficulty;
- (vii) Exploded views of all items of plant with each component and reference number cross referenced to the appropriate data sheet and spare schedule;
- (viii) Schedule of the principal items of plant and components showing the title, maker, Maker's type reference, serial number, rating etc., whereby reference to each is simplified; and
- (ix) Test results and curves, including all mechanical and electrical equipment and system test data and reports.

Particular reference is to be made in the operating and maintenance instructions to the:

- (a) Safety precautions and instructions to be taken when operating the plant;
- (b) Pre-check list;
- (c) Bearings and moving parts which require special attention;
- (d) Type of lubricants to be used, and lubrication intervals;
- (e) Routine tests which are recommended to confirm that the plant is in good working order; and
- (f) Fault finding and corrective measure guide.

Two draft copies of the manuals shall be submitted to the Engineer for his approval at least 2 weeks prior to the Tests on Completion. The Manuals shall be used for commissioning and testing rising under the Contractor's supervision when their content and accuracy will be checked.

Upon the satisfactory completion of the installation and testing of the Works and before the Final Certificate is issued, 5 copies of the Manuals, incorporating amendments and additions instructed by the Engineer shall be provided.

3.1.18 Contractor's Responsibility for Design

Subject to the requirements of this Specification where the Contractor proposes an alternative design, he shall be responsible for the general and detailed design of the complete equipment to be provided and for the dimensions and arrangements of the various parts. The contractor shall be responsible for checking the dimensions and installation conditions of the existing plant and for the design of any modifications required.

The design, construction and finish of the complete equipment supplied under this Contract shall be of first-class workmanship and in accordance with latest waterworks practice and each item of equipment shall be in every way suitable for continuous operation over the full range of duties. The plant shall be as simple and maintenance free as possible.

3.1.19 Approval of Contractor's Proposals

The Contractor shall submit 4 copies of the following documentation, giving details of his proposals for approval, to the Engineer within 4 weeks of the Contract Start Date:

- (a) Four copies of design and working drawings and data including calculation and erection information;
- (b) Four copies of full technical specifications of all plant and equipment proposed for the works; and
- (c) Details of dead and live loads imposed by each item of plant on its foundation.

The Engineer's approval of the Working Drawings, Contract Records, etc. and of the Workshop test records etc., shall not relieve the Contractor of the obligation to meet the terms of the Specifications. Any of the Plant, which upon delivery to site is found to be

incorrect or unsatisfactory, or which fails to perform its duty satisfactorily during commissioning or during the Defects Liability Period shall be replaced to the Engineer's satisfaction.

3.1.20 Testing and Inspection

The Contractor shall provide 3 copies of a test plan for both the factory and site tests and inspections, for the Engineer's approval. The plan shall consist of a logical step-by-step schedule indicating step, action and reaction. The plan shall be cross referenced to relevant sections of the Specification, Schedules, and British Standards (or equivalent where applicable), and shall state clearly the test method to be employed, the equipment to be used, the parameters to be measured, and the expected results. On satisfactory completion of the tests, etc., the plan shall be completed with the results achieved and shall be retained for record purposes.

The test may be sectionalised to suit the plant purchases and manufacturing arrangements, and programme. Each section of the plan shall be issued in draft at least 28 days before any testing, inspecting or commissioning takes place. The Engineer will notify his approval or otherwise within 14 days of receipt of the plan. Any portions of the plan, which the Engineer disapproves, shall be suitably modified before implementation of that portion of the plan. Final copies of the approved plan shall be available for the testing, inspections or commissioning.

The Contractor shall carry out during manufacture, all tests specified in the relevant British Standard and other applicable standards, amplified as may be called for in the Specification and Schedules, and shall forward to the Engineer in triplicate duly certified copies of the test results and certificate that the equipment and materials comply with the relevant British Standards.

The Contractor shall give not less than fourteen days notice in writing for the time, date and place of all impending tests so that the Engineer or his representative may be present to witness such tests. The Contractor shall furnish test certificates in triplicate for all tests whether witnessed or not.

As and when the Engineer is satisfied that any plant is in accordance with the Specification and has passed the prescribed test, he will notify the Contractor in writing to that effect.

If after inspection or tests the Engineer decides that the plant concerned or any part thereof is defective or is not in accordance with the Contract, he may reject it by giving the Contractor, within a reasonable time, notice in writing of his decision and the grounds upon which it is based.

3.1.21 Tests on Completion

When the Plant is completely erected on Site and ready for service, the Works shall be tested and commissioned under the Contractor's supervision and subjected to the prescribed Tests on Completion in the presence of the Engineer and the Employer's staff to demonstrate that it is able to perform its specified duties satisfactorily under the approved system of operation and control and that the whole conforms with the Specification. Testing of equipment and *systems* shall be fully co-ordinated with the Engineer.

Before the commencement of any site testing the Contractor shall submit to the Engineer for approval, schedules detailing the tests to be carried out in satisfaction of the Tests on completion. On satisfactory completion of the test the Contractor shall provide copies of the completed schedules for record purposes.

Except where otherwise specified, each item of plant shall be subjected to a continuous twelve-hour trial under normal working conditions, at varying heads, quantities, loads and speeds where applicable to establish correct and reliable functioning of the plant. The performance of each item of plant over its operating range shall be determined using calibrated pressure gauges, flow meters and electrical gauges and measuring devices. Electrical plant shall be tested in accordance with the Institution of Electrical Engineers' Regulations, for earth continuity, polarity and insulation resistance, and the Contractor shall supply the Engineer with three copies of the schedule of test results. The installation will not be accepted until such tests have been approved.

Power consumption, discharge and suction and delivery pressures, shall be measured in the case of pumping plant and power generation and consumption, shall be measured in the case of generating plant where applicable.

The Contractor shall supply all necessary instruments, gauges, meters and suitably qualified personnel to carry out the tests and the cost of these shall be deemed to be included in his tendered prices.

Should any item of plant or process fail to function correctly, the Contractor shall modify or replace at his own expense such items as are necessary until the Plant does meet the requirements and intent of the Specification to the satisfaction of the Engineer.

Four copies of all inspection and test certificates and records shall be furnished to the Engineer immediately after each inspection or test.

After completion of all trials on the various items of plant, the Contractor shall operate the plant for a period of 9 weeks. During this period the Contractor shall provide all skilled personnel required for the operation of the plant.

The Contractor shall instruct the plant operating staff and shall stand by the plant on a continuous basis while the trials and operation of the plant are in progress. Should the plant breakdown during the trials, the Contractor shall immediately repair it and the trial shall start again.

The take over date shall be agreed as the date upon which the successful trials and operating of the plant was completed and the Engineer shall issue a Certificate of Completion so dated, when the Record Drawings have been approved and submitted.

3.1.22 Transport and Storage

The Contractor shall be responsible for the storage and security of all material delivered to site and installed until the Issue of the Certificate of Completion. Each item shall be securely packed and adequately protected and marked to avoid loss or damage in transit.

All equipment shall be handled and stored in accordance with the manufacture's recommendations as reviewed and approved by the Engineer.

Deliveries shall be kept to the minimum number possible and any items which are required to be built in or laid under structures shall be delivered to site in ample time to avoid delays.

3.1.23 Installation

The Contractor shall give full and complete written notice of all important operations to the Engineer sufficiently in advance to enable the Engineer to make such arrangements as the Engineer may consider necessary for inspection and for any other purpose. The Contractor shall not start any important operation without the written approval of the Engineer.

The Contractor shall provide all labour, supervision, and materials and equipment for receiving, unloading, storing and erecting the plant on site.

The Contractor shall be responsible for co-ordinating all mechanical, electrical, and structural work for the equipment being installed.

The Plant shall be installed in accordance with the manufacturer's recommendations as reviewed and approved by the Engineer and shall be set and fixed in position and level.

Special care shall be taken to ensure proper alignment of all equipment with particular reference to the pumps and drives. The units requiring foundations shall be carefully aligned on their foundations by qualified millwrights after their sole plates have been shimmed to true alignment at the anchor bolts. The anchor bolts shall be set in place and the nuts tightened against the shims. After the foundation alignments have been reviewed by the Engineer, the bedplates or wing feet of the equipment shall be securely bolted in place.

The alignment of equipment shall be further checked after securing to the foundations, and after confirmation of all alignments, the sole plates shall be finally grouted in place. The contractor shall be responsible for the exact alignment of equipment with associated piping and, under no circumstances, will "pipe springing" be allowed.

All wedges, shims, filling pieces, keys, packing, red or white lead, etc., necessary to properly align, level, and secure apparatus in place including grout shall be furnished by the contractor.

All parts, intended to be plumb or level must be proven exactly so. Any scrapping necessary to bring parts proper level bearing after erection shall be done at the cost of the contractor.

The Contractor shall provide all labour and all necessary equipment including timbers, scaffolding, tools and rigging materials required in the performance of the Contract. He shall install whatever piping, and miscellaneous items that are supplied as part of the equipment including lubrication piping, pressure gauge tuning, thermocouple sensors, etc.

The major items of equipment shall be installed, calibrated and tested under the supervision of competent experts, representing the manufacturer of the equipment. This supervision will be provided by equipment manufacturers as noted under specific sections of this Contract.

The Contractor shall completely install all equipment as herein specified and as indicated in the manner that will ensure its satisfactory operation upon completion. The Contractor shall obtain all necessary information regarding equipment from the manufacturers and shall be responsible for all field assembly and installation.

Except where noted, the Contractor shall design, supply and install all hangers, supports, anchor bolts, stands, vibration mountings, etc., required for the complete and proper installation and operation of all equipment and piping.

All necessary templates for fixing the position of bolt holes, etc., shall be provided and the positioning, fixing and securing of holding down bolts, etc., shall be done in such a way that they cannot move or be affected in any way by the building-in operation.

Holes in concrete exceeding 25 mm diameter, if not formed during construction shall be cut as necessary by the Contractor with high speed rotational or impact drills in such a manner that the surrounding material shall not be damaged. The positions of such holes shall be agreed with the Engineer before cutting.

Structural steelwork, etc., shall not be drilled for fixing unless specifically approved by the Engineer.

The works shall include removal of existing plant, necessary modification to existing plinths and all breaking out reinstatement of building works.

On completion of installation and prior to start up of connected equipment, all piping, water passages and pump casings shall be thoroughly inspected and cleared of all debris, loose concrete, timber and tools.

Un-dimensioned piping, ductwork, etc. shall be installed straight and level and in accordance with the requirements of the Engineer and with the best trade practice. Adequate headroom and clearance shall be provided from existing structures and equipment.

3.1.24 Electrical Regulations

The whole of the work shall be carried out in accordance with the latest edition of the Regulations issued by the Institution of Electrical Engineers, London, the National Regulations and other equivalent authorities specified herein.

Where there are conflicts or inconsistencies among the regulations then the regulation with the higher standard in the opinion of the Engineer will take precedence.

The Contractor shall also comply with any regulations necessary to enable full insurance coverage to be effected and with any local conditions or by-laws.

3.1.25 Special Tools

With each piece of mechanical and electrical equipment or machinery having and requiring periodic repair and adjustment, any special tools, wrenches and accessories required for removing worn parts, making adjustments and carrying out maintenance shall be supplied. There shall also be furnished all gauges, indicators and lubricating devices necessary for the proper operation of the machines whether or not such accessories are specified under later sections.

3.1.26 Spare Parts and Service

Spare parts shall be interchangeable with the corresponding parts of the plant and each shall bear a corrosion proof label giving an adequate description for its rapid identification, including drawing number, part number, and maker's name and address.

3.1.27 Co-ordination with Plant Staff

The Contractor shall co-ordinate his work with the plant operating staff in order to ensure minimum disruption to production of water at the plant. Major plant shut down shall be coordinated through the Engineer.

3.1.28 Instruction of Plant Staff

The Contractor shall be responsible for instruction of the plant staff in operation and maintenance of the plant during the period of installation, commissioning and testing.

Training shall include for a 2-week training period (day-shift only), by a competent instructor, of 3no. Operation and 3no. Maintenance staff on all items of plant at the Water Booster station Works. The Maintenance staff holds Diploma's in their relevant fields of expertise. Instruction shall be in English.

Training shall include:

- a) Start up and shut down procedure for Booster pump, and ancillary plant
- b) Maintenance of pump, dismantling and re-assembly of plant for replacement of defective parts
- c) Operation of Motor Control Centre, maintenance and replacement procedures for defective parts
- d) Consequences of incorrect operation of pump

3.1.29 Temporary Buildings

The locations of any proposed temporary buildings used for staff and for construction purposes and type of buildings to be used shall be acceptable to the Engineer before erection work commences.

Temporary buildings must be kept clean and free from nuisance so as not to become a danger to the adjoining properties or to form grounds for complaints from property owners adjacent to the site.

When temporary building facilities are no longer needed for construction they shall be promptly dismantled, unless otherwise specified or directed, and removed from the site.

3.1.30 Temporary Water, Power, Light and Services

The Contractor shall be responsible for providing all water, power and light services required for him to carry out his work including testing. The existing facilities of the works may be used where available, to the approval of the Engineer and the Owner.

The quality of the water shall be to the approval of the Engineer and suitable for the purpose for which it is intended.

The Contractor shall provide throughout the period of construction of the Works and maintain and cleanse suitable and sufficient latrines for use by his employees. He shall

ensure that his employees do not foul the Site but make proper use of the latrines. Wastewater shall be disposed of clear of the Site to the satisfaction of the Engineer so as to cause no damage, complaint or in any way affect the water supply.

The temporary power and light system shall meet the standards and requirements of the local authority.

3.1.31 Facilities for Engineer

The procedure to be followed in providing the Engineer's facilities (requirements) such as vehicles, office accommodation, equipment and furniture for the office shall be as outlined below:

The Contractor shall first submit the technical details, together with any brochures and leaflets, of the vehicles, equipment, furniture, etc for approval by the Engineer.

The Engineer shall inspect the proposed facilities, where appropriate, at the supplier's premises.

The Engineer shall approve or make comments on the proposed facilities. The Contractor proceeds to procure the approved facilities.

The Contractor shall be responsible, and shall be deemed to have allowed in his rates and prices, for delivery of facilities to their final destinations, unpacking, disposing to rooms, assembling, connecting up and testing of electrical appliances, installation of all the required software, and setting the facilities to work.

(a) Office for the Engineers Staff:

The Contractor shall provide a Site office, for the use of the Engineer. The Contractor shall maintain, service and insure the offices for the Contract period or for such additional or lesser time as the Engineer may direct. The offices shall be for the sole use of the Engineer's staff.

On completion of the Works, or at such time as specified by the Engineer, the ownership of the office (if not rented) and all furniture and equipment, except for survey equipment, shall be transferred to the Employer. Prior to handing over to the Employer, the Contractor shall provide and maintain the office accommodation, furniture, equipment, facilities and services without any interruption.

The Contractor shall carry out complete redecoration, including re-painting, of the office accommodation before handing over to the Employer. The Contractor shall be deemed to have allowed in his rates and prices for this redecoration.

Location of the Buildings

The Site office building shall be provided at a position on the Site or as specified by the Engineer.

Surface water drainage facilities shall be provided to protect the buildings from surface run-off and to convey it away from the buildings.

Site Office Building

The Contractor shall construct or alternatively rent a Site office building.

The Site office building shall have a minimum floor area of 125m² and a clear inside height of not less than 2.6 m to accommodate 7No. Staff. The Contractor shall submit his proposals for the office building to the Engineer for approval. The offices shall be constructed of new, durable, strong and weatherproof material to the satisfaction of the Engineer in respect of design, siting and construction. The floor shall be of suitable construction adequately damp-proofed, ant-proofed and termite-proofed.

The whole of the office accommodation shall be adequately ventilated, insulated against heat and cold, water tight, lighted, painted, mosquito proofed and vermin proofed. It shall be adequately wired for electric light and power. The building shall have burglar proof lockable doors, burglar proof windows with lined curtains and shall be divided up by block work partitions into private offices and meeting rooms as required by the Engineer. Covered communal passageways shall connect separated units.

The Engineer's office shall have a toilet, in addition to a set of communal toilets, to cater for the Engineer's staff. Each toilet shall be complete including wash hand basin, towel rail and toilet roll holder. The office shall be provided with a kitchen complete including kitchen sink and tile-topped working surface.

The office accommodation shall be detached completely from the Contractor's site offices although they may both be contained within one compound suitably guarded and fenced with a 1.8 m high chain-linked fence and gate with padlock and chain.

The Contractor shall provide 24-hour armed security guarding for the Engineer's office.

The Contractor shall provide all services and infrastructure. The Contractor shall provide a piped potable water supply to the toilets and kitchens with a waterborne sewerage system discharging to septic tanks, cesspits, or soak away pits, a storm water drainage system, and a yard tap with a lockable device. The Contractor shall provide an electricity supply of sufficient power for general use. The Contractor shall be responsible for maintaining the water and electricity services and pay all charges and fees for the supplies.

The Contractor shall provide and maintain cleaning staff and cleaning facilities. The Contractor shall also provide an adequate refuse disposal service for the office. The office, including toilets, shall be cleaned daily and shall be maintained for the duration of the Contract. A supply of toilet paper, soap and towels is to be provided and maintained; clean towels are to be supplied each day.

The office as well as all the equipment and furniture supplied under this Contract shall be insured on a full comprehensive basis against theft, fire, water damage and burglary.

The office with all furniture, fixings, equipment, services, carport etc., all as detailed below, shall be provided complete within 63 days after the Commencement Date. Until the office accommodation is ready for occupation, the Contractor shall provide, starting from the Commencement Date, alternative office accommodation of comparable area and facilities to the satisfaction of the Engineer. This alternative office accommodation shall be furnished and equipped with similar facilities as described below. If the office accommodation for the Engineer's staff is not ready for occupation within the specified period of 63 days, the Contractor shall provide, at his risk and cost beyond the specified period of 63 days, the alternative office accommodation for the Engineer's staff.

Roads and Parking

All accommodation shall be provided with temporary, well drained access roads 3m wide and covered carports for 3 cars. Access roads and the surfaces of the carports shall be surfaced with a minimum thickness of 150 mm of well- compacted gravel properly graded, cambered, drained, and culverted. The carports shall be surfaced with a minimum thickness of 50 mm of well- compacted crushed stone aggregates of 20 mm nominal size.

In addition, the access and other roads around the offices shall be treated to make them dust free by using crushed stone. They shall be well-drained and kept trafficable and free from mud at all times.

Furniture, Fixings and Equipment

The Contractor shall supply the furniture, fixtures and equipment listed in the table below, and shall install them in the offices as required by the Engineer. They shall be for the sole use of the Engineer and his staff. All furniture, fixtures and equipment shall be supplied new, following the Engineer's approval of a manufacturer's description or catalogue. The Contractor shall keep insured all furniture, fixtures and equipment to their full value (including duty where appropriate) and shall maintain them in good order until the end of the maintenance period. On completion of the Works, the equipment shall be transferred to the Employer.

Stationery and Office Supplies

The Contractor shall supply all stationery and office consumables required for the normal functioning of the Engineer's offices, including inter alia survey books, drawing office supplies, computer CDs (re-writable and recordable), computer printout paper, (but excluding headed correspondence paper), copying paper, cartridges for printers, cartridges (toner) for photocopier, box files A4, index dividers for A4 box files, ruled pads A4, squared pads A4, pocket files (document wallets) A4, erasers, self-sticking notes (post-it), pens (assorted colours), envelopes (assorted sizes), pencil refills (leads) 0.5 mm 2B or HB and staples.

The Contractor shall also supply books for Site records including: Daily Works Records, Notice of Operation, Request for Inspection/Approval, Measurement Records (Sheets), Confirmation of Verbal Instructions, Site Instructions and Site Diary. The books shall be of A4 size, with minimum of 50 pages; and each page shall be self-carbonized and in triplicate; and each page shall have a serial number. A sample page of each book shall be approved by the Engineer before the Contractor places procurement orders for the books.

The Contractor shall also supply all consumables and spare parts for photocopier and computers from the manufactures' authorized representatives. The Contractor shall put in place a service contract with each authorized representative of the manufacturer of the office equipment.

The Contractor shall supply all the required stationery, office consumables, spare parts for office equipment, and books for Site records from the Commencement Date until the Taking-Over Certificate has been issued for the Works or until such time as specified by the Engineer. If the Contractor fails to provide the supply, the Engineer shall be entitled to withhold the issue of a Payment Certificate until such time as the supply is provided.

Gas and Electricity

The Contractor shall supply or make provision for 24-hour water, gas and electricity supplies to the Engineer's Site office and shall arrange for sewage and refuse disposal.

Whenever these supplies are not available from the public utility services, the Contractor must continue to provide the facilities from his own resources.

Communications

The Contractor shall provide for internet data and airtime for the Engineer's office and staff.

The Contractor shall allow in his rates for paying all costs, charges and fees in connection with the provision of the above facilities.

Furniture, Fixtures and Equipment for the Engineer's Office

Item Nr	Description	Unit	Quantity
	Supply, install, connect and set to work the following items of furniture, fixtures and equipment for the Engineer's office.		
1	Desk, metal framed (2.0 m x 1.0 m approx.), with 6 drawers fitted with locks	nr	2
2	Chair, swivel, upholstered, wheeled chair with arms for above desks	nr	2
3	Desk, metal framed (1.7 m x 0.8 m approx.), with three drawers fitted with locks	nr	3
4	Table, metal framed (1.2 m x 0.9 m approx.)	nr	2
5	Chair with arms for above desks	nr	5
6	Table, metal framed (4 m x 2 m approx.)	nr	1
7	Chairs, metal framed, upholstered for above table	nr	10
8	Filing cabinet, metal, 4 drawers with suspended filing system with a lock	nr	3
9	Cupboard, double door, metal with 4 shelves, locking (0.9 m wide x 0.45 m deep x 1.8 m high approx.)	nr	2
10	Scale rule, flat and triangular	nr	4
11	Calculator, 11 digits, with scientific functions	nr	3
12	Mechanical pencil sharpener	nr	1
13	Waste paper basket	nr	5
14	Letter tray, A4 size (each set of 3 trays)	set	6
15	Sundry office items: paper punches (4 inc 1 heavy duty), staplers (4 inc 1 heavy duty), scissors (4), staple removers (4), clutch or mechanical pencils 0.5mm (4) clipboard A4 size (4),	set	1

VOLUME 2: SPECIFICATIONS

Item Nr	Description	Unit	Quantity
16	Plain paper photocopier, desktop type with variable magnification that can take both A4 and A3 full- size copies, minimum capacity 25 copies/minute, including (i) supply of consumables and spare parts, (ii) service contract with the manufacturers' authorized representative and (iii) automatic voltage stabilizer with surge protection suitable for this equipment.	nr	1
17	Benching and shelving as required		As req'd
18	Horizontal plan chest on legs with eight drawers (1525 x 1080 x 740 mm high approx.)	nr	1
19	Desktop computer, colour monitor as specified	nr	4
20	Laptop computers as specified	nr	1
21	A3 colour printer HP Office jet 7000 Wide Format capable of printing up to 33 pages per minute (ppm)	nr	1
22	Scanner, 1600x3200 dpi, A4 size, with USB port and software	nr	1
23	Software as specified	nr	1
24	Internet facilities	nr	1
25	Gas plate	nr	1
26	Electric refrigerator 0.28 cubic metre capacity	nr	1
27	Electric Philips metallic kettle, minimum capacity of 1.7 litres	nr	1
28	Drinking mugs	nr	12
29	Crockery set comprising: 1 thermal flask (1.5liters), 1 tea pot, 1 milk jug, 3 sugar bowls, 12 cups and saucers, 12 side plates, 18 tea spoons, 12 small knives and 2 metallic flasks each of capacity 2 litres	set	1
30	Tea tray	nr	3
31	Electric fans	nr	5
32	Fire extinguisher including refills and servicing.	nr	1
33	First aid kit	nr	1
34	Notice board, secured (1.5 m x 1 m approx.)	nr	1
36	Toilet brush with holder (at least)	nr	2
37	Mop and bucket	nr	2
38	Plastic bucket	nr	3
39	Plastic jerry cans 25 litre capacity for water	nr	5
40	Broom	nr	2
41	Dust pan and brush	nr	2

VOLUME 2: SPECIFICATIONS

Item Nr	Description	Unit	Quantity
42	Sony digital camera, optical zoom x5, digital zoom x6, minimum 10 megapixels, storage media/capacity of 4 GB memory card, size of LCD monitor of 2.5 inches, high speed USB 2.0 memory stick reader, JPEG-RAW file format, complete with downloading cable, strap, carrying case and manuals.	nr	1

Computers

The Contractor shall supply computer hardware and software as detailed below for the sole use of the Engineer and his staff.

The desktop computers are to be tower computers of a reputable make. They shall be 2 (Two) in number and shall have minimum specifications as detailed below.

The laptop computers are to be 1 (One) in number and of a reputable make with specifications as detailed below.

Desktop Computers

The specifications for the desktop computers shall be as follows:

High Performance Desktop Computer Specifications

Item	Minimum / Specification
Brand / Model	Dell & HP or similar approved by the client
Form factor	Mini Tower (Small Form Factor)
Processor	11 th Gen, Intel Core i7, 2.8MHz,
Memory (RAM)	8.0 GB, DDR4
Cache	512MB
Hard disk	1TB, at a Speed of 7200rpm, expandable
CD-Drive	DVD-RW, Double Layer
Display	19" TFT Flat screen
NIC	10/100/1000Mbps
Video	64MB video card
Audio	16 Bit Sound blaster, or Equivalent with speakers
Ports	1 Parallel Port, 4 USB 1 Serial 1 HDMI Mouse & keyboard ports
Powering Rating	220V-240V ac, British standard (3 Pin)
Accessories	Original Optical Mouse with wire Keyboard - 44Dust Covers Mouse pad Instructions manuals Device Software drivers on DVD
Warranty	1 years on parts

VOLUME 2: SPECIFICATIONS

Item	Minimum / Specification
UPS (APC or similar)	650 kVA
Operating System	Windows 10 Professional – 64 Bit
Application Software	- Microsoft Office Professional 2019 or Higher – Preinstalled and Licensed
	- Microsoft Project – 2019 or Higher – Preinstalled and Licensed
	- Autodesk AutoCAD Civil3D 2022 Licensed
	- Latest Upgraded Kaspersky Anti-Virus

Note: All Software should be supplied with their respective Original Installation DVDs

Each computer shall be a true branded Dell or similar approved computer with widescreen display colour monitor and shall be supplied with a suitable automatic voltage regulator with surge protection. Full documentation and backup discs for the software and the computers are to be provided.

Laptop Computers

The Contractor shall supply 1 (One) laptop computers with specifications as follows:

High Performance Laptop Computer Specifications

Item	Minimum Configuration / Specification
Preferred Make/Brand	Dell, HP, or Better Brands
Processor make and speed	11 th Gen, Intel core i7 processor CPU T7200, 2.8 GHz upto 3.9 GHz
Cache	1MB on-die L2 cache
Memory (RAM)	8 GB, DDR SDRAM
Hard disk	500 GB, at 7200RPM
DVD Drive	DVD-RW+/- and CD-RW
Display	14-inch SXGA + TFT LCD
Networking (integrated)	Integrated 10/100/1000 MBps Ethernet Network adaptor Integrated Wireless network card (802.11b), Wi-Fi
Graphics Card	Intel HD Graphics 620 or better
Modem	Integrated 56k, v.92 modem
Audio facilities	Integrated audio (soundcard & speakers), with jacks for Headphone & microphone
PC Card slots	PCMCIA slot for either Type I or II
Ports	Parallel Port, 25hole, bi-directional or ECP Integrated Infra-red port (IrDA 1.1), 3 USB 2.0 ports, Video, 15-hole, SD card reader, Blue tooth enabled, Com port
Power	Integrated Lithium Ion battery, with 3-pin UK or Mobile plug AC adaptor

Item	Minimum Configuration / Specification
Security feature	Embedded finger print reader, Security lock slot with the cable locks and keys to be included with the laptop
Camera	In-built web Camera
Operating System	Windows 10 Professional – 64 Bit
Application Software	<ul style="list-style-type: none"> - Microsoft Office Professional 2019 or Higher – Preinstalled and licensed - Microsoft Project Professional 2019 or Higher – Preinstalled and licensed - Autodesk AutoCAD Civil3D 2022 Licensed - Latest, Upgraded Kaspersky Antivirus
Accessories	<ul style="list-style-type: none"> - USB Mouse – with Wire - Laptop Backpacker – approved by the client

Note: All Software should be supplied with their respective Original Installation DVDs

The computers shall be true branded Dell or similar approved and shall be approved by the Engineer. All hardware and all software shall be supplied new and fully licensed in the name of the Employer.

Printer and Related Equipment

The Contractor shall supply one office jet A3 colour printer as specified below:

- Colour Printer: HP Office jet 7000 Wide Format or similar approved capable of printing up to 33 pages per minute (ppm) black and 32 ppm colour.

On completion of the Contract or at such time as specified by the Engineer, the ownership of all computers and such like equipment shall be transferred to the Employer. The laptop computer will be handed over to the Employer at the end of the Defects Notification Period.

(b) Services to the Engineer:

The Contractor shall supply such labour, either continuously or from time to time, as may be required by the Engineer, to assist in the checking of materials on Site and in the laboratory, the setting out of the Works and in measuring the Works.

The Contractor shall provide all tools, protective clothing, wooden pegs, iron pins, water, concrete and transport for labourers as may be required by the Engineer and his staff for supervision of the Works.

The Contractor shall keep all buildings provided by himself or the Employer, for the use of the Engineer and his staff, in a well maintained, clean and fully habitable condition and shall maintain all access roads, car parks, footpaths, fences, gates, drains, potable water supplies and water-borne sewage disposal systems in a good state of repair, all to the satisfaction of the Engineer. The Contractor shall also provide an adequate refuse disposal service for all residences and offices.

The Contractor shall maintain all furniture and equipment, provided by him, in a good state of repair and usable condition and shall replace any item which becomes unserviceable due to fair wear and tear.

The Contractor shall provide soap and towels in the offices of the Engineer, cleaning and sanitary staff and cleaning equipment.

Contractor shall provide day and night watchmen for the security of the Engineer’s site offices.

(c) Laboratory - NOT USED

Test equipment shall be provided and housed and maintained by the Contractor to carry out the following on site; this equipment shall remain the property of the Contractor:

- (j) Apparatus conforming to BS 1881 “Methods of Testing Concrete” to enable site compaction and slump tests to be performed and sufficient steel cube moulds, with base plate and tamping rods, to enable the sufficient test cubes to be made to meet the requirements specified in clause 2.2.5.
- (ii) One complete set of BS sieves to comply with BS 410 for “Test Sieves” and all other apparatus necessary for testing grain sizes of gravel, sand and coarse aggregate
- (iii) Complete set of apparatus to compaction tests (Sand Cone Replacement Method) in accordance with BS 1377.

In case the Contractor fails to provide the above apparatus, he shall make arrangements with a competent laboratory to the approval of the Engineer to carryout the respective tests.

(d) Survey Equipment:

The Contractor shall provide, maintain and service the survey equipment required by the Engineer for so long as the Engineer shall require. The equipment shall be provided for the sole use of the Engineer and his staff. At the end of the Contract the equipment shall be returned to the Contractor

The Contractor shall make available any poles, pegs, staging, moulds, templates or profiles required by the Engineer for checking or for measurement of the Work including maintaining in position any poles, pegs, templates or profiles used in setting out the Works.

The survey equipment to be supplied are:

Item Nr	Description	Unit	Quantity
	Supply, install, connect and set to work the following items of surveying equipment for the Engineer’s office.		

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Item Nr	Description	Unit	Quantity
1	Total Station (Theodolite WILD T1000, Distomat WILD DI5, data recorder WILD GRE4 or similar approved), notebook with surveying software RIB STRATIS, complete with tripod, carrying case and all accessories	nr	1
2	Level, Zeiss NI 2 automatic level, or similar approved, complete with tripod, carrying case and all accessories	nr	1
3	Levelling staff, engine divided 4 m long, folding, including staff level	nr	2
4	Staff levelling plate	nr	2
5	Steel tape, 100 m length	nr	1
6	Steel tape, 50 m length	nr	2
7	Steel tape, 25 m length	nr	2
8	Steel tape repair kit	nr	1
9	Fiberglass, PVC coated tape, 30 m length	nr	2
10	Steel hand tape, 3 m long	nr	4
11	Steel hand tape, 5 m long	nr	4
12	Ranging rod, 3 m length	nr	10
13	Arrow, 400 mm length	nr	25
14	Conical plummet, 200 g weight	nr	1
15	Steel straight edge 1 m long	nr	1
16	Spirit level with aluminium body, 1 m long Torpedo	nr	1
17	Level with aluminium body, 150 mm long Pipe	nr	2
18	Measuring tape with linear and diametric scales	nr	2
19	String line, 50 m long	nr	2
20	Optical square	nr	1
21	Hammer, 3 kg weight	nr	1
22	Hand shovel	nr	2
23	Pedometer, measuring to 10 000 m at 0.1 m intervals	nr	1
24	Pocket counter, counting to 9999 with push button for automatic return plus re-set knob	nr	1
25	Thermometer, maximum and minimum graduated in °C and °F	nr	1
26	Thermometer, wet and dry bulbs, graduated in °C and °F	nr	1
27	Concrete thermometer	nr	1
28	Rain gauge with measuring bottle	nr	1
29	Flask with thermal insulation, 1-liter capacity	nr	2
30	Water containers, 5-liter capacity	nr	2
31	Portable digital Schmidt Hammer for concrete strength tests, percussion energy 2207 Nm (0.225 kgm), weight not exceeding 1.1 kg.	nr	1

(e) Vehicle and Transport:

The Contractor shall supply motor vehicles as detailed below.

Station wagon	:	1 nr.
Pick-up truck	:	1 nr.
Offroad/ Dirt Motorcycle	:	1 nr.

These vehicles shall be for the sole use of the Engineer and his staff and shall be available at all times. Only those makes of vehicles having satisfactory permanent repair and maintenance facilities already well-established in Kampala will be acceptable and shall first be approved by the Engineer. All the vehicles shall be of the same make.

All the vehicles shall be new right-hand drive diesel-powered Toyota and petrol-powered Honda/Yamaha or similar approved vehicles for the exclusive use of the Engineer. They shall have four-wheel drive capability, high ground clearance, an engine capacity of at least 2800 cc, power steering, power windows, anti-lock braking system, air bags for driver and front passenger, lockable glove box, and central locking system. The front seats for all vehicles shall be separate and all seats shall have headrests.

The vehicles shall be fitted with the manufacturer's tropical and off-highway extras including tow bars, front bull bars and air conditioning. The vehicles shall be equipped with an auto alarm system, central locking system and a smart radio and flush disc facilities. Each vehicle shall also be provided with a first aid kit supplied by the supplier of the vehicles. Kerb weight and tyre pressures shall be stated on each vehicle, and the vehicles shall conform in all respects to the regulations of the appropriate registration authority.

The pick-ups shall be double cabin type. Each pick-up shall have wireless door entry and locking system, front automatic wheel hubs for four-wheel drive, side impact beams, roll bars, textured plastic truck bed liner and a tonneau cover supplied by the supplier of the vehicles.

The station wagon shall be fully covered with permanent roof and have adequate seating for a driver and six passengers. Each station wagon shall have wireless key and remote and switch for four-wheel drive.

Below are the minimum specifications for the required vehicles.

STATION WAGON		MINIMUM REQUIREMENTS	
A	MODEL/YEAR		
	Model/year of Manufacture		Latest
B	BODY AND GENERAL		
	Body Type		5-Door Station wagon
	Overall Dimensions (mm)	Length	4,780
		Width	1,885
		Height	1,890
	Deck space (mm)	Height	510
		Length	2,285
		Width	1,590

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STATION WAGON		MINIMUM REQUIREMENTS	
	Weight (kg)	Kerb Weight	1,840
		Gross Weight	2,850
	Trunk Capacity (l)		403
	Cargo (l)		1,150
	Ground Clearance (mm)		220
	Wheel base (mm)		2,790
	Seating Capacity		7
	Exterior Colour		Silver Metallic, Grey or as approved
C CHASIS AND DRIVE TRAIN			
	Drive Train		Part time 4 Wheel Drive
	Transmission		5-Speed Automatic Transmission
	Tire Size	Front	265/65R17
		Rear	265/65R17
	Brake Type	Front	Ventilated Disc
		Rear	Leading-trailing Drum
	Suspension Type	Front	Double Wishbone
		Rear	Leaf, Rigid
	Stabilizer Bar		Front Bar
	Power Steering Type		Hydraulic
Differential Lock System		Rear Differential Lock	
D ENGINE			
	Engine Type		Diesel
	Displacement (cc)		2,800
	Fuel	Type	Diesel
		System	Common Rail Type
		Capacity (L)	150
	Cylinders	Number	16
		Arrangement	In-line
	Valve mechanism		16-valve, Dual Over Head Camshaft
	Power Output (kW)		122
	Torque (Nm)		410
E EQUIPMENT AND UTILITY			
	Antilock Braking System		Present
	Centralized door lock		Present
	Power window		Present
	Steering wheel tilt		Present
	Rear ELR3 point seat belt		Present
	Front seat pretensioner seat belt		Present
	Side impact bar		Present
	Airbags (Driver, Front Passenger, Side, Curtain & Knee)		Present
	Lockable glove box		Present
	AM/FM/CD Radio		Present
	GPS Navigation		Present
	Side steps with assist grips		Present
	Front Bull bar		Present
	Fog lamps		Present
	Alloy Rims		Present
	Spare wheel anti-theft lock		Present
	Security Alarm		Present

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STATION WAGON		MINIMUM REQUIREMENTS	
	Keyless Ignition		Present
	USB Port		Present
	Cruise Control		Present
	Zone Automatic Air conditioning		Present
	Leather Seats		Present
	Rear Reverse Camera		Present

DOUBLE CABIN PICKUP		MINIMUM REQUIREMENTS		
A	MODEL/YEAR			
	Model/year of Manufacture		Latest	
B	BODY AND GENERAL			
	Body Type		4-Door Double Cabin Pick-Up	
	Overall Dimensions (mm)	Length		5,260
		Width		1,835
		Height		1,860
	Deck space (mm)	Height		480
		Length		1,525
		Width		1,540
	Weight (kg)	Kerb Weight		1,840
		Gross Weight		2,740
	Ground Clearance (mm)			215
	Wheel base (mm)			3,080
	Seating Capacity			5
Exterior Colour			Silver Metallic, Gray	
C	CHASIS AND DRIVE TRAIN			
	Drive Train		Part time 4 Wheel Drive	
	Transmission		5-Speed Manual Transmission	
	Tire Size	Front		265/65R17
		Rear		265/65R17
	Brake Type	Front		Ventilated Disc
		Rear		Leading-trailing Drum
	Suspension Type	Front		Double Wishbone
		Rear		Leaf, Rigid
	Stabilizer Bar			Front Bar
Power Steering Type			Hydraulic	
Differential Lock System			Rear Differential Lock	
D	ENGINE			
	Engine Type		Turbo Charged Diesel	
	Displacement (cc)		2,800	
	Fuel	Type		Diesel
		System		Common Rail Type
		Capacity (L)		80
	Cylinders	Number		4
Arrangement			In-line	

VOLUME 2: SPECIFICATIONS

	DOUBLE CABIN PICKUP	MINIMUM REQUIREMENTS
	Valve mechanism	16-valve, Dual Over Head Camshaft
	Power Output (kW)	110
	Torque (Nm)	340
E	EQUIPMENT AND UTILITY	
	Antilock Braking System	Present
	Centralized door lock	Present
	Power window	Present
	Steering wheel tilt	Present
	Rear ELR3 point seat belt	Present
	Front seat pretensioner seat belt	Present
	Side impact bar	Present
	Airbags (Driver, Passenger & Side)	Present
	Lockable glove box	Present
	AM/FM/CD Radio	Present
	GPS Navigation	Present
	Side steps with assist grips	Present
	Front Bull Bar	Present
	Truck Bed Roll Bars	Present
	Rear Rigid Deck cover	Present
	Truck Bed textured plastic truck bed liner	Present
	Fog lamps	Present
	Alloy Rims	Present
	Spare wheel anti-theft lock	Present
	Security Alarm	Present
	Keyless Ignition	Present
	USB Port	Present
	Cruise Control	Present
	Zone Automatic Air conditioning	Present
	Leather Seats	Present
	Rear deck hard tonneau cover	Present
	Rear Reverse Camera	Present

- Off road Motorcycle

All the motorcycles shall be new offroad/ dirt petrol-powered Honda/Yamaha or similar approved cycles for the exclusive use of the Engineer. The Motorcycles will be used for implementation of a wide range of activities related to project. The Motorcycles are expected to be primarily used on rough and remote roads in Northern Uganda and they should be able to drive on rough and muddy gravel roads.

The offered Motorcycles should be based on the manufacturer's current standard production model.

The Motorcycles should be suitable for continuous and strenuous off-road driving in tropical conditions, in all areas of Uganda but especially in the Northern parts. The Motorcycles should be of sturdy construction and good quality.

VOLUME 2: SPECIFICATIONS

Motorcycle specifications				
Item No.	Description/ Specification		Bidders Specification (To be filled by Bidders)	Comply/ Do Not Comply (To be filled by Bidders)
	Motor Cycles			
1.	Body Type	Dual sport/ Dirt/ Offload		
2.	Seat Capacity	At least 2.		
3.	Year of manufacture	≥ 2022		
4.	Engine type	At least 120cc petrol engine, minimum 2 stroke, 1 cylinder, with heavy duty sump guard protection		
5.	Engine power output (SAE NET) at rated rpm	Minimum 6.2 KW		
6.	Starting system	Kick starter/ Electric.		
7.	Security features.	<ul style="list-style-type: none"> • Anti-theft immobilizer. • GPS location system. 		
8.	Gear box and drive train	Minimum 5 speeds constant mesh through roller chain.		
9.	Suspension	Front – telescopic oil dampers; Rear – swing arm oil dampers; 2 rear shock absorbers with double coil springs.		
10.	Odometer	In Km/hr and tachometer.		
11.	Carrier	Wide heavy duty rear carrier plus front carrier.		
12.	Steering	Mounted with protection guard		
13.	Ground clearance	Minimum 235mm		
14.	Tyres	Front minimum 2.75-19 spoke steel rims with wire spokes, Rear 4.10-18 steel rims wire spokes (or equivalent) off road grip pattern		
15.	Brakes	Front and rear drum or disc		
16.	Fuel tank	Minimum 11 litres		
17.	Protection	Foot protection bar, hand, clutch & headlamp protection bar.		
18.	Tool Kit:	Essential tools for routine maintenance.		
19.	Rider Kit	Set of riding gear to include crash helmet, leather gloves and protective riding trouser and jacket.		

Motorcycle specifications				
Item No.	Description/ Specification		Bidders Specification (To be filled by Bidders)	Comply/ Do Not Comply (To be filled by Bidders)
20.	Additional	<ul style="list-style-type: none"> • Foot Guard fender designed for off- road capabilities; • Electrical system all legal lighting with heavy duty steel protection for front and turn lights. 		
21.	Back up service:	Franchised dealer available in Uganda.		
22.	Warranty	Full warranty of a minimum of 1 year or 10,000 km whichever comes first		
23.	After sales service	Routine maintenance for 5,000 kms or 1 year whichever comes first.		

The Contractor shall provide competent English-speaking drivers to the approval of the Engineer for all vehicles used on the Site. Each driver shall have a minimum continuous driving experience of 8 years, with a certificate in defensive driving, and aged between 30 and 55 years old. The take-home monthly salary shall include all taxes and compliance with all other statutory requirements and allowances such as housing allowance, medical expenses and fees and per diem allowances for travelling. Any driver found unsuitable by the Engineer shall be replaced immediately.

These drivers shall be available during all normal Site working hours and when specifically required by the Engineer, outside those hours.

(f) Vehicle Operation and Maintenance

The vehicles provided shall be maintained at all times in good running order. Should any vehicles at any time become, in the opinion of the Engineer, unserviceable by normal use in the conditions and demands of the Site, the Contractor shall replace them without delay. If the Contractor fails to provide replacement transport, the Engineer shall be entitled to withhold the issue of a Payment Certificate until such time as a replacement is provided.

The Contractor shall provide all necessary fuel, lubricants, etc, and shall bear all expenses in connection with running, servicing, maintenance, repairs, upkeep, licensing and insurance. All vehicles shall be serviced, maintained and repaired at the supplier's workshop.

Insurance for all vehicles shall be 'comprehensive' for the replacement value of each vehicle and shall also include:

- Cover for the Engineer and his staff driving the vehicle, and for any other persons that the Engineer requires to be included; and
- Liability to third parties (including passengers whether the Engineer, his staff or others) for an unlimited indemnity in respect of death or personal injury and for the

maximum indemnity reasonable in respect of loss, destruction or damage to property.

When not used by the Engineer the Contractor shall provide adequate and secure garaging for each vehicle and will not permit use of any vehicle other than that authorized by the Engineer.

The Contractor shall provide similar replacement vehicles whenever the original vehicles are not available for use for whatever reasons.

On completion of the Works, all the vehicles shall be handed over to the Employer. The Contractor shall be responsible for the running, servicing, maintenance, repairs, etc. of one of the vehicles which shall be handed over to the Employer at the end of the Defects Notification Period. Before the vehicles are handed over to the Employer, the Contractor shall first arrange for a complete overhaul of each vehicle to the satisfaction of the Engineer. The Contractor shall arrange for transfer of ownerships and registration in favor of the Employer and pay all costs and fees. The final complete overhaul of each vehicle, before it is handed over to the Employer, shall include:

- servicing of the vehicle;
- fitting the vehicle with new tyres, new spare tyre, and new battery(ies);
- repair of all dents;
- cleaning up and technical verification of all-important parts of the vehicle;
- replacement of the parts found damaged or worn-out;
- repair and/or replacement of worn-out or damaged seats, seat covers, and floor mats;
- spraying of the vehicle to the same original colour as directed by the Engineer.

All the Contractor's expenses and costs arising under this Clause shall be reimbursed against the rates and prices entered in the Bills of Quantities. Purchase costs will be paid after handing over of the vehicles to the Engineer. Standing costs are on a number basis while operating costs will be paid according to the kilometres travelled as recorded on the vehicle odometers per month relative to the vehicle-month of 1,000km/month.

The standing costs will include items such as provision of the vehicles, insurance, registration, road taxes, delivery to Site, garaging and provision of temporary replacement vehicles. The rate will also include for the cost of the final complete overhaul, transfer of ownership and registration in favour of, and delivery of all vehicles to, the Employer.

The vehicle-monthly rate will include all day-to-day running expenses such as fuel and lubricants, routine servicing, maintenance including periodical provision of new tyres and batteries, repairs including vehicle parts replacements, provision of drivers and their overtime.

The vehicles shall be provided within 56 days after the Commencement Date. Prior to the supply of the vehicles, the Contractor shall provide and maintain temporary similar vehicles starting from the Commencement Date. If the vehicles for the use of the Engineer and his staff are not supplied within the specified period of 56 days, the Contractor shall provide, expense and cost beyond the specified period of 56 days, the temporary similar vehicles for the Engineer's staff.

(g) Housing for the Resident Engineer's staff

Provision of housing for the Resident Engineers for the duration of the construction time until handing over:

The Contractor shall provide houses in the project area, that are fully furnished, each with (sofa set with coffee table set, dining table with 4 chairs, curtains to all windows, beds (one bed per bedroom with mattresses) and fully equipped kitchen (gas cooker with oven, refrigerator, cooking pans, cutlery and crockery set) with living room with a flat screen smart TV and a decoder (with monthly subscription), bathroom with hot/cold running water a toilet and a shower. The houses shall have a perimeter fence with servant quarters, good security, an entrance gate and a place to park at least 2 cars. The houses are subject to the Engineer's approval.

Type A house - 4bedroom (preferably all self contained).

Type B house - 3bedroom (preferably all self contained).

The Contractor will be responsible for all costs for electrical power, cooking energy, water supply and 24hr security guards to the houses supplied by him for the use of the Engineer.

3.1.32 Survey Assistance to Engineer

The Contractor shall provide a survey assistant and chainmen, as and when required by the Engineer for the duration of the Contract.

3.1.33 Project Signboard

The Contractor shall supply and erect on the site of the work at the location designated by the Engineer 2No project sign boards. A suitable stable framework to support the sign shall also be provided and erected by the Contractor. No other signs or notices other than that required for purposes of warning or indicating danger to the public in connection with these works may be exhibited on the site without the express approval of the Engineer.

The signboard shall be erected as soon as work commences and shall be maintained in position until completion of the Contract.

The lump sum price stated in the Form of Tender for this item shall include the supplying, erecting, maintaining and removing after completion of the Contract.

3.1.34 Photographs

The Contractor shall supply electronic and print of progress photographs, suitably inscribed and dated, of a size not less than 200 mm by 250 mm of such portions of the Works, in progress and completed, as may be directed by the Engineer. The Contractor shall allow for a total number of print photographs required for the contract duration shall not exceed 240. The Engineer shall select a maximum of 5 photographs (each month), an additional 10 copies shall be provided for inclusion in the progress reports of which one (01No.) photograph shall be an aerial photo capturing the Water Treatment Plant Works. The electronic shall not be retouched. The electronic of the photographs shall be the property of the Employer and no prints from these electronic may be supplied to

any person or persons without the authority of the Employer or the Engineer. The Contractor shall also provide photograph albums and mounts for mounting photographs. In addition, the contractor shall make digital photographs of all construction and structures in progress.

3.1.35 Clearance of Site

The Contractor shall maintain the Site in a neat, tidy, healthy condition. He shall control vegetation so as not to detract from the amenity and appearance of the neighbourhood of the Site.

Upon completion of all work to be performed by the Contractor on any part of the Site otherwise than in connection with the care and maintenance of the Works, the Contractor shall clear the said part of the Site as specified in relevant Clauses of the Conditions of Contract.

3.1.36 Hours of Work

The Contractor may normally carry out the work during the daylight hours of any weekday, providing that he so conducts his operations as not to create a nuisance or disturb the peace unnecessarily and providing such hours meet with the approval of the Engineer. Whenever the Contractor desires to depart from his normal working hours as established by his past performance, he shall obtain the written approval of the Engineer therefore at least 48 hours prior to the contemplated change in operation.

Night and weekend work may be required for connections to existing works so as to minimise disruption to users or the operation of the existing plant.

3.1.37 First Aid

The Contractor shall provide and maintain on the site in a clean, orderly condition, completely equipped first aid facilities which shall be reasonably accessible at all times to all his employees. The Contractor shall designate certain employees who are properly instructed to be in charge of first aid. At least one such employee shall always be available on the site while work is being carried on. A telephone call list for summoning aid, such as doctors, ambulance, etc., shall be conspicuously posted.

3.1.38 Health and Safety

Health and Safety at Work

For the purpose of the Health and Safety at Work: State Regulations shall be complied with by the Contractor and he will be responsible for the Health and Safety of both people working on the Project and people entering the Site.

Contractor's health and safety plan

If before the acceptance of his tender the Contractor has not provided the Engineer with a copy of his Health and Safety Plan, he shall do so forthwith and he shall not enter on to the Site until he has done

so. The plan shall be subject to the Engineer's approval. The Contractor's safety plan shall include but not limited to the following:

- Orientation and adherence to safe working practices of all construction workers
- Safety training on how to prevent and manage accidents on site and measures to protect the general public from construction site hazards
- Provision and use of PPE for workers for different work environments
- Employment of qualified and authorized personnel to perform health and safety related tasks
- Responding to accidents and emergency evacuation procedures
- Reporting and responding to accidents

Contractor's safe systems of working

Where any part of the Works is not covered by the Contractor's Safety Policy or involves or affects the performance of existing equipment or processes, or connections to or disruption of existing supplies or services the Contractor shall submit to the Engineer a method statement covering such part of the Works. He shall immediately submit to the Engineer any subsequent additions to or amendments of his method statement. No work covered by any method statement shall be commenced unless the Engineer has reviewed the method statement.

The Contractor's Safe Systems of Working as described in his method statements shall:

- (a) be not inferior to the employer's Safe Systems of Working for any part of the premises where both shall apply;
- (b) incorporate where applicable any 'Permit to Enter' or 'Permit to Work' system employed by the employer;
- (c) take account of the fact that his employees will be less familiar with the employer's operations than are the contractor's employees and vice versa.

3.1.39 Manufacture/Supply

The Contractor shall give to the Engineer written notice of the preparation or manufacture at a place not on the Site, of any pre-constructed units or parts of units to be used on the Works, stating the place and time of the preparation or manufacture so that the Engineer may make inspection at all stages of the work.

Any units or parts which are prepared or manufactured without such prior notice having been given to the Engineer may be rejected if the Engineer considers that his inspection was necessary during the progress of the preparation or manufacture.

Before ordering any materials of any description for the Permanent Works the Contractor shall submit the names of the makers and suppliers proposed to the Engineer, and shall, after receiving acceptance, send to the Engineer, copies of the orders given by the Contractor for the materials.

The Contractor shall ensure that each supplier will admit the Engineer to his premises during ordinary working hours for the purpose of inspecting, witnessing the testing and sampling or obtaining samples of the materials. Alternatively, if required by the Engineer, the Contractor shall deliver the samples of the materials to the Engineer's office or to a laboratory nominated by the Engineer. Samples shall be taken in accordance with the relevant Standard where applicable or otherwise as described in the Contract. Materials subsequently used in the Works shall be consistent with the samples as tested or approved by the Engineer.

The Contractor shall ensure that samples are supplied to the Engineer in sufficient time for them to be satisfactorily tested. The information regarding the names of the suppliers may be submitted at different times, as may be convenient, but no sources of supply shall be changed without the Engineer's prior approval.

The Contractor shall submit to the Engineer test certificates of the material indicating compliance with the relevant Standard or other requirements of the Specification for materials for which there is no Safety Mark Accepted Quality Assurance Scheme or other accepted independent certification scheme.

The Contractor shall maintain a detailed record of all materials received on the Site or in his stores or storage and working areas in the vicinity of the Site and shall make such records available to the Engineer at such times as the latter may require.

The Contractor shall supply to the Engineer two copies in English of the manufacturers current instructions and explanatory brochures for all proprietary materials or processes specified or proposed by the Contractor at least four weeks prior to the use of the materials or processes in the Works.

3.1.40 Compensation of property

A provisional sum has been allowed in the BOQ for compensation of property individual structures and crops that are in the way of the works that will be affected by the construction of the works. This clause is exclusive of provisions in Clause 1.1.10.

3.1.41 Social Safeguards

The Contractors shall be required to develop guidelines for behavioral conduct, including penalties. This should be reflected either as independent document or component to the Contractor's Human Resource Manual.

All the Contractor's workers must be sensitized on proper social behaviour and conduct with regard to community norms prior to starting work.

Workers should be sensitized to avoid engaging in sexual relations with underage girls and married women.

In case of misunderstandings between workers and the local community, use of local leadership should always be sought as a first priority in solving these issues.

Similarly, in liaison with local leaders, contractors should prepare local communities – psychologically and otherwise – for the newcomers; efforts to be focused on instilling attitudes of tolerance, support and understanding towards the newcomers in the local communities.

Contractors will be required to have an HIV/AIDS policy and a framework (responsible staff, action plan, etc.) to implement during Project execution. This will include a reporting procedure in the event that the community members have any issues to report as a result of the Project workers' behaviour and/or negligence.

All construction workers will be orientated and sensitized about responsible sexual behaviour with Project area communities and inherent health risks associated with HIV/AIDS and other sexually transmitted diseases.

As part of their Corporate Social Responsibility, the Contractor in coordination with MWE will conduct HIV/AIDS awareness campaigns in the Project areas, particularly in slum areas, to avoid reckless lifestyle and spread of the disease in the area.

HIV/AIDS policies should be developed at workplace and Contractors should provide Free HIV/AIDS testing, counselling and condom distribution for both workers and local community.

3.2 MATERIALS AND WORKMANSHIP

3.2.1 Published Standards

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

Where reference is made to standard of Specifications, it is understood that the latest revision thereof shall apply. The Contractor shall familiarize himself fully with the requirements of the standards. If no standard is indicated then the relevant British Standard or internationally recognised standard shall apply.

The following abbreviations for Standard Control Bodies have been used for this Contract.

- (a) BS: British Standard;
- (b) ACI: American Concrete Institute;
- (c) ASTM: American Society for Testing Materials;
- (d) AWWA: American Water Works Association;
- (e) AASHTO: American Association of State Highway and Transportation Officials;
- (f) CIRIA: Construction Industry Research Information Association.

All materials and workmanship not fully specified herein shall be of such kind as is used in first class work and suitable for the climate at the Site.

The Engineer shall determine whether all or any of the materials offered or delivered for use in the Works are suitable for the purpose and the Engineer's decision in this respect shall be final and conclusive.

Summary of Standards:

The following provides a summary of standards, where standards are not complete the latest British Standard shall prevail.

Reference Standards Earthworks

Reference Standards are referred to in the text of the Specification in abbreviated form (e.g. BS 1377). The full titles of some which have relevance to this Part are given below for convenience:

Standard	Subject
BS 812	Testing aggregates.
BS 1377	Methods of test for soils for civil engineering purposes.
BS 3882	Recommendations and classification for topsoil.
CIRIA	Trenching practice

Reference Standards Metal Works

The following standards are referred to in this Part of the Specification.

Standard	Subject
BS 497: Part 1	Manholes covers, road gully gratings and frames for drainage purposes: cast iron and steel.
BS 4190	ISO metric black hexagon bolts, screws and nuts.
BS 4211	Steel ladders for permanent access.
BS 4360	Weldable structural steels.
BS 4942: Part 2	Short link chain for lifting purposes: grade M (4) non-calibrated chain.
BS 5135	Process of arc welding of carbon steels.
BS 5834: Part 2	Surface boxes, guards and underground chambers for gas and waterworks purposes: small surface boxes.
BS 6180	Protective barriers in and about buildings.

General Reference Standards

Reference is made in this Part to the Standards listed below.

Standard	Subject
ISO 216	Drawing sizes
BS 1553	Specification for graphical symbols for general Project Managing
BS 1646	Symbolic representation for process measurement control functions and instrumentation
BS 4884	Technical manuals
BS 5070	Project Managing diagram drawing practice
BS 5228	Code of Practice for noise control on construction and demolition sites

Reference Standards Painting and protective coatings

Unless otherwise specified or approved by the Engineer, painting and protective coatings, including surface preparation, shall comply with the relevant Reference Standards listed below:

Standard	Subject
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BS 245	Mineral solvents for paints and other purposes.
BS 729	Hot dip galvanised coatings on iron and steel articles.
BS 1224	Electroplated coatings of nickel and chromium.
BS 1336	Knotting.
BS 1387	Screwed and socketed steel tubes
BS 2451	Chilled iron shot and grit.
BS 2569	Sprayed metal coatings.
BS 2989	Continuously hot-dip zinc coated and iron-zinc alloy coated steel strip, sheet and plate.
BS 3416	Bitumen-based coatings for cold application, suitable for use in contact with potable water.
BS 3698	Calcium plumbate priming paints.
BS 4129	Welding primers and weld-through sealants, adhesives and waxes for resistance welding of sheet steel.
BS 4147	Bitumen-based hot-applied coating materials for protecting iron and steel.
BS 4652	Metallic zinc rich priming paint (organic media).
BS 4756	Ready mixed aluminium priming paints for woodwork.
BS 4764	Powder cement paints.
BS 4800	Paint colours for building purposes.
BS 4921	Sherardised coatings on iron and steel.
BS 5252	Colour co-ordination for building purposes.
BS 5358	Solvent-borne priming paints for woodwork.
BS 5493	Code of Practice for protective coating of iron and steel structures against corrosion.
BS 6044	Pavement marking paints.
BS 6150	Code of Practice for painting of buildings.
BS 6900	Raw, refined and boiled linseed oils for paints and varnishes.
BS 6949	Bitumen-based coatings for cold application, excluding use in contact with potable water.
BS 7079	Preparation of steel substrates before application of paints and related products.
CP 3012	Code of Practice for cleaning and preparation of metal surfaces.

Reference Standards Concrete

Unless otherwise specified, materials for concrete, concrete products and testing procedures shall comply with the following Reference Standards where relevant.

Standard	Subject
BS 812	Testing aggregates.
BS 882	Aggregates from natural sources for concrete.
BS 1199/1200	Building sands from natural sources
BS 1881	Testing concrete.
BS 3148	Methods of test for water for making concrete.
BS 4027	Sulphate-resisting Portland cement.
BS 4550	Methods of testing cement.
BS 5328	Concrete.
BS 7263: Part 1	Precast concrete flags, kerbs, channels, edgings and quadrants.
BS 8007	Concrete for Retaining Aqueous Liquids
BS 8110	Structural use of concrete.

CP 102	Protection of buildings against water from the ground.
ASTM D 512	Tests for chloride ion in water and waste water.
ASTM D 516	Tests for sulphate ion in water and waste water.

Reference Standards pipelines valves and meters

Unless otherwise specified, pipelines shall comply with the relevant Reference Standards listed below. Where a Reference Standard, or a further standard referred to in a Reference Standard, states that a requirement should be met, it shall be met unless otherwise specified, and where a Reference Standard allows a choice between other standards, preference shall be given to the standard or standards listed as Reference Standards, if any. Where pipelines or any parts thereof are outside the range of sizes covered by the Reference Standards, the requirements of the Reference Standards shall still apply where relevant, unless otherwise specified.

Reference Standards applicable to various types of pipelines include the following standards:

Standard	Subject
BS 2494	Elastomeric seals for joints in pipework and pipelines.
BS 4190	ISO metric black hexagon bolts screws and nuts.
BS 4320	Metal washers for general engineering purposes. Metric series.
BS 4504: Part 3	Circular flanges for pipes, valves and fittings (PN designated): steel, cast iron and copper alloy flanges.
BS 4865	Dimensions of gaskets for pipe flanges to BS 4504.
BS 5292	Jointing materials and compounds for water, low pressure steam installations, 1st, 2nd and 3rd family gases.
BS 7079: Parts O and A	Preparation of steel substrates before application of paints and related products: Introduction and visual assessment of surface cleanliness.
BS 8010: Part 1	Pipelines on land: general
AWWA C601	Standard for disinfecting water mains.
AWWA M12	Simplified procedures for water examination.

Ductile Iron Pipes and Fittings

Reference Standards for Ductile Iron pipes and fittings include:

Standard	Subject
BS 4771:	Ductile Iron pipes and fittings for pressure pipes, push-in joints, mechanical joints, cement mortar linings, metallic zinc coatings.
BS 4147/BS 3416:	Bituminous coatings
BS 6076:	Polythene sleeving

Steel Pipelines

Reference Standards for steel pipelines include the following standards:

Standard	Subject
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BS 534	Steel pipes, joints and specials for water and sewage.
BS 2569: Part 1	Sprayed metal coatings: protection of iron and steel by aluminium and zinc against atmospheric corrosion.
BS 4147	Bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required.
BS 4515	Welding of steel pipelines on land and offshore.
CP 2010 : Part 2	Design and construction of steel pipeline on land.
AWWA M11	Steel pipe design and installation.

Unplasticised polyvinyl chloride (uPVC) pipes

Reference Standards for uPVC pipes include the following standards:

Standard	Subject
BS 3505	Unplasticised PVC pipe for cold water services.

3.2.2 General Requirements for Plant and Components

All component parts of the plant shall be new, unused, in current production and shall comply with the latest relevant British Standard and other specified standards. All component parts shall be manufactured to strict system of limits and complete interchange ability of similar parts shall be achieved. Where there is no British Standard, or other Specification, the materials and workmanship used shall be entirely adequate for the purpose and shall not be installed without the written approval of the Engineer. Uniformity and interchange ability of mechanical and electrical components and accessories which are common to different parts of the Works shall also be achieved as far as practicable.

3.2.3 Means of Lifting

All item of Plant shall be provided with adequate means for lifting, and heavy covers and other similar components shall be drilled and tapped for lifting eyes. Parts having spigot joints or otherwise likely to be difficult to separate be drilled and tapped for starting screws unless other easy means of separation are provided.

3.2.4 Design for Low Maintenance

The general mechanical and electrical design of the Plant and particularly that of bearings, glands, contacts and other wearing parts shall be governed by the need for long periods of operational service without frequent maintenance and attention being necessary.

3.2.5 Wearing Parts

Parts subject to wear shall be indelibly marked with their part number and maker's name and address and be easily accessible. Provision shall be made for taking-up wear in bearings and other wearing parts and for easy replacement if adjustment is not practicable. If during the Defects Liability Period any parts show, in the opinion of the Engineer, signs of undue wear, corrosion or erosion they shall be replaced at the Contractor's expense notwithstanding that they may be working otherwise in a satisfactory manner.

3.2.6 Suitability for Duty

Except as otherwise specified or approved, all the Plant shall be rated for continuous service under the most onerous duty conditions that may occur under normal circumstances and shall be effectively protected against damage in the event of overloading arising from the incidence of abnormal working conditions.

Except as otherwise prescribed or approved, all apparatus and components thereof which comprise the Works shall be of tried and proved design and construction which experience has shown to be entirely suitable for service according to the Contract.

3.2.7 Access and Safety Protection

The Plant shall include such guards, hand railing, access steelwork, walkways, etc., as may be required to meet the current relevant regulations for the safety of personnel and of the plant, and to afford adequate and safe access to all parts of it. All shall be of substantial design and construction.

3.2.8 Fixings

The Plant shall be provided with all the necessary supporting steelwork, holding-down bolts, cleats, fixing, etc., whereby it shall be secured to the structures, the cost of them being included in the prices of the items with which they are associated.

3.2.9 Resistance to Vermin

All plant and equipment supplied under the Contract shall be suitably resistant to or protected against termites and vermin. No organic material shall be used and all seals, grommets, etc., shall be made of neoprene or alternative suitable material.

3.2.10 Identification Labels

Each item of Plant and each sub-assembly for which spare parts may be required, shall have attached to it an un-tarnishable metal or equal approved form of plate showing clearly the manufacture's name, serial number and basic information as to rating, speed, etc., in sufficient detail to allow the component or assembly to be readily identified in correspondence and when ordering spare parts. The foregoing information shall be secured by threaded screws and nuts or equal approved method. Self tapping screws or soft threaded rivets will not be accepted.

Switchboards and control panels shall bear a title at the top and each compartment shall bear a smaller circuit title. Components on the doors shall be grouped as far as possible and each group or single component labelled to identify its purpose. Internal components and sub-components shall bear labels to identify them relative to numbers or letters shown on their circuit diagrams. All terminals shall be numbered with the terminal number or conductor ferrule number as appropriate to the wiring system adopted so that wires may be correctly reconnected without reference to drawings.

External labels shall be engraved on black plastic with light infill and shall be secured by non-ferrous screws. Internal labels may be similar to external labels or may be painted and varnished. Adhesive labels shall not be used.

3.2.11 Lubrication

Adequate, and as far as possible, automatic means of lubrication shall be provided for all moving parts.

Where possible, bearings and pivots shall be of the self-lubricating type which requires no lubrication service or attendance. The Contractor shall keep the number of lubricants used to a minimum.

Lubricating grease points shall comprise hexagon headed nipples to BS 1486, Part 1.

All lubrication points shall be fitted with engraved plastic labels. Each label shall bear an approved identifying mark showing the frequency of attention required and the lubricant to be employed. Labels shall be so placed as to be clearly visible.

The Contractor shall supply sufficient quantities of all necessary oils, greases and electrolytes for the first filling of the plant, for use during commissioning and site acceptance trials and for twelve months operation of the plant, and shall provide a list of various grades of oil and suppliers for them in the project town.

3.2.12 Resistance to Corrosion and Abrasion

Where corrosion or abrasion of materials may be expected from contact with water or sediment or from any other cause, the Contractor shall supply suitable resistant materials. Any material showing signs of corrosion, or pitting before the expiry of the Defects Notice Period shall be replaced by the Contractor at his own expense with materials to the Engineer's approval.

3.2.13 Noise and Vibration

The Contractor shall make all reasonable provision to reduce noise and vibration to a minimum. All rotating parts of the plant shall be statically and dynamically balanced so that they operate over all specified conditions without undue vibration.

3.2.14 Flanges

All flanges shall comply with BS 4504, unless otherwise stated.

The machined faces of flanges shall be coated with a suitable protective composition in order to prevent their being affected by corrosion.

3.2.15 Protective Coatings

Paint and protective coatings shall be sufficiently durable to withstand normal wear and tear without excessive deterioration or damage and without frequent maintenance painting or other treatment being necessary.

Non-ferrous valves and parts which are to be built into the structure shall not be painted.

Switch and control boards, distribution fuse boards and similar equipment shall be supplied finished with stove enamelled surfaces painted in shades to BS 4800.

Before leaving the Contractor's works the surface condition of all painted items shall be checked and any defect made good.

Bright surfaces shall be covered with a suitable lacquer which shall be removed by the Contractor on site, machine finished surface shall be coated with preservative before shipment or being exposed to the open air.

On completion of erection and test the external surfaces of all items not painted to finish in the works shall be cleaned and finishing coats applied.

Damaged stove (baked) enamelled surfaces shall be made good to the satisfaction of the Engineer and sufficient "touching in" paint shall be supplied by the manufacturer of the equipment at the time of shipment.

If in the opinion of the Engineer, the painting is unsatisfactory, the paint shall be removed and the surfaces thoroughly cleaned and repainted at the expense of the Contractor. Only approved non-toxic and odour free paint shall be used for coating of internal surfaces of water pipelines and similar equipment.

3.2.16 Suppliers of Materials

Before ordering a material of any description, intended for the Permanent Works, the Contractor shall submit for the approval of the Engineer the name of the manufacturer or supplier proposed and the details of the place of origin and specification of the material. If requested by the Engineer, the Contractor shall supply to the Engineer for his retention a copy of each order placed.

The Contractor shall confirm with the Engineer the length of the pipe straight specials before placing order for the items.

3.2.17 Natural Materials

The Contractor shall make all arrangements for locating, selecting and processing natural materials to comply with the specification and shall submit to the Engineer for approval, full information regarding the proposed location well in advance of commencement of working of the material. Approval of a source does not imply that all material in that source is approved.

3.2.18 Compatibility of Materials

It shall be the Contractor's responsibility to ensure that all materials supplied under this Contract are compatible with each other unless specific adjacent materials have been specified herein, or shown on the drawings. For example, form oil and curing compounds used shall be compatible to the damp proofing materials and paints that are applied shall also be compatible with the original parts that are being painted over.

The Contractor shall be required to correct at his own expense any defective work caused by the non-compatibility of materials.

3.2.19 Sampling and Testing of Construction Materials

The Contractor shall provide for the approval of the Engineer samples of all construction materials and manufactured items required for the Permanent Works, if ordered. All material rejected by the Engineer shall be removed from Site. All approved samples shall

be stored by the Engineer for the duration of the Contract, and any materials or manufactured items subsequently delivered to Site for incorporation in the Permanent Works shall be of a quality at least equal to the approved sample.

3.2.20 Inspection, Rejection and Protection of Materials and Equipment

The Contractor shall submit to the Engineer full information as to materials, equipment and arrangements which the Contractor proposes to furnish or make. This information shall be submitted in a form approved by the Engineer to determine if the proposed materials, equipment and arrangements will meet the Contract requirements.

Insofar as practicable, inspection and tests of material, plant and equipment will be conducted jointly by the Contractor and Engineer before delivery to the site. Costs associated with such inspection and tests shall be included in the Contractor's rates.

In addition, the materials supplied by the Contractor for the performance of the work shall be inspected by the Engineer at the time of delivery to the Contractor and at such other times before use, as the Engineer may elect, and materials rejected after delivery to the Contractor shall be returned to the point of delivery by and at the expense of the Contractor. All work done by the Contractor shall also be subject to the inspection of the Engineer and defective work repaired or replaced as directed. Facilities for the handling and inspection of materials and work shall, at all times, be furnished by and at the expense of the Contractor, who shall provide suitable and adequate storage room for materials during the progress of work and be responsible for any loss of or damage to materials stored therein.

The Contractor shall also be responsible for any loss or damage to materials or equipment until the final acceptance of the completed work.

Any work done by the Contractor prior to a review by the Engineer, or the construction methods, materials and equipment to be employed by the Contractor, or not in accordance with the Contractor's approved construction schedule, shall be considered to have been done without the consent of the Engineer.

The review of the information covering materials, equipment and arrangements by the Engineer shall in no way release the Contractor from his responsibility for the proper design, installation and performance of any material, equipment or arrangement or from the liability to replace the same should it prove defective or deficient.

4 CIVIL WORKS

4.1 EARTHWORKS

4.1.1 Excavations

The Contractor shall make excavations in any material for the several parts of the Works and shall dispose of the excavated materials all as specified, shown on Drawings, or ordered by the Engineer.

4.1.2 Notice to be given before Commencing Earthworks

The Contractor shall give to the Engineer at least seven days written notice of his intention to commence earthworks on any part of the Site to enable the Engineer to be furnished with all ground levels and other particulars he may require for the purpose of measurement. The earthworks shall not be commenced until written approval has been received by the Contractor from the Engineer.

4.1.3 Earthworks to Lines and Levels

The whole of the earthworks for the several parts of the Works shall be carried out to the dimensions and levels shown on the Drawings, or to such other dimensions and levels as may be ordered by the Engineer. Dimensions, which are based on, or relate to, ground levels or changes shall be referred to the Engineer before commencing earthworks at any location.

For the purpose of the Specification the term ground level refer to the ground surface before the start of earthwork operations but after the general clearance of the Site.

4.1.4 Extent of Excavations

The extent of excavations shall be the minimum practicable in the opinion of the Engineer for the construction of the Permanent Works.

The construction of open channels and trenches for pipelines shall at any one time be limited to lengths previously approved by the Engineer in writing. Except with the written approval of the Engineer, work on each approved length shall be completed to the satisfaction of the Engineer before work on any new length is commenced.

4.1.5 Slips, Falls and Excess Excavation

The Contractor shall prevent slips and falls of material from the sides of the excavation and embankments.

In the event of slips or falls occurring in the excavations, and where excavations are made in excess of the dimensions of the permanent work, the voids so formed shall be filled by the Contractor at no extra cost. When such voids, in the opinion of the Engineer, may affect the stability of the ground for the support of the work, or of the adjacent structures and services, the Contractor shall fill the void solid with concrete Class 2. In other cases

the Contractor shall fill the voids with selected excavated material placed and compacted to the approval of the Engineer.

4.1.6 Excavation of Unsound Material

If any unsound material occurs in the bottom of any excavation, the Contractor shall remove it on the Engineer's instruction and dispose of it to the satisfaction of the Engineer. Unless otherwise specified or ordered by the Engineer, the Contractor shall fill the voids so formed with concrete grade 15 in the formations to structures, and with suitable granular material to the approval of the Engineer in the case of pipelines.

4.1.7 Excavations to be Kept Dry

Unless otherwise approved, and such approval will only be given in exceptional circumstances, the Contractor shall keep the excavations for structures and pipelines free of water from whatever source, so that the Works shall be constructed in dry conditions.

The destination and method of disposal of water from the excavations shall be subject to the approval of the Engineer. The cost of dewatering to keep the excavations dry shall be included in the Contractor's unit rates for the works.

4.1.8 Preparations of Formations for Structures

Where the formation of any excavation, being other than rock, is to support the foundations or floor of a structure, the bottom 150 mm thereof shall be carefully excavated and trimmed immediately before placing the permanent work upon it.

Formation in granular material shall be compacted using vibrating type compactors. The cost trimming and compaction of the formation of any excavation unless otherwise stated shall be included in the Contractor's unit rates for the works.

4.1.9 Backfill and Fill

Unless otherwise specified or approved the material used for backfill and fill shall be excavated material of particle size not exceeding 100 mm.

Backfill against the permanent work shall be selected, and free from boulders, cobbles, rock fragments and the like greater than 50 mm nominal size, unless otherwise specified or approved.

4.1.10 Compaction of Fill and Backfill

Unless otherwise specified, the Contractor shall deposit fill or backfill in layers of uniform depth not exceeding 200 mm thick and shall compact it in a manner and with the use of such construction plant as is necessary to achieve the degree of compaction specified. Where no degree of compaction is specified the fill or backfill shall be compacted by the even distribution over it of the passage of earthmoving plant and 1 labour.

The Contractor shall if necessary water the fill material prior to and during compaction so that its moisture content lies within a range of values suitable for the fill material and the adopted method of compaction as may be established by prior trials on Site.

The terms used for compaction shall have ascribed to them the meaning given in BS 1377, Part 1, and General.

The standard of compaction used throughout the work shall be the British Standard test as described in BS 1377, Part 4, Test 10. Wherever in the text of the specification the expression "X% BS Compaction" is used it shall mean a standard of compaction such that the dry density of the compacted material is X% of the maximum dry density ascertained from the afore mentioned British Standard Compaction Test.

4.1.11 Allowance for Settlement

The Contractor shall make due allowance for consolidation and settlement of fill and compacted fill such that the levels and dimensions of the finished surface at the end of the Contract are not less than those specified, shown on the plans or ordered by the Engineer.

4.1.12 Special Foundation Treatment

It is recommended for foundations for water treatment works and any other structures where poor foundation soils are encountered to be treated as described below:

- Excavate 800 mm below the designed formation level and compact the resultant surface to 95% MDD BS Heavy.
- Backfill 300 mm with approved gravel and compact to 98% MDD BS Heavy.
- Backfill the remaining 500 mm with stone - base in layers not exceeding 200 mm. Each layer should be compacted to 98% MDD BS Heavy.

The resultant surface should have a bearing capacity in excess of 200KN/m² and can accommodate the structures comfortably

4.1.13 Works at Borrow Pits

The Contractor shall select for himself the sites of borrow pits from the Site or from other areas, all subject to the written approval of the Engineer. The Contractor shall excavate at the site of borrow pits to expose the material required for fill and shall select and excavate the said material. After the required amount of material has been excavated from each borrow pit, the Contractor shall reinstate its site by spreading the previously removed superficial materials in layers not exceeding 0.25 m deep over the area of the excavation and by grading and trimming the surfaces all to the satisfaction of the Engineer. Where practicable such grading shall be made to prevent accumulation of surface water.

The Contractor shall prepare and submit in detail for the approval of the Engineer his proposal for the use of borrow pits and shall give notice to the Engineer in writing at least one month before the proposed date of starting earthworks at the site of such borrow pit.

4.1.14 Disposal of Surplus Material

The Contractor shall transport and dispose of all excavated material not required for the Works. The locations proposed by the Contractor for disposing or storing excavated material, whether temporarily or permanently, shall be subject to the approval of the Engineer.

4.1.15 Hardcore Material Below Building Floors

Where hardcore material is specified below building floors, the material shall consist of durable gravel, broken stone or crushed concrete with a particle size not exceeding 100 mm. The grading of the material shall be such that there is no migration of fines into the fill and not more than 10% of material shall pass a BS sieve with 5 mm apertures.

The method of placing shall be to the approval of the Engineer and shall ensure that fines separating out during transportation are discarded or selectively placed.

The material shall be compacted in an approved manner to give a stable fill and shall then be blended with sand to the level indicated on the Drawings.

Sand used as blending above fill shall be clean and free from all impurities. The material shall pass a BS sieve with 5 mm apertures, and shall be compacted in an approved manner to the final level of the underside of the slab.

4.1.16 Imported Backfill Material Below Building Floors

Where the compaction of imported backfill below floor slabs is specified, the material shall consist of laterite material obtained from approved borrow pits of natural occurring gravel. The percentage composition by weight of base aggregate shall conform, unless otherwise specified to the following gradation:

Sieve	Percentage Passing
40 mm	100
6 mm	35 - 60
1 mm	10 - 35
No. 200	5 - 15

The material shall also fulfil the following requirements:

Soaked CBR: Not less than 30% for sub-base material;

Bearing: On compaction the material shall provide a bearing in excess of 200kN/m².

Before commencing work the Contractor shall submit his proposals for the working and compaction of the material to the Engineer for approval.

Plant for compaction may consist of cylindrical, rubber tired or vibrating roller, mechanical tampers or other suitable plant, which will compact the base material to an acceptable density to the approval of the Engineer.

Rolling of the imported material shall continue until the aggregate is thoroughly set, creeping of material ahead of the roller is no longer visible and the dry density is at least 98% (or as specified) of the optimum dry density as determined by the Standard Proctor Density Test (BS1377). The area shall be uniformly compacted.

Sprinkling during rolling, if necessary, shall be of an amount necessary to give the required moisture content. Water shall not be added in such a manner or quantity that free water will reach the underlying layer and cause it to become soft.

4.1.17 Damp Proof Membrane

Damp proof membrane underlay to floors and ground slabs shall be 1000 gauge polyethylene sheet laid with minimum 150 mm laps and dressed over the horizontal wall damp proof course for the full width of the course.

4.1.18 Testing of Compacted Materials

The Contractor shall carry out grading analysis, moisture content tests and sand replacement tests on all compacted material as required by the Engineer. Costs for testing shall be included in the unit rates for the compacted material. The Contractor shall supply all the equipment necessary to carry out the tests. The tests shall be carried out initially on the first three layers of compaction. Once the compaction passes the density requirements and the material conforms to the specification regularly then the test shall be carried out as instructed by the Engineer.

4.1.19 Excavation of Trenches

Unless the Engineer's approval is sought and obtained in writing, trenches for pipes shall be excavated to widths 600 mm greater than the outside diameter of the pipes, rounded up to the nearest 50 mm. No additional payment will be made for any variation in trench width which the Contractor may require unless such variation is specifically ordered by the Engineer.

The Contractor's decision to excavate for pipes by open trench or heading shall at all times be subject to the approval of the Engineer, and all excavations shall be executed carefully to the line, levels and grades shown on the Drawings or given by orders in writing by the Engineer.

Depth of Trenches:

Pipes shall have a minimum cover of 900 mm unless otherwise specified by the engineer.

Where longitudinal sections are provided, chainages and details are to be taken from the longitudinal sections, and not scaled from the plans, Pipeline and sewer trench depths may differ from those shown on the Bid Drawings as the Engineer may wish to vary these on Site.

The Engineer will afford the Contractor level pegs at intervals which, when read in conjunction with the longitudinal section, will indicate the depth of excavation at the pegs, and the Contractor shall be entirely responsible for obtaining a true and even grade between pegs.

Despite any information given, the Contractor's prices will be held to be fully inclusive of all works, materials, labour and equipment necessary to execute the trenching in the manner and to the conditions as specified elsewhere in this Specification.

Wherever sandy material free from stones and clay is encountered in the excavations, the Contractor shall take care not to deposit this in the spoil dumps alongside the trench

so that it is covered by stony or clayey material, but shall deposit it in such a manner and position that it is readily available for the purpose of refilling around and above the pipes as specified in the relevant Clauses of this Specification. No extra payment will be made to the Contractor for keeping the sandy material separately available, and the Contractor shall replace, free of charge, any sandy material which has been contaminated with stones, clay, etc due to his negligence.

The length of open trench in advance of the completed pipeline or sewer shall not exceed 100 metres without the written permission of the Engineer.

No special payment will be made for side sloping or timbering trenches and, until the trenches are refilled, the Contractor shall be entirely responsible for preventing falls, slips or cavings, and for the safety of the work or men on the Site.

4.1.20 Crossing Roads and Trench Bridges

The Contractor must allow in his rates in the excavation section of the Bill for the additional work of every kind involved in crossing roads, or access to work areas and buildings. Work of this kind shall be carried out entirely in accordance with all requirements of the Employer, whether these relate to method or to timing.

When trenching across roads the Contractor shall provide uninterrupted passage for vehicles and pedestrians and will be entirely responsible for making all necessary arrangements with the Authorities concerned. Any interruption of traffic, however brief, shall be permitted only with the express permission of the Engineer. The same principles shall apply at work areas or building accesses where the Contractor shall arrange his operations so that the owner/tenant is not inconvenienced.

To allow vehicles to cross trenches, steel trench bridges are to be provided at least 8 metres wide for road crossings and 3 metres wide for entrances to work areas and buildings. The bridges are to be suitably constructed out of steel plate and sections pegged to prevent movement. There are to be sufficient bridges available to suit the lengths of trench to be opened at any one time. The extent of each vehicular crossing is to be clearly demarcated by means of drums or handrails painted white.

Pedestrian crossings of the trench shall be by timber bridges provided at each vehicular crossing or elsewhere where ordered. These bridges are to have handrails one metre high on either side, are to be at least one metre wide and are to be at least 1,5 metres longer than the trench width.

Items are provided in the Bill for the breaking up and reinstatement of surfaced and unsurfaced roads.

4.2 CONCRETE WORK

4.2.1 Codes of Practice

All concrete work shall comply with C.P. 8110 "Structural use of reinforced concrete in buildings" B.S. 8007 "Code of Practice for the Structural use of concrete for retaining aqueous liquids".

4.2.2 General Requirements

It is the intent of these specifications to ensure a homogeneous concrete of high durability, good workability, sufficiently impervious to water and specified strength for every part of the Works using Ordinary Portland Cement, and the same considerations shall guide the Contractor.

Concrete work which is required to contain liquids shall not be accepted as complete until it has been proved by test to be watertight, and shows no visible leaks on exposed portions.

In order to minimise the risk of the Works not being watertight, the Contractor shall take the greatest precautions during construction to prevent the occurrence of possible sources of leakage, and in this respect it is emphasized that:-

- (a) As far as possible concreting should be carried out in one continuous operation
- (b) Where continuous concreting is not possible, proper bond of concrete must be secured in the manner described in this specification between concrete which has set or partially set and concrete which is subsequently placed in contact therewith.
- (c) While setting, concrete shall be suitably protected from the direct heat of the sun and shall be properly cured: see Clause 2.2.20 - Curing of concrete work.
- (d) Particular care must be taken when placing concrete around "waterstops".

4.2.3 Cement

Unless otherwise specified the cement used in the Works shall be ordinary Portland cement (OPC) complying with BS 12 at the time of use.

The Contractor shall supply samples of cement, when requested by the Engineer, both from the Contractor's store on Site and from the place of manufacture.
For the purpose of BS 12, the Site shall be deemed to have a tropical climate.

Where specified or ordered, sulphate resisting cement (SRC) shall comply with BS 4027, and the provisions for samples, tests and test certificates specified above for Portland cement shall apply for sulphate resisting cement.

4.2.4 Aggregates General

Aggregates shall consist of natural sands and gravels, crushed rock, or other inert substances having clean, uncoated grains of hard, strong, durable materials in accordance with BS 882. They shall be free of reactivity with alkalis in cement, organic matter, or other deleterious substances and shall not contain soft, friable, thin, flaky, elongated or laminated particles totalling more than three percent, nor contain shale in excess of one percent or silt and crusher dust finer than No. 200 sieve in excess of two percent. These percentages shall be based on the weight of the combined aggregate as used in the concrete. When all three groups of these deleterious materials are present, the combined amount shall not exceed five percent by weight of the combined aggregate.

The Contractor shall notify the Engineer of the source of each kind of aggregate that he proposes to use, not less than 21 days in advance of the concreting operations.

Aggregate shall be so stored on platforms or otherwise as to avoid the inclusion of dirt and to prevent intermixing of aggregates.

Pit run gravel or unwashed aggregate are not permitted.

All washed aggregates shall be handled in such a manner as to permit drainage for at least twelve (12) hours before use.

All aggregates if considered unsuitable by the Engineer shall be removed from the site by the Contractor at his own expense.

4.2.5 Fine Aggregate for Concrete Works

Fine aggregate shall be natural sand or crushed gravel or stone; clean, sharp, coarse grit; pit or river sand; free from silt, dust, clay, salt or any other matter. All sand shall be washed and sieved as often as is required to make it conform to this Specification. The sand shall comply with the requirements of BS 882.

Fine aggregate shall be graded within the limits shown below.

Sieve Size	Total Passing Sieve % by Weight
9.5 mm	100
No. 4	95 - 100
No. 8	80 - 100
No. 16	50 - 85
No. 30	25 - 60
No. 50	10 - 30
No. 100	2 - 10

Not more than 45 percent shall be retained between any two consecutive sieves of those shown in that table.

4.2.6 Coarse Aggregate

Coarse Aggregate shall be natural gravel, stone or other approved materials, hard strong and durable, nonporous, free from adherent coating or other harmful matter and shall pass or be crushed to pass the meshes specified in the concrete mixes and be well graded in conformity with the Grades of aggregate detailed below. Coarse aggregate shall be washed as often as required to make it conform to this Specification. The aggregate shall comply with the requirements of BS 882.

Unless otherwise directed, the grades used shall be as follows:

Concrete 400 mm or more in thickness: Grade No. 1;
 Concrete elsewhere: Grade No. 2.

The size of coarse aggregate shall be selected from the standard sizes given below.

Sieve Size	Total Passing Sieve Size by Weight	
	Grade 1	Grade 2
	40 mm Nominal Size	20 mm nominal Size
50 mm	100	
37.5 mm	95 - 100	
26.5 mm		100
19.0 mm	35 - 70	90 - 100
13.2 mm		30 - 75
9.5 mm	10 - 30	20 - 55
No. 4	0 - 5	0 - 10
No. 8	0	0 - 5

4.2.7 Aggregate for Granolithic Concrete

Aggregate for granolithic concrete shall conform to the requirements of B.S. 1201, "Aggregates for Granolithic Concrete Floor Finishes". Unless otherwise stated aggregate for granolithic concrete shall be graded to comply with the limits specified in B.S. 1201, Table 2, and "Fine Aggregate".

4.2.8 Additives

Concrete shall be made from cement, aggregates and water as specified. No other ingredient shall be mixed with the concrete without the Engineer's approval.

4.2.9 Storage of Materials

The Contractor's arrangements for storing and handling the materials for concrete shall be to the approval of the Engineer. Such arrangements shall be directed towards preventing the deterioration, adulteration or segregation of the various materials and ingredients thereof.

A well ventilated waterproof shed or sheds to store the required amount of cement shall be provided by the contractor at his own expense. Each shed shall have a suitable floor built at such a height that the cement is kept dry at all times. Delivery and stacking shall be so arranged that the various consignments can be used in the order of their delivery. Cement shall not be taken from the shed until immediately before its use in the Works.

Any cement which is stored on the site for a period in excess of 28 days shall be tested in accordance with the relevant British Standard prior to use. No cement which, in the opinion of the Engineer, has deteriorated or hardened shall be used on the Works and such cement shall be immediately removed from the Site.

4.2.10 Water

Water used in the Works shall be from a source approved by the Engineer, free from oil, acid, alkali and any matter vegetable organic, which is harmful to any material with which it is used. If available, a drinking water supply shall be used.

4.2.11 Grades of Concrete

Grades of concrete used in the Works are designated Grade 35, 30, 25, 20, 15, 10 and No-fines and composed of cement, sand, stone and water as already specified. The grade of concrete to be used for a particular part of the work will be identified by the Grade number followed by the stone size, eg Grade 30/20 refers to a Grade 30 mix with 20mm stone.

4.2.12 Design of Concrete Mixes

Design Procedure

The concrete mixes to be used on the Works are to be designed in a laboratory specified by the Engineer. The laboratory will be bound by the requirements of this Specification, which are to guide Bidders when pricing.

The Contractor shall supply and deliver to the Engineer, at least six weeks before the placing of any concrete in the Works, suitable samples of the aggregates which he proposes to use in the concrete mixes.

The Engineer may direct the Contractor to dispatch these samples to a specified laboratory for approval of the materials, the detailed design of concrete mixes and the preparation and testing of trial cubes. The Contractor shall use only the mixes recommended by this laboratory. No concrete shall be placed until the Engineer has received from the laboratory, and endorsed, approval of the aggregates, the design mixes, and the results of the laboratory tests.

The laboratory design of the mixes shall comply with BS 5328 and shall comply with the following requirements:

Compressive Strength

The characteristic compressive strength in megapascals (or N/mm²) of a mix is numerically equal to the grade of the mix; thus for a Grade 30 mix it is 30 megapascals.

The specified compressive strength shall have been attained when the following conditions are met:

- (a) the mean strength determined from the first two, three or four consecutive test results, or from any group of four consecutive test results, complies with the appropriate limits in column A of Table E1 below:-
- (b) any individual test results complies with the appropriate limits in column B of Table below

Characteristic compressive strength compliance requirements			
Specified grade	Groups of test results	A	B
		The mean of the group of test results exceeds the specified characteristic compressive strength by at least:	Any individual test result is not less than the characteristic compressive strength less:
		N/mm ²	N/mm ²
20 and above	first 2	1	3
	first 3	2	3
	any consecutive	3	3
	4		

7.5 to 15	first 2	0	2
	first 3	1	2
	any consecutive	2	3
	4		

Mix Design for Water Retaining Concrete

Grade 30 concrete or above shall be used for all water retaining structures and, in addition to the above requirements, shall have a maximum water/cement ratio of 0,53 by mass (ie total water content not to exceed 26 litres per 50 kg sack of cement) and a minimum cement content of 335kg per cubic metre.

Tenderers should note that the cement content required for water retaining concrete may exceed the minimum stated above and will be dependent upon the quality and size of the aggregate and the other requirements of this Specification. No additional payment will be made for cement content in excess of the minimum stated above.

Proportioning of Non-design Mixes

No-fines concrete shall be proportioned as specified in Clause 2.2.12.

4.2.13 Testing Concrete

General

The Contractor will be required to prepare concrete test cubes and to arrange for these to be tested at an approved laboratory. The cost of carrying out tests for concrete including slump tests, concrete cube tests and any other as required in the contract are to be covered under the contractor’s rates for the concrete works. The cost for carrying out confirmatory tests as directed by the Engineer will be covered under a separate bill item in the Bills of Quantities.

The equipment used and the method of preparing cubes and conducting tests shall comply with BS 1881 to which the Contractor should refer for descriptions and tolerances.

Compliance with Specified Requirements

Strength

The characteristic strength of concrete is that 28 day cube strength below with not more than 5% of the test results may be expected to fall.

Compliance with the specified characteristic strength shall be judged by tests made on cubes at an age of 28 days unless there is evidence, satisfactory to the Project Manager, that a particular testing regime is capable of predicting the strength at 28 days of concrete tested at an earlier age, when compliance may be based on the results of such tests alone.

The minimum rate of sampling and testing shall be in accordance with Table No. 3.

The application of the rates is to be as follows:-

- Rate 1 High stressed items
- Rate 2 Ordinary structural work
- Rate 3 Mass concrete not subject to high stresses

Higher rates of sampling and testing may be applied at the start of work, to establish the level of quality quickly, or during periods of production when quality is in doubt.

The actual rate of sampling at any time may be expected to fluctuate according to the random selection of batches to be sampled and may be increased in appropriate circumstances. In any case at least one test shall be taken on each day that concrete of that grade is used.

RATES OF SAMPLING AND TESTING

Rate of Testing	Rate 1	Rate 2	Rate 3
	<p>Three samples selected randomly from the different batches to represent an average volume of no more than:</p> <p>10m³ or 10 batches 20m³ or 20 batches 50m³ or 50 batches</p> <p>whichever is the lesser volume</p>		

Test equipment

For casting concrete cubes, the Contractor shall supply metal moulds having sides measuring 150mm x150mm x 150mm which will not distort but will be perfectly true in the horizontal and vertical planes with square and sharp corners. A standard steel tamping bar with a mass of 1,8kg, 380mm long and 25mm square is to be supplied. The number of cube moulds available must allow one set of cubes to be taken from every concrete pour, except that for large pours, one set of cubes shall be taken from every 10 cubic metres or part thereof.

For slump tests, the Contractor shall provide one metal mould, consisting of a truncated cone 300mm high, with top and bottom diameters of 100 and 200mm respectively. With it shall be supplied a round-ended 16mm steel rod 600mm long. The cone shall be fitted with lifting handles and foot pieces.

Making Test cubes

Where required by the Engineer samples of the concrete shall be taken by the Contractor from random batch mixes as placed in the concrete structures during a pour, and a set of six cubes shall be prepared and cured. They shall be marked with a distinguishing sign which shall be entered in a Concrete Cubes Log Book with origin of each cube and date of casting also entered..

At the time of preparing the test cubes a slump test shall be taken of the batch of concrete from which the cubes are made and the results recorded by the Engineer.

Crushing tests

The Engineer may direct that two of the cubes so prepared shall be tested for compressive strength at 3 days' or at 7 days' age, and the remaining four cubes at 28 days' age. Alternative testing arrangements may be advised by the Engineer during the course of the Contract. The results of these tests must be given to the Engineer immediately such tests have been carried out and be confirmed in writing by the laboratory.

Evaluation of test results

Two compressive strength test specimens for the selected age for compliance testing shall be prepared from the sample as described in BS 1881 : Part 108 and both the specimens shall be cured in one of the following ways.

- a) for 28 days as described in BS 1881 : Part 111:
- or
- b) by any other regime of curing specified or agreed between the producer and purchaser (eg 7 days, normal curing or accelerated curing at an elevated temperature (see BS 1881: Part 112)) that will enable the strength at 28 days to be predicted.

On completion of the curing, the specimens shall be tested and the mean of the two results shall be taken as the test result.

When the difference between the two results divided by their mean exceeds 15% the test result shall be deemed invalid.

When both the following conditions are met, the concrete complies with the specified compressive strength.

- a) The mean strength determined from the first two, three or four consecutive test results, or from any group of four consecutive test results complies with the appropriate limits in column A of table (5.1).
- b) Any individual test result complies with the appropriate limits in Column B of table 5.1.

Failure to pass crushing tests

In the event of the tests not meeting the specified strengths the Engineer will instruct the Contractor on what steps to take. The Engineer may condemn the concrete from which the representative concrete cubes were taken, or order the Contractor to carry out further tests ie test cores, test load or similar in order to satisfy the Engineer that the concrete is acceptable. If so ordered, the Contractor shall remove the defective concrete or take such steps to rectify the defective concrete placed, and to strengthen, secure and remove all danger of damage to the structure or other structures as the Engineer may deem necessary. In this respect the Engineer's decision will be final. The Contractor shall carry out all such work expeditiously and entirely at his own cost.

4.2.14 Measuring Concrete Ingredients (Weighbatching)

Cement, sand and stone are to be measured by mass using an approved type of weighbatcher. This is at all times to be properly maintained by the Contractor, and for this purpose the Contractor is to arrange for a monthly inspection and maintenance check. Should this period prove unsatisfactory or the rate of concreting be abnormally high, the Engineer may order fortnightly or weekly checks at his discretion. In addition, the Contractor is to check the accuracy of the weighbatcher each day to the satisfaction of the Engineer.

At the end of each day's concreting, the weighbatcher is to be thoroughly cleaned by high-pressure water jet and covered with a suitable tarpaulin if it is in the open. For this purpose, and for preparing concrete surfaces prior to placing a subsequent lift, a high-pressure water jet is required on Site for the full period during which concreting is in progress.

The batching plant shall be so sized that it can adequately deal with the mixes to be used without overloading, and the errors of measurement shall not exceed 2% of the desired amounts.

Volume batching will not be permitted, except in exceptional circumstances and with the written approval of the Engineer, and in such cases the quantity of cement must be increased by 10%, the cost of which to be borne by the Contractor.

Water shall be accurately measured using suitable calibrated containers properly controlled, the amount used being no more than is necessary for workability.

All measurements are to be supervised and controlled by a competent operator who shall be constantly engaged in supervising the operations of measuring, mixing and placing of concrete.

4.2.15 Mixing of Concrete

All concrete shall be thoroughly mixed in mechanical batch mixers of approved type, size and design to ensure positively that the mixing operation gives a uniform distribution of all the ingredients throughout the mass. Each mixer and its operation shall be approved by the Engineer, and, if in his opinion any mixer is producing unsatisfactory results, the Contractor shall discontinue its use until such time as it is repaired or replaced temporarily or permanently with an approved mixer, as required by the Engineer. The total capacity of the mixing plant on the job must be sufficient to permit any reasonable pour which may be ordered to be satisfactorily completed in one operation in daylight.

The sequence of charging the mixer shall be subject to the approval of the Engineer and the same sequence shall always be followed unless otherwise authorised. The exact quantities of cement, sand, stone and water for each particular grade of concrete shall be fed into the rotating mixer, which shall thereafter be run at an even speed for a period of not less than two minutes for mixers with rated capacity up to 3 m³ concrete, or such longer period as may be required by the Engineer, provided that mixing shall continue for not less than one minute after any final adjustment to the quantity of water used. A reversible sandglass or other approved device shall be used to measure the time of mixing.

The mixer shall discharge in a manner which ensures that there is no segregation of the ingredients of the mix, and the entire batch shall be discharged before recharging. Whenever the mixer stops running for any considerable period it shall be thoroughly cleaned out, with particular attention to the removal of all materials from the drum, loader and paddles.

4.2.16 Placing of Concrete

Preparations for placing concrete

Before placing concrete, the Contractor shall ensure that foundations, formwork and reinforcement are inspected and approved by the Engineer. Immediately before placing concrete, formwork shall be cleared of all rubbish and loose material and the concrete surfaces prepared to receive the new concrete. All foundations or previous lifts shall be cleaned of all loose or extraneous matter through suitable openings in forms, washed and thoroughly damped before concreting.

No concrete shall be deposited during inclement weather. In cold weather, concreting operations may be restricted to the warmer periods of the day and the Contractor shall

ensure that concrete shall have a temperature of at least 5°C and that its temperature shall be maintained above 5°C until it has thoroughly hardened. When necessary, the water for concrete making shall be heated before mixing and all concrete cast previously which has been damaged by frost or any other cause shall be removed prior to placing new concrete. Stripping times must be increased to the approval of the Engineer if temperatures are below 15°C.

During the placing of concrete sufficient competent carpenters and steel fixers must be available on site to rectify any defects in formwork or steel fixing which may arise..

Transporting and Placing

Concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which will prevent segregation or loss of the ingredients, and deposited as nearly as practicable in its final position to avoid re-handling or flowing.

When concrete is conveyed in chutes, the plant shall be adequate to ensure practically continuous flow in the chute. The slope of the chute shall allow the concrete to flow without the use of any additional water and without segregation of ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. When the operation is intermittent, the spout shall discharge into a hopper. The chute shall be thoroughly flushed with water before and after each working period; the water used for this purpose shall be discharged outside the formwork.

The concrete shall be placed in its final position before setting has commenced and shall not subsequently be disturbed. For this purpose it shall be assumed that setting commences three quarters of an hour after mixing and concrete that has been mixed for longer than this period before placing shall be rejected as unsuitable for use upon these Works.

In each lift, concrete shall be deposited in layers of such depth as may be authorised by the Engineer, and successive layers shall follow at such intervals as to ensure that the concrete already poured is exposed for not longer than an hour before being covered by fresh concrete. Care shall be taken not to disturb any embedded fixtures, steel or formwork during concreting operations. All timber distance pieces shall have wires securely attached for their easy removal as the work proceeds. Such wires shall project above finished work level.

Concrete shall be placed without shock and it is not to be dropped or thrown from a distance into place.

Any rest pauses, such as for meals, shall be avoided, and the Contractor shall make the operation continuous by working shifts. A workable arrangement must be approved by the Engineer before each concreting operation commences.

(a) Compaction

While it is being placed and immediately thereafter, concrete shall be thoroughly compacted and worked around the reinforcement, around embedded fixtures and into the corners of formwork and foundations and thereafter it shall be left undisturbed.

All Grade 15 and stronger concrete is to be vibrated immediately after placing by means of vibrators of an approved type applied direct to the concrete and not to reinforcement or formwork. Care is to be taken to avoid over-vibration and to apply vibration only to concrete which has been mixed less than an hour previously; no vibration shall be applied in the vicinity of concrete which has set or commenced to set until at least ten hours have elapsed since the placing of such concrete. Sufficient vibrators shall be in use and on hand as spares to ensure continuous adequate vibration of the concrete while being

placed to the satisfaction of the Engineer. No concreting will be allowed unless the Engineer is satisfied that sufficient vibrators in good working order are available on site.

Contractors are at liberty to vibrate other grades of concrete in which case the same precautions are to be observed.

4.2.17 Construction joints

General

The position and arrangement of construction joints must be approved by the Engineer before each lift is commenced and in general these shall be straight and perpendicular to the member, while formwork shall not project above the plane of construction joints except with the approval of the Engineer. The Engineer shall delay concreting until formwork or formwork for the construction joint has, in his opinion, been properly set in position. Construction joints shall be formed with tongued and grooved or other approved form of key and the Contractor's billed price for concrete shall allow for all necessary formwork for forming such joints.

Horizontal Construction Joints

In walls or columns, the forms are to be overfilled with concrete to a slight extent and the poorer material which collects at the top, such as scum, laitance and the porous concrete immediately underlying these, removed by striking-off level with the top of the formwork. This procedure is to be completed within four hours of placing the concrete.

Where fresh concrete is to be added after a period of ten hours the surface of the concrete previously placed is to be wire brushed after the initial set has taken place but prior to the final set. Immediately before new concrete is placed it is to be cleaned with a high-pressure water jet to remove loose particles, dirt, sawdust, etc, painted with a neat cement/water slurry of the consistency of cream, well-scrubbed into the surface, and then coated with a 10mm layer of cement mortar of a strength similar to that of the concrete. This should be done in stages immediately before the new work proceeds, so that no mortar is exposed longer than 30 minutes before being covered with concrete.

If the Engineer is not satisfied with the appearance of the concrete surface after wire brushing or if he considers that the final set took place before wire brushing started, the whole of the surface of the lower lift is to be chipped to expose the aggregate before being thoroughly flushed with clean water to remove all loose particles. The exposed surface is then to be kept clean and damp for 24 hours. Immediately before the placing of the new concrete, a neat cement/water slurry of the consistency of cream shall be painted over and scrubbed into the surface, followed by the cement mortar and concrete as described above.

Horizontal construction joints in a water retaining or excluding structure are to be formed with a continuous well defined female key at least 75 mm wide and 50 mm deep in the centre of the lower lift of the wall. The whole surface of the joint is to be treated as described above before the next lift is placed and the forms blown out with compressed air in addition. The Contractor shall not commence the next pour until the Engineer has approved the preparation of the joint. To obviate shrinkage problems successive lifts shall follow each other as rapidly as practicable.

The Contractor should note that Clause 2.2.14 - "Measuring concrete ingredients" requires a high-pressure water jetting equipment to be on site for the whole period during which concreting is in progress, and this must be available for cleaning concrete faces prior to placing fresh concrete.

"Kickers" shall be used (approximately 80mm deep) to ensure good quality concrete at bottoms of walls.

Vertical Construction Joints

Vertical or inclined construction joints of any kind will be permitted only where ordered or authorised by the Engineer. To avoid such joints placing of concrete in walls shall commence at convenient points on the perimeter of the wall and shall proceed both ways simultaneously until the ends of the lift unite at points opposite or adjacent to the points of commencement, so that fresh concrete meets fresh concrete. The Contractor's equipment and organisation is to be capable of pouring a lift of not less than 500mm height for the full circumference of any such structure in one continuous operation not exceeding 10 hours in duration.

Unless otherwise detailed vertical construction joints, if approved, will be formed with a central key at least 75mm wide and 50mm deep and, for water retaining or excluding structures, with a 150mm dumbbell PVC water stop. The exposed concrete face will be chipped and washed as described above before adjoining concrete is poured. An item is provided in the Bill for the vertical construction joints shown on the Drawings, but no payment will be made for any other joints required for the additional convenience of the Contractor.

(b) Construction Joints shown on Drawings

Certain construction joints may be shown on the Drawings, particularly where they affect the basis of design, and the Contractor must comply with such requirements unless he has the Engineer's written authority to depart from them.

(c) Concrete on Rock

All rock surfaces on which concrete is to be placed shall be chipped, brushed, washed and cleaned, all loose material shall be removed, every fissure filled with cement grout or concrete as ordered by the Engineer, and immediately before concrete is laid the rock surface shall be thoroughly covered with cement mortar or grout or both, whichever may be ordered by the Engineer.

4.2.18 Formwork

General requirements

For all cast in-situ concrete, the Contractor is to allow for the provision and use of the necessary Formwork which must be of wrought hardwood timber, shutter grade plywood or metal to give a good clean finish, true to face and free from any defects. Formwork to be used on faces exposed to water and for concrete which will ultimately be exposed to view, shall be faced with plywood or steel and shall be free of all defects which may be reproduced as blemishes on the finished concrete surfaces.

Formwork shall be carefully designed and constructed to ensure that the concrete can be properly placed and thoroughly compacted and so that the hardened concrete shall conform accurately to the required shape, position and level, subject to the tolerances specified in Clause 2.2.21 - "Tolerances for concrete finishes" and the standards of finish specified in Clause 2.2.21 - "Concrete finishes". Special care must be taken to maintain the stability of the formwork and the tightness of the joints during vibrating operations. Cement grout must be prevented from escaping from formwork during construction. All formwork shall be so constructed that it can be easily withdrawn after allowing the requisite period of time for setting, without damage to or defacement of concrete work.

The depth of formwork shall facilitate cleaning, placing, working and vibrating without the necessity for displacing reinforcement or other work. Unless approved by the Engineer, the depth of forms shall not exceed two metres, except for columns, and temporary openings to facilitate cleaning and inspection shall be provided at the foot of all formwork. Extraneous material and rubbish shall be removed from within the forms on completion so that concrete will be uncontaminated

(d) Formwork ties

The use of wire ties, bolts, or other similar devices to hold the forms will be permitted in the structure, provided that if wire ties or bolts are used they shall be cut off 50 mm within the surface of the concrete after formwork has been removed and the holes left after cutting off the ties soundly stopped with epoxy putty or cement mortar neatly finished to a smooth surface uniform with that of the surrounding work. Proprietary brand ties with removable rubber cones are preferred, and, if these are used, the recess should be roughened after removal of the cone while the concrete is still green and great care is to be taken when caulking to prevent shrinkage. In the walls of all water retaining or excluding structures only steel ties with a central puddle flange may be used.

On no account shall Formwork be secured to reinforcement, nor shall any oil or similar shutter treating compound contaminate reinforcement.

(e) Prechamber

Unless otherwise stipulated, formwork for slabs and beams shall provide the midspan cambers shown below in mm:-

Depth of Member (mm)	Span (m)					
	4	5	6	7	8	Over 8
1 000	5	5	5	5	10	10
900	5	5	5	10	10	
800	5	5	5	10	10	
700	5	5	5	10	15	
600	5	5	10	10	15	
500	5	5	10	15	20	
400	5	10	10	15	20	
300	5	10	15	20		
200	10					

(f) Stripping formwork

Formwork shall be removed without shock or vibration after the concrete has been allowed to set for the time shown in the following table (temperature is daily minimum atmospheric temperature adjacent to the concrete):-

Location of Concrete	Stripping Time : Days (PC15/OPC)		
	Above 18°C	5-18°C	Below 5°C
Beam sides, walls and unloaded columns	1/2	3/4	4/6
Slabs (props left at panel centres)	4/6	6/9	7/10
Beam soffits (props left at midspan) and ribs of a ribbed floor	7/10	10/12	12/14
Slab props	10/12	14/15	17/19
Beam props	14/15	21/21	28/28

The formwork and supports must be so designed that props form part of the original support and so that the formwork to the soffits of slabs, and to the sides and soffits of beams may be removed without in any way disturbing them either by the removal and replacement of such supports or by the readjustment of wedges. Should the formwork not be so designed, then all formwork to slabs and beams must remain undisturbed for the stripping periods detailed above after the placing of the concrete.

Neither beams nor slabs must be subjected to any superimposed load until the concrete has been proved to have attained the specified 28 day characteristic strength, particularly any heavy or concentrated loads such as machinery or stacks of bricks, cement, stone, sand or timber.

4.2.19 Reinforcement

Steel reinforcement for concrete work shall be round, square twisted or high-yield steel bars or other reinforcement as billed, of the sizes required by the Drawings or as detailed in the Bending Schedules of reinforcing steel to be supplied to the Contractor. Bars shall be straight or bent cold to the shapes and dimensions required under steady even pressure without any jerk or impact in suitable bending machines before the bars are fixed in place. Bars for hoop steel reinforcement are to be bent to even radius in a hooping machine.

All bending dimensions are to be in accordance with BS4466.

All rod reinforcement is to be accurately and regularly fixed in strict accordance with the dimensions and details given on the Drawings and carefully maintained in correct position during construction. Steel for beams and other such members should wherever possible be assembled together, wired and set into position as one unit. All crossings shall be tied and laps bound with 1,60 mm soft annealed iron wire. Not more than one rod in three is to be spliced at any vertical section in the wall of a water retaining or excluding structure.

Where its use is required or permitted by the Engineer, welded wire mesh fabric of approved size and manufacture shall be supplied in suitable rolls or sheets, and properly cut to suit the shape and dimensions of the concrete panels.

Steel shall be carefully retained in position by spacers, stools, hangers, clips or distance blocks with all tying wires bent away from the forms.

To ensure that steel in walls shall be afforded the necessary concrete cover, it must be supported by plastic stools to maintain the necessary clearance from the finished surface of the concrete. For bars larger than 25mm diameter, or a cover greater than 40mm, precast concrete or asbestos cement stools may be used if plastic stools are unobtainable, and these alternatives shall be used to maintain bottom cover to horizontal steel. Precast concrete spacer blocks shall be of Grade 30/10 concrete, cured in water for 14 days.

On no account must reinforcing steel be used as a means of support for formwork or scaffolding and the steel must be kept entirely free from strain while concrete is being placed.

The minimum cover of concrete from the nearest surface of any rod to the adjacent face of the concrete work encasing it must not be less than 25 mm or the diameter of the bar,

whichever is the greater, on interior protected faces, and not less than 40 mm elsewhere, unless otherwise indicated on the Drawings or required by the Engineer.

4.2.20 Water stops

Water stops shall extrude polyvinyl chloride (PVC) of the centrally placed profile as "Supercast Water foil", 200 mm wide manufactured by *Expandite Ltd*, London, UK, or approved equivalent.

The Contractor shall supply, for the Engineer's approval, samples of proposed water stop at least 60 days before the date of its intended use.

The Contractor shall furnish all materials and equipment for cutting and splicing water stops. All splices in water stops shall be made by means of a suitable approved portable electric heat welding/splicing machine with dies and clamps which exactly match the water stop profile, in strict accordance with the manufacturer's specifications.

The Contractor shall take suitable precautions and provide means to support and protect water stops during the progress of the work and shall repair or replace, at his own expense, any damaged water stops. The Contractor shall supply all necessary supports and ties required for placing the water stops, the cost of which shall be included in the unit rates for water stops.

Water stops shall be installed with equal widths of the material embedded in the concrete on each side of the joint and shall be held rigidly in place. Formwork shall be joined at the water stop locations such that the centreline of the water stop is located in the plane of the edge of the concrete pour. The concrete shall be carefully placed and vibrated around water stops to ensure complete filling of the forms in the areas around water stops and a complete bond between the concrete and all embedded areas of the water stops. Concrete shall not be deposited directly onto the water stops.

4.2.21 Curing of Concrete Work

The Contractor must allow in his rates for adequate curing, of all concrete work. After concrete has been placed it is to be prevented, in a manner approved by the Engineer, from drying out too rapidly and, in his rates for concrete work the Contractor shall allow for flooding, spraying with water or covering with sacks, sheeting or sand and keeping the work damp for a period of six, eight or ten days after placing, when ambient temperatures are over 18°C, 5-18°C or below 5°C respectively. For the first three days of the curing period, concrete shall be maintained at a temperature between 10 and 25°C and all surfaces protected from the undesirable effects of high air temperature, low relative humidity or high wind velocity.

All vertical surfaces are to be thoroughly rubbed down immediately after stripping to remove all fins and marks from formwork. Small vertical members such as columns may be wrapped in plastic sheeting into which water shall be regularly introduced at the upper end of the member to make good the loss of water from the member to the inner surface of the sheeting and to supply the additional water required for curing. Larger members may be covered with hessian which shall be frequently watered. A curing compound may be used only with the express permission of the Engineer which will be given only when the compound has been tested and approved by the Cement and Concrete Institute.

Floors and roofs are to be cured by flooding with water to a minimum depth of 15mm and for this purpose a nib of mortar shall be constructed around each panel or section of the work and all drains or openings sealed. Moist curing of the floors of water retaining structures shall continue beyond the specified curing period until roof construction is sufficiently advanced to afford protection from the direct rays of the sun and the effects of frost or, if there is no roof, until water is introduced and covers the floor. Curing of floors and roofs is to commence immediately the final set has taken place.

None of this work is billed and the rates for concrete must allow for curing.

4.2.22 Concrete Finishes

General

All concrete work shall be finished to the lines, levels, slopes and outlines shown on the Drawings or as otherwise directed.

Note that wherever concrete work is required to contain, exclude or conduct water, absolute watertightness of the concrete is an essential feature of construction and the quality and finish of the work should be such that no after-treatment in the nature of plastering or cement washing should be necessary to ensure this condition but, if done with the Engineer's permission either to secure watertightness or to produce a finish which shall be satisfactory to the Engineer, it must be so done at the responsibility of the Contractor and at his own expense, unless specifically provided for under the Contract.

Various classes of finish are required, as follows:

Formed surfaces:

(g) Class F1

This is for concrete which is below ground or otherwise concealed. Unwrot formwork is billed for this finish and shall consist of sawn boards, sheet metal or any other suitable material.

(h) Class F2

This is for concrete which may be visible but where the highest standard of finish is not required. Wrot formwork is billed for this finish and shall consist of dressed timber with square edges, plywood or metal panels free from defects likely to detract from the general appearance of the finished surface. Joints between boards and panels shall be horizontal or vertical unless otherwise directed.

The finish shall require no general filling of surface pitting, but fins, surface discolouration and other minor defects shall be remedied by methods approved by the Engineer.

(i) Class F3

This is for concrete prominently exposed to view and water retaining structures where good alignment and appearance are desired. This finish shall consist of plywood or metal panels free from defects. The finish shall be such that minor defects within the specified tolerances may be remedied by rubbing down with carborundum blocks.

(j) Class F4 – Not Used

Screeded or Floated Surfaces:

Class U1

This is a screeded finish. The concrete shall be levelled or screeded to produce a uniform plane or slightly ridged surface, surplus concrete being struck off with a straight edge

immediately after compaction. Unless a floated finish is specified all horizontal (or nearly horizontal) surfaces shall be finished in this way without extra payment beyond the rate quoted for the concrete.

(k) Class U2

This is a wood floated finish. Floating shall be done only after the concrete has hardened sufficiently, and care taken to work the concrete no more than is necessary to produce a uniform surface free from screed marks. Items are provided in the Bill for this finish.

(l) Class U3

This is a hard smooth steel-trowelled finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked to the surface. The surfaces shall be trowelled under firm pressure and left free from trowel marks. Items are provided in the Bill for this finish.

Class U4

This is a special finish for sliding joints. The lower surface is in every instance, when the concrete is poured, to be dusted with neat cement and steel-trowelled to a special glass-like finish.

4.2.23 Tolerance for Concrete Finishes

The permissible tolerances in formed and unformed surfaces for the various classes of finish specified in Clause 2.2.21 - "Concrete finishes" shall not exceed the limits shown in the following table or on the Drawings:-

TYPE OF IRREGULARITY (see notes below)	Tolerances (mm)							
	Type of Finish							
	Formed				Unformed			
	F1	F2	F3	F4	U1	U2	U3	U4
Departure from cross-sectional dimensions								
Slab depth or wall thickness	+ 5	+ 5	+ 5	+ 5				
Beams, ribs and columns								
(i) Dimensions up to 500mm	± 5	± 5	± 5	± 5				
(ii) Larger dimensions: for each additional 250 mm or part thereof, add to tolerance	± 3	± 3	± 3	± 3				
Footings	+25 -10	+25 -10	+25 -10	+25 -10				
Departure from plumb of columns								
(i) Height up to 4.5 m	± 5	± 5	± 5	± 5				
(ii) Greater height: for each additional 3m or part thereof, add to tolerance	± 3	± 3	± 3	± 3				
Departure from alignment or grade	+ 40 - 12	± 12	± 12	± 12	± 12	± 6	± 6	± 1
Abrupt irregularities	12	6	3	3	12	2	2	1
Deviation from template in long dimensions	± 12	± 10	± 6	± 6	± 12	± 6	± 6	± 3

Notes

- (i) Departure from alignment and grade will be measured by theodolite or stretched lines along the whole length of the structure.

- (ii) Variations in cross-sectional dimensions are for structural members for which it is desirable to keep tolerances within closer limits than specified for alignment and grade.
- (iii) Gradual irregularities caused by misalignment of formwork or poor workmanship will be measured from a straight or appropriately curved template 1 metre long.
- (iv) Abrupt irregularities are sudden off-sets such as caused by displaced or misplaced formwork or trowel marks.

4.2.24 Defective Concrete

All finished concrete must be sound and free from defect of any kind. Concrete which is honeycombed, porous, soft after setting or defective in any way, or which is not entirely watertight when intended to retain or exclude water, will be rejected by the Engineer as defective work. Upon the rejection of such work, the Contractor will be required to take such steps as he may find to be necessary to rectify it promptly, either by cutting out the defective work and replacing it entirely with sound concrete, or by adopting such other measures as will be acceptable to the Engineer and will ensure the soundness of the work to the Engineer's complete satisfaction. The application of screeds and/or surface coatings to defective concrete is unlikely to be acceptable to the Engineer

4.2.25 Concrete Blinding

Where specified, a concrete screed or blinding layer in Grade 10 concrete is to be laid on the trimmed foundation to give an even working surface. The screed must be laid immediately following the completion of trimming and cleaning the foundation, and is to be level or graded to a fall as shown on the Drawings.

Unless otherwise specified, blinding shall be 50 mm thick.

4.2.26 Concreting around pipes

Where pipes pass through or are to be set into concrete work, they shall be well cleaned (to bare metal in the case of steel pipes) and the concrete worked thoroughly into contact with the pipe wall.

The greatest care shall be taken to ensure that pipes are correctly aligned and that formwork is carefully cut to the shape of the pipe. No concrete shall be poured until the Engineer has satisfied himself that the pipes are in the correct position and the formwork is satisfactory.

All pipes to be anchored against thrust are to be cast into concrete and in any event the Contractor will not be permitted to leave openings into which pipes are to be set at a later stage without the approval of the Engineer. If this approval is granted, a square hole to accommodate the pipe shall be left in the concrete, preferably exposing part of the reinforcement, bars around the pipe. The hole must be large enough to provide at least 75mm clearance around the puddle flange of the pipe, but should not be unnecessarily large.

A recessed tapered central key shall be formed in the bottom and sides of the opening. The key is to be 50mm deep and tapering from 75mm wide at the top to 50mm wide at the base of the key for walls up to 200mm thick, and 100 to 75 wide for thicker sections.

The soffit of the opening shall not have a recessed key formed but shall instead be inclined upwards at an angle of approximately 30° from the centre of the wall to the outside faces, to ensure that no air can be trapped under the soffit during concreting.

Prior to pipe installation, the faces of the opening shall be thoroughly chipped to expose the aggregate and remove any weak or porous concrete, and washed down. The interconnecting pipework passing through the wall shall then be erected to final line and level, to avoid any possibility of misalignment when it is concreted in. Formwork shall then be carefully cut to fit around the pipe, and placed so that it forms a clearly-defined "letter-box" opening not less than 150mm wide on both sides of the wall, extending to a height of 300mm above the soffit of the opening. Formwork shall be caulked if necessary to prevent grout loss during concreting.

Concreting shall take place from one side of the opening only. The concrete shall be placed in small quantities and compacted using a small-diameter vibrator. The addition of concrete shall continue until the concrete rises up to the full height of the "letter-box" opening on the other side of the wall. After the concrete has taken on its final set, but while it is still "green", the "letter-box" forms shall be carefully removed and the excess concrete struck off, avoiding any shock to the pipe. The surfaces shall then be neatly finished off with mortar and the concrete properly cured with wet sacking for 7 days. The joint between old and new concrete is then to be hacked back on both sides of the wall to form a vee-joint 20mm deep, which is to be caulked with approved epoxy mortar.

In the event of any leakage being apparent during testing for watertightness, then the whole area of more recent concrete surrounding the pipe on the wetted face of the wall is to be scabbled and plastered with approved epoxy mortar applied in accordance with the manufacturer's instructions. This plastering is to be overlapped 100mm onto original concrete and 50mm onto the projecting barrel of the pipe.

The rates quoted for setting pipes in concrete are to allow for all special formwork where pipes are to be cast in or fixing the special forms where pipes are to be caulked in.

4.2.27 Setting Bolts, Frames etc in concrete

Where necessary, bolts shall be set directly into position by template. A small annular opening may be provided when holding-down bolts are set into concrete to provide for final adjustment by bending. Manhole frames, step irons and all such metal work, are wherever possible, to be set directly in place, or where necessary bedded on a previously prepared bed of concrete or mortar, and the surrounding concrete work carefully tamped into contact with such metal work. After setting of concrete and removal of formwork, the surface of the concrete work is to be neatly finished off by pointing around metal work, all exposed surfaces of which are to be carefully cleaned and twice coated with black bituminous paint, unless billed differently.

Boltholes shall be formed in concrete work either by setting tapered boxes into position before concrete is placed, or by drilling into concrete work after this has set. The method adopted shall be at the discretion of the Engineer.

The position of boltholes must be accurate to within 10 mm and particular care must be taken to ensure that the depth of any hole is not excessive.

4.2.28 Grouting

General

Grouting holding down bolts, around pipes, under baseplates, etc, shall be done to the instructions of the Engineer using materials of suitable consistency. Unless otherwise directed, grouting mixtures shall consist of one part cement to two parts sand by volume,

well mixed and with sufficient water added to obtain the required consistency. Where recesses to be filled are of appreciable dimensions, the Engineer may direct the Contractor to replace a proportion of sand with fine stone to reduce shrinkage. The Engineer may also require the Contractor to use non-shrink or other additives in grouting mixtures where these are allowed for in the Bill of Quantities.

Liquid Grout

Where liquid grout is required for bolt holes, etc, water shall be added in such quantity that, when the material is thoroughly mixed and stirred, it shall flow readily to fill all recesses and air spaces in the work to be grouted. Before grouting, the surfaces to receive grout shall be thoroughly cleaned and flushed with water. The grout shall then be introduced in such a manner as to fill all recesses effectively. When the grout has set the surface of the work shall be finished off flush and smooth with cement mortar.

Cement Mortar

Where cement mortar is specified for filling around pipes, etc, water shall be added to obtain a firm paste which can be worked with a trowel but is not fluid. Surfaces to receive mortar shall be well wetted and excess water removed or allowed to drain. The mortar shall be worked into place with a trowel or tamping rod, exposed surfaces floated off and covered with wet hessian for 24 hours while the mortar hardens without disturbance.

Dry Caulking

Where dry caulking is specified, under baseplates, etc, only sufficient water shall be added to make the mixture ball when squeezed in the hand. Before any caulking is done the surfaces between which the caulking is to be placed shall be thoroughly cleaned and flushed with water. All visible surplus water shall be wiped or blown away and the dry caulking rammed or hammered into place using suitable tools. Exposed surfaces shall be finished off neatly with a trowel and extensive exposed areas shall be covered with wet sacking and kept damp for at least 24 hours.

Where additives are specified for grouting operations these shall be brought onto Site in the manufacturer's unopened containers and used strictly in accordance with the manufacturer's instructions which the Contractor shall not fail to obtain. If necessary, the Engineer may require the Contractor to undertake preliminary tests to check the behaviour of proprietary additives under the conditions obtaining on the Site.

4.2.29 Valve Chambers

Valve chambers are to be watertight and they shall not be accepted as complete until they show no visible leaks on all internal exposed sections.

In order to minimise the risk of the chambers not being watertight, the Contractor shall take the greatest precautions during construction to prevent the occurrence of possible sources of leakage into the chambers.

In the event of leakage being evident at any time during the Defects Liability Period the Engineer, before issuing a Final Certificate for the Works, may call for further rectification and will have the right to withhold his Certificate until he considers the work to be satisfactory.

4.2.30 Anchor Blocks for Pipework

Anchors of Grade 10 concrete are to be provided to the satisfaction of the Engineer at all horizontal and vertical bends and tee-pieces on pipework, on steep slopes, and at other specified points. Concrete protection to pipework may also be required at certain points.

The form and dimensions of these concrete works will be specified or detailed and payment for them will be made under items provided in the Bill of Quantities.

4.2.31 Surface Water Channels

The Bill of Quantities may contain a provisional quantity for surface water channels. These are to be formed in Grade 10 concrete to a minimum thickness of 75 mm to afford a segmental waterway 450mm wide and 100mm maximum depth. The channels are to be firmly bedded on 50mm of sand, graded to suit the fall of the ground or as directed by the Engineer, and finished with a steel trowel.

The rate quoted for channels shall cover all the necessary work including excavation to set the upper edges of the channel flush with the surface of the ground.

4.2.32 No-Fines concrete (NFC)

No-fines concrete (NFC) is used as a drainage and/or pressure equalising medium beneath floor slabs and wall foundations of various structures. The amount of mixing water is critical and must be just enough to produce a cement paste the consistency of paint, capable of coating each particle of coarse aggregate uniformly.

NFC shall consist of 1 part cement to 8 parts of well-shaped single size 13mm stone mixed with approximately 22 1/2 litres of water. The quantity of water shall be confirmed on site by a trial mix and up to 1/2 part of pit sand may be added to improve the consistency of the cement slurry.

NFC shall be mixed in a normal mechanical concrete mixer. Stone and half the mixing water shall be mixed for 1/2 minute in order to wet the aggregate. Cement and the remainder of the water (plus sand if required) shall be added to the drum and mixing shall continue for a further 2 minutes.

The anticipated mean crushing strength of NFC shall be 3.0 and 4.4MPa at 7 and 28 days respectively.

NFC shall be placed in a single layer and lightly rodded; mechanical vibrators must not be used to compact NFC. The surface of the NFC shall be screeded level.

Between 12 and 24 hours after placing on NFC panel a 1:8 cement mortar screed mixed to a semi dry consistency shall be worked into the surface of the NFC and wood floated to provide a smooth but porous working surface.

The porosity of the floated surface shall be checked by wetting the surface and checking that applied water penetrates through the screed and into the NFC.

NFC, with or without the surface screed, shall be damp cured for at least 7 days after placing.

4.2.33 Special Provisions for Concrete Reservoirs

N/A

4.2.34 Precast Concrete Work

General

Precast concrete work shall be made in suitable machines or moulds, designed to produce castings of the requisite size and with the highest quality finish requiring neither rubbing down nor plastering in order to present smooth even faces true to shape, with sound edges and free from cracks and defects of any kind.

Unless otherwise specified, concrete for products cast on site by the Contractor shall be Grade 20/13 poured carefully into the prepared moulds, vibrated or rammed to ensure a dense impermeable concrete and finished with a steel float on exposed surfaces. After pouring the concrete, the concrete shall be protected by a covering of saturated hessian and stored in a cool place for 24 hours after which time it shall be removed from its mould and immersed in water if practical or protected by a covering of saturated hessian for a further period of 7 days. The Contractor shall be responsible for ensuring that the curing water does not freeze in frosty weather. Castings damaged by frost or having cracks, fractures, spalling or other defects shall be removed and replaced by the Contractor at his own expense.

The price for such work shall allow for the provision and use of the necessary moulds, which must be adaptable to the requirements of the work, and for all stacking, curing of the work underwater and finally placing and bedding in position to required lines and levels.

4.2.35 Concrete Floor Finishes

Concrete floors shall be screeded with granolithic concrete.

Where specified the Contractor shall remove existing screed. The surface shall be roughened and cleaned of all loose material to the satisfaction of the Engineer. The surface shall then be moistened and a new granolithic screed shall be placed. The depth of the screed shall not be less than 50 mm shall be finished as follows:

(a) Steel Trowel Finish (F1):

Finishing shall be with a steel hand trowel generally as follows. The screed shall be finished initially with a wooden float to line and level as agreed with the Engineer on the site and so as to present a uniform surface. Final finishing shall be with steel trowel after the concrete has sufficiently hardened.

(b) Wood Float Finish (F2)

A wood float finish shall be provided on all pads and walkways and as directed by the Engineer. If screening is not required by the Engineer the floating shall not be carried out until some stiffening has taken place in the concrete surface.

The Contractor shall take particular care to protect the floor finishes from damage after they have been placed, by laying protective timbers and keeping traffic over the area to a minimum.

Should the floor be damaged before handover, the Engineer may require the Contractor to cut and remove the damaged portion and replace with a new hardened floor finish, at his own expense.

4.2.36 Sleeves and Openings

Suitable sleeves shall be set in the concrete for all cables, conduits and small piping (60 mm or less in diameter) where such piping passes through concrete walls or floors as specified in the Plumbing Section. Such sleeves shall be set with reference to their position in the final finish.

Where large pipes are required to be built into walls or floors without the use of wall castings, the Contractor will be permitted to leave the necessary openings with sufficient clearance for later grouting.

Where clearance is required between the built in item and the wall (exhaust pipework, etc.) the wall shall be finished with clean neat lines. A suitable heat resistant material shall be loosely placed around the pipe such that it allows for movement between the pipe and the structure. The design and detailing of which shall be to the equipment supplier's requirements.

4.2.37 Setting Anchor Bolts, etc.

The Contractor shall set all bolts, anchors, miscellaneous metals or other steel work in the concrete forms for architectural, structural, mechanical and electrical items. These shall be as required by the equipment suppliers and the Contractor shall be fully responsible for the setting of such materials in the forms and concrete and shall correct any fittings, etc., not installed in a proper location or manner at his own expense.

4.2.38 Grouting of Equipment Base

The Contractor shall supply all labour and materials required for grouting and all equipment and base plates. The concrete surface shall be thoroughly cleaned and saturated with water prior to grouting. Grouts shall consist of equal parts cement, fine aggregate and expanding aggregate or non-shrink grout. The amount of mixing water shall be such as to produce a plastic to flowable mix.

After the grout has set, it shall be cut off back at least 15 mm and refilled with plain cement mortar to produce a flush surface with the base. If cavities are present after grouting, the Contractor shall regrout until the bases are supported over their entire area.

4.3 BUILDING WORKS

4.3.1 General

The following sections relate to rehabilitation and or construction of various pump houses, staff housing, offices, storage buildings, and other miscellaneous structures. The Contractor shall also refer to other relevant sections of the specifications.

4.3.2 Footings and Foundation Walls

Footings to be of reinforced Class 25/20 concrete as shown on the drawings. Footings to be placed on 50 mm of fill concrete placed immediately after excavation to avoid deterioration of the excavated material.

Foundation walls to be either solid concrete or double layer brick as shown on the drawings, with full bed wire, and ladder type reinforcement at 450 mm spacing maximum.

The Contractor shall provide openings for pipes, conduits, etc., as required.

4.3.3 Floor Slabs

Floor slabs to be 150 mm Class 25/20 concrete with reinforcing mesh as shown on the drawings, on minimum 150 mm well compacted hardcore, on DPC when placed directly on fill material.

The Contractor shall co-ordinate and place anchor bolts, equipment bases, housekeeping pads, piping and conduit. All piping through the floors to have a double layer of polyethylene to ensure a bond break between piping and concrete.

4.3.4 Precast Concrete Blocks

Precast concrete blocks shall be manufactured to BS 2028, 1364. Blocks used for construction of buildings shall be hollow blocks - Type B with a strength designation of 2.8 N/mm² and shall be 390 mm long x 225 mm x 190 mm high nominal size, jointed and bedded in mortar of 10 mm average thickness, while for certain internal partition walls the block wall shall be 390 x 152 x 190 mm or equivalent.

Blocks used for construction of manholes, inspection chambers and septic tanks shall be solid as detailed on the Drawings and shall be 440 mm long x 215 mm x 215 mm nominal size, jointed and bedded in mortar of 10 mm average thickness.

All blocks shall have a dense, even surface and a density of not less than 1500 kg/m³.

Block shall be loaded and unloaded by hand and not tipped, and shall not be used until 4 weeks after casting unless otherwise approved by the Engineer.

4.3.5 Blockwork

All blockwork unless otherwise specified shall comply with the recommendations of BS 5628 (Load bearing walls), and CP 121: Pt 1: 1973 (Brick and block walling). All surfaces on which blockwork is to be built shall be clean. The use of chipped or defaced blocks will not be permitted in any facework. All work shall be built uniform, true and level, with all pretends vertical and in line, all cross joints shall be solid, filled with mortar in every course as the work proceeds. No work shall rise more than 1,200 mm above the adjoining works and such risings are to be properly raked back. Joints in walling to be plastered or rendered shall be raked out to form a key. All blocks shall be thoroughly wetted before laying and any defective blocks found in the work shall be cut-out and replaced by sound ones at the Contractor's expense.

All cross (vertical) joints shall be filled by well buttering the ends of the block with mortar and then sliding it against its neighbour.

Blockwork of single block thickness shall be laid in stretcher bond, and blockwork of double block thickness in alternate courses of headers and stretchers. No broken block will be accepted except where necessary for bonding.

Alternate courses of load bearing block walling at intersection shall be carried through the full thickness of the adjoining wall.

Course heights shall not vary throughout the building and each course shall be level and set out so that bed joints occur in line with sills, lintels and other features.

4.3.6 Mortar

Mortar for both masonry and blockwork shall be cement mortar in proportions of 1:4 ordinary Portland cement to sand by volume, mixed with just sufficient water to make the mixture workable.

Mortar used in foundation masonry below damp-proof course level shall be positioned in accordance with Clause 3.3.18 of this Specification.

Natural sand shall be used in cement mortar unless otherwise approved. The sand shall be obtained from sources approved by the Engineer and shall comply with the requirements of BS 1200. When tested in accordance with BS 812 the grading of the sand shall be within the limits given in Table 1 of BS 1200.

4.3.7 Mortar Mixing

All materials shall be accurately gauged by gauge boxes and mechanically mixed to a uniform consistency. Mortars shall be used within 1 hour of the addition of cement after which they shall be discarded. Re-tempering of mortar will not be permitted. Gauge boxes and mixers shall be kept clean.

4.3.8 Damp-Proof Courses in Walls

Damp-proof course in walls shall be bituminous damp-proof course to BS 743 weighing not less than 3.8 kg/m² overlapped 75 mm at all jointing and bedded in mortar whilst the mortar is still wet.

Damp proof course shall be:

(a) below all concrete floor slabs in contact with existing ground or hard core;

in the first layer of blockwork at ground floor level of any new structure or modification.

4.3.9 Storage of Materials

All blocks shall be handled carefully from manufacture to laying and properly stacked in position convenient for the work. They shall be kept free from standing water and protected from rain, mud and contamination by other materials.

Sand shall be stored separately on a clean, hard, dry standing and protected from contamination.

Cement shall be stored off the ground under cover and away from damp, and in such a manner as to enable it to be used in rotation in order of delivery.

4.3.10 Protection

When constructing masonry or blockwork in unfavourable weather and in protecting the finished work, the Contractor shall observe the same instructions as are specified for concrete work.

4.3.11 Non Load-Bearing Walls

Internal walls which are not load-bearing shall not be brought up to final finished level until the construction of the reinforced concrete roof slab has been completed and the roof finishes installed.

4.3.12 Ties to Structures

Ties at junctions with reinforced concrete work shall be of the "butterfly" type to BS 1243 and shall be cast into the concrete at 225 mm centres in line with the centre of the depth and width of mortar joints.

4.3.13 Plaster

The Cement and Fine Aggregates shall comply with that described previously under the Concrete works.

External and internal plastering shall be of two coats of each not less than 10 mm thick and shall consist of 1:3 cement to sand ratio, and shall be finished fair and smooth with a wood float unless otherwise directed. Immediately prior to plastering all surfaces shall be thoroughly wetted. All plaster shall be kept wet for two days after being applied. No decoration shall be applied to plaster surfaces until the walls and plaster are thoroughly dry to the satisfaction of the Engineer.

4.3.14 Louvered Windows

Louvered windows shall consist of louver blades fitted between a pair of parallel channel frames fabricated from aluminium alloy, each fitted with the requisite number of tension clips and mounted on forged alloy bearing in embossed housings on the frames.

Bearing shall be riveted to bevy gauge operating bars complete with flush lever handle and lock. Weather-seal strips shall be provided at hand and sill.

4.3.15 Aluminium Frame Windows

Aluminium frame windows shall be of robust construction. The colour shall be natural unless otherwise specified. The glass shall be natural unless otherwise specified. The glass shall be 5 mm glazing. The number of panels shall be as indicated or sized to suit the opening that it is to be installed. Generally where aluminium windows are specified they do not require to be opened and shall be suitable for partitioning using a glazed

system. The frames shall match and form a robust integral unit with aluminium sliding doors or other aluminium fixtures.

4.3.16 Industrial Steel Doors and Frames

Door frames of 230 mm pressed steel shall be positioned and securely mortared into place as the brick work is installed. Frames to have heavy duty backing plates for hinges, and other hardware.

Doors to be heavy-duty steel doors (fabricated from 3 mm plate), corrugated and reinforced for increased strength and drilled to receive the required hardware.

Doors and frames to have two coats shop applied primer suitable for a marine environment and in accordance with system S2 in the paint specifications. The final coats shall be applied on site after all building works have been completed.

The single door hardware is to include:

3 x 100 mm heavy duty security hinges;

1 x maximum security type lock (master keying to LSWC locks to be provided);

and

1 x aluminium threshold.

The double door hardware is to include:

6 x 100 mm heavy duty security hinges;

1 x maximum security lockset;

2 x 225mm barrel slide bolts, at top and bottom of the inactive leaf; and

1 x aluminium threshold.

All locks and latches shall be subject to the approval of the Engineer.

4.3.17 Aluminium Sliding Doors

The aluminium sliding doors shall be heavy duty and of a robust construction suitable for a harsh environment. The frame colour shall be natural. The glass should be 5 mm shatterproof glazing. The number of panels shall be as indicated or sized to suit the opening that it is to be installed.

4.3.18 Plastering and Rendering

Before plastering or rendering is carried out all joints shall be raked out to a depth of 10 mm, the surface of the wall cleaned and all foreign matter removed.

External rendering shall be applied in two coats of cement/sand mortar of mix type II, Table 1, BS 5262 with a wood float finish to a minimum overall thickness of 20 mm.

Plastering to internal walls and ceiling surfaces shall be applied in two coats to a minimum overall thickness of 20 mm as follow:

- ◆ Undercoat: cement/sand - Type II, Table 2 BS 5492; and

- ◆ Finish: anhydrous gypsum plaster to BS 1191, Part 2 C, with smooth finish.

Undercoats shall be thoroughly applied, straightened and scratched and brought to a true surface. Finished surfaces shall be left true, even and free from blemishes and all corners shall be finished true, vertical and even and carried out at the same time as adjacent wall surfaces.

Retempering or reconstitution of mixes will not be permitted after the initial set has taken place.

4.3.19 Glazed Ceramic Wall Tiles

Glazed tiles shall be white, complying with BS 1281. They shall be laid on a bed of cement mortar (1:4 cement/sand ratio) and pointed afterwards with accurate and straight joints.

Wall tiles shall comply with BS 6431 Glazed Ceramic tiles and Tile Fittings for Internal Walls.

All tiles shall be of the size, colour and quality as described in the Particular Specification of Bills of Quantities and shall be perfectly true to shape and free of all blemishes and flaws.

Samples shall be submitted to the Project Manager for approval.

All wall tiling shall be fixed on a perfectly plane vertical screed of cement and sand (1: 3).

Tiling shall be bedded on the prepared screed in a slurry of cement and sand (1: 4) or in an approved tile adhesive. The surface of each tile shall finish flush with the adjacent tiles. Joints shall be continuous straight joints both horizontally and vertically not exceeding 3 mm wide and shall be flushed up with white cement. Spacers shall be used to ensure that the correct joint width is maintained.

All cutting shall be kept to a minimum and the tiling shall be set out so that only the largest possible pieces of cut tiles are used.

Purpose made tiles with round on one edge shall be fixed to all vertical external angles and to the top edge of dadoes and the wall face over.

4.3.20 PVC Tiling and Skirting

Vinyl floor tiles shall be heavy-duty flexible PVC based complying with BS 3261, Part 1, Type A in an approved colour. Tiles shall be size 250 x 250 x 3 mm thick and skirting shall be 125 x 250 x 3 mm thick fixed in line and location using adhesive as recommended by the manufacturer.

4.3.21 Partitions

Where building partitions are indicated to be of the movable type they shall be made using softwood 100 x 50 mm frames and 50 x 50 mm sub-frames, clad with 20 mm thick gypsum board with craft paper fixed with counter sunk screws. All openings for

doors and windows shall be framed internally with wooden sub-frame and covered with metallic pressed steel frame for the doors.

4.3.22 Clear Sheet Glass

Glass shall comply with BS 952 and shall be transparent type of ordinary quality (OQ) sheet glass as in Clause 4 of BS 952 and of 4 mm thickness (unless otherwise specified) but for louvered glazing shall be ground glass (opaque quality) and in 5 mm thickness. Glass made by the float process and equivalent to this standard will be acceptable.

4.4 ROOFING AND SIDE WALL CLADDING

4.4.1 Galvanised Steel Roof and Cladding Materials

Galvanised steel roofing and side cladding sheets shall be of 24 SWG, fully galvanised and pre-painted where painted sheets are specified.

4.4.2 Fixing of Galvanised Steel Roof and Cladding

Sheets shall be laid with end laps of 300mm and side laps of two corrugations on the side away from the prevailing wind. Holes shall be drilled through the ridges of corrugations, not in the hollows. Fitting steel bolts, nuts and washers and nails shall be galvanised of approved manufacture.

4.4.3 Roof Tiling

The roofing tiles shall be first quality local clay tiles of the type as specified in the contract drawings and documents and shall be similar to those obtained from a firm approved by the Project Manager.

All tiles shall be well and evenly burnt, uniform in shape, size and colour and free from cracks, twists and other defects.

Samples shall be submitted to the Project Manager for his approval before the work commences and all tiles used shall be of equal quality to the approved sample.

Ridge and hip tiles shall be saddle back or half round tiles as indicated on the contract drawings of similar quality and manufacture as the roofing tiles.

Tiles shall be carefully graded for size shape and colour upon delivery and again before fixing.

All tiles shall be carefully stacked on edge in the site and rows of tiles shall be separated with a layer of straw, elephant grass etc. between each to prevent damage.

Any chipped, cracked or defective tiles shall not be used.

Nails, when required, shall be stout zinc nails not less than 36 mm long.

Mortar for bedding shall be gauged mortar as before described and if required shall be tinted with an approved colouring compound to match the tiling.

When required, tile battens shall be of sawn pressure impregnated structural timber as described in Carpenter.

Tile battens shall be not less than 50 x 35 mm sectional area or as indicated on the drawings and shall be accurately spaced at the specified gauge and securely fixed at the intersection with each rafter with 75 mm stout round wire nails.

All tiling is to be laid with the specified lap and when laid on battens the head of each tile shall be securely double nailed to the battens in every alternate course unless otherwise described.

An underlining of "Sisalkraft" orange label or other equal and approved reinforced waterproof paper shall be provided under all tiling battens. The paper shall be laid over the rafters with the length of the roll at right angles to same. Laps at heads of adjacent sheets shall be laid over the rafters with the length of the roll at right angles to same. Laps at heads of adjacent sheets shall be not less than 75 mm and at the ends 300 mm. End laps shall be made at a rafter. Sheets shall be lightly tacked in position to prevent movement whilst tiling battens are being fixed.

Form all verges, eaves, valleys, hips etc. as described, do all cutting, replace all broken or damaged tiles and leave all perfect and watertight on completion.

4.4.4 Aluminium Roof and Cladding Materials

N/A

4.4.5 Fixing of Aluminium Roof and Cladding.

N/A

4.4.6 Asbestos Cement Roof and Cladding Materials

N/A

4.4.7 Fixing of AC Roof and Cladding

N/A

4.4.8 Water Proofing System (Flat Roof Slabs

N/A

4.4.9 Patching of Roof and Cladding

Where required, repairs to existing roof and side cladding shall include for the patching of holes using material of similar composition, shape and corrugation with a bitumen. In all cases the repairs are to conform to the manufacturers recommendations.

The Contractor is to include in his cost for any temporary structures, required to carry out the repairs including supply and delivery of all materials and the carrying out the repairs to the Engineer's satisfaction.

4.4.10 Replacement of Roof Panels and Cladding

Where required and instructed by the Engineer the Contractor shall replace individual sheets of roofing and cladding with new ones of identical shape, size and corrugation.

The Contractor is to include in his cost for any temporary structures required to carry out the repairs including supply, delivery and fixing of all materials to the satisfaction of the Engineer.

4.4.11 Damage to Existing Roof and Cladding

The Contractor shall be responsible for any damage to existing roofing and cladding that may occur as a result of his actions whilst on site. The cost of any repairs shall be carried out by the Contractor at his own expense and to the satisfaction of the Engineer.

4.5 CARPENTRY AND JOINERY

4.5.1 Structural Timber

All Mvule and Mahogany and all other hardwoods shall be selected quality, kiln seasoned or air dried.

Structural timber shall comply with CP 112, Part 2; shall be of species S1, S2 or S3 except Parana Pine and Western Red Cedar, and shall be of Grade 50. The timber shall have a moisture content not exceeding 14% of its dry weight at the time of delivery to the Site.

The Contractor shall submit to the Engineer certified copies of the Grading and Inspection certificates issued by the accredited government timber inspector of the country of origin to cover each consignment of graded timber.

All structural timber shall be treated in conformity with BS 4072 to the tropical proofing schedule.

The same preservative treatment or a solution in accordance with Clause 3.11.1 of the Standard shall be used for the treatment of cross-cuts and other exposed surfaces.

Records of the preservative treatment and a certificate of compliance with the above BS shall be kept by the Contractor.

4.5.2 Chipboard

Chipboard shall be of certified termite-proof grade and approved manufacture and each sheet shall bear a distinguishing mark or title to this effect.

4.5.3 Plywood

Plywood shall comply with BS 1455 and shall be grade 3 veneer both sides with type MR bonding.

4.5.4 Preparation and Workmanship

All carpenter's timber shall be cut as soon as possible and kept carefully stacked clear of the ground and protected until required.

Carpenter's work shall be framed and put together in a workmanlike manner with a sufficient number of nails of adequate size to maintain the work. All necessary notching, halving, nogging, etc., shall be carefully executed and bearing surfaces shall be in proper contact.

All form of joints shall be such to transmit safely the loads and stresses to which the timber will be subjected and shall be to the satisfaction of the Engineer.

Glue shall comply with BS 1204 Part 1, and shall be classification WBP of the resorcinol-formaldehyde (CRF) or phenol-formaldehyde (PF) type, and shall be used strictly in accordance with the manufacturer's instructions.

4.5.5 Timber in Length

Beams, purlins and structural timbers are to be in as long lengths as possible. Where joints are unavoidable in beams or purlins they shall be properly scarfed and where required bolted with four 12 mm galvanised bolts with nuts and washers, let in flush where exposed. Scarves, unless otherwise directed, are to be of a length equal to twice the depth of the timber scarfed, and supported at the ends provided the adjacent timbers are continuous. Wall plates shall be halved at angles and joints in length if otherwise unobtainable in one piece.

4.5.6 Timber Roof Trusses

Prefabricated roof trusses shall be to the manufacturer's design. Structurally it should be designed to the CP 112 (timber code). The roof trusses shall be sized to meet the cladding specified and imposed loading requirements as stipulated in CP3 chapter V. The spacing of timber roof trusses shall not be greater than 3m centre to centre. They shall be anchored to a double 50 x 200 mm wall plate anchored to a reinforced concrete tie beam with 12 mm galvanised bolts mortared into place.

Timber to be structural grade. In addition, all openings between the roof and wall shall be sealed. In all cases, fascia and soffit shall be provided for a finished appearance.

4.5.7 Joinery Timber

Joinery timber shall comply with BS 1186, Part 1. Hardwood for external door and window frames shall be Class 1 hardwood as Appendix B, and all other joinery timber shall be Class 2 softwood as Appendix A of BS 1186, Part 1, except Cedar; Western Red; Cedar, yellow; Hemlock; Western; and Parana Pine. The timber shall have a maximum moisture content of 15 % at the time of delivery to the Site.

All joinery timber shall receive preservative treatment to BS 1282 and BS 4072 which shall be a water-borne copper/chrome/arsenic composition applied in accordance with the manufacturer's instructions and BS 5268 : Part 5. Before treatment the timber shall be of the correct moisture content specified and free from surface moisture and dirt.

Treatment shall be carried out after all cutting and shaping is completed and care shall be taken to avoid damage to surfaces of treated timber in subsequent handling. If treated timber is unavoidably cut or damaged, a liberal application of preservative is to be made to cut or damaged surfaces. After treatment timber shall be carefully open-stacked in a well ventilated covered place to ensure complete evaporation of surplus solvent of the preservative before incorporation in the work.

4.5.8 Plywood and Chipboard

Plywood and chipboard shall be termite proof grade and of approved manufacture.

4.5.9 Preparation

Joiner's work shall be framed up as soon as possible and kept carefully stacked clear of the ground and protected until required. It shall not be glued and wedged or doweled until immediately before being required for use.

4.5.10 Workmanship

Joiner's work shall be framed with proper joiner's joints; door frames, etc., shall have full mortise and tension joints with hardwood dowels or wedges, glued and cleaned up.

The quality of workmanship shall comply with BS 1186, Part 2, and shall be generally in accordance with that of the samples of joinery to be indicated by the Engineer on the Site.

No unnecessary jointing on the length or piecing will be permitted.

4.5.11 Priming

The priming specified in the paint specifications shall not be carried out until the prepared timber has been inspected and approved by the Engineer, but shall be done before the final assembly and fixing.

4.5.12 Samples

The Contractor shall assemble one finished prototype of each component, fitted with ironmongery for approval of the Engineer before any repetitive production commences.

4.5.13 Fixing

Where joinery is to be plugged the plugs shall be hardwood cut, on the twist, dovetail hardwood fixing blocks cast in-situ or "Raw plugs" as may be directed.

Door and window frames shall be secured with expansion fastener bolts (Hilti or equivalent) or cranked galvanized iron cramps 25 x 3 x 178 mm girth with one end turned up, drilled countersunk for screwing to back of frame, the other end fish tailed for building in as detailed. Door and window frames shall be secured with at least 3 clamps per side or as detailed, spaced generally at 600 mm centres for bedding into joints solidly in mortar.

4.5.14 Defects

If in 12 months from completion any shrinkage, warping or winding should occur or any other defect appear in any of the joinery which is attributable to defective materials or workmanship, such defective work is to be taken down and replaced to the Engineer's approval. Should any other work be affected by the removal and replacement thereof it also shall be made good at the Contractor's expense.

4.5.15 Ironmongery

All moving parts of joinery components are to be fixed with equal tolerance spaces all round. Hinges, etc., are to be fitted in perfect alignment, locks and fastenings are to engage properly in their striking plates or sockets without clatter. Screws for fixing ironmongery shall be of the same metal as the hardware. On completion all joinery shall be adjusted and ironmongery oiled and the whole shall be in perfect working order. Removable ironmongery, except hinges, shall be removed for painting and refixed prior to the final coat of paint or on completion as ordered by the Engineer.

4.5.16 Locks and Keys

Locks are to be fixed in the buildings and in the doors unless otherwise instructed. All external door locks shall have three keys, and all internal locks two keys.

All locks and moving parts are to be oiled and left in perfect working order and all keys shall be properly marked and labelled and delivered up to the Engineer as required.

4.5.17 Lamination

The lamination to toilet doors in contact with water splashing on internal faces, shall be laminated with PVC 1.5 mm thick Formica or equivalent press applied with glue as per manufacturer's recommendations.

4.6 STEEL WORK**4.6.1 Samples and Test Certificates**

Steel bars, plates and sections shall be ordered in sufficient lengths to enable the Engineer to select samples from any bar, plate or section for testing. The Contractor shall, when requested by the Engineer, supply manufacturer's test certificates for steel to be used in the Permanent Works.

4.6.2 Materials and Workmanship

Unless otherwise approved, steel and other metal work shall comply with the following British Standard Specifications:

- (a) BS 4, Structural Steel Sections, Part 1, Hot-rolled sections;
- (b) BS 153, Steel Girder Bridges;
- (c) BS 639, Covered Electrodes for the Manual Metal-Arc Welding of Mild Steel;
- (d) BS 709, Methods of Testing Welds;
- (e) BS 916, Black Bolts, Screws and Nuts;
- (f) BS 1083, Precision Hexagonal Bolts, Screws and Nuts;
- (g) BS 1775, Steel Tubes for Structures;
- (h) BS 1856, Metal-Arc Welding of Mild Steels;
- (i) BS 2642, Arc Welding of Carbon Manganese Steels;
- (j) BS 4395, High Strength Friction Grip Bolts;
- (k) BS 4604, High Strength Friction Grip Bolts; and

(l) BS 4360, Weldable Structural Steels.

4.6.3 Working Drawings

After approval of the order for steel and other metal work, and before fabrication commences, the Contractor shall submit to the Engineer for his approval design calculations, working and shop drawings of the steel and other metal work to be supplied under the contract.

The Contractor shall be responsible for the correctness of his shop details and for shop fittings and site connections.

4.6.4 Welding

Welding shall be metal-arc welding complying with the requirements of BS 1856 or BS 2642, as appropriate. All welds shall be continuous. Electrodes shall comply with BS 639.

Welding shall be carried out only under the direction of an experienced and competent supervisor and only certified welders qualified in this class of work shall be employed.

The Contractor shall supply samples of welds the Engineer when required by him for examination or testing.

4.6.5 Nuts and Bolts

External bolts and filing rag bolts, nuts and washers shall be sherardised steel. Assembly nuts, bolts and washers on galvanised fittings or equipment shall be galvanised. Sherardising shall be in accordance with BS 729: Part 2.

Nuts and bolts shall comply with BS 1494 and BS 916 and shall have Whitworth threads to BS 84 unless otherwise approved.

4.6.6 Works Erection

If required by the Engineer, the steel and other metal work shall be temporarily assembled at the place of manufacture for inspection by the Engineer and, if considered necessary, for testing before delivery.

4.6.7 Site Erection

The Contractor shall fix the steel and other metal work complete and shall provide and erect all temporary staging and bracing necessary for carrying out the Works.

The Contractor shall be responsible for the accuracy of setting out of all steel and other metal work. He may use shop details and other necessary drawings provided by the supplier. The approval of the Engineer for any such drawings shall not relieve the Contractor of responsibility for the correct fitting of all material.

Before any work on erection is begun on the Site, the Contractor shall submit to the Engineer for his approval the methods he proposes to use for the erection of the steel and other metal work and shall make any arrangements and take any precautions directed by the Engineer. Notwithstanding these requirements the entire responsibility for the adequacy of the Temporary Works shall rest with the Contractor.

4.6.8 Marking of Parts

Steel and other metal work shall be uniquely and indelibly marked to indicate the position and direction in which it is to be fixed.

4.6.9 Connections

The ends of all columns shall be machined perfectly square and special precautions shall be taken to ensure good bearing at all column splices, etc.

Connections of metal members shall be bolted, or welded as shown on the Drawings or approved by the Engineer.

Bolted joints subject to vibration shall be securely locked.

In general, bolted or welded joints shall not be weaker than the connected members. Members meeting at a point shall, wherever practicable, have their gravity axis meeting at a point so as to avoid eccentricity.

All steel bases shall be positioned 50 mm above the concrete foundations on steel wedges and after the stanchions have been plumbed and levelled, the intervening space shall be filled with a stiff mixture of cement mortar 2:1.

The contractor shall be responsible for the perfect fitting of all materials supplied and shall replace at his own expense all materials which do not fit.

4.6.10 Step Irons

The Contractor shall supply and fix galvanised malleable iron step irons of general purpose pattern, which shall comply with BS 1247 with a 120 mm tail. They shall be built into walls truly level and in vertical lines as shown on the Drawings and directed by the Engineer.

4.6.11 Manhole Covers

Every manhole or manhole access shaft shall be fitted with a removable air tight cast iron cover of adequate size and strength, fixed in a manner which prevents surface water gaining access.

4.6.12 Staircases and Ladders

The structural steel works material shall be as specified for other items of works. Hand railings and balustrade shall be fabricated using circular tubes to BS 1389. All chequered plate shall be hot-rolled in thickness shown on drawings as per relevant BS.

4.7 PLUMBING INSTALLATIONS

4.7.1 Materials and Workmanship

All materials and workmanship shall be of best quality and comply with the relevant British Standards and British Standard Codes of Practice 305 - Sanitary Appliances and 310 Water Supply where applicable.

The contractor shall submit full details together with drawings of his proposals for approval of the Engineer before commencing the work and shall carry out all tests and inspection of the finished work as may be considered necessary by the Engineer.

4.7.2 Plastic Pipes for Hot and Cold Water Services

Plastic pipes for hot and cold water services shall be Durapipe ABS, or other similar approved, with solvent welded joints and fittings, installed and fixed in accordance with manufacturer's printed instructions.

4.7.3 Coupling Unions

Coupling unions shall be installed at reasonable intervals on vertical and horizontal pipe runs to facilitate erection and dismantling of the pipework without interference to the structure. Similar union connections shall be provided for connecting the pipework to all valves, cisterns, electric heaters, etc.

4.7.4 Brackets

Pipework shall be fixed to walls using an approved pattern plastic brackets for screwing into walls or concrete. The brackets shall be such that the pipe is held 25 mm clear of the finished wall surface. Brackets shall be fixed at regular intervals appropriate to the pipe diameter in order to ensure that the pipe is securely fixed to the wall.

4.7.5 Pipe Sleeves

In all cases where pipes pass through floors or walls, rigid PVC sleeves shall be provided, extending the full thickness of the floor or wall and of bore just sufficiently large for the pipe to pass through.

4.7.6 Valves

Stop valves to BS 1010 shall be used on rising mains; gate valves fullway pattern to BS 1952, Type "a", shall be used on pipework to be supplied from water storage tanks. All valves shall be gunmetal.

4.7.7 Manhole Cover and Frames

Cast iron manhole covers and frames shall be manufactured in accordance with the requirements of BS 49, and shall generally fall into the following categories;

- ◆ Heavy duty - for traffic areas;

- ◆ Medium duty - for footpaths;
- ◆ Light duty - for domestic purposes or other places where they do not have to carry wheeled traffic.

Manhole covers and frames will be fixed in the positions shown, the frames will be solidly bedded in cement mortar so that the covers when in position are fair and even with the adjacent surfaces. Where shown or directed, frames will be bedded on one or two courses of blockwork in cement mortar.

4.7.8 Draw-off Taps

Draw-off tap shall be chromium plated or natural finished gunmetal high pressure screw down easy clean pattern, threaded for union with crutch handles as BS 1010, fitted with hose union.

4.7.9 Overflow Pipes

Overflows to water storage tanks and WC cisterns shall be in PVC tubing as specified for service pipes.

Overflow pipes shall be visible externally, and shall incorporate a vertical drop of 300 mm as a barrier. They shall project 60 mm beyond and discharge clear of the wall face. All external overflow pipes shall be painted and fitted with a mosquito proof filter.

4.7.10 Ball Float Valves

Ball float valves shall be suitable for use with the storage cisterns specified and the pressure of the mains served and shall be unplasticised PVC pipes in accordance with BS 4576.

The pipes shall be jointed and erected in accordance with the manufacturer's instructions, special care being given to the installation of expansion joints and anchors.

Particular attention shall be paid to proper transportation and horizontal storage of the pipes and fittings on a level surface in the shade. Distorted and broken pipes will not be accepted.

The assembly of stacks vertically and branch wastes to falls shall be carefully planned before actual erection is commenced. Holes for pipes shall be carefully measured and marked out for forming as the work proceeds, alterations involving cutting out and making good shall be at the Contractor's own expense.

Vertical runs shall be fixed by means of PVC brackets.

The bends at the foot of all vertical stacks shall be 400 mm radius pattern bedded rigidly in concrete below the slab to prevent movement, and set with the coupling above the slab.

4.7.11 Waste Pipes of 50 mm Diameter and Under

Waste pipes of 50 mm diameter and under shall be high temperature PVC and shall be jointed with solvent welded fittings. Jointing shall be carried out strictly in accordance with the manufacturer's printed instructions.

Waste pipes shall be fixed at least 25 mm clear of finished wall surfaces with PVC brackets.

Fixing intervals shall be 0.5 m horizontally and 1.2 m vertically except that 50 mm pipes shall be fixed at 0.6 m intervals horizontally.

4.7.12 PVC Traps

PVC traps shall be to BS 3943 with 75 mm deep seals and shall be connected to waste pipes with a coupling union designed to allow future dismantling.

4.7.13 Sanitary Appliance

Sanitary appliances shall generally comply with CP 305: Part 1.

WC suites shall comprise a plastic ring seat and cover, a white vitreous china pedestal, WC pedestal pan and UPVC flush pipe. Flushing shall be hand operated from a 9 litre plastic cistern with plastic ball valve to BS 2456. The overflow pipe shall discharge into the pan.

Wash-hand basins shall be white vitreous china (635 mm x 475 mm) to BS 1188, with concealed fixing brackets and bolts, fitted with 13 mm hot and cold chrome plated pillar taps to BS 1010, Part 2, (basins with cold supply only to be fitted with a china blanking-off plug) complete with trap, waste and overflow assembly to BS 3380: Part 1.

A drinking water sign 150 mm x 150 mm metal base with stove enamel covering and letters shall be affixed where detailed on Drawings.

4.7.14 Storage Cisterns

Storage cisterns shall comply with BS 417 Grade A. Cisterns shall be supplied complete with inlet connection and ball valve, overflow connection with pipe, outflow connections, and drain connection with gate valve.

4.7.15 Pipework and Fittings

Pipework and fittings of nominal bore 50 mm and less shall be galvanised steel (GS) to BS 1387 medium weight. Fittings shall be galvanised malleable cast iron to BS 143. Screwed threads shall be clear taper threaded to BS 21.

Pipework and fittings of nominal bore greater than 50 mm diameter shall be UPVC to BS 4514 and of the spigot and socket push fit type, with suitable connections to GS pipework.

Bends shall be used where practicable in preference to elbows. Square elbows will not be accepted.

Pipelines shall be straight except at changes of direction, which shall be made using standard fittings.

Eccentric reducing sockets shall be used (to facilitate air venting and draining) where changes of diameter are made in runs of normally horizontal pipework.

Pipework shall be installed to permit even fluid flow, draining and dismantling of the system.

Unless otherwise shown on the Drawings or instructed by the Engineer, all pipes shall have a minimum clearance of 75 mm from floors and ceilings and 25 mm from the finished face of walls or other surfaces.

The expansion and contraction of pipelines shall be taken up in the geometry of the layout.

Pipes passing through walls, partitions and ceilings shall be provided with pipe sleeves. Sleeve sizes shall allow for the free movement of the pipes. Sleeves passing through finished surfaces or exposed to view shall be flush with the surface of the partition through which they pass and they shall be provided with suitable end covers of approved pattern and finish.

Where soil waste and vent pipes pass through roofs they shall have a UPVC roof terminal and be positioned to enable the roof finish to be suitably weather proofed. The vent shall terminate with a balloon guard to the approval of the Engineer.

4.7.16 Rainwater Pipes and Gutters

Eaves gutters to be uPVC Half round system, 110mm half round Profile, with 75mm diameter downpipes, complying in all respects with the requirements of British Standard 4576 and shall, where appropriate, bear the British Standard Kitemark, manufactured to BS 4576.

Gutter connecting fittings shall incorporate provision for fixing to fascia boards, rafters or brickwork such that the fixing screws shall not be in contact with the inner surface of the gutter and shall have provision for expansion of the gutter clearly marked in the fitting.

All rainwater systems shall be installed in accordance with the Polypipe Terrain's installation guide. Gutters shall be supported on support brackets at one metre maximum centres. In areas of heavy snow load, brackets shall be provided at 800mm centres. Gutters shall be installed to accommodate thermal movement. Expansion joints shall be provided at maximum 4 metre centres.

4.7.17 Down Spout

Down spout shall be precast "U channel" fixed at required level and sealed with waterproof membrane.

4.8 PAINTING

4.8.1 General

Unless otherwise specified, the workmanship and quality of materials for painting shall comply with CP 231. The paint systems used shall comply with BS 5439 and shall have a 10 to 15 year period to first maintenance for the environment that it is exposed to.

The proper preparation of surfaces to be painted is of utmost importance, to ensure the production of sound, clean and dry surfaces, which shall have no detrimental effect on the material to be treated and the subsequent treatment.

Technical information on all paint products shall be submitted to the Engineer for review and approval a minimum of 21 days in advance of the work being carried out. No paint shall be used without the prior approval of the Engineer.

Paints are to be thoroughly mixed under the supervision of a competent foreman. Paints are not to be applied until the surfaces to be painted have been properly prepared.

Successive layers of paint that are applied shall have differing colours. This is essential to ensure correct application of the paint over the whole surface to be protected.

No paint shall be used after the date of expiry of the 'shelf life' marked on its container, and on such expiry the paint shall be immediately removed from the site.

No painting shall be done in wet weather, or without the Engineer's prior approval, or when during the period of painting or hardening the temperature is or is likely to be less than 15 °C or more than 35 °C or the relative humidity more than 90%. During hot weather and when requested by the Engineer the surfaces shall be shaded from the direct rays of the sun during the application and hardening of paint.

Internal paintwork to buildings, other than priming and scaling, is not to be commenced until all trades have finished and, all plastered or rendered surfaces have fully hydrated and dried.

4.8.2 Preparation and Maintenance of Surfaces

Rags, brushes and tools used in the preparation of surfaces contaminated with oil or grease shall be cleaned with white spirit. Immediately before paint is applied the whole of the surface to be painted shall be thoroughly cleaned of all dust, loose paint or grease by washing down with fresh clean water and as necessary brushing with a bristle brush.

Surfaces to be painted shall be maintained clean of cement grout or concrete and any such contamination shall be thoroughly washed away with clean water before it has hardened.

4.8.3 Hardwood

The paint system of existing and new timber shall conform to one of the following systems and as specified in the Basis for Payment in the Schedule of Quantities.

System T 1 All hardwood joinery shall receive preservative treatment with water preservative in accordance with BS 4072.

Hardwood surfaces shall not be painted but shall be treated with a water based penetrating stain finish obtained from an approved manufacturer and applied strictly in accordance with the manufacturer's written instructions.

4.8.4 Softwood

The paint system of existing and new timber shall conform to one of the following systems and as specified in the Basis for Payment in the Schedule of Quantities.

System T2 All softwood joinery shall receive preservative treatment with water based preservative in accordance with BS 4072.

Joinery which is to be painted shall be primed with one coat immediately after fabrication. The primer shall comply with BS 2521 and BS 2523. Other softwood shall be primed before fixing. Contact surfaces with brick masonry or concrete shall be given a second coat of primer. After fixing and before applying any subsequent coats of paint the primer, especially factory applied primer, shall be examined for defects and holes. Powdery, brittle or peeling primer shall be removed.

Holes, cracks and blemishes in exposed surfaces shall be stopped with putty, and knots shall be treated with an approved knotting. The priming of exposed surfaces shall be made good with primer, as specified, and painted with one undercoat and two gloss finishing coats of compatible oil based paints from the same manufacturer. The first gloss finishing coat shall be rubbed down on interior surfaces before the top coat is applied.

4.8.5 Existing/ New Concrete and or Blockwork

The paint system of existing and new concrete and blockwork shall conform to one of the following systems and as specified in the Basis for Payment in the Schedule of Quantities.

System B 1 Where existing concrete and blockwork structures are required to be painted, the existing surfaces should be abrasive cleaned of all existing paint. In the case of new structures, rendering, plaster and blockwork which are specified or ordered to be painted shall be allowed to dry out after completion. All surfaces shall be thoroughly dusted down prior to the application of the paint.

The existing and new surfaces shall then be cleaned with a fungicidal wash.

Subject to the approval of the engineer, the fungicidal wash may be omitted if the first or priming coat of paint to be applied incorporates suitable fungicide.

The cleaned surface shall then be primed with a suitable alkyd undercoat.

This shall be followed with a minimum of two coats of alkyd resin gloss paint containing durable pigments and suitable for a Marine Environment with the colour as selected by the Engineer. The dry film thickness of each layer of paint shall not be less than 30 microns (dry film thickness). The paint shall be applied with brush, roller or other approved means.

Each coat of paint shall be allowed to dry and harden thoroughly before the application of the next coat.

4.8.6 Steel

The paint system of existing and new steel work shall conform to one of the following systems and as specified in the Basis for Payment in the Schedule of Quantities.

System S1 Steel to have all grease, oil and other contaminants removed and sand blast cleaned to a minimum standard of cleanliness of Swedish Standard SIS 05 50 00. Surface profile shall not exceeding 100 microns. All dust should be removed from the surface and the first coat of paint should be applied within 24 hours of sand blasting. Before painting, the surface should be covered to ensure that no condensation or rain comes into contact with the sandblasted metal.

Paint used shall be suitable for use in structures containing potable water. The paint used should have a typical life to first maintenance of 10 to 15 years and conform to the requirements of BS 5439. The paint should be a two pack, high build epoxy coating with excellent resistance to abrasion, fresh and salt water, non-oxidising acids and alkalis. The total dry film thickness of the paint including prime and secondary coats should be 250 microns with a minimum of two secondary coats applied to achieve this.

This system shall be as required to suit any final colour requirements. The thickness of coats should within the tolerances of the paint supplier.

System S2 Steel to have all grease, oil and other contaminants removed. The surface should cleaned with mechanical tools, manual chipping and wire brushing to remove all loose paint, and scale to a minimum cleanliness of Swedish Standard SIS 05 59 00. Excessive burnishing of the steel should be avoided. All dust should be removed before the paint is applied.

The cleaned surface shall then be primed with a suitable alkyd undercoat.

This shall be followed with three coats of an alkyd resin gloss paint containing durable pigments and suitable for a Marine Environment with the colour as selected by the Engineer. The dry film thickness of each layer of paint shall not be less than 30 microns (dry film thickness). The paint shall be applied with brush, roller or spray.

Each coat of paint shall be allowed to dry and harden thoroughly before the application of the next coat.

System S3 Galvanised surfaces and existing handrails shall be treated before painting with an approved primer (other than a mordant containing copper), which shall be supplied in two parts for mixing at site in

accordance with the manufacturer's written instructions. The surface shall afterwards be thoroughly rinsed with clean water and allowed to dry.

The cleaned surface shall then be primed with a suitable alkyd undercoat. This shall be followed with three coats of an alkyd resin gloss paint containing durable pigments and suitable for a Marine Environment with the colour as selected by the Engineer. The dry film thickness of each layer of paint shall not be less than 30 microns (dry film thickness). The paint be applied with brush, roller or spray.

Each coat of paint shall be allowed to dry and harden thoroughly before the application of the next coat.

Metals that are to be hot dip galvanised are to have all oil and other contaminants removed by the use of wire brushing and chemical cleaners. All chemicals used in the cleaning process should be removed with the use of high pressure water and allowed to dry. The metal shall then be hot dip galvanised such that the weight of the final zinc coating is not less than 610 grams per square metre or having a total nominal thickness of not less than 90 microns.

4.8.7 Interior Concrete in a Corrosive Environment

The paint system of existing and new concrete floors shall conform to the following system and as specified in the Basis for Payment in the Schedule of Quantities.

System C1 All concrete laitance should be removed by wire brush, and acid etching. Any blow holes shall be filled with an epoxy filler.

The surfaces shall be primed according to the manufacture's recommendations.

Paint used shall be suitable for use in structures containing potable water.

The paint used should have a typical life to first maintenance of 10 to 15 years and conform to the requirements of BS 5439. The paint should be a two pack, high build epoxy coating with excellent resistance to abrasion, fresh and salt water, non-oxidising acids and alkalis. The total dry film thickness of the paint including primer, secondary and final coats shall be 250 microns with a minimum of two secondary coats applied to achieve this. Two final epoxy finish coats shall be applied to meet the colour requirements of the Engineer. The thickness of coats should be within the tolerances of the paint supplier.

4.8.8 Steel Work in a Chlorine Environment

The paint system of existing and new concrete and steel work shall conform to the following system and as specified in the Basis for Payment in the Bill of Quantities.

System C2 Steel to have all grease, oil and other contaminants removed. The surface should be cleaned with mechanical tools. Manual chipping and wire brushing to remove all loose paint, dust and scale to suit Swedish Standard SIS 05

59 00. Excessive burnishing of the steel should be, avoided. All dust should be removed before the paint is applied.

The steel shall be primed according to the manufactures recommendations.

The paint used should have a typical life to first maintenance of 10 to 15 years and conform to the requirements of BS 5439. The paint should be a single pack chlorinated rubber compound which is chemical resistant and suitable for use in a corrosive chlorine environment. The total dry film thickness of the paint including primer, secondary and final coats shall be 200 microns with a minimum of two secondary coats applied to achieve this. The final finish shall consist of two coats of a chlorinated rubber with a colour to suit the Engineer's requirements. The thickness of coats should be within the tolerances of the paint supplier.

4.8.9 Repairs to Newly Painted Surfaces

Newly painted surfaces (including repainted elements) shall be protected from damaged due to construction activities and the elements. The Contractor shall make good, at his own expense, any damage to painted surfaces that have been caused by his work, or the work of any sub-trades associated with the Work, or due to inadequate protection from the elements.

4.8.10 Paint Testing

If, in the opinion of the Engineer, the protective coating does not meet the specification the Engineer shall require the Contractor to carry out testing under the engineer's supervision. All work that does not meet minimum requirement shall be rejected and removed from site. Rejected material shall be replaced with acceptable material at the contractor's expense.

4.8.11 Colours

Colours shall be as ordered by the Engineer. Sample specimens shall be provided by the contractor for approval and retained by the Engineer for the purpose of maintaining colour, finish and workmanship. Finished materials not meeting the quality of the submitted samples shall be removed from site as directed and replaced at the contractor's expense.

4.9 ROAD WORKS

4.9.1 Standards

The requirements of the following British Standards shall be observed:-

British Standards

B.S. 1621 Bitumen Macadam (with crushed rock or slag aggregate)

B.S.	340	Precast concrete kerbs, channels, edgings and quadrants
B.S.	368	Precast concrete flags
B.S.	4428	General landscape operations (excluding hard surfaces)
B.S.	3882	Recommendations and classifications for tree work soil
B.S.	3936	Nursery stock
B.S.	3998	Recommendations of tree work

NOTE: Preambles to preceding trades where applicable shall apply equally to the work contained herein

4.9.2 Generally

Standard specification

In case where no particular specification or standard is given for any article or material to be used in the Contract, the relevant Specification of the British Standards institution or other relevant standard shall apply unless otherwise stated.

Submission of samples

As soon as possible after the Contract has been awarded, the Contractor shall submit to the Architect a list of the suppliers from whom he proposes to purchase the materials necessary for the execution of the works. Each supplier must be willing to admit the Architect, or his representative to this premises during ordinary working hours for the purpose of obtaining samples of the materials in question. Alternatively, if desired by the Architect, the Contractor shall deliver the samples of materials to be used as aggregates, shall be taken and tested in accordance with the provisions of British Standard 812: Sampling and Testing of Mineral Aggregates, sands and Fillers. Subsequent supplies shall conform, within the specified tolerances, to the quality of approved samples.

The information regarding the names of the suppliers may be submitted at different times, as may be convenient, but no source of supply shall be changed without the Architect's prior approval.

Samples of materials approved will be retained at the Architect's office until the completion of the Contract. Samples may test to destruction.

All materials delivered to site must be at least equal in all respects to approved samples.

Manufacturer's Certificates

The Contractor shall, whenever required obtain from the manufacturer and submit to the Architect, certificates showing that tests of materials have been carried out in

accordance with the requirements of the relevant British Standards, or other approved Standards, or with the requirements of this Specification.

No payment will be made in respect of any costs incurred by the Contractor or by the manufacturers in connection with tests required by this clause or for supplying test certificates in respect thereof.

Rejected materials

Should any materials or articles manufactured on or off the site be, in the of the judgement Architect, of inferior quality, or damaged in any way as to make it unsuited for the work, then such materials or articles shall not be used on the works and shall be removed and replaced, all at the Contractor's expense and in each case as the Architect shall decide and direct.

Building stone

All building stone shall be capable of withstanding when wet a crushing stress of 1.4kg/sq.mm. The source shall be approved by the Architect and stone supplied there shall be free from magadi,overburden, mudstone, cracks sandholes, veins laminations or other imperfections. The stone shall be chisel-dressed into true rectangular blocks, with each surface even and at right angles to all adjoining surfaces, to the size specified. For exposed stonework the maximum permissible variation of any of the specified dimensions shall be 6mm provided that cut stone, supplied as rock face stone may be hammer dressed on one face only, or on the face and one end, if in other respects it conforms with this specification. Stone shorter than 75mm will not be accepted.

Unless the Architect allows otherwise the Contractor shall at his own expense provide and dress for 100mm cubes of stone for testing.

The stone shall be sound when tested in accordance with B.S. 1438: media for Biological percolating filters, Appendix B, (sodium sulphate soundness test) except that:

- a) The treatment shall be repeated for 10 cycles only ; and
- b) The second criterion of failure shall be amended to allow for a loss of weight of not more than 20% of its original weight.

Stone dust

Stone dust for blinding shall be blacktrap screened to the following grading:-

- Passing 10mm sieve 100%
- Passing No. 4 sieve 85% - 100%
- Passing o. 100 sieve 5% - 25%

4.9.3 Site Clearance and Earthworks

Levels to be agreed in advance

Prior to any site clearance, the Contractor shall satisfy himself that the existing ground levels as indicated on the Drawings or schedules of longitudinal or cross section levels are correct. Should the Contractor wish to dispute any levels he shall submit to the Architect a schedule of the position of the levels considered to be in error and a set of revised levels. The existing ground relevant to the disputed levels shall not be disturbed before the Architect's decision as to the correct levels is given. If the Contractor fails to take the requisite levels, the ground levels shown on the Drawings and sections or as determined by the Architect shall be taken as correct.

Clearing

Prior to commencement of any earthworks, the Contractor shall clear the area of the Site indicated on the Drawings, unless otherwise directed by the Architect. He shall also, at times required or approved by the Architect, clear the site over the area of stockpiles, road junctions, lines of ditches or drains and such areas as the Architect may require.

All surface objects and all trees, hedges, scrub, undergrowth, stumps and tree roots, not designated to remain, shall be cleared and/or grubbed.

Materials and debris which cannot be burnt shall be carted to tips provided by the Contractor or otherwise disposed of to the satisfaction of the Architect.

Removal of topsoil roots and grass

Topsoil, roots and grass shall be stripped in a separate operation from clearing.

Unless otherwise directed by the Architect, topsoil, roots and grass shall not be stripped over the full area of the site, but only over the area affected by the earthworks.

Dust

The Contractor shall implement measures to control dust, by periodically spraying the works with water.

The Contractor shall take all necessary precautions against the growth on the site of weeds and shall remove them as necessary throughout the period of works and maintenance.

Earthworks limits

The Contractor shall restrict his workings to the limits described in the Contract, unless otherwise approved by the Architect.

Definitions

Fill-material "Fill-material" shall mean material deposited in accordance specifications from any of the classes specified in clause W.9 in order to build up an earthworks construction to formation level as shown on the Drawings or as ordered by the Architect.

Spoil-material “Spoil-material” shall mean material deposited in accordance with these specifications from any of the classes specified in clause W.9 and which, being obtained from “cut” is unsuitable surplus to the requirements of the works.

Sub-grade “Sub-grade” shall mean the upper layer(s) of material, either insitu or infill. Where there is no improved sub-grade, the top of the sub-grade is at formation level. When an improved sub-grade is placed, the top of the improved sub-grade is then considered as the formation level. In this section, unless otherwise specified, “sub-grade” shall mean the upper 300mm of earthworks (compacted thickness), either in-situ or infill.

Improved sub- grade: “Improved sub-grade” shall mean the layer(s) of selected infill material, the top of which is at formation level, placed where the natural in-situ or fill-material is, in the opinion of the Architect, unsuitable for the direct support of the pavement. The material for sub-grade shall be obtained from borrow areas. The thickness of an improved sub-grade shall be at least 150mm.

Classification of excavated material

Excavation will be paid for separately for the following three classes of material:-

- a) Class 1 Hard material (or rock) : This class shall include all material which, in the opinion of the Architect, either:-
 - (i) requires blasting for its removal or
 - (ii) requires the use of metal wedges and sledge hammers for its removal, or
 - (iii) requires the use of compressed air drilling for its removal or,
 - (iv) is such that, when worked with a tractor of at least 200kw (270 flywheel h.p.), fitted with a rearmounted heavy-duty hydraulic single tune of 100mm maximum width, the tine
 - (v) penetrates to a depth less than 75mm.

- b) Individual boulder greater than 1C.M. in volume shall be included in this class when their nature and size are such that, in the opinion of the Architect they cannot be removed without recourse to one of the above methods

- c) Where a portion of excavation contains 50% or more by volume of boulders of this order, such portion shall be considered as class 1 material throughout.

- d) Class 11 :Medium-hard material (or rippable) : This class shall include all material such as consolidated gravel, weathered or stratified rock, stones or boulders less than 1 C.M. in volume, which, in the opinion of the Architect:-

- (i) Can be extracted without recourse to the methods specified for class 1 material, but
 - (ii) requires ripping for its removal, or
 - (iii) in confined spaces, requires hand-excavation using compressor tools for its removal.

- e) Provided all reasonable steps have been take to the satisfaction of the Architect, to facilitate the removal of the material by other methods.

- f) Class 111: Normal Material: This class shall include all material which does not require recourse to the methods for class 1 and 11 materials.

Excavation

Over excavation: Any excess excavation shall be made good at the Contractor's own expense by backfilling with approved "base" material, deposited and compacted as specified.

Where slopes in rock are excavated in excess the tolerance specified shall be reinstated in class 25 reinforced concrete all suitably bolted to the rock face as directed by the Architect at the Contractor's own expense.

Excavation below embankments and below formation level: where any material below the natural ground level under embankments or below formation level in cuttings is required to be excavated, it shall be removed to such depth and over such areas as shown on the Drawings or as directed by the Architect. The resultant excavation shall be backfilled with an approved material deposited and compacted as specified for the forming of embankments and sub- grade.

If, after the removal of material as specified in the above paragraph, the Contractor allows the material exposed to reach a condition where compaction of back-filling is impracticable, he shall make good at his own expense, either by additional excavation and backfilling or by other measures.

Stockpile areas

The Contractor shall obtain the approval of the Architect to the sitting of the stockpiling areas.

No material shall be stockpiled without the consent of the Architect. The Contractor shall give the Architect at least 24 hours notice of his intention to stockpile. Stockpile areas shall be chosen and prepared and all stockpile material shall be deposited in such a way as to facilitate subsequent measurement of stockpile volume and in all instances shall be to the satisfaction of the Architect.

Construction of embankments and fills

General: All embankments and fills shall be formed and completed to the correct lines, slopes, widths and levels shown on the Drawings.

Where shown on the Drawings or directed by the Architect, shoulders and beam shall be constructed as part of the earthworks operation and paid for as such.

Unless otherwise specified, where an embankment of less than 1m below formation level is to be made, topsoil and all vegetable matter shall be removed from the surface upon which the embankment is to be placed and the cleared surface shall be completely broken up by ploughing or scarifying to a minimum depth of 150mm. This area shall then be compacted to a dry density of at least 95% MDD (Standard Compaction).

Unsuitable material: Embankments and fills shall be constructed only of material approved by the Architect, obtained from the excavations of cuttings, ditches and borrow-areas.

Materials with high swelling characteristics or high organic matter content and any other undesirable material shall not be used, unless specifically directed by the Architect. Unsuitable material shall include:-

- a) All material containing more than 5% by weight, of organic matter (such as topsoil, material from swamps, peat, logs, stumps and perishable material)
- b) All material with a swell of more than 3% (such as black cotton soil).
- c) All clay of liquid limit exceeding 80 or plasticity index exceeding 50.
- d) Materials having moisture content greater than the maximum permitted for such materials.

Rock-fill:

“Rock-fill” shall consist predominantly of class 1 material of such size that the material can be placed only in layers of compacted thickness exceeding 300mm.

Unless otherwise directed by the Architect, stones and boulders greater than 0.2 C.M. in volume (average size: 600mm) shall not be used for the construction of embankments and fills.

Selection of materials for the upper layers:

The Architect may direct the certain materials to be excluded from the sub-grade (see clause W.15) or from the upper layers of fill. He may also direct that other materials be set apart or obtained from borrow and used only for these layers. The Contractor shall then comply with the Architect’s directions and shall allow in his rates for such selection of materials.

Rock-fill shall not be placed less than 600mm below formation level.

Laying of Compaction:

Where material other rock-fill is used for the construction of embankments and fills, it shall be placed in layers of compacted thickness not exceeding 300mm, unless otherwise

directed by the Architect. The layers shall be parallel to the top of sub-grade level and cross-section.

Unless otherwise specified, the layers of fill material shall be compacted throughout to a dry density of at least 95% MDD (Standard Compaction), except for the upper 300mm (sub-grade) which shall be compacted to a dry density of at least 100% MDD (Standard Compaction).

The moisture contents of the material shall be adjusted so that the above minimum compactions are obtained. Unless otherwise accepted by the Architect, the moisture contents at the time of compaction shall not exceed 105% of the optimum moisture content (Standard Compaction). Where water needs to be added, it shall be applied in an even manner and the rate of application shall be such that no transverse or longitudinal flow occurs.

Where rock is used a filling, the rock shall be placed in the bottom of the embankment or as directed by the Architect. The largest portions of rock shall be placed in layers of maximum compacted thickness of 1m. The interstices shall be filled with spalls and finer material approved by the Architect. The whole layer shall be material approved method, until the interstices are completely filled and until the specified compaction is obtained.

Drainage of works

All cuttings and embankments shall be kept free of standing water and drained during the whole of the construction.

Should water accumulate on any part of the earthwork either during construction or after construction the Contractor shall remove and replace at his own expense any material, which in the opinion of the Architect, has been adversely affected.

The Contractor shall so order his construction programme that the construction of culverts and drains does not lag behind the earthworks. Well in advance of commencing the earth-moving operations over swampy or waterlogged areas, the Contractor shall cut drains and ditches and carry out any other works as necessary to assist in draining the ground.

All drains and ditches shall be maintained in proper working order throughout the duration of the Contract.

The Contractor shall allow in his rates for draining the earthworks satisfactorily at all stages during the construction and arrange his methods and order of working accordingly.

He shall provide within the site where necessary temporary water- courses, ditches drains, pumping or other means of maintaining the earthworks free from standing water. Water discharged from the site shall not be run into a road but be carried direct to an approved sewer, ditch or river through troughs, shutes or pipes

Such provision shall include carrying out the work of forming the cuttings and embankments in such a manner that their surfaces have at all times a sufficient minimum crossfall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

In pumping out excavations and in any lowering of the water table the Contractor shall pay due regard to the stability of all structures.

Side ditches

Side ditches, considered as earthworks and measured and paid for as such, shall be shaped by excavating to the lines, slope and widths shown upon the Drawings and finished off so that the sub-grade levels and Camber or super-elevation of the of the sub-grade level and cross fall of the shoulders and slope and invert levels of the side ditches are everywhere in accordance with the Drawings or as directed by the Architect.

Sub-grade and improved sub-grade

Unless otherwise specified or directed by the Architect, materials forming the direct support of the pavement shall comply with the following requirements:-

CBR (100% BS - 4 days soak)	: Minimum 5%
Swell (100% BS - 4 days soak)	: Maximum 2%
Organic matter (percentage by weight)	: maximum 3%

Where, in the opinion of the Engineer, material unsuitable for the direct support of the pavement occurs in cuttings, the Contractor shall excavate it to the depths and widths directed and replace it with selected fill material to form an improved subgrade. The work will be paid for at the appropriate rates of "spoil" and "fill" and no additional payment will be made.

Laying and compaction:

The maximum compacted thickness which shall be laid, processed and compacted at one time shall be 300mm.

The layer shall be clarified, water shall be uniformly mixed in or the material allowed to dry out to the correct moisture content.

The upper 300mm of the earthworks (that is to the sub grade) shall be compacted to a dry density of at least 100% MDD (Standard Compaction) in cuttings where there is no improved sub grade and everywhere in fills and embankments.

In cuttings where an improved subgrade is to be placed, the upper

150mm of the subgrade prior to the placing of the improved subgrade layer(s), shall be compacted to at least 100% MDD (Standard Compaction), unless otherwise specified.

All improved subgrade shall be compacted to a dry density at least

100% MDD (Standard Compaction) for its full depth.

The moisture content shall be adjusted in order that the above minimum Compactions are obtained. Unless otherwise accepted by the Engineer, the moisture content at the time of compaction shall not exceed 105% of the optimum Moisture Content (BS).

Top of subgrade (including improved subgrade) : During the above process, the surface of each subgrade layer shall be graded to level, parallel to the crossfall and camber and profile shown upon the Drawings or directed by the Engineer and to the Tolerance specified.

The subgrade shall be cleaned of all foreign matter and way potholes, loose material ruts, corrugations, depressions or other defects which have appeared in the subgrade layer, due to improper drainage, traffic or any other cause, shall be corrected. If directed by the Engineer, the Contractor shall scarify, grade and recompact the subgrade to line, level and specification at his expense.

No work above the subgrade shall be executed until the subgrade has been inspection and approved by the Engineer.

4.9.4 Construction of Sub-Base and Bases

General

The term “gravel” used throughout this section shall be deemed to include; lateritic gravel, Quartzitic gravel, some forms of weathered rock, soft stone, coral rag and conglomerate.

A “grade” base will be made up of one of these natural gravels, or of sand or clay sand, or of a combination of these materials, without the addition of any stabilizing agent.

Material requirements

Unless otherwise specified or directed by the Engineer, the material shall comply with the following requirements:-

California bearing ratio:

- a) The material for base shall have CBR of least 80.
- b) The material for sub-base shall have a CBR of at least 30.
- c) Unless otherwise specified, the CBR shall be measured at a dry density corresponding to 95% MDD (heavy compaction) and after 4 days.

Requirements for gravel:

In addition to the CBR requirements, the gravel material shall comply with the following specification:-

Gravel for	Base	Sub-base
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Plasticity Index	-	Maximum	15	25
Loss Angels value	-	Maximum	30	70
Aggregate Crushing value	-	Maximum	35	75

Grading:

The grading curve of the material, after processing compaction shall be a smooth curve within either of the following envelopes, as applicable:-

Sieve Size (mm)	Percentage by weight passing				
	Base		Sub-grade		
80	-			100	
63	-			95	100
50	100			90	100
40	95	-	100	85	100
28	80	-	100	72	100
20	60	-	100	55	100
10	35	-	90	30	100
5	20	-	75	18	85
2	12	-	50	10	65
1	10	-	40	8	52
0.425	7	-	33	7	43
0.075	4	-	20	4	35

Clayey Sand:

In addition to the CBR requirement, the clayey sand for sub-base shall comply with the following specification:-

Percentage passing 2mm Sieve:	Maximum 95
Percentage passing 0.075 mm Sieve	Maximum 10 - Maximum 30
Uniformity coefficient:	Minimum 5
Plasticity Index	Minimum 5- Maximum 20

Setting Out Sub-base to line and level

The Contractor shall set out the road line and level at intervals of not more than 25 metres or such lesser intervals on horizontal and vertical curves as the Engineer may require, and sufficient to ensure that the levels of the sub-base are constructed within the specified tolerances and the minimum thickness ordered for the course. Reference pegs shall be provided clear off the road and at right angles to it from which the centre-line or level can be re-established at any time. These shall be maintained so long as they are needed by the Engineer to check the work.

All setting out shall be agreed by the Engineer before any sub-clause or base course work is commenced.

Laying and compacting natural material sub-base and base

The sub-base and base material shall be deposited in such quantity and spread in a uniform layer across the full width required, so that the final compacted thickness is nowhere less than shown upon the Drawings or ordered by the Engineer.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 200mm and where a greater compacted thickness is required, the material shall be laid and processed in two or more layers.

The material shall be broken down so that the maximum size of any particle is not greater than specified. This may require a grid-clearer sheep-foot roller or a pulverizer and the Contractor shall allow for such processing in his rates.

Any oversize material which cannot be broken down to the required size shall be removed and disposed of as directed by the Engineer.

The layer shall then be scarified and water shall be uniformly mixed in, as directed by the Engineer. It shall be graded, Compacted to a dry density of at least 95% MDD (Heavy Compacted) and graded to final level.

The moisture content shall be adjusted so that the above minimum Compaction is obtained. Unless otherwise directed by the Engineer, the moisture content at the time of compaction shall be between 80 and 105% of the optimum Moisture Content (Heavy Compaction).

Tolerances

The Sub-base and base shall be constructed within the tolerance specified.

Surface levels of flexible pavement course and concrete pavement

The level of any point on the surface of each of the pavement course of the carriageway, the true level as specified, shall on completion of compaction, conform to that shown on the Drawings within the tolerances stated in column 3 of the following table.

Compliance with the requirement shall be checked, in respect of the surface of each course, either by levelling in relation to a survey Datum using pegs or pins, or if raised or flush kerbs or concrete marginal haunches, concrete form, rails or bankettes have been laid, by use of a template or stretched line, using a datum the top surface of the levelling device after the profile or level of the latter have been approved by the Engineer. All longitudinal profile devices shall be laid true to line and level each within a tolerance of +/- 3mm the tolerance in level being measured over 8 metres. If this tolerance is exceeded the level and alignment shall be corrected, if necessary, by lifting and relaying or resetting.

In case of the base course and wearing course of flexible surfacing, and the surface of concrete pavements, the finished surface, in addition to conforming to the limits of tolerance from the true surface levels as specified above, shall when tested with a 3

metre straight edge placed parallel to the center line of the road, have no depression greater than the appropriate one stated in the following table:-

Measurements of level of tolerances shall be made while the material is still warm and rectification where necessary, carried out immediately; otherwise the Engineer may require the whole area involved to be removed to the full depth of the layer and reconstructed with fresh material.

Tolerance from Maximum Depression tested Surface true surface level with 3m straight edge placed on the surface parallel to the center line of carriageway Sub-grade +0-50mm

4.9.5 Drive Ways and Parking Areas

Excavations

Excavations to areas to receive bitumen macadam or other road or paved finish shall be carried out in a manner ensuring that excavations plant and vehicles do not cause shear failure more than

250mm in the sub-grade. Wheel loads and tyre pressures shall be limited and work shall be interrupted to let the sub-grade dry out as necessary to avoid such sub-grade failure.

If shear failure more than 250mm deep occurs in the sub-grade, the soil affected shall be excavated and replaced by soil filling as described.

If the soil develops highly elastic conditions as excavation approaches formation level, excavations shall be interrupted until the excess pore consequently disappears.

Before any further work is executed the formation level must be inspected and approved by the Engineer.

Compaction

The sub-grade shall be compacted by a smooth-wheeled roller of 8 to 10 tonnes weight or vibrating roller of minimum 1,300kg., or other approved plant. The number of coverages shall be at least 10 and there shall be a 50% overlap of successive coverages. If so instructed by the Engineer, water shall be added during compaction to obtain optimum water content. Filling shall be compacted as above but in maximum 200mm deep layers.

Sub-grade surface finish

The surface of the sub-grade shall be finished to the levels, falls and crossfalls shown on the Drawings within the following tolerances:-

- i.) The level shall not be above and not more than 50mm below the level shown on the Drawings.

- ii.) The falls shall be within 10% of the falls shown on the Drawings.
- iii.) The smoothness shall be such that departures from a 3 meter straight edge laid in any direction shall not exceed 50mm and there shall be no ponding of water.

Coarse Aggregate

Coarse aggregate for the base shall be crushed stone or rock conforming to the following requirements:-

Sub-base

The material for use in the sub-base shall consist of crusher dust as described, or other approved material. It shall be placed in one layer of such thickness that when compacted it shall attain the finished thickness shown on the Drawings. The material shall be watered as necessary and compacted as described. The sub-base material shall have a CBR value (soaked) for not less than 25.

Base

The material for use in the basecourse shall consist of one layer of coarse aggregate as described of which the interstices are filled with fine material consisting either of crusher dust or a mixture of crusher fines. The proportions of crusher dust and crusher fines in the fine material shall be such as to obtain the maximum density of base course when compacted.

The procedure for construction shall be as follows: The coarse aggregate shall be placed in a layer of such thickness so as to obtain the required thickness after compaction. It shall then be compacted lightly until the Engineer is satisfied that a layer true to shape and level has been obtained. The fine material shall then be spread over the layer by hand mechanical means. The application of fine material shall be made gradually in successive layers not exceeding 25mm in thickness and each be worked into the voids in the coarse aggregate before the application of the succeeding layer. The fine material shall be laid as described and brushed into the coarse aggregate and rolled and consolidated by an approved vibrating roller fed to the bottom of the layer.

Final compaction shall be by an 8-10 tonnes smooth-wheeled roller until there is no visible movement under the action of the roller and until the required tolerances are achieved. Water may be applied during final compaction subject to the Engineer's approval.

Compaction shall in any case achieve 100% maximum dry density in accordance with B.S. 1377.

Quarry waste

Quarry waste shall mean material to the same specification as crusher dust, except as follows:- ii). The material may have up to 35% of stones not larger than 38mm provided that the material passing the 5mm sieve is within the limits specified.

Quarry waste shall be clean and completely free from earth, organic or other foreign matter.

- i). The plasticity index taken on material passing the No. 36 sieve shall not exceed 16%

Basecourse finish

The surface of the base course shall be finished to the levels, falls and crossfalls shown on the Drawings subject to the following.

- i.) The level shall be within + or - 12mm of the levels shown on the Drawings.
- ii.) The falls shall be within 19% of the falls shown on the Drawings.
- iii.) The smoothness shall be such that departures from a 3 metre straight edge laid in any direction shall not exceed 12mm..

The surface of the basecourse shall be inspected and approved by the Engineer before bitumen paving is commenced.

Immediately before applying the priming coat, the surface of the basecourse shall be brushed free from dust and loose stones. The material for the priming coat shall be a cutback of M.C.O. grade or other approved.

Approximately 30 minutes before applying the priming coat the surface of the basecourse should be made slightly damp by use of a water spray.

The priming coat shall be applied at a temperature of 100-150 degrees Fahrenheit at a rate of 0.60 litres per square meter.

After application of the primer graded premix of 30mm to 40mm compacted thickness shall be used, with a seal coat.

Bitumen macadam surfacing

A single course open graded premix of 30mm to 40mm compacted thickness shall be used, with a seal coat.

Course aggregate shall be crushed blacktrap with particles having a cubicle shape to the Engineer’s approval and shall be washed free from dust.

The Coarse aggregate gradings shall be:-

Sieve Size	Percentage passing
19 mm	100
13 mm	60 – 100
10 mm	45 - 70
6 mm	30 - 50
4 mm	25 - 40

8 mm	15 - 25
200 mm	2 - 5

The binder shall be shellmac MC/RC2 or other approved. The percentage by weight of binder shall be 4.5%. Mixing shall be in an approved mixer and mixing shall proceed until the stone is evenly coated with binder. The temperature (at mixing) shall be within the following range:-

Binder Aggregate 150° F

Mixing Temperature 50° 95° F 125°

The laying temperature shall be not less than 20o F below the mixing temperature.

The mix shall be spread evenly over the primed surface and shall be thoroughly compacted by rolling with a minimum of 6 passes. A smooth-wheeled roller of not less than 5 tonnes weight and with rear wheel loading of 0.25 kg per square millimeter width shall be used.

Rolling

Any longitudinal joints shall be rolled first, after which rolling shall start longitudinally at the side and proceed towards the center of the carpet. Each pass of the roller shall overlap the preceding one by at least one half width of the rear wheel. Alternate passes of the roller shall be of varying length. Immediately following initial compaction, the surface shall be checked with a straight edge to ensure that it meets the surface finish requirements. Minor variations shall be corrected by rolling, but major imperfections shall be compacted by adding or taking away mix while it is still workable.

Surface finish

The surface of the bitumen macadam shall be finished to the levels, contours and slopes shown on the Drawings with the following tolerances:-

- i). The level shall be within + or - 6mm. of the level shown on the drawings.
- ii). The gradient shall be within 10% of the gradient shown on the drawings.
- iii). The smoothness shall be such that departures from a 3 metre straight edge laid in any direction shall not exceed 6mm.

Seal coat

The seal coat shall consist of precoated fines consisting of crushed blackstrap stone graded from 3mm to dust, or coarse sand. The binder shall consist of 4.5% by weight of

MC/RC2. The seal coat shall be spread and brushed into the macadam surface at the rate of 180 square metres per tonne and compacted by rolling as for the macadam.

4.10 SUPPLY AND INSTALLATION OF SEWER PIPE AND APPURTENANCES

4.10.1 Work to be Done

Work to be done under this Section shall include the supply of all materials, plant and labour for the construction of the sewers and appurtenances as shown on the Drawings, and as specified herein. The work shall include supplying, laying and jointing of the pipe to the details and in the locations indicated on the plans and as may be directed by the Engineer. Site excavation, fill, backfill, finish grading, concrete and miscellaneous metal work shall be described under other Sections of the Specification.

4.10.2 Sewer Pipe

Sewer pipe shall be unplasticized polyvinyl chloride (UPVC) sewer pipe.

Unplasticized PVC Sewer pipe for pipe diameters up to 150 millimetres nominal outside diameter shall comply with British Specification No. 44660. For nominal outside diameters of 200 millimetres and larger the pipe shall comply with British Specification No. 5481.

Reinforced concrete, pipes shall be used for culverts and shall comply with British Standard No. 5911.

4.10.3 Transporting and Storage of Pipe

All pipes shall be carefully loaded, transported and unloaded from delivery vehicles. Pipe shall not be dumped but shall be carefully raised and lowered by means of hoists or on ramps. The Contractor shall deliver the pipes as near to the trenches as is convenient and so as to impede the traffic on nearby streets as little as possible.

All pipe stored alongside roads shall be stacked in a manner so as to minimize the hazard to vehicular and pedestrian traffic.

The Contractor shall be responsible for replacing all pipe, specials, fittings, etc., which in the opinion of the Engineer are unsound or damaged, both before and after being placed in position and the rejected or damaged materials shall be removed immediately from the site at the Contractor's expense.

4.10.4 Manholes

(a) General

Manholes shall be constructed of brick, cement blocks, precast reinforced Concrete or of cast-in-situ reinforced concrete as shown on the Drawings. For details, the Contractor's attention is drawn to the Drawings.

(b) Ladders, Steps and Miscellaneous Iron

The Contractor shall furnish and set galvanized malleable iron steps to B.S. 1247 or aluminium ladders as specified and as shown on the Drawings.

(c) Frames and Covers

Cast iron frames and covers shall be supplied and installed by the Contractor. Manhole frames and covers shall meet the British Standard No. 497. Details shall be as shown on the Drawings. Alternatively, the contractor may propose the use of Composite Covers prior to the approval by the Project Manager.

(d) Mortar and Concrete

All mortar and concrete shall be as specified under Division 3 - Concrete of these Specifications.

(e) Manhole Chimney

All manholes shall be built to grade or as shown on the Drawings and directed by the Engineer. The chimney wall shall be built with precast reinforced concrete rings or cast-in-situ.

Final adjustment of the frame and cover may be done using a brick cap but shall be limited to two layers. All bricks shall be accurately laid by competent trades people in a full bed of mortar with all joints, vertical and horizontal, filled solid, true, level and perfectly plumb. Joints shall be 10 mm maximum. Vertical joints shall be staggered horizontally.

(f) Poured Manholes

Where possible, cast-in-place manholes and chambers shall be constructed in one, continuous pour, otherwise the position of construction joints must be approved by the Engineer and adequate keys must be provided.

(g) Benching

The inverts of manholes shall be benched in the concrete base (as shown, and) in such a manner as to provide the least possible resistance to flow through the structure. All necessary inflow and outflow pipes shall be securely embedded in the concrete base and walls so as to ensure the structure is watertight.

(h) Interlocking Joints

Precast concrete manhole sections must be supplied with interlocking joints. These joints shall be sealed on site using an extended bitumen compound.

4.10.5 Alignment and Grade

All pipe shall be laid and maintained in accordance with the sizes, locations, dimensions, and other particulars as shown on the Drawings. Pipe shall be laid to line and grade as set out in accordance with the Specifications.

Pipe which is not in alignment or which incurs any settlement after laying shall be taken up and rebated entirely to the satisfaction of the Engineer at the expense of the Contractor.

Care shall be taken to

align the pipe properly before joints are forced home. The pipe shall be adequately supported by a hand sling or crane as required to minimize lateral pressure on the gasket and to maintain concentricity until the gasket is properly positioned. Once the joint has been made, deflection of the joint shall be held to an absolute minimum.

4.10.6 Trench Conditions

Conditions in the trench shall be such that pipe jointing can be accomplished without mud, silt, gravel or other foreign material entering the joint or the pipe. In general this means that the trench shall be adequately dewatered with a firm bottom free of mud. A suitable approved plug shall be inserted in the end of the latest pipe laid by a crew to prevent foreign material entering the sewer and the plug shall be kept in place until the said crew is about to install a further pipe. Unless specifically permitted by the Engineer in writing, the installed sewer shall not be used for draining the trench.

The trench shall be kept dry and free from water, no pipes being laid in water except by permission of the Engineer. The pipes shall be kept clean as the work progresses, and no sand or dirty water will be allowed to run through them during construction. No pipe shall be laid until the preceding pipe joint has been completed, and the pipe carefully embedded and secured in its place.

4.10.7 Laying Pipe

All lumps, blisters and excess coating shall be removed from the ends of each pipe and they shall be washed and wiped clean and dry and free from oil before the pipe is laid.

The Contractor's facilities for lowering pipe into the trench shall be such that neither the pipe nor the trench will be damaged or disturbed.

The laying of the pipe in the finished trench shall generally be started at the lowest point, and continue between manholes with no gaps.

All pipes shall be firmly and accurately set with the inverts smooth and uniform.

Sufficient pressure shall be applied in making the joint to ensure that the joint is made as detailed in the standard installation instructions provided by the pipe manufacturer. Sufficient restraint shall be applied to the line to ensure that joints, once completed, are held so by placing fill material under and alongside the pipe, or otherwise. At the end of a day's work the last pipe shall be blocked in such a manner as may be required to prevent movement during down time.

Before lowering a pipe into position in the trench all dirt or foreign matter shall be removed.

Every precaution shall be taken to keep the interior of the pipe clean while it is placed in the line.

Adequate bracing or supports shall be provided as necessary to adequately hold the pipe in place, and care shall be taken to prevent damage to the pipe and to adjacent structures and appurtenances. Pipe bedding shall be substantially completed before the supports and bracings are removed.

The Contractor shall take precautions to prevent floating of the pipe prior to backfilling.

At any time when pipe laying is not in progress, the open ends of the pipe shall be closed by a watertight plug which has been approved by the Engineer.

4.10.8 Field Inspection

All pipes, bends and junctions shall be inspected by the Engineer and those pipes not conforming to the requirements of this Specifications will be rejected and must be removed from the site by the Contractor. The Contractor shall furnish all labour necessary to assist the Engineer in inspecting the material.

4.11 ELEVATED TANKS

4.11.1 General

The levels of the finished tanks must be precisely in accordance with the levels shown on the drawings. All support towers shall be set on concrete foundation slabs which also support all fittings and valves at ground level. Support towers shall be of steel construction as specified below

All tanks shall be fitted with pipes as shown on the drawings. The overflow shall be fitted below the level of the supply valve. The tank drain may be connected to the overflow drain via an appropriate gate valve. All tanks shall be fitted with a drain to allow them to be completely emptied.

Flow into the tank shall be controlled by a float-operated valve. Outlet services shall be taken from the bottom of the tank, and the outlet opening(s) shall be situated higher than the drain opening.

All tanks shall be fitted with float level indicators which shall be easily readable from the ground.

Covers/ Roofs:

All tanks shall be equipped with covers/ roofs to protect the contents. The covers/ roofs shall be suitable for all loading types including those imposed by men on maintenance and other duties.

Covers/ roofs shall be adequately ventilated to prevent the build up of pressure or vacuum inside the tank. Ventilation shall be mosquito proof. covers/ roofs have lockable access hatch openings that shall be of such dimensions as to allow entry into the tanks for servicing and maintenance.

4.11.2 Steel Support Towers

Steel support towers shall be designed for a wind velocity of 45 m/s. They shall be made of commonly available steel profiles conforming with BS 5950. The profiles shall be connected by bolts. For corrosion protection the steel structure shall be galvanized or painted in accordance with BS 5493 SL5 or equivalent, with:

- ◆ Two coats of two- pack epoxy zinc phosphate primer (KP 1A) to total D.F.T. of 140 microns.
- ◆ Two coats of two- pack epoxy undercoat (KU 1B) to total D.F.T. of 200 microns.
- ◆ One coat of chlorinated rubber finishing coat (HF 1D) to 100 microns D.F.T.

Alternatively the finishing coat could be two-pack polyurethane (KF 2D) to 100 microns D.F.T. in accordance with BS 5493. SK4 painting system or equivalent.

Steel support towers to be designed and supplied by the manufacturer supplying the tank.

4.11.3 Sectional Steel Water Tanks

All sectional steel tanks shall be of rectangular construction using mass-produced tank plates, 1220 mm square and bolted together. All tanks shall conform to BS 1564 or equivalent.

The plates shall be hot pressed embossed steel to BS 4360 grade 43A, or equivalent and shall be between 4 to 6 mm in thickness, determined by the depth of the tank.

Plates shall be formed with 45° or 90° flanges according to their position on the tank. All plates shall be clearly marked to identify them for erection purposes.

Pipe connections shall be flanged.

Tank plates and cover plates shall be hot dipped galvanized to BS 729 or equivalent and then treated with protective coating against corrosion corresponding to BS 5493 SF8 or equivalent after suitable pre-treatment.

Cleats and Stays

All internal fittings shall be designed to ensure the rigidity and strength of each tank. They shall be manufactured from steel to BS 4360 grade 43A or equivalent.

Bolts, Nuts, Washers and Jointing Materials

All bolts, nuts and washers shall comply with BS 4190 or equivalent. Steel tanks shall be supplied with a complete set of spanners and a percentage of spare nuts, bolts and washers.

Jointing strips shall be used between the flanges of adjacent tank plates, under the tank cleats and for seating cover plates. Materials for jointing strips shall be acceptable for use with potable water.

4.12 FACTORY COATED BOLTED STEEL TANKS

4.12.1 General

The work to be done under this section consists of furnishing all materials, labour, tools and equipment and performing all operations necessary to design, construct, test and commission factory coated bolted steel water storage tanks and appurtenances as shown on the drawings and as specified herein, including all excavation and backfill. The work also includes all material, equipment, tools and labour for the design and construction of a foundation for the tank. This item is included as a lump sum in bill of quantities.

4.12.2 Reference Standards

The following standards form a part of these specifications:

- ◆ API Specification 12B - Bolted Tanks for Storage of Production Liquids
- ◆ ANSI/AWWA D103 – Factory-Coated Bolted Steel Tanks for Water Storage

4.12.3 Design Criteria

Design:	API Principles
Product stored:	Potable water
Specific gravity:	1.00
Seismic zone	0 AWWA
Wind load:	160 KPH
Deck live load	98 kg/m ²
Operating temperature:	15-35 degrees C

4.12.4 Materials Specifications

Plates and Sheets

- ◆ Steel plate will conform to the requirements of ASTM A36 with a minimum yield strength of 36,000 psi. High strength plate will conform to the requirements of ASTM A572.
- ◆ Steel sheet will conform to hot rolled quality per ASTM A570 with minimum yield strength of 40,000 psi. Minimum thickness will be 2.65 mm.

Rolled Structural Shapes

- ◆ Rolled structural shapes will conform to ASTM A36.

Horizontal Wind Girders

- ◆ When intermediate wind girders are required, the girders will be either rolled structural shapes or a truss design of equivalent strength, coated the same as the tank exterior.

Hardware

- ◆ Bolts used in tank joints will be 12.7 mm diameter and will meet the minimum requirements of API-12B, Appendix A.
- ◆ Bolts will conform to ASTM A307, or API-12B as required by the tank design.
- ◆ Bolts will be mechanically galvanized to Class 50 of ASTM B695, or hot dip galvanized to ASTM A153 as required by the tank design.
- ◆ All bolts in contact with the stored liquid will be provided with nitrite or neoprene backed steel washers for placement between the nuts and the steel sheets. Other joints will have steel flat washers under the nuts to protect the external coatings.
- ◆ Gaskets will be 40 mm wide pre-punched and made of material suitable for the stored liquid. Sealant will be used only when joining discontinuous gasket sections.

4.12.5 Coatings

Cleaning

- ◆ Following fabrication, parts will be thoroughly cleaned by a power wash-rinse process followed immediately by hot air drying.

Surface Preparation

- ◆ Following the wash-rinse and drying, the parts will be steel grit-blasted to the equivalent of a near-white finish SSPC-SP10-63T.
- ◆ The surface anchor pattern will not be less than 1.0 mil (25 microns)

Coating

- ◆ All parts must be coated within 30 minutes after blasting and no shaping, bending, punching, flanging or grinding may be done on the steel after blasting and before coating. Interior coatings must be certified for potable water usage.

Inspection

- ◆ All coated parts are to be inspected prior to shipment, and marked with a part number which will correspond to the appropriate tank erection drawings to clarify and simplify tank assembly.
- ◆ All coated sheets and parts are to be inspected for colour uniformity.
- ◆ A representative sampling of coated sheets are to be inspected in accordance with AWWA D103, Section 10.5.3 to verify minimum coating dry film thickness.
- ◆ All scratches or defects in the factory applied coating that are noted in the field are to be removed and repaired at the discretion of the engineer.

4.12.6 Appurtenances

Unless otherwise noted, standard appurtenances will be as follows:

Roof Manway/ Hatch Covers

The tank roof hatch will have a curbed, upward opening 610 mm square manway. The curb will extend 100 mm above the tank. The tank cover will be hinged and provisions made for locking. The hatch cover lip will extend for a distance of 50 mm down on the outside of the curb.

Shell Manway

The shell manway will be 610 mm diameter with a bolt-on cover in accordance with API specifications. Shell flush clean-outs will be 610 mm wide x 1200 mm high with a two-piece bolt-on cover.

Nozzles

Tank nozzles will be bolt-on for field installation, and will include all necessary hardware and gaskets for attachments to tank. Nozzles will have a minimum 150mm projection from tank wall.

Vent

A mushroom screened vent will be furnished above maximum water level of sufficient size to accommodate normal inlet and outlet water flow. The vent will be designed and constructed as to prevent the entrance of birds or animals.

Outside Tank Ladder

Outside tank ladders will be vertical and in accordance with applicable safety standards. All required rest platforms and safety cages will be included. Ladder and safety cages will be hot dipped galvanized.

Deck Perimeter Guardrail.

A deck perimeter guard rail will be provided. The guardrail will have top rail, mid rail and toe board and will be galvanized.

Inside Wall Ladder.

Inside wall ladders will only be used on tanks up to 1220mm high.

Liquid Level Indicator.

Liquid level indicator will be a gauge board type with internal float and exterior gauge board with target. Gauge board will be marked in metric units.

Overflow and Washout.

Provide a tank overflow and washout to ground level, supported at proper intervals with suitable brackets. The overflow and washouts may be joined through a valve fitted in the washout pipe. The overflow/ washout pipe will terminate through an outfall structure fitted with a flap valve through an elbow at the bottom, appropriate pipe length to direct the water to natural drainage courses and away from properties.

4.13 TESTING AND STERILIZATION OF WATER RETAINING STRUCTURES

4.13.1 Testing

All concrete water retaining structures shall be tested by the Contractor. Tests shall be carried out in accordance with BS 8007.

Testing of pressed steel sectional tank shall be filled with water on site after all installation is completed to ascertain a water tight condition.

The Contractor shall provide the water and all test equipment necessary for the testing.

4.13.2 Sterilisation

On completion of the test for watertightness, the Contractor shall thoroughly clean the interior of the reservoir or tank by hosing down the roof, walls, columns, baffle walls and floor, as applicable, with clean, potable water from an approved source, and remove all debris, soil, silt or other material.

After the reservoir or tank has been cleaned as described, the Contractor shall, when instructed by the Engineer and under his direction, sterilise the reservoir or tank by chlorination as described below.

The Contractor shall provide a suitable chlorinator (including the provision of the chlorine), which shall be capable of injecting the required concentration of chlorine solution at a steady rate into the reservoir or tank.

The Contractor shall introduce at least 30 parts per million of free chlorine whilst filling the reservoir or tank to a minimum depth of 100mm.

The Contractor shall then spray all surface areas to the underside of the roof, walls, columns and pipework with the heavily chlorinated water by means of a stirrup pump or similar appliance, No pump which requires petrol or fuel oil for its prime mover shall be used inside the reservoir or tank, but at the Engineer's discretion an electrically driven pump may be used.

On completion of the spraying the Engineer's satisfaction, the heavily chlorinated water shall be drained out of the reservoir or tank and each compartment shall be filled with potable water, from an approved source, to a minimum depth of 200mm. This water shall then be drained out and the reservoir or tank filled with potable water to overflow level.

Samples shall be taken as directed by the Engineer after the reservoir or tank has been full for a period of at least two hours and shall be sent to a qualified bacteriologist for analysis. If the results of the test show that the water contains any presumptive or typical coliform organisms in a 100ml. water sample then sterilisation procedure the cost of water and bacteriological examination of water shall be at the Contractor's expense.

On completion of sterilization the Contractor shall close off access to the reservoir or tank to all personnel, and no further work shall be permitted in areas allowing direct access to the interior of the reservoir. Should any unauthorized access occur, and if the Engineer rules that contamination may have resulted, the Contractor shall carry out at his own expense such tests, as the Engineer may require, to determine the extent of the contamination, and shall also carry out and bear the cost of any additional sterilization measures required by the Engineer.

The safe disposal of the heavily chlorinated water shall be included in the rates for sterilization.

5 MECHANICAL WORKS SPECIFICATIONS

5.1 GENERAL REQUIREMENTS

5.1.1 Related Work

The Contractor shall, under this section, co-ordinate with the Electrical Section of these Specifications to ensure compatibility with electrical and control components and completeness of supply without extra cost to the Employer.

5.1.2 Shop Drawings and Operating Manuals

Assembly/Shop drawings for all units to be furnished under this section shall be provided in accordance with the General Clauses.

5.1.3 Appurtenances, Fittings, Connecting Piping and Accessories

All appurtenances, fittings, connecting piping and accessories necessary for the proper functioning of the equipment or reasonably inferable from the Drawings shall be supplied and installed with the equipment, whether or not indicated on the Drawings or specified herein.

5.1.4 Materials Handling and Storage

The Contractor shall ensure safe delivery of all materials to the site. Materials are to be handled at all times with care to avoid damage. Loading, unloading and movement of materials into place by means of hoists, ropes or skid ways shall be carried out in such a manner as to avoid shock of any kind resulting from having been dropped or rolled against one another.

The Contractor is to ensure that materials and equipment are properly stored and protected onsite against weather, damage and theft to the satisfaction of the Engineer.

5.1.5 Materials and Workmanship

Furnish under this contract only materials and equipment which are first-class in every respect and can be constructed and finished in a workmanlike manner. Use materials suitable for the service intended and selected and fabricated in accordance with the best engineering practice. Equipment shall be modern in design and shall not have been used at any time previous to delivery except as required by tests.

The contractor is responsible for the total of the installation and good operation, manual as well as automatic where specified.

5.1.6 Concrete Equipment Bases

Unless otherwise recommended by the equipment manufacturer, equipment shall be finally set on 25 mm of cement grout, on a 150 mm high 'housekeeping' concrete base, chamfered at the edges.

Where equipment is to be set on a concrete base, the concrete base itself shall be anchored to the floor slab with cast in-place reinforced steel. If bases are to be cast onto an existing floor, the steel shall be epoxy grouted a minimum of 150mm deep into the existing concrete. The existing concrete shall also be roughened and coated with a suitable epoxy immediately prior to plating of the plinth or housekeeping base so as to ensure a good bond between the existing and new concrete. Concrete used in paths and housekeeping bases shall be 25 MPA concrete (Class 25/20)

5.1.7 Anchors Bolts

Unless otherwise specified, anchor bolts for equipment shall be of stainless steel type AISI 304 or cadmium plated steel having ample size for the purpose intended. They shall be set by the Contractor in accordance with the manufacturer's reviewed shop drawings.

5.1.8 Diesel Motors

N/A

5.1.9 Direct Connected Motors

Provide flexible shaft couplings to motors directly connected to pumps or equipment.

5.1.10 Guards

Covers all belt drives and motor shaft couplings with a suitable guard.

5.1.11 Motors

Unless otherwise specified, electric motors supplied for equipment under this Section shall be of the high efficiency totally enclosed fan-cooled, tropicalised class F. insulation, Class B temperature rise with anti-condensation heaters, 1.15 service factors; all copper windings.

- ◆ Less than 0.375 kW: 240V/1 p/50Hz power supply;
- ◆ 0.375kW and larger: 415V/3 p/50Hz power supply;
- ◆ Enclosure: TEFC, Corrosive Chlorine Atmosphere;
- ◆ Service Factor: 1.15

5.1.12 Standards

The design and construction of systems and equipment shall comply with the requirements of these Specifications and:

- ✓ ASME Codes or equivalent BS standards;
- ✓ Chlorine Institute Standards or Equivalent BS Standards

In case of conflict among the requirements those with the higher standards shall apply.

5.2 PIPEWORK AND VALVES

5.2.1 Steel Pipes

Steel Pipes and fittings shall be in accordance with BS 534 and shall be protected externally against corrosion by hot applied bitumen coatings to BS 4147. All pipe sections which pass through walls of water retaining structures shall incorporate integral paddle flanges for building in and shall be left un-coated externally over the length encased in the concrete. All internal coatings shall be of non-toxic material.

5.2.2 Iron Pipes

All cast iron pipework shall be vertically cast or spun iron pipes, of grey or ductile iron and manufactured in accordance with BS 4622 or BS 4772 as appropriate. Flanged pipes shall comply with BS 2035 or BS 4772.

Pipes and fittings shall be coated internally and externally with hot applied bitumen coatings to BS 4147 or equivalent. Ductile iron pipes manufactured with cement mortar lining are acceptable.

5.2.3 Plastic Pipes (PVC and HDPE)

All polyethylene and PVC pipes shall comply with BS 3284, BS 3505, BS 6427, BS 6573 or as 6730 as applicable. Plastic pipes shall not be used where they would be exposed to direct sunlight or where they would be susceptible to damage by vermin.

HDPE pipe shall comply with DIN 8076, BS 5114, Pipes constructed of HDPE shall conform to the relevant British standards or DIN norms. Pipe lengths are to be butt welded. All fittings and specials shall be constructed in HDPE to match the equivalent rating of the piping on which they are being installed. Bends are to be shop fabricated or moulded with a radius of 5D unless otherwise stated on the Drawings. Branches are to be socket or butt welded. Reducers shall have weld ends to suit the manufacturer's range.

All HDPE pipework installed above ground level shall be supported continuously on pipe supports provided by the Civil Contractor. Flanges are to be used at flanged valves, equipment items, at intervals of 30m for straight pipe lengths or as directed by the Engineer. Flange stub ends shall be of the same pipe class as the HDPE piping on which they are installed. Backing flanges shall conform to the appropriate pressure rating BS 4504 and be constructed of galvanised carbon steel.

The Contractor is required to make appropriate arrangements to deal with thermal expansion of the pipework. These arrangements shall require written approval of their suitability by the Engineer before installation.

Gaskets shall be constructed of Neoprene 3mm thick. Dimensions of gaskets shall conform to BS 4865 Part I Table 16b to suit flange stub ends.

Laying of HDPE pipes shall be in accordance with the appropriate British Standard. Pipe lengths are to be butt welded. All fittings and specials shall be of HDPE to match the rating of the piping on which they are being installed.

5.2.4 Asbestos Cement Pipes

N/A

5.2.5 Copper Tubes

N/A

5.2.6 Pressure Testing

On completion of erection, all pipework shall be hydraulically tested to twice the maximum working pressure, in any case, not less than 7 bar. The test pressure shall be maintained for two hours in the presence of the Engineer and any leaks shall be rectified to the satisfaction of the Engineer.

The Contractor shall supply all necessary equipment including pumps, blank flanges, gauges, etc., for these tests.

5.2.7 Valves - General

Valves incorporated in the delivery pipework shall be sized such that maximum velocities do not exceed 2.5 meters/sec. Each pump delivery pipe shall incorporate gate valve type isolating valve and a check valve.

All valves shall be manufactured by specialist manufacturers and shall be of long-proven design in regard to spindle, gland, seating, operating gear and electric motor actuator. Insofar as they are applicable, the requirements of BS 5163, BS 5133 and BS 5515 shall be observed as appropriate.

The working pressure rating of valves shall be suitable for 120% of the maximum pressure that can be developed by the pump in the pipework system plus the maximum pressure at the pump inlet.

Except as otherwise specified or approved, valves shall be of double-flange cast iron construction and shall be designed and tested to the declared Standard Specification. Nonferrous materials shall be used for valves and cocks of 50mm nominal bore and below. Such valves may be flanged or internally threaded for screwed tube.

Gland packing shall be entirely suitable for use in a tropical conditions.

Each valve shall have cast-in lettering showing maker, year of manufacture, nominal bore, rated working pressure and the Standard with which the valve conforms and, where appropriate, an arrow to indicate the direction of flow. In addition each sluice and butterfly valve shall be provided with a complete set of operating gear as set out below.

5.2.8 Valve Operation

Each valve shall be fitted with a handwheel and headstock and shall be suitable for operation by one man against the maximum working head. Valves shall be geared if necessary to permit this and shall be closed by clockwise operation of the handwheel. Handwheel shall be readily removable.

Where gearing is required for operation the gear shall be machine cut and shall be fully enclosed with external greasing points.

The position of valve handwheels and operating gear shall be carefully arranged so as to afford easy operation from the adjacent floor or platform level.

Valves having extended operating shafts shall be provided with all necessary lubricated support brackets for the shafts extensions.

5.2.9 Sluice Valves

Sluice valves of 50mm to 600mm size shall comply with BS 5163. Sluice valves over 600mm size shall be of an equivalent standard to those specified in BS 5163 and shall be of approved design and manufacture. Each valve shall have cast or stamped on the outside of its body, the manufacturer's name, its size and its pressure rating.

Each valve shall be fitted with a handwheel. Manually operated valves shall be suitable for operation by one man against the maximum working head. Valves shall be geared if necessary to permit this and shall be closed by clockwise operation of the handwheel. Handwheels shall be readily removable. Geared actuators shall be of the enclosed type and easily lubricated in a cast iron housing. Gland packing shall be entirely suitable for use in a tropical country.

5.2.10 Butterfly (Wing) Valves

Butterfly valves shall comply with BS 5155 and shall be of the drop tight closure, short or wafer type body with flanged ends of the appropriate char, stainless steel spindles. The valves shall have cast or ductile iron body and disc, and removable neoprene or nitrile rubber sealing faces against stainless steel seats. Means of slinging shall be provided for sizes 300 mm diameter. and larger.

Each electric motor and actuator shall be fitted with a handwheel, so arranged that the valve will close by clockwise operations of the handwheel. Valves shall be geared for one man operation and shall be fitted with indicators. Handwheels shall be readily removable.

5.2.11 Check Valves

All check valves complying with BS 5 153 shall be of the slanting disc type designed to close rapidly without shock for the first 90% and gently for the remaining 10%. The valves shall have a cast iron body to BS 1452, and gunmetal sealing faces to BS 1400. The valve covers shall be of ample size to allow clear access to the valve seats when the valve is fully open.

Each check valve shall have the direction of flow, nominal pressure rating and size cast or stamped onto the body.

5.2.12 Air Release and Vacuum Valves

These shall function to let air out of the discharge column during pump starting, and allow air into the column at pump shut down. Valves shall be of cast or ductile iron body,

flanged connection and stainless steel trim. Isolating gate valves, flanged ends shall be included.

5.2.13 Shop Testing

(a) Butterfly Valves:

Test all butterfly valves on liquid service in the shop. Valves shall be bubble tight at 1.5 times the working pressure. The Engineer reserves the right to witness any or all tests at no extra cost to the contract.

(b) Check Valves:

Shop test check valves on liquid service for performance and for water tightness and resistance to distortion under internal pressure. Test shall be carried out at 1.5 times the maximum pressure the valve will be subjected to. Under test pressures there shall be no leakage through the metal or permanent deformation of any casting. All joints and seats shall be watertight. Submit certified test report for each of the above tests.

(c) Combination Air Release/Vacuum Values:

Air release/vacuum valves shall receive a shop performance test prior to shipment. Tests shall be carried out at 'Design Pressure' conditions. Submit certified *test* report prior to shipment.

(d) Operators:

Operators shall be mounted to their respective valves in the shop and fully assembled unit operated at least three times to test the function of the complete operating mechanism.

5.2.14 Shop Painting

Thoroughly clean any unfinished ferrous surfaces of rust, sand, scale and foreign substances prior to painting.

Surface preparation shall conform to "Commercial Blast Cleaning". Unless otherwise specified, paint interior surfaces with two coats of cold-applied, tasteless and odourless bituminous paint. Paint exterior surfaces of valves with one coat of "Epoxy Phenolic Shop Primer dry film thickness 2 mils or to manufacturer's standard

Coat all machined surfaces with an approved anti-rust compound. Touch up all damaged shop-painted surfaces before finish paint application. Perform painting in accordance with the Painting section.

5.2.15 Identification Tags

Fit each valve with a numbered bar tag of 37 mm diameter corresponding to its tabulated number.

5.2.16 Certificates of Installation

On completion of installation and testing, the manufacturer's certification of the correctness of the installation shall be submitted to the Engineer.

5.2.17 Filter Airscour pipework

Each filter shall be provided with an air scour pipe grid independent of the washwater system. The airscour manifold and laterals shall be threaded plastic pipe to ASTM D 1785-76 schedule 80.

The OD 26.7mm (3/4") lateral pipes shall be accurately pre-drilled with 4mm diameter in a straight line. The laterals shall be installed so that the air holes are accurately aligned in level and elevation.

The compressed air supply line at the Filters shall be galvanized steel tube to BS 1387 above ground and threaded plastic pipe to ASTM D 1785-75 schedule 80 below ground.

5.3 HORIZONTAL PUMP UNITS

5.3.1 Design Workmanship and Construction

The Pump shall be 'KSB' or Nijhuis or equivalent. They shall be designed and built for continuous operation and suitable for starting against an open valve. Similar pumping units shall be of identical design and manufacture with corresponding parts interchangeable

Castings shall be free from flaws and imperfections and machined surfaces shall be finished true. All joints shall be machined and all castings shall be shop faced for nuts. All similar parts shall be made to similar gauge wherever possible.

The inside and outside corners and edges of all castings shall be rounded off, wherever possible, with fillet and chamfers. All screws, bolts and nuts shall be US Standard or metric standard, as specified under CLASS 1.8. large nuts 30 mm and larger shall have bronze cotter pins. No patching, plugging, shimming or other such means of overcoming defects, discrepancies or errors shall be resorted to without the written permission of the Engineer.

The drives shall have adequate capacities to run the pumps at all conditions of operation. All pumps shall be statically and dynamically balanced.

An operating and maintenance manual shall be submitted during shop drawing preparation for review by the engineer.

5.3.2 Performance

The pumps shall meet the requirements as shown in the scope of work.

5.3.3 Pump Construction

5.3.3.1 Casing

- Close grained high tensile cast iron to ASTM A-278 class 25 or equivalent; or ductile from ASTM A-395;
- Back pall out design with flanged suction and discharge nozzles cast integrally with the main pump casing;
- suction and discharge flanges to ANSI clam 125, faced, drilled and spot faced;
- provide tapped openings for drain and gauge connections;
- hydrostatic to 1.5 times the sum of maximum suction pressure and shut off head;
- provide lifting lugs or eye bolts.

5.3.3.2 Impellers

- bronze, cast in one piece;
- enclosed, non-overloading type, secured to the shaft by a key and locked in place;
- Statically and dynamically balanced.

5.3.3.3 Wearing Rings

- Provide wearing rings for casing and impeller;
- renewable bronze or a combination of bronze and stainless steel;
- Where suitable, double labyrinth type design is preferred.

5.3.3.4 Shaft

- high grade carbon steel, heat treated, annealed, machined and polished; adequately sized to take all kinds of loading without vibration and fatigue failure;
- fitted with sleeves of corrosion-resistant iron- chromium alloy (11 to 14% Cr.) or equivalent, easily replaceable design. Provide O-ring type seals to prevent leakage.

5.3.3.5 Stuffing Boxes

- designed for integral water scaling;
- bronze lantern gland packed with PTFE or Nitril Synthetic Fibre or equivalent, no asbestos, and non-toxic packing material;
- provide drip boxes and tapped drainage opening allow collection of waste SCW water to drain;
- provide defector or slingers rings to prevent entry of water into the bearings.

5.3.3.6 Bearings

- designed to take line and thrust loads under all operating conditions;
- anti-friction type, sized and rated for at least 100,000 hours B-10 Bearing Rating Life;
- Oil or grease lubricated.

5.3.4 Pump Accessories

5.3.4.1 Couplings

- forged steel, gear type flexible shaft coupling or Fenner “tyre type” with spacer to connect pump and motor;
- designed to transmit full power limit end play of motor; absorb angular and parallel misalignment as well as axial movement due to vibration or thermal expansion and contraction of pump and motor;
- provide coupling guard of expanded metal construction, properly anchored to the baseplate.

5.3.4.2 Baseplates

- heavy cast or welded steel common baseplate with machined hub for mounting both pump and motor;
- provide: grouting holes; drilled lugs for anchor bolts; drain gutter around pump area, fitted with 25 mm diameter. drain connection;
- both pump and motor shall be assembled in the shop for initial alignment and doweling.

5.3.5 Pressure Gauges

- provide suction and discharge pressure gauges for each pump;
- 99 % accuracy over 90 % of range;
- 150 mm diameter Bourdon tube;
- black phenol case;
- supply snubbers and isolating cocks;
- range (dual graduation): suction -10 m to + 10 m (water bend); discharge 0 to + /- (Closed Valve Pressure + 20 m).

5.3.6 Motors

Motors to meet Electrical specifications.

5.3.7 Shop Painting

All non-machined surfaces of the pumping units shall be thoroughly cleaned and smoothed before painting. Surface preparation shall conform to Specification SSPC-SP-6 'Commercial Blast Cleaning'.

The interior of the horizontal pump casting shall be given three coats of an approved taste and odour free paint before shipment.

Exterior surfaces of the pumps shall be primed with two coats of Epoxy Ester Phenolic primer, dry film thickness of 38 to 50 mil.

Electric motors may be supplied with the manufacturer's standard finish, colour as directed by the Engineer.

Other machined surfaces such as shafting shall be well coated with grease or anti-rust compound before shipment.

5.3.8 Anchor Bolts

The Contractor shall furnish anchor bolts of type 304 stainless steel having ample size for the purpose intended.

They shall be set by the Contractor in accordance with the Manufacturer's approved working drawings.

5.3.9 Shop Tests

All pumps shall be tested in accordance with the 'Hydraulic Institute Standards' Test Code for centrifugal pumps.

Each pump shall be guaranteed for the rating capacity and efficiency when operating the specified conditions of head and load.

The pumps shall be shop tested by the manufacturer over their range of operation from shutoff pressure to a point at least 20% beyond the point of rated capacity. A certified test curve in duplicate showing head, capacity, efficiency and power shall be furnished to the Engineer for review.

Standard commercial shop tests shall be carried out on motors and certified data submitted to the Engineer for review.

The Engineer reserves the right to request a factory test with standard protocol for his review.

5.3.10 Installation of Pump Units

All pumping units shall be installed by the Contractor in accordance with the manufacturer's instructions reviewed by the Engineer. Only mechanics with at least 5 years' experience in the installation of rotating machinery shall be employed.

5.3.11 Supervision

A Supervision period of two days shall be allowed for manufacturer's representatives to inspect the installation of the equipment, to start up the equipment and to instruct operating personnel in its operation and maintenance. This period may be divided into two or more separate periods as required by the Engineer.

5.3.12 Field Tests

The pumping units supplied shall be tested by the Contractor and manufacturer's representative and witnessed by the Engineer after installation to ensure that the specified requirements are met, and that the operation of the unit is satisfactory in all

respects. In the event of any unit failing to meet the requirements of these specifications, the Engineer reserves the right to reject it. Subsequently, the equipment shall be repaired or made good to the satisfaction of the Engineer.

5.3.13 Spare Parts

The Contractor shall supply the following spare parts for each pump.

- ✓ Shaft sleeves - 2 pieces;
- ✓ wearing rings - 2 sets;
- ✓ bearings (line & thrust) - 2 sets;
- ✓ packing gland complete with cages - 3 sets;
- ✓ gasket material (no. of changes) - 2 changes;
- ✓ packing material (no. of changes) - 3 changes.

All spare parts shall be plainly tagged and marked for identification and reordering, and they shall be boxed properly.

The contractor shall supply special tools for mounting and demounting the pumps and motors as specified by the manufacturer

5.3.14 Certificates of Installation

On completion of installation and testing, the manufacturer's certification of the correctness of the installation shall be submitted to the Engineer.

5.3.15 Painting

All piping supports, valves, and equipment shall be cleaned and all rust, dirt, grease and oil be removed, whether such items are to be painted or not.

All items of equipment supplied under this Section shall receive shop painting consisting of one primer coat and two finish coats. All steel work, other than galvanised, plated or stainless steel, shall receive at least one coat of zinc chromate-alkyd primer. Finish painting, where required, to the colours to be selected by the Engineer.

All scratched and marred finish and primer coats shall be retouched to the satisfaction of the Engineer.

5.4 BOREHOLE PUMP UNITS

5.4.1 General

The pumps are required to pump underground water and be suitable for installation and operation in 75 to 90 OD HDPE casing.

The pumps shall be either:

- High-lift multi-stage centrifugal submersible borehole pumps and motors, or
- Positive displacement pumps and motors.

5.4.2 Design, Workmanship and Construction

The pumps, discharge heads, motors etc shall be designed and built for continuous operation. Similar pumping units shall be of identical design and manufacture, with corresponding parts interchangeable.

Castings shall be free from flaws and imperfections and machined surfaces shall be finished true. All joints shall be machined and all castings shall be spot-faced for nuts. All similar parts shall be made to similar gauge wherever possible.

The inside and outside corners and edges of all castings shall be roughed off, wherever possible, with fillets and chamfers. All screws, bolts and nuts shall be metric standard. Large nuts 30mm and larger shall have bronze cotter pins. No patching, plugging, shimming or other such means of overcoming defects, discrepancies or errors shall be resorted to without the written permission of the Engineer.

All drives shall have adequate capacities to run the pumps at all conditions of operation.

All pumps shall be statically and dynamically balanced.

5.4.3 Performance

The pumps shall meet the requirements as shown in the scope of work.

5.4.4 Submersible Centrifugal Borehole Pumps and Motors

The pumps and motors are to be located at the depths detailed in the scope of works. The motor casing and pump shall be stainless steel and form one unit.

The submersible motor shall be manufactured and shop tested for continuous operation on a 415 volt, 3 phase, 50 Hz system. The motor shall operate satisfactorily with voltages from 10% below to 10% above the motor nameplate rating. The motors are to be protected with lightning or surge arrestors installed at the top of the main adjacent to the casing. The motor is to include stainless steel casing and caps, carbon sleeve bearings, graphite thrust bearings and thrust shoes, seals, etc.

The pump shall be multi-stage, with bronze impellers of the enclosed non-overloading type. The pump is to be statically, dynamically and hydraulically balanced. Wearing rings are to be provided.

The shaft is to be high-grade carbon steel, heat treated, annealed, machined and polished; adequately sized to take all kinds of loading without vibration and fatigue failure. Bearings shall be designed to take line and thrust loads under all operating conditions and be of the anti-friction type, size and rated for at least 100,000 hours.

A flow inducer sleeve shall be fitted to the pump and motor to ensure proper flow of water past the motor. It shall be fabricated from corrosion resistant steel or heavy plastic.

The pump is to have a non-return valve installed at the bottom of the borehole piping and first in-line after the pump unit.

Piping from the pump to the surface is to be stainless steel and provided with screw joints. A screwed non-return valve shall be fitted between the pump and start of piping

(if pump is not fitted with non-return valve). Clamps are to be provided on the borehole piping for the fixing of electrodes and cables. Rubber stabilisers should be provided to prevent vibration and movement of the pipe.

The pump and piping is to be fixed on the surface with a base plate suitable for all loads that may be expected. The piping at the top of the casing is to include a flanged gate valve, a silent check valve (globe type), dismantling coupling and pressure gauge.

5.4.5 Positive Displacement Borehole Pumps and Motors

The pumps are to be located at the depths detailed in the scope of work.

Motors shall be suitable for vertical mounting or as required by the discharge head. They shall be of the drip proof (fully guarded) squirrel cage induction type with class "B" insulated windings. The motor is to be sized to give approximately 15% safety margin in excess of the power requirements of the pump at any point on the characteristic curve and in no case shall be less than specified. The service factor shall be 1.15. Each motor shall be fitted with thermistor on each phase.

Motors shall be manufactured and shop tested for continuous operation on a 415V, 3 phase, 50 Hz system. The motor shall operate satisfactorily with voltages from 10% below to 10% above the motor nameplate rating.

Motors shall have an anti-condensation heater suitable for operation at 110V from the control circuit.

Bearings shall be of the heavy-duty, anti-friction type of liberal size for continuous service without overheating. They shall be sealed and lubricated for life. Adequate thrust bearing capacity shall be provided to carry the loading of rotating members of the motor and from pulleys.

The sound pressure level shall not exceed 82dBA measured 1.6m distant from the motor in accordance with IEEE standards.

Diagonally split, gasketed, approved type terminal boxes shall be provided together with conduit fittings. A manufacturer's rating nameplate in non-ferrous, permanently inscribed material shall be attached to the motor. Ground connection and lifting eyes or lugs shall be provided. Electric motors may be supplied with manufacturer's standard finish, colour as directed by the Engineer.

The motor is to be mounted parallel to the discharge head and it will require a pulley drive. The belt drives and motor shaft couplings shall be enclosed by guards. Belt drive guards shall have tachometer cut-outs.

The discharge head and all non-machined surfaces shall be thoroughly cleaned and smoothed before painting. Surface preparation shall conform to specifications SSPC-SP-6 "Commercial Blast Cleaning". Bearings shall be designed to take line and thrust loads under all operating conditions and of the anti-friction type, sized and rated for at least 100,000 hours. The bearings are to be sealed and lubricated for life. The bearings are to be protected from the ingress of dirt and water. The discharge head is to be provided with stuffing box with stainless steel bolts and nuts, packing, motor mounting bracket etc.

The rising main is to include precision machined column butts (inside socket) with no exposed threads. The threads are to be rolled to ensure optimum strength and high accuracy to ensure that power from the motor is transmitted efficiently to the rotor. Bobbin bearings of rubber on stainless steel bearing pieces are to be provided at 1.6m spacing so as to centralise the shaft (see pump unit) in the rising main. Rubber stabilisers are to be provided at 3m spacing to hold the pump and column in the borehole and prevent any vibration.

The pump unit is to consist of the strainer, element, body and shaft between the discharge head and the pump unit. The pump unit is to be driven via high grade stainless steel flexible shaft sufficient in size to absorb the rotors eccentric motion and forces. The shaft extends from the discharge head to the rotor. The rotor is to be provided with a hard chrome finish and the stator is to consist of a resilient neoprene based compound, vulcanised to the outer casing. The rotor is to maintain a full seal across the stator and travelling constantly up to the pump to provide uniform positive displacement throughout the cycle.

The piping out of the discharge head is to include a silent check valve, pressure gauge and dismantling coupling.

5.4.6 Shop Painting

All non-machined surfaces of the discharge head shall be thoroughly cleaned and smoothed before painting. Surface preparation shall conform to specifications SSPC-SP-6 "Commercial Blast Cleaning". Exterior surfaces of the discharge head shall be primed with two coats of Epoxy Ester Phenolic primer, dry film thickness of 38 to 50 micron.

Electric motors may be supplied with the manufacturer's standard finish, colour as directed by the Engineer.

5.4.7 Anchor Bolts

The Contractor shall furnish anchor bolts of type 304 stainless steel having ample size for the purposes intended. They shall be set by the Contractor in accordance with the manufacturer's approved working drawings.

5.4.8 Shop Tests

All pumps shall be tested in accordance with the "Hydraulic Institute Standards" test code.

Each pump shall be guaranteed for the rating capacity and efficiency when operating under the specified conditions of head and load.

Standard commercial shop tests shall be carried out on motors and certified data submitted to the Engineer for review.

The Engineer reserves the right to witness any of the pump and motor tests without extra cost to the Employer.

5.4.9 Installation of Pumping Units

All pumping units shall be installed by the Contractor in accordance with the manufacturer's instructions and reviewed by the Engineer. Only mechanics with at least 3 years' experience in the installation of borehole pumps shall be employed.

5.4.10 Supervision

A supervision period of one day shall be allowed for the manufacturer's representative to inspect the installation of the equipment, to start up the equipment and to instruct operating personnel in its operation and maintenance.

5.4.11 Field Tests

The pumping units supplied shall be tested by the Contractor and manufacturer's representative and witnessed by the Engineer after installation to ensure that the specified requirements are met, and the operation of the unit is satisfactory in all respects. In the event of any unit failing to meet the requirements of the specifications, the Engineer reserves the right to reject it. Subsequently, the equipment shall be repaired or made good to the satisfaction of the Engineer.

5.4.12 Spare Parts

The Contractor shall supply prices for the following spare parts. The prices are to be included in the relevant section of the Bill of Quantity:

- Shaft sleeves; 2 pcs
- Wearing rings; 2 sets
- Bearings (line and thrust); 2 sets
- Packing gland complete with cages; 3 sets
- Gasket material (no. of changes): 2 changes
- Packing material (no. of changes): 3 changes

All spare parts shall be plainly tagged and marked for identification and re-ordering, and they shall be boxed properly.

5.4.13 Certification of Installation

On completion of installation and testing, the manufacturer's certification of the correctness of the installation shall be submitted to the Engineer's representative commissioning the works.

5.5 CHEMICAL FEED FACILITIES

5.5.1 Work Description

This section covers the design, supply, installation, testing and supervision of initial operation of chemical feed facilities which include, but not limited to the following systems and equipment:

- Chlorination.
- Testing equipment

Equipment and systems shall be complete in all respects to achieve a satisfactory installation and operation of the chemical feed facilities to the requirements and intent of these Specifications.

All electrical and piping connections to this equipment, and all concreting for foundation bases (excluding grouting and shimming) shall be done under the respective Sections for such work.

5.5.2 Design and Detailing of layout of Pumps and Tanks

The Contractor shall be responsible for providing a layout and working drawings conforming to the specifications, that may be accommodated into the proposed Chemical House. The Contractor shall include for any changes required to the layout to suit the equipment that he may propose.

Pipework shall be designed so as not to adversely affect the operation and ensure that velocities are sufficient so as to prevent settlement and clogging of the delivery lines. Provided always that the pressures developed do not exceed the pressure rating or affect the long-term life of the pipework.

5.5.3 Enclosures for Control Panels

NOT USED

5.5.4 General Material Requirements

Materials used in the manufacture of chemical feed equipment which comes into direct contact with a corrosive liquid or solution shall be entirely suitable for complete corrosion-resistant service.

Chemical feed equipment and systems shall comprise alum, and chlorination.

The supplier of equipment shall be fully experienced in the application, design, construction and operation of equipment for this purpose, and shall have furnished chemical feed equipment with a proven record of at least ten years successful operation.

5.5.5 Plant Flow

Chemical equipment shall be designed for the operating conditions and service plant flow.

5.5.6 Fabrication and Testing of Chemical Storage Tanks

N/A

5.5.7 Shop Testing of Equipment

The Contractor shall ensure that the manufacturer/fabricator avails all necessary equipment for shop testing of respective components and facilities for compliance with the intended specifications.

5.5.8 Installation of Equipment

Install the equipment in accordance with the manufacturer's reviewed working drawings and installation directives. Equipment shall be installed by qualified mechanics having experience in the installation of chemical feed equipment.

5.5.9 Field Testing

Field testing of various components of the Works shall be in accordance with these the respective provisions in these specifications or according to the manufacturer's guidelines. The carrying out of the field tests shall be jointly witnessed by the duly appointed representatives of the Contractor and the Engineer.

The Contractor shall prepare and submit to the Engineer a report of the Field testing including the description of the testing procedure, the analysis and interpretation of the results.

5.5.10 Shop Painting

One shop coat of primer shall be applied to metal items, with the exception of concrete encased items or faying surfaces of friction connections. The minimum film of thickness shall be 0.05mm. Surface preparation for painting shall be blast cleaning.

Surfaces to be field-welded shall not be painted.

5.5.11 Field Painting

Coat exterior of motors, gear reducers and other metal surfaces in accordance with the Section on 'Painting and Protective Coating'.

5.5.12 Test equipment for plant

Testing of various equipment for the plant for the Works shall be in accordance with the respective provisions of in these specifications or according to the manufacturer's guidelines.

5.6 CHLORINE FEED EQUIPMENT

5.6.1 Work Description

This section covers the design, supply, installation and supervision of initial operation of disinfection facilities which include, but are not limited to the following systems and equipment.

- ◆ The supply and installation of hand regulated gravity doser for chlorine solutions.
- ◆ The supply and installation of solution tanks and accessories necessary for a complete operating system
- ◆ The supply and installation minimum 100 micron filters before the feeders.
- ◆ The supply and installation of a dosing flow meter.
- ◆ Constant Level tank complete with float valve.
- ◆ The supply of recommended spare parts.
- ◆ Operator training

Equipment and systems shall be complete in all respects to achieve a satisfactory installation and operation of the disinfection facilities to the requirement and intent of these Specifications.

The system will operate without electricity or any power source other than water flow. It will be self-priming and continuously adjustable to flow.

All piping connections to this equipment, and all concreting for foundation bases (excluding grouting and shimming) shall be done under the respective sections for such work.

5.6.2 General

Materials used in the manufacture of chlorine feed equipment which comes into direct contact with a corrosive gas, liquid or solution shall be entirely suitable for complete corrosion resistant service.

In general, chlorine feed equipment and auxiliaries furnished under this section shall be equivalent to that manufactured by '*Paterson Candy International Ltd*, but shall be in conformity with these Specifications.

The supplier of chlorine feed equipment shall be fully experienced in the application, design, construction and operation of equipment for this purpose, and shall have furnished liquid and gaseous chemical feed equipment with a proven record of at least ten years successful operation.

5.6.3 Service

Chlorination equipment shall be designed for the operating conditions and service described on the drawings and in the scope of work.

The chlorination system shall be designed for optimum flexibility of operation by designing and equipping the chlorination equipment so that each unit can function as a standby to the other by simple switching of controls and manipulation of valves.

5.6.4 Chlorinators

Chlorinators will be sized individually based on main line flows. Dosing flow Between 0.0375 – 0.3 l/min

Supply and install items with the following features:

- ◆ Constant Level tank complete with float valve;
- ◆ Manually regulated gravity doser as FRO or FRN type manufactured by *Paterson Candy International Ltd*, or approved equal, dosing flow between 0.0375 – 0.3 l/min;
- ◆ Dosing Flow Meter

5.6.5 Chlorine Feed Accessories

- ◆ Junction parts including a flow limiter
- ◆ Suction tube with suction filter

- ◆ Hose clamps
- ◆ Water line pressure gauges
- ◆ Isolating valves
- ◆ Flow limiter to be fitted before the feeder

5.6.6 Pipe and Fittings

Piping system shall be supplied as part of the equipment and shall be suitable for chlorine service and comply with the following:

- ◆ Chlorine solution: Schedule 80 PVC pipe and fittings

5.6.7 Solution Tanks

Solution tanks to be 500 litre capacity complete with hand-stirrer of stainless steel construction. Tank to be enclosed with opening in cover for the insertion of suction tube and filter.

5.6.8 Chlorine Test Kit

Two chlorine test kits to be provided to provide reading range from 0.1 to 1 mg/l and 1 to 5 mg/l (*Hach, dr Lange* or approved equivalent manufacture)

5.6.9 Spare Parts

A set of spare parts will be supplied with each unit based on the manufacturer's recommendations, including O-rings, gaskets, lubricants, filter bags etc;

5.6.10 Operational Manual

An operating manual shall be submitted during shop drawing preparation for review by the engineer. The manual shall include:

- ◆ P & I drawings showing all components of the chlorination system;
- ◆ A narrative description of the intended operation of the chlorination system;
- ◆ List of major components, model designation, capacity rating, etc;

After review by the Engineer, six copies of the approved and final operating manual shall be submitted, prepared as follows:

- ◆ Letter size paper
- ◆ Double spaced
- ◆ Fold out P & I drawings
- ◆ Table of contents
- ◆ Coloured dividers with tabs
- ◆ 3-ring binder with hard plastic cover

5.6.11 Installation of Equipment

The installation shall be carried out in accordance with the requirements of the Chlorine Institute and with the manufacturer's reviewed working drawings and instructions.

Equipment shall be installed by qualified mechanics having experience in the installation of chemical feed equipment, particularly chlorine.

5.6.12 Testing

Perform all tests required by any law or ordinance or by any public authority. Provide all test results and certificate prior to starting equipment.

After satisfactory installation, the contractor and his supplier shall test chlorination facility and demonstrate to the Engineer that all functions and controls comply with the requirements and intent of these specifications.

5.6.13 Supervision

A supervision period shall be allowed in this Contract for factory-trained technicians to inspect the installation of the equipment, to test and to start up the equipment.

5.6.14 Certificates of Installation

On completion of installation and testing, the manufacturer's certification of the installation shall be submitted to the Engineer.

5.7 ALUM FEED SYSTEM

5.7.1 Design of the Alum Feed System

The Contractor shall be responsible for providing a layout and working drawings for the Alum Feed System conforming to the specifications. The Contractor shall include for any changes required to the layout to suit the equipment that he may propose.

Pipework shall be designed so as not to adversely affect the system operation and ensure that flow velocities are sufficient so as to prevent settlement and clogging of the suction and delivery lines with sediment coming out of solution. Provided always that the pressures developed do not exceed the pressure rating or affect the long-term life of the pipework.

5.7.2 Alum Storage Tanks

Solution tanks to be 500 litre capacities complete with facilities and easy access for manual mixing. Mixing spades (Hand Agitator) are to be provided by the contractor. The tanks are to be installed with a drain.

5.7.3 Alum Dosing

Supply and install items with the following features:

- ◆ Constant Level tank complete with float valve;
- ◆ Hand regulated gravity doser as FRO or FRN type manufactured by *Paterson Candy International Ltd*, or approved equal, dosing flow between 0.1 - 1 l/min ;
- ◆ Dosing Flow meter

5.7.4 Delivery Piping

Supply and install suction and discharge piping including the necessary valves and fittings:

- ◆ Section headers 63 mm dia. PVC;
- ◆ Discharging piping 25 mm dia.;
- ◆ Discharge branches PVC.

5.7.5 Overflow Pipework

Provide at least 75mm diameter overflow outlets, properly piped to the nearest drain.

5.8 METERING ELEMENTS

The pumping mains shall be filled with differential pressure type meters to be provided and installed by the Contractor. These instruments shall have flow indicating, integrating and recording functions. When installed on rising mains from pumping stations, pressure recording facilities shall also be included. The meters shall consist of the following elements:-

5.8.1 Differential Pressure Producing Unit.

This shall be of the short insert venturi tube type in cast iron with epoxy polyimide finish. The tapping nipples must clear the clamping flanges and be provided with gunmetal plug cocks. The plugs to offer a 12mm BSP female thread connection for galvanised steel pipe.

5.8.2 Recording, Indicating and Integrating Unit.

This shall be provided with a wall mounting bracket, to a cast-iron housing holed for 2no, x 12mm dia. bolts cast into the wall of the recorder house. The measuring element shall be a liquid filled differential pressure bellows unit. Mercury shall not be used. The instrument shall be driven by clockwork which is to have an endurance of eight days between windings. Flow indication by means of a crescent scale, recording on a circular chart geared to one revolution per week. The chart shall also include pressure recordings, where required. Flows to be measured in m³/hour (pressure in bars). The maximum chart reading to be the next highest manufacturer's denomination above the maximum flow stated on the Drawings and/or the Bills of Quantities. The integrator to be of the 6 digit type, the lowest integer representing 10 cubic metres.

The unit shall be provided with an identification plate, 100 circular charts, expendable spares for two years operation, air purging connection and a 3 months continuous inking pen system.

Under the recorder a control head, with isolating and air bleed cocks, is required. An adaptor, 200mm below the control head, for 2 x 19mm ND male threaded galvanised steel pipe shall be connected to the control head.

5.8.3 Connecting Pipework.

Two parallel 19mm ND galvanised steel pipes shall connect the differential pressure producing unit and the recording instrument. The 12mm ND tapings, on the unit, shall be fitted with 12/19mm reducers. From these points, the pipes shall firstly incline below the horizontal to prevent ingress of air from the main. The pipes shall continue to the recorder house and connect to the adaptor fitted 200mm below the instrument control head.

6 ELECTRICAL WORKS

6.1 GENERAL REQUIREMENTS

6.1.1 Work to be done

The Contractor shall design, construct, supply deliver and install all electrical equipment and electrical related services specified herein and/or detailed on the drawings, unless otherwise noted.

For pumps and motors, head and power are approximate calculated values that, after award of contract and before ordering of the equipment, have to be checked and (if needed) corrected by the Contractor. The tender price has to be based on the mentioned value. Prior to ordering pumps and motors approval is required by the engineer after review of the contractors detailed pump head calculations.

The provision of electrical power and control equipment shall be carried out by personnel qualified and experienced in such type of works and under proper supervision, acceptable to the owner.

Without limiting the intent of the above, the work is generally described under the following sub-sections.

The Contractor shall undertake all civil work ancillary to the electrical work required for the project, whether that electrical work is the subject of this Contract or of other contracts. Such work will generally include excavating cable trenches and sealing cable ducts where cables enter buildings. Existing floor cable trenches are not to be used. All cabling is to be above ground level.

The provision of lighting, socket outlets, cabling and switchboards shall be carried out so as to provide a complete functional electrical installation to the buildings.

The external lighting is indicated on the drawings, but the exact positioning is to be agreed on site with the Electrical Inspector.

6.1.2 General Clauses & Conditions

All work carried out under this section shall be governed by the General Clauses and Conditions of the Contract which, although not repeated herein, govern all electrical works.

6.1.3 Relation to Other Trades

The Contractor shall be responsible for all cutting and patching needed for electrical work in new or existing structures where such openings and refinishing are not provided for use by all trades under the General Contractor's work.

The Contractor shall notify responsible members of other sub-trades of all openings, inserts, anchors, sleeves, hangers, foundations, etc., necessary for his installation, and he shall be responsible to see that these are provided and correctly installed at the proper time.

No cutting or welding of beams, Columns or structural surfaces shall be permitted without approval of the Engineer. All damage to finish or unfinished surfaces shall be made good to the satisfaction of the Engineer.

Although the provision of temporary power for construction is the responsibility of the General Contractor, the work shall include full co-operation with all in the provision and maintenance of electrical power in all areas throughout the period of construction.

The work under this contract shall not interfere with the operations of the owner's plant. Work requiring electrical isolation shall be performed after obtaining prior written approval of service interruption, by the owner's representative and that of the Engineer. The Contractor shall give adequate written notice of his intention to interrupt power.

6.1.4 Codes, Permits and Electrical Inspections

The work shall be tendered on and shall be carried out in accordance with:

- a) All relevant British Standards Specifications and Codes of Practice or approved equivalent, The Institute of Electrical Engineers, "Regulations for Electrical Installations" and by-laws of the National Electricity Regulatory Authority, International Electrotechnical Commission, and the Uganda National Bureau of Standards;
- b) By-laws of the local authority and any other authorities having jurisdiction over the installation;
- c) Codes of Practice for the Protection of Buildings against lightning;
- d) Fire Office Regulations;
- e) Labour Act or by-laws or similar existing Laws;
- f) Work detailed in this Specification and associated contract drawings;
- g) The Engineer's instruction.

In no instance, shall the standards established by the Drawings and Specification be reduced by any of the codes referred to above. In the event of conflicting requirements, the codes shall take precedence over these Contract documents and the Engineer's decision shall be final.

The Contractor shall arrange for and obtain all necessary permits, inspection and approvals from authorities having jurisdiction, and shall pay all applicable fees. The Contractor shall confirm Municipal Codes, Regulations, and by-laws that affect the work.

Before starting any work, submit the required number of copies of Drawing and Specifications to the Authorities for their approval and comments. Comply with any changes requested as part of the Contract, but notify the Engineer immediately of such changes for proper processing of these requirements. Prepare and furnish any additional Drawings, details of information as may be required by such Authorities.

On or before the completion of this Contract, the Contractor shall obtain at his own expense the necessary Certificates of Inspection from the relevant electrical authorities; and shall forward the Certificate to the Engineer before final acceptance of the work.

6.1.5 Contract Drawings

The drawings for electrical work are essentially outline drawings, partly diagrammatic, intended to convey the type and extent of work. They indicate general arrangement and approximate location of apparatus and fixtures and typical sizes and locations of equipment and connections. The Drawings are not intended to show architectural, structures or mechanical details.

Dimensions to structures, etc., shall not be scaled from the Drawings, but information involving accurate dimensions shall be obtained from those shown on Architectural and/or Structural Drawings, or by site measurement of existing facilities. The Contractor shall follow the electrical Drawings, in laying out of work. Contractor shall consult the General Construction Drawings and Detail Drawings to become familiar with all conditions affecting the work under this specification and he shall verify spaces in which the work shall be installed and structures to which it will be attached.

The Contractor shall make, at no additional cost, any changes or additions to materials and/or equipment necessary to accommodate structural conditions (runs around beams, columns, etc.) or shall alter, at no additional cost the location of materials and/or equipment as directed, provided that the changes are made before installation and do not necessitate additional material or labour.

The exact location and mounting elevation of equipment and fixtures as related to Architectural and Structural details shall be confirmed on the site.

The Contractor shall confirm the locations of outlets and/or connection points for equipment supplied by other trades before installation.

6.1.6 Construction Drawings

The Contractor shall prepare Construction Drawings in conjunction with all trades concerned, showing sleeves and openings for passage through structures and all sizes and location of all inserts needed for electrical work. The Contractor shall prepare cable schedules showing all cable sizes, lengths, route destinations, tag numbers and termination gland sizes.

The Contractor shall also prepare composite Construction Drawings, fully dimensioned, of all cable, conduit, bus duct and equipment in mechanical and electrical equipment rooms, Transformer station ceiling spaces and all other critical locations to avoid conflicts with other trades. Equipment Drawings shall be based upon Shop Drawings and shall include, but not necessarily be limited to, all detail pertaining to clearances, accesses, sleeves, elevation of pipes, ducts, conduits etc., obtained from consultation with and agreement of the other trades involved.

All Drawings be prepared to scale and dimension, and forwarded to the Engineer for his records. Print copies in a number as specified elsewhere in the Contract Documents, but not less than four or transparencies shall be provided.

The Contractor shall bind one complete set of Construction Drawings showing as-built conditions in each operating and maintenance instruction manual.

6.1.7 Workmanship

All equipment, bus ducts, cable trays, conduit and cables shall be installed in a workmanlike manner to present a neat appearance and to function properly to the approval of the Engineer. Exposed systems and equipment shall be neatly installed and grouped to present a neat appearance, without conflict to other services. Attention should be placed on cable spacing and grouping as required by the relevant code regulations.

The Contractor shall leave space clear and install work to accommodate future materials and/or equipment as indicated and to accommodate equipment and/or material supplied by other trades. The Contractor shall verify all equipment sizes in relation to space allowed and check all clearances, install conduit, cable tray and bus duct runs to maintain headroom and clearances and conserve space in galleries, mechanical rooms and ceiling spaces.

Equipment and apparatus requiring maintenance, adjustment or eventual replacement shall be installed with due allowance therefore, in terms of space and accessibility.

All requirements of manufacturers as shown on the Shop Drawings or manufacturers' installation instructions shall be included in the work, whether or not detailed on the Contract Drawings and Specifications.

Work unsatisfactory to the Engineer shall be replaced, as directed, without cost to owner.

All equipment shall be protected from damage during delivery to the site and during installation. Any damage or deterioration whatsoever shall be made good to the satisfaction of the Engineer, and shall be covered by guarantee equal to the new.

6.1.8 Material and Equipment

All equipment material, wiring and devices shall conform to the relevant BS code or equivalent for the purpose for which they are to be used.

6.1.9 Equivalents

The equipment specified must be used in the Tender Price and used in the design of the works. Alternative equipment to that specified may be used if approved by the Engineer but all alternatives must be submitted at the time of tendering as required by the Information for Tenderers.

6.1.10 Equipment Finish and Classification

Unless otherwise specified, all electrical equipment in this Contract shall have a high-quality factory-applied finish comprising two coats of a semi-gloss air-dried or baked enamel, applied over two coats of a suitable Primer and preceded by an approved rust-resistant or bonderised treatment. All steel panels are smooth, level, cleaned and degreased before finishing. All colours shall be selected and approved by the Engineer.

All equipment located outdoors or in areas shown on the Drawings as being weatherproof shall have approved weatherproof enclosures, and all equipment, junction boxes, etc., located in galleries or below grade shall have an appropriate enclosure with gasket covers.

All plant equipment supplied under this contract shall be fully tropicalised, and suitably resistant to or protected against termites and vermin. No organic material shall be used and all seals, grommets, etc., shall be made of neoprene or alternative suitable materials.

6.1.11 Equipment Identification and Warning Signs

All warning signs shall be provided in accordance with National Regulations. Engraved "trafolite" nameplates with white letters on black background shall be provided and secured to all equipment as identified under the detailed equipment sections, and the engraving shall be approved by the Engineer. All control stations and field-mounted equipment shall be suitably identified with equipment designations using engraved 6 mm lettered trafolite nameplates. Adhesive-backed punched ('Dymo') labels shall not be acceptable.

All cables shall be tagged at both ends, at junction boxes, or cable tray transitions and identified by equipment designations or other approved code, using permanently printed or PVC cable markers. Conductors of any multi-conductor cables shall similarly be identified and shall also have individual cores identified at each end using ferrule numbers.

After finished painting is completed, each bus duct, main feeder cable and/or conduit SCMCC, shall be identified, by an approved indelible stencil or tag with its approved designation, at the following locations:

- (a) Behind each access door;
- (b) At each change of direction and junction box;
- (c) Every 15 m in straight runs of exposed conduit and bus ducts, but on both sides of sleeves or cable tray transitions;
- (d) Above each floor or platform for ex vertical conduits and bus ducts, preferably 1500 mm above the floor or platform.

The identification shall describe system voltage and service. The Contractor shall confirm that each manufacturer's nameplates are affixed to each equipment showing the size, name of equipment, serial number and all information usually provided, including voltage, frequency, number of phases, kW rating, etc., and the name and address of the manufacturer. All stamped, etched, and engraved lettering on plates must be perfectly legible.

6.1.12 Inserts, Sleeves, Curbs and Trenches

Provide all necessary inserts, hangers, fastenings, sleeves and curbs for electrical equipment suspended from or passing through structural walls or floors, to suit the specific location and as approved by the Engineer. Inserts and fastenings shall be as follows:

- (a) Factory-made threaded or toggle-type inserts as required for support and anchors properly sized to the load to be carried. Inserts shall be placed only in parts of the main structure and not in any finishing material;
- (b) Factory made expansion shields where inserts cannot be placed, but only where approved by the Engineer and for weights within the shield rating.

Explosive-actuated tools shall not be used unless with written permission of the Engineer.

The Contractor shall supply and locate all inserts, holes, anchor bolts and sleeves while walls, floors and roof, etc. are under construction. Drilling and breaking out of new work must be kept to a minimum.

Where cable trays are sharing a mechanical pipe rack, the Contractor shall provide suitable support.

Sleeves shall be provided through all waterproof floors, generator room and mechanical equipment areas, and wherever possible shall comprise standard galvanised conduit sections cast in with the concrete construction. Bus ducts and cable trays shall be sleeved through all walls and floors (other than gas tight structures) by use of a 1 mm galvanised steel section, or removable wood box-out. Sleeves shall allow a 13 mm clearance over the O.D. of all cables or conduits, 25mm horizontally and vertically for rectangular openings and shall be finished flush with the wall finish each side or flush with the ceiling and curb top. Sleeves shall be packed with either a fire-resistant insulation sealed with a resilient silicone compound or waterproofed with a suitable compound (if in exterior walls), subject to the Engineer's review.

The Contractor shall co-ordinate, with the civil works specification for the sizing and location of all concrete curbs and mounting bases, making proper allowance for floor openings, sleeves conduit terminations etc.

Cable trenches shall be excavated and backfilled by the Contractor. The Contractor shall lay all cables in trenches and supervise backfilling of trenches. Cables shall be laid in the same trenches as water pipes where possible. Trenches shall be excavated smooth, with bedding sand where necessary, before cables are laid. Cable route markers shall be supplied and installed at every joint, change of direction and 100 m of straight run.

6.1.13 Requirements for Conduit & Fittings, Ducts & Tray

The Contractor shall supply all conduit, fittings, ducts and cable trays necessary to complete the distribution of all power and control conductors to electrical equipment specified in this Contract. The Contractor shall include all that is necessary for connection to instrumentation, controls, also mechanical, heating and ventilating and equipment specified under other Section.

All electrical conduit shall be heavy duty, rigid galvanised steel for use above grade and in dry areas. Outside use and when embedded in concrete below grade, conduit shall be premium grade and shall be zinc coated outside, enamelled inside.

Except where specifically indicated on the Drawings, conduit below grade elevation shall not be installed in poured concrete walls or floors, particularly where such form part of a water bearing structure. Wherever conduit has to be installed in locations subject to condensations, adequate facilities shall be made for drainage. Conduit embedded in

poured concrete must be watertight and after the clean threads have been screwed up tightly, the joints shall be painted with red lead or bituminous paint and allowed to dry before being encased. The outside of all conduit boxes shall be similarly treated after connecting the conduit and before being encased.

Whenever rigid PVC is approved for use outdoors, fittings and boxes shall be compatible PVC and all rims provided with approved thermal expansion/contraction 'O' rings, installed to meet suppliers instructions.

Conduit runs that are exposed shall be neat in appearance and run parallel to the structural lines of the building and neatly grouped on common mounting straps or channels where practical. Where exposed conduit is attached to reinforced concrete walls or ceilings they shall be fastened by lead cinch or expansion anchors only using malleable iron one-hole pipe straps.

Conduit routing and runs may be modified to best suit the site conditions, subject to the Engineer's review.

Conduit terminations, for the equipment specified shall be carefully checked for the location of all conduit turn-ups, to ensure that they comply with the requirements for the actual equipment, which is to be installed.

Where conduit sizes are indicated on the Drawings/Specifications, these shall be adhered to. In all other cases, conduit shall be of adequate size for all wires, which have to be pulled in. The number of wires in each conduit to outlets shall not exceed the Code requirements. Minimum size of conduits shall be 19mm. All bends in conduit shall be made cold and the radius of bend shall not be less than 9 times the conduit diameter. No bend shall be permitted to flatten the conduit by more than one tenth of its diameter. When the number of right angle bends in one run exceeds two, junction or pull boxes shall be provided. No conduit shall be closer than 305 mm to steam, flue or exhaust pipes or closer than 150 mm to hot water pipes.

All threads on steel conduit shall be cut neatly, the ends shall be square and the inner diameter reamed smooth to remove burrs. Cover screws for all conduit fittings or junction boxes shall be carefully cut to length to avoid damage to wires. Conduit boxes for all receptacles, outlets, switches or other electrical equipment, which are indicated as weatherproof or any box, exposed conduit or cable, will be of cast construction. Recessed boxes shall be of pressed steel construction, no sectional boxes shall be allowed.

All outlets shall be properly secured with lock nuts and bushings supplied where necessary. Cable trays shall be heavy-duty galvanised cable tray manufactured from at least 1.6 mm steel. Tray shall be supported at least every 3 metres, and at every change of direction. Trays shall be of sufficient size to accommodate all cables in a single layer with at least 10% spare space.

All open ends of conduit shall be capped with proper threaded caps immediately after installation. The use of wooden plugs will not be permitted. Empty conduit for future equipment shall be capped flush with the finished floor. Conduit terminations at equipment whose position is adjustable or is subject to vibration, shall be flexible galvanised steel conduit with liquid-tight jacket for a length not exceeding 600 mm.

Where indicated on the Drawings the Contractor shall supply and install all ducts buried below grade or within structural members in the building. These shall comprise non-metallic material, coupled with approved fittings, and shall be concrete encased, under roadways, etc.

6.1.14 Requirements for Wiring Systems (11 kV & below)

All cables, wiring and associated termination kits, connectors etc. shall comply with the requirements of the relevant British Standards, and Uganda National Bureau of Standards or equivalent and with the wiring regulations of the International Electrotechnical Commission. Power cables shall be copper conductors with PVC insulated, sheathed, steel wire armouring and overall jacket of impregnated tropicalized PVC to BS 6346 or equivalent for cables up to 1000V, to BS 5467 or equivalent for cables up to 3300V, and IEC 502 or equivalent for cables up to 11000V.

Control cables used for wiring interconnection of control and indicating equipment shall be PVC insulated single wire, armoured and PVC jacket for 250/440V grade.

It shall be the contractor's responsibility to ensure correct cable sizes and connections are made for the intended purposes, to all power and control equipment covered under this contract. If size and wire are detailed in this specification or in drawings, which are an integral part of this contract, they are to be considered only as a guide. The size and type of cable selected shall be based on capacity short circuit availability, or voltage drop and shall not be reduced to smaller sizes without the Engineer's review. Cable voltage drop shall be less than 2% at full load. When selecting cables, consideration shall be given to proximity of other cables, temperature derating and size of incoming breakers and outgoing feeder breakers. Direct buried cables shall be stranded copper conductors, PVC insulated, with PVC overall jacket, galvanised steel armour with an overall PVC outer jacket.

Cable in trays shall be similar and in accordance with Uganda National Bureau of Standards or British Standards. Wiring in conduits shall be stranded copper conductor PVC insulated wire. Multi-conductor control cables shall be used, wherever practicable for instrumentation signals and control wiring. Unless otherwise noted these shall be 1.5mm² stranded copper conductors PVC SWA PVC cables. All wiring connections shall be compression type using an approved compression tool such as T & B colour key or equivalent.

All metallic sheathed cable termination shall be carefully made off with cable glands, in accordance with manufacturer's recommendations. All connectors shall be of the waterproof type and supported by gland plates.

The following general requirements shall be applicable to all conductors, wire or cable used in this section.

- (a) Conductors shall be of high conductivity copper;
- (b) Conductors shall be stranded;
- (c) Single conductors and conductor forming part of multiple conductor cable shall be colour coded for phase identification:
 - ◆ Line 1: Red;

- ◆ Line 2: Yellow;
 - ◆ Line 3: Blue; and
 - ◆ Neutral; Black.
- (d) Phase relationships and terminal arrangements shall be consistent;
- (e) Care shall be taken in terminating all metallic sheathed cables, to follow the manufacturers instructions and use approved kits where possible. All connectors shall be of the weatherproof type;
- (f) On single conductor cables, ensure non-ferrous plates are used at terminating, ferrous enclosures shall be slotted, to minimise eddy current effects. Transpose long feeder runs in tray at specified intervals and ensure conductors run in multiple are of exact impedance, to share the load equally.

6.1.15 Grounding System

A complete co-ordinate grounding system shall be provided for all electrical equipment and building structural steel, at each site, conforming to the Code. The main ground bus shall comprise a loop of 70 mm² stranded bare copper as indicated in the particular specification and as required by the inspection authority.

All transformer neutrals and distribution system neutral connections shall be solidly grounded. The ground bus provided in switchboards and motor control centres shall be metallically connected. All metallic cables sheaths shall be securely bonded to the ground bus, and a separate ground conductor shall be provided in conduit systems where necessary and shall be used for equipment ground. Lightning arresters shall have a separate conductor. Ground connections underground and to structural steel shall be made by means of a fusion weld indicated or as approved by the Engineer.

The main ground system shall comprise an adequate number of 19 mm diameter x 2000 mm long ground rods, mat, structure, equipment, and connections. The resistance to ground shall not exceed 1 ohm. Inspection boxes with covers and disconnect links for testing shall be as required by the Inspection Authority. The ground system shall be tested using a 4-point "Megger" Earth Tester and the result submitted for approval.

6.1.16 Removals

Part of the Contract includes removals and replacement of valves, piping, pumps, all electrical materials and panels from existing operating pumping stations.

The Contractor shall co-ordinate his operations with the Local Water Authority operating staff to ensure continued service of the facilities, and to minimise down time.

The Contractor may have to schedule night, or weekend work to coincide with low flow conditions to carry out disconnecting and reconnecting work. In addition, temporary piping, wiring and diversion may be required. In general, valves, fittings, piping, panels, and cables etc., will be passed to the owner for salvage. Where not required, the Contractor shall arrange for their disposal.

6.1.17 Trial Usage of Electrical Systems

The owner has the privilege of the trial usage of electrical systems or parts thereof for the purposes of testing under load the new installation and learning the operational procedures. The trial usage shall be continued for a length of time as deemed reasonable by the owner and all related costs shall be included in the Contract.

The operations shall be carried out only with the express knowledge, and under supervision of the responsible sub-trades who shall not waive any responsibility because of trial usage. Whilst trial usage will be kept to a minimum, it shall not be construed as acceptance by the owner.

6.1.18 Completion and Testing

All equipment, electrical systems, control systems and documentation shall be tested and operated to the satisfaction of the Engineer after installation. This is in order to ensure that the specified requirements are met, and that the operation of equipment and systems are satisfactory in all aspects and that the operating manuals are complete, correct, and fully consistent with equipment and system operations. In the event of any equipment, system or manual failing to meet the requirements of these Specifications the Engineer reserves the right to reject it. Subsequently, the equipment or manual shall be repaired or made good to the satisfaction of the Engineer at no extra cost.

The Contractor shall be responsible for ensuring that the protective device ratings and settings are all properly co-ordinated to suit the actual equipment he is supplying and/or installing or to which he is connecting.

It shall be the Contractor's responsibility to ensure that sufficient data are submitted by the supplier(s) for all protective devices and to the Engineer for approval.

All data shall be submitted for review sufficiently in advance of equipment ordering to enable a proper review to be made.

In addition to the general requirements specified, the Contractor under this section shall pay particular attention to the following:

- (a) Upon completion of all work, equipment shall be cleaned thoroughly by vacuum, the exterior surfaces cleaned, waxed and polished, all electrical connections checked and tightened, lighting fixtures cleaned and lenses washed, all lamps, fuses or other material showing any deterioration replaced, all to the satisfaction of the Engineer;
- (b) All spare parts or maintenance tools, specified or normally furnished by manufacturers, shall be itemized and given to the Engineer prior to the acceptance of the work;
- (c) Earth continuity and resistance tests shall be carried out and the readings reviewed by the Engineer;
- (d) Before any equipment is energized, an insulation resistance (Megger) test shall be applied to the complete power distribution system using equipment approved by the Engineer. The value shall not be less than ten (10) meg-ohm and, in any event, shall be acceptable to the Electrical Inspection Authority;

- (e) Single-phase loads shall be distributed equally among the phases of three-phase system, and load-balance tests shall be made by the Contractor when all equipment is in full operation. The load-current imbalance shall not exceed 5%;
- (f) Voltage drop tests under full load shall be carried out on critical feeders, as directed by the Engineer;
- (g) The Contractor shall perform any additional testing as requested by the Engineer to confirm that electrical, telemetry, instrumentation and control equipment installed under this Contract is operating satisfactorily and in accordance with the intent of these Specifications. This shall include the provision of factory-trained field service specialists, when necessary, to fully test and commission special electrical systems to the satisfaction of the Engineer, and include the supply and use of test equipment as necessary to carry out acceptance tests;
- (h) The Contractor shall pay particular attention to correct phasing of all three-phase systems and check that all motors are properly connected for correct rotation. Note that no mechanical equipment shall be operated without specific approval of the sub-trade involved.

The Contractor shall co-operate with the equipment supplier(s) in carrying out all tests on the instrumentation and control systems to ensure that all operation and documentation is as specified and completely satisfactory to the Engineer. The Contractor shall carry out verification testing of all equipment at its voltage level. The major items to be tested shall include, but not limited to, the following:

- ◆ High Voltage Switchgear;
- ◆ Transformers;
- ◆ Distribution Panels;
- ◆ Motor Control Centres;
- ◆ Control Panels;
- ◆ Interconnecting Cables; and
- ◆ Generator Panels and Auxiliaries

The inspection and testing prior to the system being energized shall include, but not be limited to, the following:

- (a) Testing, cleaning where necessary and calibrating all relays and circuit breaker trip devices. Calibration of all protective devices shall conform to requirements of approved co-ordination curves;
- (b) Torquing of transformer connections to supplier standards, removal of packing materials, checking of ratios, insulation levels, power dissipation insulation factors, auxiliary relays, indicators or fans function;
- (c) Checking of all high voltage switchgear, transformer connectors, checking of breakers, feeders, motor starters, auxiliary devices, overload relays CTs, PTs, etc.;
- (d) Checking of motor control centre connections, removal of blocking, checking of disconnecting and auxiliary devices, checking overload relays against the full load nameplate current of the motors being protected;
- (e) Functional testing of associated control devices;

- (f) Reviewing the co-ordination for the electrical equipment supplied and make sure that all approved settings are adhered to;
- (g) All materials (such as fuses, bulbs etc.) destroyed in testing shall be replaced at no additional charge.

Subsequent to energizing of the system, when sufficient load has been applied and 3 months before expiry of the manufacturer's and Contractor's warranty period, the system shall be inspected by means of an infra-red scanning camera.

The Contractor shall be responsible for the removing of all covers and the opening of all doors, prior to the survey, to permit access to all of the equipment to be surveyed. The infra-red survey shall include but not be limited to all accessible major pieces of equipment and associated joints and connections as follows:

- ◆ high voltage cables;
- ◆ motor control cables distribution; and
- ◆ power panels

6.1.19 System Acceptance

Copies of original letters from manufacturers of all major systems shall be submitted indicating that their technical representatives have inspected and tested the respective systems and are satisfied with the methods of installation, connections and operation. Where existing systems are extended, such letters shall cover both new and existing equipment and connections. These letters shall state the names of persons present at testing, the methods used and a list of functions performed with date and location where applicable.

6.1.20 Record Drawings

Before commencing work the Contractor shall obtain two sets of Electrical Drawings for showing 'as built' conditions. As the job progresses, the Contractor shall mark on the field set of prints to accurately indicate installed work.

This set shall be available for each job meeting. At conclusion of the job, the Contractor shall transfer all information onto the master set and certify their accuracy before forwarding these to the Engineer for record use. The record Drawings shall show 'as built' all outlets and equipment, including all changes and revisions, as well as all service entering the building and on the property. Dimensions of underground services and concealed main and sub-feeder conduits at key points in relation to structure and building shall be recorded. Record all elevations for underground services in relation to the ground floor level of the building.

These Drawings shall also indicate the size and exact location of all services left for future additions.

6.1.21 Instructions to Operating Staff

The Contractor shall instruct the operating representative in all aspects of the operation of systems and equipment. He shall include, arrange for, and pay for services of service

engineers and other manufacturers' representatives required for instruction on specialised portions of the installation.

Submit to the Engineer at the time of final acceptance, a complete list of systems stating for each system.

- (a) Date instructions were given to the Owner's staff;
- (b) Duration of instruction;
- (c) Name of persons instructed;
- (d) Other parties present (Manufacturers' representative, Consultants etc.); and
- (e) Signature of the Owner's representative/ Staff stating that they properly understood the system installation, operation and maintenance requirements.

6.1.22 Operating and Maintenance Manuals

In addition to the general requirements specified in earlier sections, the Contractor under this section shall pay particular attention to the following detailed manuals for electrical instrumentation and control systems:

(a) *High Voltage Switchgear:*

- ◆ Catalogue description of all equipment used as part of the assembly;
- ◆ List of parts (bills of material) with catalogue number and source of supply, complete with drawings indicating the location of each part in the complete assembly, and source of supply of replacement parts;
- ◆ Characteristic curves and thermal overload relay settings;
- ◆ Operating and maintenance instruction;
- ◆ Instrument and relay catalogue leaflets indicating wiring, adjustment and part numbers;
- ◆ Complete wiring diagrams, grounding layout and all Shop Drawings related to the Switchgear; and
- ◆ Test and acceptance report of pre-service inspection.

(b) *415V Distribution Boards & Motor Control Centre:*

- ◆ Catalogue description of each equipment used as part of the assembly;
- ◆ List of parts with catalogue number and source of supply, complete with drawings indicating the location of each part in the complete assembly, and source of supply for replacement parts;
- ◆ Thermal overload relay settings and other characteristic curves;
- ◆ Operations and maintenance instruction;
- ◆ Instrument and relay catalogue leaflets indicating wiring, adjustment and part numbers;
- ◆ Complete wiring diagrams, grounding layout and all shop drawings related to the motor control centre or switchboard;
- ◆ Test and acceptance reports of pre-service inspection.

(c) *Transformers:*

- ◆ Nameplate data;
- ◆ List of parts (bill of material) with catalogue number, complete;
- ◆ Operating and maintenance instructions with particular reference to inspection and maintenance guide of cleaning instruction for units purchased;
- ◆ Complete wiring diagram and all Shop Drawings relating to the transformers.

(d) *Circuit Breakers:*

Catalogue leaflets for each different frame describing rating, operation, trip curves, dimensional data, etc.

(e) *Fuses:*

Catalogue leaflets for each different type and rating of fuse, describing rating, characteristics, type of refill (if applicable).

(f) *Motor, Pump Motor, and Starters:*

A list of all motors connected under Contract properly identified, showing motor nameplate data (Manufacturer, serial, voltage and full load amps, temperature rise, also, type and size of starter, and rating of overload heaters).

(g) *Lighting Fixtures:*

- Catalogue leaflets for each different type of fixtures describing rating, replacement parts and other pertinent data;
- Catalogue leaflets for different type of ballast used giving catalogue number, wiring diagram, voltage and sound ratings.

(h) *Lamp List:*

- ◆ List of all different lamps used giving catalogue number, rating, colour information. The list shall indicate the fixtures for which a given lamp is to be used;
- ◆ Complete list of all ballast indicating the type, voltage, lamps, etc. cross-reference to the fixtures for which a given ballast is to be used;
- ◆ Complete data for all battery-operated emergency units, giving maintenance instructions applicable.

6.1.23 Spare Parts and service

The Contractor shall ensure that all spare parts and services are available in Uganda.

6.2 SUPPLY AUTHORITY AND SERVICE DETAILS

6.2.1 Incoming Power

The local utility authority, Uganda Electricity Distribution Company Ltd (UEDCL) is responsible for supply of power to the boundary of the waterworks and the provision of

kWh meters. In the event of a new requirement, or for the use of a temporary service, the contractor shall supply an approved enclosure for UEDCL kWh meter, which shall also house a mains supply circuit breaker. The Contractor shall be responsible for co-ordinating the supply and metering with UEDCL.

Where contractor is required to extend power requirement to Pumps House, it shall be stated in the Specifications and or Bill of Quantities (BoQ).

6.3 HIGH & MEDIUM VOLTAGE METALCLAD SWITCHGEAR

6.3.1 Type of Switchgear

The Switchgear shall be of the air insulated metal clad indoor suitable for floor mounting with truck mounted oil or vacuum breakers arranged for vertical or horizontal isolation and horizontal withdrawal. The switchgear shall be suitable for operation in climatic conditions at the location of installation.

6.3.2 System of Supply

The switchgear shall be suitable for operations on the following systems of supply.

- ◆ 11 kV Switchgear;
- ◆ 11000 Volts, 3phase, 3W, 50Hz neutral point resistant grounded.

6.3.3 Standard and Codes

The switchgear shall comply with the latest revision of BS 5227 - Specifications for AC metal enclosed switchgear and control gear of rated voltage above 11kV and up to and including 72.5kV, and all other related standards for all components. Any proposal of equipment to other standards shall be accompanied by a statement of deviations from the specified standards.

6.3.4 Enclosure

- (a) The switchgear assembly shall be indoor type and shall consist of the number of breaker cubicles and auxiliary equipment as outlined in the main single line diagrams;
- (b) The arrangement of breaker cubicles, instrument transformers, relays, auxiliary equipment etc., within the switchgear assembly, shall be subject to review by the Engineer;
- (c) Utilise unitised type construction to form rigid, welded steel, self-supporting, dead front I.E.C. 298, enclosure mounted on suitable floor channels supplied by vendor;
- (d) Each vertical section complete with oil or vacuum breaker, main bus and fittings, instrumentation and cable fittings, equipped as required, on drawings;
- (e) Design breaker compartment to house a horizontal, drawout type oil or vacuum breaker. Each breaker assembly shall include racking mechanism, mechanical interlocks, the stationary primary and secondary disconnecting devices, automatic safety shutters, & tee phase bus compartment, instrument compartment and cable terminating compartment. Provide suitable ground connectors;

- (f) Rear of each cell allows access to buswork, current transformers and power cable connections. Provide hinged access panels;
- (g) Locate all instruments, relays, secondary control devices, fuses, terminal blocks etc. in separate section above or adjacent to the respective breaker compartment. All devices shall be mounted on formed front hinged panels;
- (h) Enclose each set of potential transformers in a separate, compartment with draw out features. Make provision to prevent an arc on the primary disconnecting contacts of each PT by arranging to open the secondary circuits before the primary disconnecting contacts parts. Make provision for protecting personnel from coming in contact with PT primary fuses until after the primary disconnecting devices are separated by a safe distance and automatically grounded;
- (i) Provide continuous steel floor channels suitable for levelling up, grouping in place in concrete and complete with anchor bolts, for the entire structure;
- (j) Provide floor openings in each compartment to permit bottom entry of and power cables as indicated.

6.3.5 Bus Bars

The busbars shall be of high conductivity copper or aluminium and of adequate cross-section, braced for the rated normal current and rated short time current specified. The switchgear shall be arranged for ease of extension at one end, with the minimum disruption to the supply. It shall be possible for an extension to be erected alongside an existing switchboard with the existing bus bars alive. Isolation of the supply shall be necessary only for final connections of bus bar and auxiliary supplies.

6.3.6 Current Transformers

Current transformers shall comply with BS 3938, and shall be the dry type with ratings ratio and accuracy according to the protection and instrumentation requirements. Protective current transformers shall have a secondary winding for the injection of testing currents. Wiring of all secondary leads of CT's shall be to short circuiting type terminal blocks.

6.3.7 Voltage Transformers

Voltage transformers shall comply with BS 3941 "Voltage Transformers" and shall be indoor, dry type, suitable for isolation withdrawal whilst the high voltage circuit is energised. Each transformer shall have integral current limiting primary HRC fuses and cartridge type HRC fuses on secondary, the primary fuses shall be accessible only when the transformer is isolated. The secondary fuses shall be accessible at all times.

6.3.8 Safety Shutters

Automatically operated safety shutters shall be provided to cover the bus bar and circuit spouts when the breaker is isolated. Only the appropriate shutter shall open, when a grounding operation is performed. Shutters shall have manual opening for maintenance, inspection and testing purposes and shall remain latched in the open position. When the

breaker is inserted into the compartment automatic operation of the shutters is resumed. The shutters shall be pad-lockable in the closed position only. Automatically operated safety shutters shall also be provided for the voltage transformer spouts.

6.3.9 Integral Grounding

Provision shall be included for grounding the bus bars and circuits by means of integral grounding equipment and shall be positively interlocked to prevent grounding of energised circuits. No loose component grounding system is acceptable. Grounding shall be through a manually operated switch or through the breaker and shall be moved to a ground position. Positions for grounding and normal operation shall be clearly labelled. In the grounding position, the breaker and grounding switch shall be pad-lockable.

6.3.10 Labels

Circuit breaker housing shall be labelled with the circuit number and function on the front and rear of the housing and on the front of the breaker. All components, fuses instruments, relays, etc. shall be clearly labelled. Warning labels shall be fitted to indicate possible sources of danger. Labels shall be fixed in position by screws.

6.3.11 Special Tools

All special tools required for testing and maintenance shall be provided in a wall mounting box suitably labelled. A list of the tools provided shall be permanently fixed inside the lid of the box.

6.3.12 Circuit Breaker Truck

The circuit breaker shall be mounted on a wheeled truck of robust construction. The truck shall be guided and positively located in the selected position to ensure accurate alignment of all contacts.

6.3.13 Vacuum Breaker or Oil Circuit Breaker

The breakers shall be 3-pole, electrically operated, mechanically and electrically trip free, motor or manually operated stored energy closing, drawout truck mounted, with ratings as indicated on the drawing.

Circuit breakers of the same rating shall be interchangeable with each other. The breakers shall be electrically operated by local and remote control switches. Provision shall be made for manual spring close and mechanical tripping. Over-current, ground fault shunt and under-voltage release coils shall be fitted as required. The circuit breakers shall have three definite and distinct positions within the enclosure. The 'operating' position (connected), the 'test' position and the 'withdrawn' position.

These positions shall be clearly indicated. Provision shall be made, for mechanical interlocks to prevent moving the breaker to or from the connected position with the circuit closed. Each circuit breaker shall be equipped with not less than eight auxiliary contacts (four normally open and four normally closed) mounted on the breaker and used for operation and control. All auxiliary contacts shall be electrically separate, reversible type and wired to terminal blocks.

The circuit breaker control circuit shall be arranged for operation at the switchgear and at the control desk. Where the breaker is controlling a motor, controls shall be provided at the motor. Control and indicating lights shall be provided as required.

6.3.14 Safety & Key Interlocks

The safe operation of the switchgear shall be ensured by the provision of key Interlocks which shall include, but not be limited to:

- (a) Breaker operating sequence as indicated. Key interlock connectors shall be made to operating mechanism, mechanically and not in electrical control circuits;
- (b) Breakers will not close when control switch is in 'close' position, if contactor is locked open by key interlock or any safety interlock;
- (c) Prevention of moving circuit breaker in any position but the selected position;
- (d) Prevention of opening energised voltage transformer;
- (e) Prevention of closure of circuit breaker unless it is in the isolated normal service position.

6.3.15 Terminals and Cable Boxes

Terminal and cable boxes shall be of robust construction and shall provide ample space for cabling and changing connections. Where single core cables are to be used gland plates shall be of brass or other approved non-ferrous material. Where paper insulated cables are to be used each cable base shall be suitable for filling with hand setting compound and shall be provided with all requisite fittings including filling and drain plugs, air vent hole, provision for compound expansion, a brass cone wiring gland and cable armour clamp. Control circuit wiring shall be brought out to a separate cable box provided with a removable gland plate suitable for terminating PVC armoured cables.

6.3.16 Degree of Protection

The switchgear shall provide complete protection of persons against approach to live parts or contact with internal moving parts. The degree of protection shall be 1 PH 6.

6.3.17 Anti-Condensation Heaters

Anti-condensation heaters shall be provided in each panel of the switchgear. The parts of the heater circuit, which remain energized when the panel is isolated shall be guarded against accidental contact by a transparent insulating cover clearly labelled with the supply details. A disconnect shall be provided for controlling the heater supply to each switchboard.

6.3.18 Spares

A separate price for spares shall be included. Each item of spares shall be priced separately.

6.3.19 Motor Pushbuttons

A stop-lock type pushbutton or switch in a metal enclosure with a minimum degree of protection IP54 shall be provided as a loose item for each motor circuit. For motors installed outside buildings, a start pushbutton shall also be provided.

6.3.20 Testing

The following tests shall be carried out in the manufacturer's works in accordance with BS 5227. Three copies of the manufacturer's records of all tests shall be submitted to the Engineer immediately following completion of the tests.

(a) Type Tests (Witnessed):

Unless evidence of type tests on similar switchgear and control gear can be produced to the satisfaction of the Engineer, the first assembly of each design shall be subjected to and shall satisfactorily withstand type tests in the presence of the Engineer as follows:

- ◆ Power frequency voltage dry test;
- ◆ Voltage tests on auxiliary circuits;
- ◆ Mechanical operation;
- ◆ Test of auxiliary electrical devices;
- ◆ Check of wiring;
- ◆ Impulse voltage dry tests;
- ◆ Temperature rise;
- ◆ Short-time current tests on main circuits;
- ◆ Short-time current tests on grounding circuits;
- ◆ Verification of rated making and breaking currents;
- ◆ Verification of the degrees of protection of persons against hazardous approach of live parts and moving parts

All assemblies not subjected to "type" tests shall withstand the routine tests specified below.

(b) Routine Tests (Witnessed):

Each assembly shall be subjected to and shall satisfactorily withstand routine tests in the presence of the Engineer as follows.

- ◆ Power frequency voltage dry tests;
- ◆ Voltage tests auxiliary circuits;
- ◆ Mechanical operation;
- ◆ Tests of auxiliary electrical devices;
- ◆ Check of wiring

6.4 POWER TRANSFORMER

6.4.1 Type of Transformer

The transformer shall be of the oil-immersed naturally air-cooled type suitable for outdoor installation in direct sunlight.

6.4.2 Climatic Conditions

The transformer shall be suitable for operation in the climatic conditions at the location of installation.

6.4.3 System of Supply

The transformers shall be suitable for the following system of supply:

- ◆ 11 kV Primary;
- ◆ **11,000 volts, 3phase 3 W, 50 Hz neutral point resistance grounded.**

6.4.4 Standards

The transformers shall comply with the latest revision of BS 171 "Power Transformers" and related standards for all components. Any proposal of equipment to other standards shall be accompanied by a statement of all deviations from the requirements of the specified standard.

6.4.5 Enclosure

The transformer enclosure shall provide complete protection against approach of persons to live parts.

6.4.6 Cores

Cores shall be constructed from non-ageing cold rolled grain oriented steel suitably insulated to reduce core losses. Joints between the limbs and the yoke shall be overlapped and/or mitred. The yokes shall be held between substantial clamps to provide adequate strength for lifting the core and windings from the tank.

6.4.7 Windings

All windings shall be adequately insulated rigidly supported and braced throughout their length to provide adequate strength under short circuit conditions.

The conductor material shall be copper. The high voltage winding shall be provided with tapings for adjustment of the transformation ratio.

6.4.8 Tank

Tanks shall be of fabricated steel construction suitably stiffened to withstand the load imposed during manufacture delivery to site and erection. Cooling tubes shall be welded into the tank sides.

6.4.9 Tap Changing Switch

An off-load switch shall be provided for changing the transformation ratio. The switch shall be operated from outside the tank by a hand wheel, provided with facilities for padlocking in any position. The hand wheel shall be located on the side of the tank.

6.4.10 Terminal and Cable Boxes

Terminal and cable boxes shall comply with BS 2562 "Cable sealing boxes for oil-immersed transformers" shall be of substantial construction, and shall be fixed to the transformer so as to provide a weatherproof enclosure. Ample space shall be provided within the box for cabling and changing connections. Boxes shall allow for cable entry from below. Each transformer shall be provided with primary and secondary cable boxes to suit the cables specified. Small wiring for Buchholz relay, thermometer contact etc. shall be brought to a separate terminal box, suitable for the termination of PVC cables. Cable boxes shall be suitable for disconnection of any cable without dismantling any cable gland.

Where single core cables are to be used, gland plates shall be of brass or other approved non-ferrous material. Where paper insulated cables are to be used, each cable box shall be suitable for filling with hard setting compound and shall be provided with all requisite fittings including filler and drain plugs of adequate dimensions, an air vent hole, provision for compound expansion, a brass cone wiring gland, and a cable armour clamp

6.4.11 Fittings

The following fittings shall be provided:

- (a) Rating plate;
- (b) Terminal marking plate; Lifting lugs;
- (c) Tank grounding terminal;
- (d) Oil filling hole and plug;
- (e) Oil level indicator;
- (f) Drain valve with plug;
- (g) Conservator with detachable end plate;
- (h) Dehydrating breather;
- (i) Thermometer Pocket;
- (j) Jacking lugs;
- (k) Rollers;
- (l) Buchholz double float relay;
- (m) Oil thermometer with alarm contacts (5 MVA and larger only).

6.4.12 Oil

The transformer shall be complete with the first filling of oil, which shall comply with BS 148, insulating oil for transformers and switchgear.

6.4.13 Special Tools

All special tools required for testing and maintenance shall be provided in a wall mounting box suitably labelled. A list of tools provided shall be permanently fixed inside the lid of the box.

6.4.14 Spares

A list of spares recommended by the manufacturer for five years operation shall be provided. Each item shall be priced separately and quantities reconnected shall also be marked against each item.

6.4.15 Testing

The following tests shall be carried out at the manufacturer's works, in accordance with BS 171.

Three copies of the manufacturer's record of all tests be submitted to the Engineer immediately following completion of the tests.

(a) Type Tests (Witnessed):

Unless evidence of type on similar transformers can be produced to the satisfaction of the engineer, the first transformer of each design shall be subjected to and shall satisfactorily withstand type tests in the presence of the Engineer as follows:

- ◆ Winding resistance;
- ◆ Voltage ratio on each tapping;
- ◆ Polarity;
- ◆ Phase relationship;
- ◆ Impedance voltage;
- ◆ Load losses;
- ◆ No load current;
- ◆ Induced over-voltage withstand;
- ◆ Separate source voltage withstand;
- ◆ Insulation resistance of each winding in turn to all other windings, core, frame and tank;
- ◆ Oil and winding temperatures immediately prior to insulation resistance test;
- ◆ Temperature rise;
- ◆ Impulse voltage;
- ◆ Octave band noise level analysis.

All transformers not subjected to type tests shall withstand the routine tests specified below.

(b) Routine Tests (Witnessed):

Each transformer shall be subjected to and shall satisfactorily withstand routine tests in the presence of the Engineer as follows:

- ◆ Winding resistance;
- ◆ Voltage ratio on each tapping;
- ◆ Polarity;
- ◆ Phase relationship;
- ◆ Impedance voltage;
- ◆ Load losses;

- ◆ No load current;
- ◆ Induced over-voltage withstand;
- ◆ Separate source voltage withstand;
- ◆ Insulation resistance of each winding in turn to all other windings, core, frame and tank;
- ◆ Oil and winding temperatures immediately prior to insulation resistance test.

6.5 LOW VOLTAGE SWITCHGEAR AND MOTOR CONTROL COMPONENTS

6.5.1 Type of Switchgear and Control Gear

The switchgear and control gear shall be of the enclosed cubicle type arranged for floor mounting.

6.5.2 Climatic Conditions

The switchgear and control gear shall be Suitable for operation in the climatic conditions at the location of installation.

6.5.3 System of Supply

The switchgear and control gear shall be suitable for operation on a 400V/240V, 3 phase, 4 wire, 50 Hz system with the neutral point solidly earthed.

6.5.4 Standards

The switchgear and control gear shall comply with the latest revision of BS 5486 "Factory-built Assemblies of Switchgear and Control gear for Voltage up to and including 1000V a.c. and 1200 V d.c." and related standards for all components. Any proposal of equipment manufactured to other standards shall be accompanied by a statement of all deviations from the requirements of the specified standard.

6.5.5 Enclosure

The switchgear and control-gear shall be of the enclosed type providing a minimum degree of protection against contact with live or moving parts of IP 53. The enclosure shall be of fabricated sheet steel construction over a substantial angle iron or similar frame.

6.5.6 Bus bars

The bus bars shall be of high conductivity copper or aluminium and of adequate cross section and adequately braced for the rated normal current and rated short time current specified. The switchboard shall be arranged for ease of extension at both ends, with the minimum disruption to the supply. It shall be possible for an extension to be erected alongside an existing switchboard with the existing bus bars alive. Isolation of the supply shall be necessary only for final connections of bus bars and auxiliary supplies.

6.5.7 Ground Bus

A ground bus extending the whole length of the switchboard shall be provided in a convenient position for grounding the armouring of incoming and outgoing cables. To this bus shall be connected all grounding contacts and other components of the switchgear intended to be maintained at ground potential. Adequately dimensioned terminals shall be provided at each end of the ground bus for connection to the plant grounding system.

6.5.8 Circuit Breakers

Circuit breakers shall comply with BS 4752 "Switchgear and control gear for voltages up to and including 1000 V a.c. and 1200 V d.c. Part 1 Circuit Breakers" and shall be of the truck mounted triple pole air break type with electric motor charged spring operated power closing type. The closing mechanism shall be trip free.

Circuit breaker shall be equipped with manual tripping. Over-current, ground fault, shunt trip, and under-voltage release coils shall be fitted as required.

A mechanically operated ON and OFF indicator shall be provided to give a true indication of the contact position. Each circuit breaker shall be equipped with four potential free auxiliary switches all wired to terminals. The contacts shall be of the type that may readily be converted from 'normally open' to 'normally closed' without the addition or removal of any components.

The circuit breaker control circuit shall be arranged for operation at the switchgear and at a centralized control desk. When a circuit breaker is controlling a motor, controls would also be provided local to the motor.

6.5.9 Motor Starters

Motor starters of the direct-on-line type shall comply with BS 4941 "Motor Starters for Voltages up to and including 1000 V a.c. and 1200 V d.c. Part 1 Direct-on-line (full voltage) a.c. starters". Star delta starters with two main contacts complete with mechanical and electrical interlocks and an adjustment time with auxiliary contacts and other types of starters shall comply with BS 587 "Motor Starters and Controllers". Motor rated 37.5kW and above, shall be fitted with two sets of P.T.C. thermo-resistors and equipped with anti condensation heaters. The thermo-resistor relays and anti-condensation heater control relays shall be included in each starter as appropriate.

6.5.10 Current Transformers

Current Transformers shall be of the toroidal type in accordance with BS 3938 "Current Transformers" and shall be of the ratings, ratios and accuracy according to the protective relay and instrument requirements.

6.5.11 Disconnectors

Disconnectors for feeder circuits and motor starters shall be for the air break type and shall comply with BS 5419 'Air-break switches, air break disconnection and fuse combination units for voltages up to and including 1000 V a.c. and 1200 V d.c.

Each disconnecter shall be pad-lockable in the open position and shall be interlocked with the compartment door such that:

- ◆ The door cannot be opened whilst the disconnecter is closed;
- ◆ The disconnecter cannot be closed whilst the door is open;
- ◆ The disconnecter may be closed whilst the door is open only, by the manual operation of an interlock releasing lever.

Disconnecters for motor starters shall be rated for breaking the motor locked rotor current.

6.5.12 Fuse Links

Fuse links and fuse holders shall comply with BS 88 Parts 1 and 2 "Cartridge fuses for voltages up to and including 1000 V a.c. and 1500 V d.c." and shall be of high breaking capacity.

6.5.13 Contactors

Contactors shall be of the air break type and shall comply with BS 5424 "Contactors - Part 1 Contactors for voltages up to and including 1000 volts a.c. and 1200 volts d.c." Contactors shall be rated for uninterrupted duty.

Each contactor shall be fitted with two auxiliary contacts designed such that they may be changed from normally open to normally closed without the use of special tools and without the addition or removal of any components.

6.5.14 Over-current and Earth Fault Relays

Over-current relays shall be of the triple pole hand reset type arranged for the detection of single-phase operation. For motors rated up to and including 74kW the relays shall be of the thermal type. For motors rated above 75 kW relays shall be instantaneous earth fault relays, complete with auxiliary control relay.

Protective relays shall be of the flush mounting type fitted with clear mechanical indication of operation.

Thermal overload and anti-single phasing relays for motor protection shall be of the moulded case enclosed type with one thermal element per phase and incorporating a differential action between elements to provide anti-single phasing protection. Relays shall conform with IEC 2922 and VDE 0660. The relays shall be capable of being hand reset with reset button mounted on the door of the starter compartment. Relays shall be selected to suit the motor and adjusted on site to match motor full load current before starter is energized. Auxiliary relays for mounting in MCC shall be of the attracted amateur instantaneous self resetting type provided with an adequate number of 220V ac 10A rated circuit openings and closing contacts for the immediate and future requirements of the control system.

Time delay relays of the synchronous motor type shall be self instantly resetting. The time setting shall be adjustable and the range shall be specified in control specification. They shall be preferably of the plug in type and fitted in dust proof cases on the chassis plate of the switchboard. Time delay relays for controlling the operation of secondary contactors in star delta starters shall be electronic relays.

Thermo-resistor protection relays shall be estimated by the positive lump coefficient probe to which it is associated, conforming to standard I.E.C. 292-2 and insulating rating to IEC 158-1. They shall be provided with auxiliary contacts or relays as required in the control system.

6.5.15 Terminals and Gland Plates

Cables up to and including a conductor cross sectional area of 16mm² shall be terminated in clamp type connectors. Cables of conductor cross sectional area 25mm² and larger shall be terminated on steel type terminals.

The insulation material for clamp type connectors shall be of the non-brittle type. Clamp connectors shall be retained in position by locking bars.

Steel type terminals shall be so fixed as to prevent the studs turning or slackening when the terminal nuts are alternatively tightened and loosened.

Gland plates or cable boxes shall be provided for all cables. Gland plates for single core cables shall be of brass or other approved non-ferrous material.

Gland plates shall not be closer to the terminals than 25cm for cables up to and including 16mm² conductor cross sectional area, and at proportionately greater distances for larger cables.

All terminals, which remain energized when the circuit breaker or disconnector is isolated, shall be guarded against accidental contact by a transparent cover clearly labelled with the supply details.

6.5.16 Auxiliary and Control circuits

Auxiliary and control circuits wiring shall be PVC insulated and have a minimum conductor cross sectional area of 1.5mm².

Wiring between fixed and moveable portions of the switchgear and control gear shall be of the flexible type. All auxiliary and control wiring shall be numbered in accordance with the circuit diagrams using cylindrical type slip on ferrules having black characters on a white background.

6.5.17 Instruments

Instruments shall be of the flush mounting type conforming to the requirements of BS 89 with square bezels and 270° or 360° circular scales. Ammeters shall have a full scale reading equal to the associated C.T rated primary current. Voltmeters shall be of suppressed "zero" type having the range specified in BS 89.

6.5.18 Anti-Condensation Heaters

Anti-condensation heaters shall be provided in each panel of the switchgear and control gear. The parts of the heater circuit, which remain energized when the equipment is isolated shall be guarded against accidental contact by a transparent insulating cover

clearly labelled with the supply details. An isolator shall be provided for controlling the heater supply to each switchboard.

6.5.19 Control Transformer

An adequately rated control circuit transformer shall be provided in each switchboard. The transformer shall be double wound and shall be provided with means of isolation and protection against overloading.

6.5.20 Labels

Each circuit shall be labelled with the circuit number and function on the front and rear of the housing and on the terminal block if terminals for different circuits are grouped together.

All components, fuses, instruments, relays, etc. shall be clearly labelled.

Warning labels shall be fitted to indicate possible sources of danger. Labels shall be fixed in position by screws.

Special Tools - All special tools required for testing and maintenance shall be provided in a wall mounted box suitably labelled. A list of tools provided shall be permanently fixed inside the lid of the box.

6.5.21 Spares

A list of spares recommended by the manufacturer for five years operation shall be provided. Each item shall be priced separately and quantities recommended shall be marked against each item.

6.5.22 Motor pushbuttons, Selector Switches and Indication Lights

A stop-lock pushbutton or switch in a metal enclosure with minimum degree of protection IP54 shall be provided as a loose item for each motor circuit.

For motors installed outside buildings, a start push-button shall also be provided.

Selector switches shall be of approved robust construction of rotary multi-position type.

Switches shall be mounted behind front panels with operating handles projecting in front panel of board, position being clearly marked.

Indication lights shall be manufactured to BS 4794 with IP 66 degree of protection on pilot light heads. They shall be continuously rated for 220V bulbs and be provided with circular heads.

6.5.23 Testing

The following tests shall be carried out at the manufacturer's works, and in accordance with BS 5486 Part 1.

Three copies of the manufacturer records of all tests shall be submitted to the Engineer immediately following completion of the tests.

(a) Type Tests (Witnessed):

Unless evidence of type tests on similar assemblies can be produced to the satisfaction of the Engineer, the first assembly of each design shall be subjected to and shall satisfactorily withstand "tests" in the presence of the Engineer as follows:

- ◆ Dielectric strength;
- ◆ Protective circuit effectiveness;
- ◆ Inspection and functional testing of all components, wiring and circuits;
- ◆ Temperature rise;
- ◆ Short circuit strength.

All assemblies not subjected to type tests shall withstand routine tests as specified below.

(b) Routine Tests (Witnessed):

Each assembly shall be subjected to and shall satisfactorily withstand routine tests in the presence of the Engineer as follows:

- ◆ Dielectric strength;
- ◆ Protective circuit effectiveness;
- ◆ Inspection and functional testing of all components, wiring and circuits.

6.6 INDUSTRIAL TYPE THREE PHASE INDUCTION MOTORS

6.6.1 Type of Motors

The motor shall be of the single speed continuously rated induction type with either squirrel cage or wound rotors and shall be suitable for operation on the system of supply specified. The motors shall be designed for ease of inspection, cleaning, replacement and repairs and for use where continuity of operation is the prime consideration.

6.6.2 Performance

The performance of the motors shall comply with BS 2613 Specification for the Electrical Performance of Rotating Machines, duty class S1 - Continuous running duty maximum continuous rating.

6.6.3 Dimensions

The motor dimensions shall be in accordance with BS 4999, Part 10.

6.6.4 Insulation

All motors shall be provided with class 'F' insulation in accordance with BS 4999 Classification of Insulating Materials for Electrical Machinery and Apparatus. Glass fibre insulating material shall be used in preference to asbestos. All windings shall be held firmly in position with fixings of adequate electrical and mechanical strength. Coil ends shall be designed to withstand the most severe conditions.

The completed windings shall be fully impregnated and tropicalised with varnish or compounds of the highest quality which shall be waterproof, non-hygroscopic, impervious to oils, fungus proof and capable of retaining their flexibility under stresses arising from alternate heating and cooling.

6.6.5 Rating

The ratings of the motor shall be in accordance with the power demand of the driven equipment or as specified in the schedules and shall be achieved under the most onerous system conditions in a cooling air temperature of 50°C. The motors shall be capable of at least two starts per hour as part of the continuous duty rating, without any cooling period. The tenderer shall state the maximum number of starts per hour the motors are capable of making.

The motors shall be capable of operating at rated frequency for a period of not less than 5 minutes at a voltage of 75 % of the rated value, without injurious effect on the winding.

6.6.6 Temperature Rise

The maximum temperature rise of each part of the motor shall not exceed the values shown in BS 5000 after due account has been taken of the ambient temperature.

6.6.7 Thermo-resistors

Each motor rated 37.5 kW or higher shall be equipped with two thermo-resistors for phase embedded at the hottest known spot of the stator winding. All connections to the thermo-resistor shall be insulated, supported and brought out to terminals in separate terminal box suitably labelled.

Thermo-resistor shall have a set value of 140°C for tripping and 120°C for alarm.

6.6.8 Anti-Condensation Heaters

Each motor rated 37.5 kW or higher shall be equipped with anti-condensation heaters rated to maintain the temperature of the windings at least 5°C above ambient temperature, when the motor is at rest. All connections to the heater shall be supported and brought out to terminals in a separate terminal box suitably labelled.

6.6.9 Terminals

All terminals other than grounding terminals shall be suitably insulated and so fixed as to prevent them turning or slackening when the terminal nuts are alternatively tightened and loosened. Terminal blocks shall be of non-tracking material.

Terminals shall be suitable for the termination of the incoming cables, which shall be rated in accordance with the motor current and climatic conditions, or listed in the schedules. An internal grounding terminal shall be provided in the terminal box of each motor and an external grounding terminal on the stator frame.

All terminals shall be clearly and permanently marked in accordance with the latest addition of BS 822: "Terminal markings for rotating electrical machinery".

Both ends of each phase winding shall be brought out to the terminals of a terminal board. All necessary links shall be provided.

A suitably designed terminal board shall accommodate the tails of the stator windings. Each tail shall be fitted with a terminal lug and shall be marked with a slip-over type ferrule. The terminal board shall be designed to prevent the entry of small particles into the motor.

6.6.10 Terminal and Cable Boxes

Terminal and cable boxes shall be of robust construction and shall be fixed to the motor so as to provide an enclosure with a degree of protection IP 55 (weatherproof) in accordance with BS 4999 Part 20 Classification of types of enclosure. Ample space shall be provided within the box for cabling and changing connections. The boxes shall allow for cable entry from any one of four directions at 90° in a vertical plane.

Terminal boxes shall be located on the left hand side of the motor when viewed from the non-driving end, but stator frames shall be reversible so that the location of the terminal base may be changed to the opposite side.

Each terminal box shall be provided with a suitable cable box and gland for the cables to be terminated.

Wiring for heater, thermo-resistors, pilot motors, limit switches, etc. shall be brought to separate terminal boxes fitted with glands, shrouds and removable gland plates suitable for the cables specified in the schedules.

Cable boxes and terminal boxes shall be so designed to allow disconnection of all cables without dismantling any cable gland.

Rotor connections for slip-ring motors shall be brought out to a separate terminal box fitted with a suitable cable box and gland for the cables, which shall be rated in accordance with rotor current and climatic conditions, or as specified in the schedules.

Where single core cables are to be used, gland plates shall be of brass or other approved non-ferrous material. Where Paper insulated cables are to be used each cable box shall be suitable for filling with hard setting compound and shall be fitted with filler and drain plugs, air vent hole, gland and cable armour clamp.

6.6.11 Bearings

Bearings shall be of the grease lubricated ball and roller types provided with grease nipples and grease relief valves. Bearing caps and seals shall prevent entry of grease into the motor interior and the entry of dust into the bearings.

Bearings shall be of reputable manufacture and of a type readily available and interchangeable with other makes.

Bearings shall be suitable for direct coupling of the motors, and one bearing shall be arranged to take the end thrust.

6.6.12 Rotors

Each rotor shall be free from excessive axial thrust; shall be in good dynamic balance and run true at all speeds.

The rotor design shall allow for the fixing of balancing weights, which shall not be of lead or other unstable material.

Fans shall be balanced and located by means such that incorrect assembly is impossible. Motors fitted with fans designed for unidirectional rotation shall be clearly marked accordingly.

Shaft ends shall be provided with a suitably threaded hole to facilitate the fitting and removal of couplings, etc.

6.6.13 Stator Frames

Stator frames and end-shields shall be of either cast or sheet steel fabricated construction. Cores shall be rigidly supported within the frame and accurately machined to ensure a concentric air gap. End-shields shall have an accurately machined spigot and shall be rigidly bolted to the stator frame.

Fan covers shall be of metal, robustly constructed, painted inside and out and rigidly supported from the frame.

Each motor shall be provided with lifting lugs or eyebolts.

Pilot holes suitable for enlarging to accept locating dowels shall be provided in the feet of all motors. Tapped holes for jacking screws shall be provided in the feet of large motors.

6.6.14 Slide Rails

Slide rails shall be provided where specified in the schedules, and shall consist of two cast iron rails. Designed for floor mounting each complete with motor holding down bolts and belt tensioning bolts.

6.6.15 Slip-Rings and Brush Gear

The tails of rotor windings shall be brought out to slip rings, which shall be accommodated in a separate compartment on the main frame. The slip ring assembly shall be keyed to the shaft such that it can be removed as a complete assembly.

The slip rings shall be rated for continuous or starting duty according to the requirements. Slip rings rated for starting duty shall be provided with motor actuated short-circuiting and brush lifting gear as specified in the schedules. The motor actuator shall be provided with a hand wheel for emergency operation. The actuating mechanism shall be provided with limit switches and mechanical stops at each end of the travel. The limit switches shall be of the 'snap' action type and have a minimum contact rating of 15 amps at 415 volts.

6.6.16 Testing

The following tests shall be carried out at the Manufacturer's Works and in accordance with BS 2613 Clause 24 of the Conditions of Contract and in compliance with the mechanical works specification.

Three copies of the Contractor's records of all tests shall be submitted to the Engineer immediately following completion of the tests.

(a) Type Tests (Witnessed):

Unless evidence of type tests on similar machines can be produced to the satisfaction of the Engineer, the first motor of each design shall be subjected to and shall satisfactorily withstand type tests in the presence of the Engineer:

- ◆ No load test;
- ◆ Measurement of winding resistance with temperature during test;
- ◆ High voltage test;
- ◆ Insulation resistance before and after temperature rise and high voltage test;
- ◆ Bearing noise check;
- ◆ Mechanical balance check;
- ◆ Direction of rotation check;
- ◆ Locked rotor test at full load current (with slip rings short circuited);
- ◆ Locked rotor test at full voltage (with slip rings open circuited);
- ◆ Starting performance test at full voltage - cage rotor motors;
- ◆ Measurement at full load, three-quarter load, and half load to determine, efficiency, power factor, torque and slip;
- ◆ Temperature rise test for a duration of six hours or until the motor has attained thermal equilibrium;
- ◆ Momentary overload test;
- ◆ Over-speed test;
- ◆ Measurement of air gap;
- ◆ Octave band noise level analysis.

All Motors not subjected to type tests shall withstand routine tests as specified below.

(b) Routine Tests

Each motor shall be subjected to and satisfactorily withstand routine test in the presence of the Engineer as follows:

- ◆ No load test;
- ◆ Measurement of winding resistance with temperature during test;
- ◆ High voltage test;
- ◆ Insulation resistance before and after temperature rise and high voltage tests;
- ◆ Bearing noise check;
- ◆ Mechanical balance check;
- ◆ Direction of rotation check;
- ◆ Locked rotor test at full load current (with slip rings short circuited);
- ◆ Locked rotor test at full voltage (with slip rings open circuited);
- ◆ Starting performance test at full voltage-cage rotor motors;
- ◆ Measurements at full load, three-quarter load, and half load to determine, efficiency, power factor, torque and slip.

6.6.17 Drawings and Documents**(a) Tender Drawings:**

The following drawings and performance data for each type and rating of motor shall be submitted with the tender:

- ◆ Dimensioned general arrangement drawing, with slide rails if required, and foundation details;
- ◆ Torque speed curves;
- ◆ General arrangement of motor terminal base.

(b) Contract Drawing:

The Contractor shall resubmit the above drawings for approval and supply the under mentioned drawings and data in accordance with the specifications:

- ◆ Reproducible certified general arrangement and foundation drawing;
- ◆ Sectional arrangement drawings;
- ◆ Detailed drawing of terminal boxes showing the termination of cables;
- ◆ Diagram of internal connections;
- ◆ A statement of weight;
- ◆ A statement of rotor inertia;
- ◆ Details of bearings with makes, types, sizes.

6.7 INSTRUMENTATION, CONTROL PANELS AND DEVICES**6.7.1 Enclosure**

Any instrument or control gear shall be totally enclosed in weather proof, vermin proof, and termite proof casings and suitable for use in humid tropical atmospheres. The instrument and control gear shall be wall mounted, or mounted on a steel frame firmly fixed to the floor, or mounted in a free-standing metal enclosure. Panels shall be manufactured from fabricated sheet steel, comprising mounting rails, mounting plate, wire-ways, terminal blocks and hinged door for access to the internal items. The Panel shall be designed and built to conform to the relevant BS specification for corrosion free, dust proof enclosures. All instruments, switches, and devices shall be labelled externally and inside the equipment.

The main control panel shall include:

- Main Incomer MCCB suitably rated (including automatic thermal switch)
- MCCBs for each pump and compressor (including automatic thermal switch)
- On/off indicators for each pump pumps
- Voltage and amp meter for each pump
- Thermal safety indicator for each pump
- Running hour indicators per pump and compressor
- Incoming Volt/Amp meter

6.7.2 Indicating Lights

Lamps shall be low voltage operated via a transformer. Bulb shall be front replaceable type capable of a minimum life of 3000 hours. Lenses shall be tinted to the required colour made of toughened plastic with dichroic bezel.

6.7.3 Indicating Instruments

Indicating instruments shall conform to BS 99 for industrial accuracy. They shall be flush mounted with transparent non-reflecting glass surfaces, adjustable red pointers and front zero adjustments.

6.7.4 Fuses

Fuses and link carriers and bases shall be of good quality moulded unbreakable insulating material, conforming to BS 2692 and BS 88 as appropriate, HRC type, with a capacity at least equal to fault rating. Fuse lines in tripping circuits and protective gear test links, shall be mounted such that they are readily accessible. Fuses and hub shall be grouped and spaced according to their function, in order to facilitate identifications. Test links shall be provided to enable protective equipment to be tested without having to remove wires.

6.7.5 Push Buttons

Push buttons shall be diaphragm type. 'Stop-Reset' buttons shall be coloured red; the 'start' buttons shall be coloured green and shall be shrouded to prevent inadvertent operations lamp test pushbutton shall be black. Where the starter is mounted more than 3m away from the motor, a separate emergency stop mushroom head pushbutton shall be provided near the motor. The button shall be coloured red and shall be locked down in the depressed position, twist open to release. Stop buttons shall be connected in the fail-safe mode and shall have auxiliary contacts.

6.7.6 Pressure Switches

Pressure switches shall be manufactured to IEC standards. They shall have separately adjustable set points and span, and equipped with an IP 55 terminal box with sufficient space for glanding a 1.5mm² PVC/SWA/PVC cable.

6.7.7 Solenoid Operated Valves

N/A

6.7.8 Level Indicator/Transmitters

The level switches shall be solid state with probe contacts that can be adjusted to six different levels. They shall be manufactured to IEC standards, suitable for operation in a liquid of specific gravity of 0.95-1.0 and a temperature of 50°C. The contacts shall be rated at 10A at 220V AC. The switches shall be supplied with at least 3 interchangeable contacts for control and indication. All cabling shall terminate into an IP.55 terminal box with sufficient space for glanding a 1.5mm² PVC/SWA/PVC cable.

6.7.9 Flow Metering

NOT USED.

6.7.10 Control Wiring

Control wiring shall be securely connected in position preferably at the side of the panels and shall be so arranged to enable a neat appearance and easy access for tracing. Wiring shall be stranded conductors with insulation to protect it from mechanical damage. Wiring shall be colour coded as follows.

- ◆ Red: Red phase in current and voltage transformer circuits and in low voltage 3 phase, auxiliary circuits;
- ◆ Yellow: Yellow phase in current and voltage transformer circuits and in low voltage 3 phase, auxiliary circuits;
- ◆ Blue: Blue-phase connection in current and voltage transformer circuits and in low voltage 3 phase auxiliary circuits;
- ◆ Black: AC neutral connections;
- ◆ Green/yellow: Earthed connection;
- ◆ Grey: Connection in DC circuits, those connected in tripping and closing circuits shall also be identified with 'T' or 'C' respectively in addition to wire numbers.

Wires shall not be jointed or tied between terminal points and shall have number ferrules at both ends. No terminals shall have more than two wires connected. Circuits fed from a supply common to a number of panels, shall be protected so that failure of a circuit in any one panel does not prevent operation of other panels.

Circuits within one panel shall be capable of isolation for maintenance purposes without affecting other circuits. Instrument wiring and terminal blocks shall be segregated from control wiring as far as possible. Terminal blocks shall be provided with sectionalized groups of associated terminals permitting work to be carried out without disturbing other sections of the panel wiring.

Instrumentation control grounding shall be designed for installation in accordance with BS practices for wiring and grounding instruments.

6.8 DIESEL ELECTRIC GENERATOR UNITS

Small diesel engines shall be all air cooled.

All engines selected shall be so designed for ease of maintenance with minimum of special tools. Where these are required, they shall be supplied with the engine.

All engines and generator selected shall be long life and operate under local climatic conditions and be suitably rated. Heavy-duty air filters shall be provided for use in dusty environments.

Engine speeds shall not exceed 1500 rpm and where large base loads are required then consideration shall be given to 1000 rpm.

All engines shall be provided with mounted day tanks capable of running the engine for eight hours at full load capacity.

All sets shall be arranged for manual start and stop. Electric starting shall be provided and each set shall be complete with starter motor, batteries and charging system. All sets under 15 kVA shall be provided with a facility for hand cranking.

Control panels for Diesel Generating sets shall include:

- ◆ Line ampere meter
- ◆ Volt meter and selector switch
- ◆ Hours counter
- ◆ Frequency meter
- ◆ Outgoing circuit breaker

6.9 SOLAR PHOTOVOLTAIC (PV) POWER SUPPLY SYSTEM MODULES AND BATTERIES

6.9.1 Scope

This section of the regulation gives guidance on safe installation and utilization of photovoltaic power supply system as an alternative source of energy.

6.9.2 Photovoltaic (PV) Modules

PV Modules (Panels) Specifications

The output current and voltage of the modules or panels shall be appropriate for the application, and shall be clearly established by the contractor from the manufacturer's documentation and stated in the contract. The pertinent conditions are solar radiations of 1 KW per sqm or less and cell temperature of 35°C or higher.

The Uganda National Bureau of Standards is able to provide advice on quality and finish of panels, and can test new panels under local conditions where necessary.

The module shall have a quality mark from PV GAP or any other Accredited Testing Laboratory on the module. This mark provides assurance that the module has been tested to IEC 61215 or IEC 61646 and that the manufacturing has ISO 9000 certification and periodic auditing.

PV Modules Position

No object (trees, buildings, etc.) should shade any part of the PV-panel at any time of the year between 90 minutes after sunrise and 90 minutes before sunset.

Should shading be unavoidable, this shall be compensated for by reducing the daily energy output in the system design. Note that reduction in output due to partial shading will typically be much greater than the portion of the array that is shaded.

Where possible, the PV-panel shall be installed on the roof of a building near the controller and battery bank.

PV Modules Orientation

The panel must be installed facing due north/south, at an angle of between 10 and 20 degrees to horizontal plane.

PV Modules Lighting Protection

- (i) PV-panels shall be installed lower than the highest point of the building.
- (ii) The support frame shall be provided with a short lightning rod if this becomes the highest point of the building.
- (iii) The UNBS or other specialized contractors will provide expert advice in case of doubt.
- (iv) The contractor should make the client aware of the risks that can arise due to unsafely earthed structures. Where grounding of structures for lightning protection is needed a minimum of 16mm² cable shall be connected to a 1.5m earth rod.

PV Modules Support Structure

The support structure for panels shall be made of permanent materials, be strong enough to withstand all climatic conditions (wind, heat, water) without deflection or vibrations and be securely braced and fixed to the roof or the wall of a building or the ground.

Frames, support structure and other metal parts shall be made of non-corroding materials, or protected against corrosion by galvanization, painting, etc. as appropriate for the material used. It is good practice to keep dissimilar metals separate, unless they are well sealed against water by paint or sealing compound.

Calculations and supporting documentation to demonstrate adequate design may be required.

PV Modules Roof Mounting

Fixing to roofs shall be done so that leakages are prevented and no corrosion of roofing materials will occur.

Bolts to be fixed through top of corrugations on corrugated metal roofs, to be secured to purlins, or special supports to be fixed to the roof structure if the purlins are of poor quality.

All holes in the roofing shall be thoroughly sealed and made waterproof with UV- resistant silicone sealant or suitable sealing compound.

PV Modules Ground Mounting

- g) Solid foundations shall be provided at each corner of the array with additional support as required by the design of the supporting structure.
- h) Panels shall not be mounted closer than 0.8m from the ground to avoid shading by grass and other vegetation.

- i) Small arrays may alternatively be fixed to a single pole, securely buried into the ground and if necessary secured with stays.
- j) The location shall be chosen such that no damage can be caused by animals (and the site shall be fenced).
- k) This method of mounting should be avoided whenever possible.

6.9.3 Batteries

Type

Batteries shall be of a design suitable for PV applications. Deep discharge and long cycle life batteries are recommended.

Conventional car/truck starter batteries are not generally acceptable. For specifications of batteries, refer to US 149-1: 2000 Specification of batteries for photovoltaic systems.

The technical implications of the choice of battery and the costs and benefits of different types should be explained to the client in general terms.

Installation

- l) Batteries shall be installed in boxes, racks, or cupboards to protect the connections (terminals) against accidental short-circuiting while still being checked.
- m) At least 20mm free space shall be left between the batteries, the wall, and the top of the box.
- n) Ventilation of the enclosure shall be ensured to avoid build up of explosive gases during charging.
- o) The box shall be made of suitable durable materials and if made of wood, it shall be well preserved against insects (termites), rot and acid.
- p) The box shall be securely fixed in position and each battery shall be marked with the date of manufacture and year and month of installation by the installer.
- q) Maintenance requirements shall be clearly laid out in the owner's manual.

Controllers and Circuit

Controllers shall be designed and installed to protect the batteries against overcharging, as well as over-discharging.

Voltage disconnect/reconnect settings shall depend on the type of battery.

The rated capacity of the controller shall be selected to handle the maximum short circuit current from the PV-array and the maximum load.

The charge controllers and circuit breakers / fuses shall bear manufacturers PV quality mark, PV GAP or any other Accredited Testing Laboratory PV Quality Mark.

This quality mark provides the assurance that the module has been tested by an Accredited Testing Laboratory to IEC 61215 or IEC 61646, and that the manufacturing has ISO 9000 certification and periodic auditing.

A warning system consisting of a light and or an audible alarm providing at least three minutes advanced warning of disconnection should be installed.

Where the controller is installed in a room which is not regularly used, a remote alarm shall be installed at a place where it can be easily noticed.

Essential Service (ES) circuits may be provided with a switch to facilitate bypass of the over- discharge protection or to bypass the regulator completely.

Warning for low battery shall however be included as for Non-Essential Services (NES).

The owners manual and markings on the bypass device shall clearly indicate the implications and potentially irreversible damage that may be caused by bypassing this protection.

The system shall be protected against damage due to accidental short-circuits by use of fuses or circuit breakers.

Any consumer circuits shall have circuit breakers.

Individual circuits from the battery shall have a maximum rated capacity of 25 amperes where not otherwise specified

Each circuit shall be so designed that the peak demand does not exceed 80% of the rated capacity of the fuse or circuit breaker.

Required fuses and circuit breakers may be integrated in the controller box or installed separately in a fuse or distribution box positioned near the controller and battery.

Each fuse or circuit-breaker shall be clearly marked with rated capacity and for which circuit it is used.

6.9.4 Samples

Where new components or of innovative techniques, are used by the contractor samples of materials and equipment shall be submitted for approval before installation commences. It is recommended, where possible, to show the client an existing installation so that any ambiguities may be explained.

6.9.5 System Design - Essential and Non- Essential Service (ES and NES)

Design data

The client may provide data for dimensioning of each system where the design is not prepared in detail by the contractor.

It shall be the responsibility of the contractor to ensure that such system details are consistent with the:-

- r) Type of lights and appliances
- s) Essential Services (ES)and Non-Essential Services (NES)
- t) Daily Load (DL)

The contractor shall specify the manufacturer, types of equipment with relevant rated capacities to be installed and enclose calculations and other documentation to prove that all requirements are met.

Calculations

Calculations of requirements for a functional system shall depend on whether it is considered NES or ES.

The system sizing rules are based on mathematical modeling with daily solar radiation records from Uganda over the period of at least 5 years, taking into account panel degradation as well as battery ageing.

Essential Service (ES) and Non- Essential Service (NES) systems should in general be installed as totally separate systems.

Where a combination of ES and NES are connected to the same system, it shall be sized as if all services are ES, unless particular calculations are provided to prove that the design of all combined system will satisfy the requirements to both types of services

System Autonomy

The period of autonomy of a Photovoltaic system may be defined as the total period for which the system shall provide power to its regular load without solar energy input. In other words, this is the period for which the system will operate normally without sunlight.

The autonomy of a system depends mostly on the depth of discharge of the batteries under normal daily loads and the number of batteries included in the system.

If a battery is only discharged by a small fraction of its total capacity each day, it will clearly provide more days of operation than a battery that is discharged by a large fraction each day.

The overall life of a battery is affected by the depth of its regular daily discharge; the life being inversely proportional to the depth of discharge (i.e. the shallower the discharge the longer the battery life).

The contractor shall give careful consideration to the sizing of the batteries in relation to the system load requirements. The cost implications of this should be presented clearly to the client

Essential Services (ES)

The battery capacity shall be at least 5 times the maximum daily load in Ah. This provides a normal cycle depth of 20% or less, assuming ample battery service life, and will provide 5 days autonomy in case of total array failure.

The array output current / in amperes under conditions as specified above shall be at least $DL (Ah)/4(h)$.

Non-Essential Services (NES)

The total nominal capacity of the batteries in Ah shall be at least 4 times the daily load in Ah.

The array output current; in amperes under conditions as specified above shall be $DL(Ah)/4(h)$.

6.9.6 Labels

Supply and fixing of labels shall be carried out by the contractor.

Labels shall be made of; permanent inerasable material with clearly legible letters and shall be displayed in a prominent position(s), providing the following information.

u) Battery enclosure:

"Danger!" "Explosive gas". "Do not smoke". "Do not use open flames". "Do not short circuit battery terminals!"

v) At Controller

Name and address of electrical contractor responsible for installation
Date of installation
How to read performance (display or coloured lights)
Operation of circuit breakers or fuses (replacement of fuses)
Identification of circuits from the controller
Instructions on maintenance/cleaning of photovoltaic panels.

w) Distribution Board (if using wiring for 240V a.c.) the following phase shall be clearly indicated- "Use 12 Volt appliances only".

x) Remote Warning if is installed, shall have an explanation of the warning signals.

y) At main entrance to building or home, the following text in English and/or Swahili, or any other appropriate local dialect shall be clearly marked "Please save energy. Switch off lights and appliances when leaving room".

6.9.7 Inspection and Testing

On completion of installation the system shall be inspected to ensure expected operation.

In addition to checking that all parts are correctly installed and operating satisfactorily, the electrician will certify in writing that:

z) Voltage drop (loss) in cables does not exceed specifications

aa) Output from PV modules is within 5% of manufacturer's specified value

bb) All wiring has been installed in an appropriate manner d) No safety hazards exist

cc) All signs and labels have been sensibly placed

6.9.8 Maintenance, Spare Parts and Warranties

The contractor shall be liable for all repair or replacement as per the installation warranty that he will provide.

Spare parts and expertise for maintenance and repair shall be made available by the contractor for the equipment after expiry of the warranty period.

Cost shall be separately detailed in the original quotation

Notwithstanding any third party warranties that may be passed on by the contractor, the minimum warranty period of some important system components shall be as follows:

Components	Minimum warranty period
Light bulbs	1 year
Batteries	1 year
PV modules and Wiring to PV modules	5 years
Controller / Inverter	3 years
Complete system	1 year

6.9.9 Registration, Approval and Acceptance for Photovoltaic Installations

Registration of Contractors for photovoltaic installation shall be carried out by the Uganda National Bureau of Standards (UNBS).

The UNBS shall issue certificate of registration to the registered Contractors who will then be entitled to use the title and logo of

"UNBS Approved Contractor" in their Company and promotional literature.

The certificate shall be issued subject to a nominal certification fee, and shall be uniquely numbered with the contractor's number.

The certificate shall remain the property of the UNBS, as the agent for the Code of Practice control body.

The Code of Practice Control Body will reserve the right to publicize all newly approved contractors in the public media in Uganda.

All contractors shall be required to maintain numbered records of all Photovoltaic installations they perform. Such records shall include the date, system type, unit installed, serial number, etc.

All contractors shall be required to inform the UNBS the date, type and system details of all new installations, but need only refer to their own internal reference number. Such detail may not include commercial or financial information.

The Control Body shall at random select installations from each contractor by these reference numbers for follow up inspections. It is planned to inspect one installation per year for each approved installation.

6.9.10 Field of Application

This code shall be read in conjunction with the relevant parts of the current IEE Regulations for Electrical installations, and shall apply to installation of direct current (d.c.) Photovoltaic (PV) energy systems.

This code has been drafted for 12V and 24V systems for residential applications, the so-called Solar Home Systems and is not intended to be used for other PV systems such as PV- pumping systems and grid -connected systems.

The application of this Code of Practice shall include everything necessary to provide lights and outlets for power as part of a photovoltaic power system.

Where drawings or instructions are not specified, then they shall be specified by the client, or as shown on the contractors drawings, including PV-panels, batteries, controllers, fuses and/or circuit breakers, switches, socket outlets, wiring, appliances, etc., The work shall also include repair of all damages to buildings and grounds caused by the installation where not otherwise specified by the client.

6.9.11 Installation Design

Where the layout of the installation is shown in drawings or detailed specifications are given, these shall be accurately followed.

Where no detailed drawings are provided, the installation shall be designed as efficiently as possible to minimize the loss of energy through cables and junctions.

A system design specified for a client by a contractor should be in a form that may be readily explained to a non-technical client.

This design information should be kept on file by the contractor, and may prove useful after completion of the installation in case of any subsequent dispute.

In the case of a client-specified installation, it is the responsibility of the contractor to inform the client of any areas that do not conform to this Code of Practice.

The contractor is entirely responsible for any deviations from the established code of practice and wiring standards.

Under no circumstances, even by client dispensation, shall any unsafe practice be acceptable. Written dispensation from the client should be obtained where necessary to protect the interests of the contractor.

6.9.12 Wiring Methods and Cables

Conduit Wiring

Surface mounted conduit with single wire conductors shall be installed using saddles or supports at suitable interval.

Conduits must be supported using saddles or supports. Drooping or unsupported runs shall be avoided.

PVC conduit may be used under floors but steel conduit should be used in all places where heavy or unpredictable loads may occur.

Under floor conduit should not be less than 19mm to allow for subsequent maintenance.

Cable Wiring

Surface mounted cables shall be installed using appropriate fasteners at suitable intervals to prevent sagging as shown on drawings.

Conductor Cross-section and Voltage Drop

The cross-sections of the conductors shall be according to Building Code "Code for Electrical Installations and Equipment in Buildings", APPENDIX 3 and the relevant tables in the IEE Wiring Regulations 16th edition.

The rated current carrying capacity at 35°C for any given wire cross-section shall not be exceeded. Wires of cross section area less than 2.5mm² are not recommended for use with photovoltaic systems.

The voltage across any appliance shall not be less than 5% volts of the battery terminal voltage. Under no conditions is a voltage of less than 10.5V permissible across an appliance. The voltage shall be measured with all appliances in the circuit, including those connected to socket outlets.

Voltage drop between the PV-panels and batteries shall not exceed 1.0V or 5% measured at maximum charging current. This voltage drop measurements will include any series or protection diodes.

To avoid using long cable runs with large numbers of T and star junctions, the load may be split into several circuits from the controller.

Use of Existing 240V AC Wiring

The existing wiring of 240V a.c. shall be used, provided it complies with other conditions in Clause 5.13.3 above.

If new wiring is installed in 240V a.c. conduits, it shall also be in accordance with IEE Wiring Regulations 16th edition for 240Va.c.

Cable Connections

Cables can be connected by the use of junction boxes, block connectors or soldering joints (with insulating sleeves).

All cable joints must be contained within a suitable junction box where they will be visible.

The rated capacity through the joints shall not be less than for the circuit they form a part of.

Lights, switches and sockets may be used as junction boxes where this is practicable.

Power Intake - Underground and Overhead

Underground cables shall be at least 0.6m below the surface and be indicated with markers (coloured plastic tape, minimum 50mm wide or lining with bricks or slates, 0.2m above the cable).

Underground cables shall be used across all areas with vehicular traffic and they may also be used for aesthetic reasons or to achieve a short cable run as instructed by the client.

The cables must be designed for this type of application and conduit must be able to withstand vertical loads if heavy vehicles are expected to cross the area.

Suspended cables shall be mounted so that the lowest point is at least 2.7m above ground level.

The cables shall be held in position by suitable brackets and strain relief to prevent mechanical wear and stress of the electrical connections.

Cables for outdoor exposed usage, shall be fully UV-resistant

Attachment of cables or conduit to concrete, bricks or mortar, walls etc. shall be made with appropriate fasteners and attachment of cables to metal or asbestos sheeting or similar material shall be made by use of suitable toggles.

Holes through roofing should be avoided where possible. Cables through roofing shall be contained in roof-entry boxes, which also shall form a waterproof seal to avoid leakage.

All holes for cables shall be drilled at top of corrugations. All holes in the roofing shall be thoroughly sealed and made waterproof with UV-resistant silicone sealant or equivalent.

Where wires or cables are fixed to or passing through particularly flammable materials (thatch, etc.) they should be shielded in non-flammable conduits.

Fittings must be fastened to suitable supports, which may need to be provided if not already present. No conduit or fitting should be attached directly to thatch, or any other non- supportive surface.

Holes for cables through walls shall be sealed with mortar or putty and the surfaces touched up with paint. Holes that penetrate external walls must slope downwards slightly towards the inside to prevent the ingress of water.

6.9.13 Workmanship and Finishing

Where no detailed specifications are provided by the client for choice of materials or workmanship, standard practice for the trade shall be followed.

Regarding the approval of quality, assessing capacity of PV- panels, batteries, controllers and other components, the client or contractor may seek assistance from the Uganda National Bureau of Standards (UNBS), or from the Energy Unit of the Ministry of Energy and Mineral Development.

The installation shall include the completion and tidying up of any work that is a direct result of the installation. Any damage to surface walls or fittings caused by or as a result of the installation should be repaired by the contractor.

6.9.14 Light Fixtures

For general purpose and task indoor lighting, fluorescent lamps that comply with BS 1853 shall be recommended.

Ballasts for tubular fluorescent lamps shall comply with BS EN 60920 and 60921. Power factor correction shall be provided and this shall be not less than 0.85 lagging unless otherwise indicated.

Tungsten incandescent lamps that comply with BS 161 shall be used for particular tasks as required.

Halogen lamps in approved adjustable or portable fixtures shall be used for task light or spot light.

Where lamps are fitted next to thatched or flammable ceiling materials a metal lamp fitting or a metal shield shall be used to minimize the risk of fire.

For outdoor lighting such as security and street lighting, sodium vapour or other monochrome high intensity lamp shall be used.

Where there are insect's lamps with enclosures or defractors must be capable of being opened for cleaning by the client.

Where tools are necessary to open lamps for cleaning, such tools should be provided by the contractor as part of the installation.

6.9.15 Sockets

Socket outlets to be connected to solar PV system shall be designed for 12V d.c. and 2-pin plugs and shall not be possible to reverse the polarity.

Domestic appliances such as radios, fans spotlights, rechargeable torches, refrigerators and special instruments shall be connected to the solar PV system through socket outlets designed for such voltage or provided with suitable and efficient adaptors or inventers.

Any 12 V appliance shall not have a 240V a.c. mains type plug attached to it.

Where 240V outlets from a d.c.-a.c. inverter are provided, mains type socket shall be used and a label on each socket shall be added to show the maximum power available from that socket.

All wiring in these circuits shall conform to IEE wiring regulations for 240V a.c. mains wiring

Circuit breakers and proper earth safety system shall be provided to prevent damage to the inverter in case of an overload.

All installations that have d.c. sockets shall be wired so that the large diameter pin in the plug is always positive.

All positive connections shall be made with red insulated wire and all negative connections with black insulated wires.

6.9.16 Switches

Standard switches for 240V a.c. shall not be used as an alternative to special switches for 12 V d.c. unless written approval from the manufacturer is obtained which shall include acceptable d.c. voltage and current limits.

All switches shall be rated at twice their expected current carrying load.

Where particularly required, special time switches, photosensitive switches, remote and relay switches shall be specified and these shall be of good quality and performance, as specified for each purpose.

All switches shall include a clear visual indication of their state.

6.9.17 Installation

The whole of the installation and components shall be in accordance with:-

- dd) The current edition of "Regulations for the Electrical Equipment of Buildings" issued by the Institution of Electrical Engineers.
- ee) Relevant British Standard specifications.
- ff)
- gg) Relevant Uganda Government Legislation.

6.10 LIGHTING

Luminaries shall be complete with all supports, suspension flexible cables, pendants and plugs. They shall be connected to the main circuit wiring with heat resistant flexible cables of a minimum core size of 24/0.20mm

Light fittings and lamps shall be supplied, installed, checked, connected, lamped and tested by the Contractor, who shall, however, place no order for them until samples have been approved by the Engineer. The Contractor shall submit to the Engineer details of make and type of each light fitting. Light fittings shall be complete with mounting brackets and other attachment arrangements, galvanized where necessary, cool-white tubes or high-pressure sodium lamps as applicable. The Contractor shall be responsible for design of mounting brackets for the different light fittings and applications.

The cost of fixings, even if not specifically specified, is to be included in the cost of the fittings.

7 PIPELAYING

7.1 GENERAL REQUIREMENTS

The pipes, valves and fittings required for this Contract are all to be supplied by the Contractor and for this purpose drawings and schedules have been included which list all the material needed in detail.

The Contractor's rates are to cover supplying, taking delivery, transporting, loading, inspecting, stacking, stringing, laying, jointing and testing all the material listed.

In executing all such work, the Contractor shall take every precaution to ensure the safe and efficient handling of material in such a manner that it shall in no way be damaged while under his care. Care in loading and offloading is essential and all materials shall be lifted and carefully placed in position during loading or offloading operations without being dropped or subjected to impact. Bitumen sheathed pipes in particular may not be rolled and must be carefully supported on sandbags or suitably padded skids at all times prior to laying. Wide slings and approved lifting gear are to be used for moving the pipes or completed pipeline sections.

Vehicles shall be driven at a speed consistent with the condition of the roads over which they are required to travel so that no damage to material may occur during transport, and overloading must be avoided. Bitumen sheathed pipes must have their lime wash protective coating maintained until the pipes have been backfilled.

7.2 FACTORY INSPECTION AND TESTING

7.2.1 General

Every valve, pipe and fitting supplied to the Contractor for the contract, whatever the source of supply, shall be subject to inspection (and testing, where provided for in the appropriate Standard or specified herein) at the Manufacturer's factory by Inspectors to be appointed by the Engineer. At his absolute discretion, the Engineer may waive this requirement for standard items manufactured in accordance with appropriate quality control procedures (eg ISO 9000 series) and/or carrying the mark of a recognised national or international Standards Organisation.

7.2.2 Pipework

The Engineer's Inspector shall be entitled to make regular inspections of all pipework during fabrication and prior to dispatch, and to witness all tests carried out on pipework to establish compliance with relevant Standards and/or the requirements of this Specification. No pipework shall be delivered to Site without the prior approval of the Engineer or his designated Inspector.

It is not anticipated that radiographic examination or hydraulic pressure testing of low-pressure pipework will be required on a regular basis. However, the Inspector may call for radiographic examination of welds and/or a hydraulic pressure test on any item of pipework whenever he is not entirely satisfied after a visual examination. For high-pressure pipework and/or major pipelines, radiography and hydraulic pressure testing is mandatory, and appropriate items are included in the Bill of Quantities to cover this. All costs incurred in retesting defective items will be for the Contractor's account.

When instructed by the Inspector, the welds on pipes and specials shall be examined radiographically by either X-rays or Gamma rays, and the acceptance limits for welds shall be in accordance with BS 2633. The test pressure for hydraulic pressure tests will be one and half times the maximum working pressure (including surge), at which pressure there shall be no sign of leakage or other defect of any kind.

After application of the specified protective coatings the pipework shall be examined both visually and, when appropriate, by means of a Holiday Detector supplied by the Contractor. At least seven days prior to conducting the examination the Contractor shall inform the Engineer of his intention to examine the pipework and the Engineer's Inspector shall be entitled to attend the examination. The entire surface area of bitumen-lined and fiberglass/bitumen-sheathed pipework shall be subjected to examination by a Holiday Detector operating at 10 to 15kV, and all holidays and defects shall be repaired to the satisfaction of the Inspector.

The entire surface area of other protective coatings shall be subjected to examination by approved instruments supplied by the Contractor and designed to measure the film thickness and continuity of the protective coating system used and all defects shall be repaired in accordance with the coating system manufacturer's repair procedures to the satisfaction of the Engineer's Inspector.

7.2.3 Valves

The Engineer's Inspector shall be entitled to inspect all valves at the supplier's premises during manufacture and prior to dispatch, and to witness all tests carried out on valves to establish compliance with relevant Standards and/or the requirements of this Specification. No valves shall be delivered to Site without the prior approval of the Engineer.

The Engineer will not normally require factory inspection or testing of valves manufactured in accordance with and bearing the mark of approval of a national or international Standards organisation. Once details of the valves are known the Engineer will notify the Contractor of any requirements for factory inspection or testing.

Valves subject to factory testing shall be pressure tested on body and gate.

- (a) Visual and dimension checks shall be carried out on all valves and they shall only be accepted if they comply with the Specifications and Standards in every respect.
- (b) Casting faults may only be repaired on the written authorisation of the Engineer's Inspector.
- (c) Hydraulic tests shall be carried out on each valve to the pressure specified for that class of valve and each must withstand the test pressures without showing any signs of sweating or leakage.

Bidders are warned that valves supplied ex-stock either from the factory or from an agent, may not have been tested in accordance with this Specification and must be returned to the manufacturer for testing if the Engineer so requires. At least seven days prior to conducting tests on returned valves, the Contractor shall inform the Engineer of the date of the tests and the Engineer's Inspector shall be entitled to attend the tests. The manufacturer will normally charge for testing of returned valves, and all such charges and other related costs such as transport and handling shall be borne by the Contractor.

7.3 SITE INSPECTION AND TESTING

7.3.1 General

All items delivered to site are to be carefully inspected by the Contractor's Site Agent immediately they arrive upon site, and carefully checked against their detailed specification both for manufacturing defects and for damage since manufacture. Any defect or damage shall be reported at once to the Engineer and the damaged or defective valve, pipe or fitting laid aside for his inspection, when he shall decide whether to permit repair of the item or to reject it. The Contractor is then to replace or repair the damaged valve, pipe or fitting and thereafter shall again submit the valve, pipe or fitting for inspection and approval by the Engineer, and the repaired valve, pipe or fitting shall not be laid until so approved. The Engineer will have the right to order the removal from the site of any defective or damaged item which has not been so rectified and approved by him whether it has been laid and jointed or not, and the Contractor shall thereupon at his own expense effect its removal and replacement to the entire satisfaction of the Engineer.

The duty of inspection is an onerous one which should be most painstakingly carried out in order to ensure that work is not interrupted by the belated discovery that the equipment or fitting supplied is unsatisfactory

7.3.2 NOT USED

7.4 LEVELS FOR PIPELAYER

Immediately before pipelaying begins, the Contractor's Agent shall check the level of the pegs to which the pipelayer is to work, using an Engineer's level.

7.5 LAYING PRESSURE PIPELINES

The Contractor will be responsible for the correct distribution of the various classes of pipes, valves and fittings along the trench so that they are convenient for laying.

The Contractor shall re-inspect every item of pipework carefully immediately before laying, both inside and out, reject any which are damaged or defective, remove all dirt and foreign matter within the bore, and for bitumen sheathed pipes carry out the holiday inspection detailed above.

After a sufficient length of trench has been prepared for laying, the pipes are to be carefully lifted and not skidded or rolled but lowered into place on the trench bottom. With the approval of the Engineer, pipes for a welded pipeline may be welded together on the trench-side to form longer sections or a continuous line, before laying in the trench. Approval for either of these procedures will only be given if, in the opinion of the Engineer, the Contractor can demonstrate that he has the necessary expertise and experience to carry out the procedure and has made available adequate cranes and/or side-booms for the proper support and placing of the pipe sections or continuous pipeline. In the event of these procedures being approved, external protective coatings (and internal linings if already applied) are to be made good and checked by Holiday detector before and after placing in the trench.

Where pipes are to be laid to an appreciable gradient laying is to be commenced at the bottom of the incline and is to proceed uphill.

Pipes with bitumen sheathing are not to be skidded or rolled under any circumstances.

Each pipe must bear evenly on the full length of its barrel and where hollows, bumps or irregularities of the trench bottom occur which prevent the pipe from being solidly supported along its entire length between joint holes, the pipe is to be lifted from the trench or moved to one side while the trench is regraded. All pipes and fittings are to be laid true to line and level as indicated by the Drawings or as directed by the Engineer. Pipes must be concentric and bore to bore and the specified clearance must be maintained at joints.

During pipelaying a "badger" on a sound rope is to remain in the bore of the pipe previously laid and jointed, and is to be drawn forward throughout the whole length of the pipeline as the work proceeds. The badger and ropes used are to be of soft material which will not damage the internal surface of the pipes.

In order to prevent the entry of stones or loose material into the pipeline, plugs or caps are to be provided to cover the mouth of any open pipe at all times while pipelaying is not actually proceeding.

7.6 LAYING SEWERS AND DRAINS

7.6.1 General

For sewers, the Engineer may at his discretion specify various types of bedding. It is probable that pipes with rigid joints (eg earthenware and/or concrete pipes with caulked joints) will normally be bedded on concrete while pipes with flexible joints (eg asbestos-cement, earthenware and/or concrete with rubber ring joints) will be bedded on selected fill, but the choice of method shall be at the discretion of the Engineer.

7.6.2 Bedding on Concrete

Where this bedding is specified pipes will be laid and bedded solid on their barrels on Grade 10 (20) concrete. The base of the concrete bed shall extend no less than 75mm beyond the outside of the pipe at an angle of 45° so that the bottom quarter of the circumference of the pipe is bedded solid on the concrete. Each pipe shall be laid with its spigot end pushed tight into the socket of the last pipe laid and the barrel gently tapped into the newly laid concrete leaving the joint free for caulking and collaring.

The amount of concrete used shall be calculated using the nominal outside diameter of the sewer pipes as given by the relevant Standard, or by the manufacturer where no Standard exists, and paid for at the rate entered in the Bill. The cost of the additional 75 mm of excavation required below the invert of the pipe must be included in the rate for concrete.

7.6.3 Bedding on Selected Fill

Selected fill may be material selected from the excavation of the trenches or imported from borrow pits. Where the Engineer directs that the pipes are to be bedded in selected

material resulting from the excavation of the trenches, no payment will be made for the import of spoil.

Where this bedding is specified, the trench will be excavated to a depth of 150 mm below the underside of the pipes. Selected fill will then be placed in the bottom of the trench, watered and compacted to achieve a density of 95% Lower Compactive Effort. The surface of the selected material will be trimmed to a final correct level for the bedding of the pipe, joint holes formed and the pipes laid and jointed. The entire preparation of the bed shall be to the satisfaction of the Engineer.

The amount of selected fill to be placed in the trench must be sufficient for a layer slightly thicker than 150 mm to remain after compaction, so that after trimming the pipe can be laid true to line and level.

Whatever the source of any material to be used as imported fill, the Contractor will be required to clear a suitable site for a borrow pit, excavate, load, transport, offload and place the material as directed.

The quantity of imported fill to be paid for in the Bill of Quantities for pressure pipelines will be calculated using the net cross-sectional area i.e. the gross cross section less the cross sectional area of the pipe.

The amount of selected fill required for sewers shall be calculated by multiplying width of trench as specified in the Bill of Quantities by the depth of fill (taken as outside diameter of sewer plus 150 mm) deducting the gross area of the sewer, and multiplying the remainder by the length of the sewer between manhole walls. The Contractor shall be paid for importing material to site in accordance with the rates billed and the additional 75 mm of excavation required beneath the invert of the pipe will be included in the depth of the trench as measured for payment.

7.7 JOINTING OF PIPES AND FITTINGS

7.7.1 General

Before being butted together, the ends of valves, pipes, fittings, couplings and all flanges are to be inspected and cleaned to ensure that all parts forming the joints are undamaged and clean. Buried flanges, and the ends of bitumen-lined steel pipes shall be painted with two coats of approved bituminous paint.

Only qualified and competent men are to be employed in carrying out the work of laying and jointing, and proper tools are to be used in the execution of the work. Where plain ended pipes are to be coupled together a gap must be left, and the Site Agent is to ensure before pipelaying commences that he has the necessary gauges available on Site to ensure that these gaps are maintained.

Jointing is to be carried out in a manner suited to the type of joint used and to the approval of the Engineer. In particular, all recommendations of the pipe manufacturer for jointing are to be carefully followed.

In all cases care must be taken that the pipes are kept to line and grade during jointing, and any jointing material that has found its way into the barrel of the pipe shall be immediately removed with a badger or other approved tool, whereafter the interior of the

pipe is to be wiped clean and the joint on the inside of the pipe trued up and cleared of any protuberances so as to offer no obstruction to the passage of liquids. Except as authorised by the Engineer for pipelines with full-strength welded joints (steel, PVC and HDPE), pipes are not to be moved or disturbed after jointing and any pipes so moved or disturbed shall have their joints cut out and be rejointed.

Where pipes with rigid joints connect into manholes, valve-chambers and /or other concrete structures subject to settlement, the pipes entering and leaving the structures shall be laid in position but shall not be jointed until the completion of a reasonable amount of concrete work in the structure. This is to avoid breaking of built-in pipes.

When pipes with flexible joints connect into structures, a flexible joint shall be provided within 1 metre of the manhole wall, and a second 1 metre from the first.

7.7.2 Welded steel pipelines

N/A

7.7.3 Steel and Cast Iron Pipes with Flexible Joints

These pipes, together with plain ended fittings, will be jointed by means of Viking Johnson or similar approved detachable couplings, each consisting of one center collar, two special flanges, two rubber rings and mild steel bolts.

The flanges are first put on, one over the end of each pipe, and the rubber rings fixed by stretching them over the pipes. Any twists in the rubber rings must be eliminated, and the rings put into position so that the distance from the end of the pipe to the ring is equal to half the length of the collar. The collar shall then be placed over the end of one of the pipes and the two pipe ends brought to within 20 mm of each other, whereupon the collar shall be set concentrically over the pipe joint. The bolts shall now be inserted into the flanges and carefully tightened up evenly across diameters to ensure a watertight joint. Bolts on flexible couplings for steel pipes are to be tightened to the torque specified by the coupling manufacturer and a torque wrench must be used for this purpose.

On completion of the joint, the metal work of the joint shall be protected with an approved polythene tape wrap, or as directed by the Engineer on site.

The jointing of plain-ended valves and specials to the pipes shall be executed in the same way.

7.7.4 Asbestos-Cement Pressure Pipes

N/A

7.7.5 Flanged Joints

Flanged faces shall be cleaned thoroughly and the jointing material, cut properly to size and holed for bolts, inserted immediately before bringing the two flanges together. Before closing the joints, the flanges must be parallel to each other, with at least two-thirds of all bolts inserted in the bolt holes and evenly distributed over the circumference of the flange.

After the flanges have thus been aligned and well supported, the joint shall be closed by bolting up all bolts to uniform tightness. All bolting up must be done by the use of torque wrenches.

7.7.6 Screwed and Socketed Pipes

Prior to jointing, the threads shall be thoroughly wiped clean and then treated with a thin layer of an approved pipe jointing compound to be supplied by the Contractor. The pipes and fittings shall be brought into correct alignment and the joints screwed up tightly. Tightness of the joints must be obtained by means of screwing only. Threads may not be caulked except where specially permitted by the Engineer. Care shall be taken to avoid damage to the surface due to improper use of tools or other causes.

7.7.7 Spigot and Socket Pipes with Caulked Joints

Each pipe or fitting is to be laid with its spigot butting into the end of, and concentric with, the socket of the previously laid pipe. Before inserting the spigot a neat film of cement mortar shall be worked into the seat of the socket of the pipe already laid and the pipes then butted as closely as possible. The joints shall then be filled with dense 1 : 1 cement mortar as stiff as can be reasonably worked, well rammed home with a caulking tool and finished off outside the pipe with a 45 degree bevel. No gasket or packing shall be used.

When the joints have hardened the Contractor shall complete the concrete bedding under the joints so as to make a homogenous mass of concrete under the whole length of the pipeline. After jointing, the pipes must be protected with damp sacking until they are tested, and after testing they must be again protected until refilling is undertaken. The branch of each junction shall be supported at the required angle.

7.7.8 Pipes with Roll-on Rubber Ring Joints

Rubber rings will be placed over the spigot or spigots of the pipes to be laid which will then be carefully aligned; the rings must be carefully placed square to the axis of the pipe, untwisted and free to roll. The joint must then be made with a short sharp shove and the final position of the rubber ring checked with a feeler gauge to ensure that it has taken up its correct position. The same method will be followed for spigot and socket pipes and for double spigot and collar joints.

Where the pipes are laid on concrete bedding, the flexibility of the joint must be preserved by breaking the concrete bedding at the joint in a manner approved by the Engineer and producing a gap not less than 15 mm wide.

7.7.9 Earthenware Pipes with Flex drain Joints

The rubber jointing sleeve is to be set on the spigot of the pipe with the bead flush with the extreme end of the pipe. The spigot is then inserted into the socket so that the bead on the jointing sleeve engages around the whole circumference of the lead-in section of the socket. The spigot is then to be pulled home, using the special jointing tool to obtain an even and square pull. The final position of the rolled sleeve should be well down the socket, and the spigot should touch the shoulder of the socket.

If any joint feels too tight when pulled, the spigot pipe should be laid aside and used elsewhere in the line, in order to avoid breaking the socket.

7.7.10 HDPE Pipes

Laying of HDPE pipes shall be in accordance with the appropriate British Standards or ISO norm. Pipe lengths are to be butt welded. All fitting and specials shall be of HDPE to match the rating of the piping on which they are being installed.

All HDPE pipework installed above ground level shall be supported continuously on pipe supports provided by the Civil Contractor.

Branches are to be socket or butt welded. Reducers shall have weld ends to suit the manufacturer's range.

Flanges are to be used at flanged valves, equipment items, at intervals of 30m for straight pipe lengths or as directed by the Engineer.

The Contractor is required to make appropriate arrangements to deal with thermal expansion of the pipework. These arrangements shall require written approval of their suitability by the Engineer before installation.

7.8 TOLERANCES IN PIPELAYING

7.8.1 Water Mains

For sections permanently exposed above ground the deviation from the specified line and level shall not exceed 5 mm if the section is not longer than 30 metres and 10 mm for longer sections. For buried pipelines the deviation shall not exceed 15 mm.

The deflection at any joint shall never exceed the maximum recommended by the manufacturer, and should in general be less than three-quarters of that deflection except with the permission of the Engineer.

7.8.2 Sewers and Stormwater Drains

The invert of a sewer or storm drain at a manhole or catch pit shall be within 10 mm of the level specified.

The level of any joint shall not differ by more than 5 mm from the straight line between the joints on either side of it and the horizontal deviation from the specified alignment shall not exceed 15mm.

7.9 CUTTING OF PIPES

Concrete pipes which have to be cut on Site should be marked and cut by means of sharp chisels, and if the pipe is reinforced, the reinforcement must be severed without shock by cutting each rod with a suitable saw; further, the face of the cut section is to be properly trimmed and dressed with an abrasive stone. The cut end shall then be coated with a 5mm layer of an approved trowelling-grade epoxy coating and jointed as for uncut pipes.

Closure lengths of spun lined and sheathed or coated steel pipes shall be flame cut on Site and the edges of the cut pipe ground smooth. All damage to the lining and external protection shall then be made good to the satisfaction of the Engineer.

After asbestos cement pipes have been cut, the cut ends shall be turned down to the correct external diameter to suit the detachable joint by means of the special turning tool made by the manufacturer for field use and to be supplied by the Contractor. The Contractor shall take all necessary precautions to protect his workers against inhalation of asbestos-cement dust while cutting and turning pipes.

Cut pipes shall be used only where permitted by the Engineer and the ends which have been cut shall be dressed square and to a smooth even finish, which shall not be inferior to that of the uncut pipe. The finished dimensions of the ends cut at Site must be within the tolerances applicable to the particular type of joint.

Unless billed separately, the cost of all cutting and trimming, and where necessary screwing, shall be included in the rates for laying and jointing of the pipes.

7.10 NOT USED

7.11 CONCRETE PROTECTION TO PIPELINES, SEWERS AND EXISTING SERVICES

Where the Engineer directs, pipes will be laid on a concrete mat, or haunched, encased or surrounded with Grade C10/20 concrete. The Contractor shall receive payment based on the quantity of concrete required, calculated from the exact specified geometric sectional area of the concrete and the exact length haunched or surrounded, and this shall apply also to concrete in drops or ramps. Where haunch or surround is discontinued at flexible joints, no payment will be made for forming the discontinuity, but no deduction will be made from the volume of concrete.

Where any new pipe passes under an existing service, the Contractor shall consult the Engineer who will determine whether a reinforced concrete supporting beam shall be provided under the service prior to backfilling. Any work of this kind will be paid for at agreed rates unless separately billed.

The rates quoted for concrete protection shall allow for all the associated excavation and shuttering.

7.12 AGRICULTURAL DRAINS

Where the Engineer orders that agricultural drains shall be laid in a pipe or sewer trench in order to keep it dry, they shall be laid parallel to the pipe sewer but to one side, the top of the drain being at the same level as the bed of the trench. Joints shall be open butt joints not less than 6 mm and not greater than 10 mm. Before the trench is refilled, stone complying with the relevant Clause of this Specification shall be packed 75 mm thick around the drain. At manholes the drain shall be laid under the floor of the manhole. Outlet drains are to be laid where the Engineer directs.

The width of the sewer trench shall be increased to allow for the agricultural drain and the extra excavation shall be paid for at a rate proportional to the increase in width.

The Engineer will normally require an agricultural drain to be laid only when it will be of permanent benefit as a subsoil drain or when in his opinion it is impracticable to proceed without a drain owing to excessive infiltration. No payment will be made for drains laid solely to reduce the costs of pumping, although the Contractor will normally be allowed to provide drains at his own expense in order to achieve this.

7.13 SETTING VALVES AND PIPE FITTINGS IN POSITION

All valves and fittings are to be set correctly into positions indicated and supported on concrete supporting stools as shown on the Drawings. Valve spindle guide brackets and stays shall be secured to concrete work, and shall be set and carefully adjusted to give true vertical alignment of the spindle wherever possible.

7.14 CONNECTING PIPEWORK

The connection of new pipework to the existing system shall be done at whatever time of the day or week the Engineer directs. This time will be chosen to suit operational convenience, and all instructions given in this respect shall be strictly observed by the Contractor.

7.15 TESTING GRAVITY SEWERS AND DRAINS

7.15.1 General

All sewers, drains and similar non-pressure pipelines designed to flow only part-full are to be tested to a pressure prescribed by the Engineer but not exceeding 750 mm head of water for air test. The supply of all necessary materials, equipment and labour for testing shall be included in the Contractor's rates.

7.15.2 Supply of Test Equipment

For testing sewers and drains, the Contractor shall supply expanding plugs, flexible bag stoppers, smoke cartridges and equipment for detecting leaks, an *Eclipse* testing machine (or equal approved) and a suitable air pump or compressor. Any other equipment necessary or desirable for the work shall also be supplied by the Contractor.

7.15.3 Inspection and Testing

24 hours after sewers or drains have been laid they shall be inspected and checked by the Engineer for grade, direction, alignment and appearance of inner surface. Any pipes inaccurately laid to grade, direction, alignment or the interior surface of which shows open joints, ragged edges, protruding mortar or other material, must be made good or re-laid as ordered by the Engineer, so as to conform with the Specification. Thereafter each length of pipe and each connection shall be subjected to the air test.

Tests shall be made between manholes. The portion of the sewer to be tested shall be closed with suitable expanding plugs and an air pressure applied. For sewers with nominal bore 300 mm or less, the air pressure shall not exceed 150 mm head of water, the test shall last for one minute, and there shall be no detectable loss of pressure. For larger sewers the air pressure shall be 750 mm head, the test shall last for five minutes (during which time the sewer will be patrolled) there shall be no audible or visible leaks, and the loss of pressure shall not exceed 50 mm head.

Should any loss of pressure occur during the required time at the stated pressure, a smoke test shall be applied for the purpose of locating the fault. Any failure of the sewers to withstand this test and any defects which may be found while they are under test must be made good by the Contractor at his own expense and a new test carried out subsequently. All defective pipes and joints must be carefully removed and made good in a proper manner to the satisfaction of the Engineer. Upon the successful conclusion of a test, concrete bedding, haunch or surround (where specified) will be placed in the manner previously described and, after at least 48 hours have elapsed, the trench shall be backfilled to a depth of 150 mm over the crown of the pipes and the test again applied; any defects found shall be made good by the Contractor at his own expense.

If the Engineer requires, a final test shall be made after backfilling is complete and the same condition shall apply. No additional payment will be made for this test.

7.16 INSPECTION OF PRESSURE PIPELINES

7.16.1 General

Before being filled with water, pipelines shall be inspected externally and, where large enough to permit it (normally 600 mm nominal internal diameter and above), internally by the Engineer or his designated Representative/Inspector, and the Contractor shall provide all necessary attendance including lighting and other facilities for this purpose except transport and inspecting trolleys.

7.16.2 Inspection Trolleys and Torches

When internal inspection is required, an item will be allowed in the Bill of Quantities for the supply of two trolleys for use in inspecting the interior of the pipeline. These trolleys shall each have four pneumatic tyred wheels running on ball bearings and shall be suitable for conveying a person along the inside of the pipeline. They shall be comfortable to lie on and shall be so sized as to enable inspection of the interior of the pipe to be performed without difficulty.

Suitable torches with a supply of batteries and bulbs shall be provided, as required by the Engineer, for lighting the interior of the pipeline, the cost of which is to be included in the price quoted for the trolleys.

7.17 FILLING AND TESTING PRESSURE PIPELINES

7.17.1 Filling

In rainy weather or where the ground is wet, suitable arrangements shall be made to prevent pipes from floating before they are filled and each portion of the pipeline shall be filled with water as soon as possible after it has been laid, the water being obtained solely from the Employer, unless otherwise agreed by the Engineer.

Before filling any section of the pipeline with water, the Contractor shall ensure that all pipe specials and valves are properly anchored to prevent movement. The main shall then be cleaned and flushed with water so that it is completely clear of all foreign material, silt, dirt, rags or other objects. Filling shall be carried out carefully so as to avoid shock and prevent the entrapment of air anywhere in the main, and for this purpose suitable arrangements shall be made for the escape of air and for introducing water into the pipeline at a rate of flow approved by the Engineer. All filling shall be carried out strictly in accordance with the instructions of the Engineer who shall be warned well before filling takes place.

Suitable blank flanges capable of withstanding the test pressure and provided with 40 mm diameter nipples at crown and invert of the pipe are to be supplied and installed at the ends of each section under test. In the event of air and scour valves not being available by the time testing is due to commence the Contractor will be required to provide suitable blank flanges for all scour and air valve branches within the section under test. Blank flanges for air valve branches shall be provided with a 19 mm diameter nipple and stop cock for the release of air during filling. Items are provided in the Bill of Quantities for the supply of all necessary blank flanges.

Testing of pipelines shall be included in the rates for laying pipelines unless separate items are provided in the Bill for this. The Contractor must make his own arrangements for obtaining water for flushing and filling of each pipeline for test purposes, and for refilling the main for retesting as necessary

7.17.2 Testing

7.17.2.1 Pre-testing

After filling, but before the application of the specified field test pressure, the test section shall be allowed to stand for a minimum of 24 hours. In the case of asbestos-cement and concrete pipes the objective is to ensure saturation of the pipe and coupling surfaces. In addition, and irrespective of the type of pipe and coupling, the entire test section shall be inspected to check for:-

- (b) Visual leaks or sweating at couplings, flanges or through pipe walls
- (c) Signs of pipe, fitting or anchor block movement
- (d) Air discharge
- (e) Leakage of any kind

Any faults thus found shall be made good prior to the application of the specified/detailed Field Test Pressure.

7.17.2.2 Field Testing of Asbestos Cement, Concrete or Cement Mortar Lined Steel Pipes

After satisfactory completion of the "Pre-Test" detailed above, the test section shall be hydraulically tested to the specified Field Test Pressure. The Contractor will be responsible for all the temporary measures necessary for anchoring blank flanges at the ends of the section under test, and testing against closed valves will not be allowed. The lengths of pipeline to be tested shall be approved by the Engineer whose decisions shall be final, but they may be limited to avoid having long sections of trench open. Testing shall only be carried out at such times and in such manner as the Engineer shall direct.

The Contractor shall be responsible for supplying a suitable and approved pump complete with all necessary connections, all plugs, stoppers, valves, a calibrated pressure gauge, and all the necessary tools, pipe specials and labour required to carry out the tests. The Contractor shall provide test flanges fitted with 40 mm diameter nipples and an item is provided in the Bill for these. The calibrated pressure gauges which must be approved by the Engineer, shall be tested by an independent laboratory whenever required by the Engineer and a copy of the test certificate given to the Engineer prior to carrying out the field test. The pressure gauge dial shall not be less than 200 mm diameter and shall be calibrated within a range suitable for the pressures required so that an accuracy of 3% can be obtained.

Notwithstanding the objectives of the "Pre-Test" detailed above, in the case of asbestos cement, concrete and cement mortar lined steel pipes when subjected to pressures, a further absorption into the walls or lining can be expected resulting in a pressure drop. To make good this pressure drop the Contractor will be allowed to introduce make-up water to the test section to maintain the specified field test pressure. The required make-up water shall be measured and recorded at hourly intervals during the overall test period and the maximum permissible make-up water shall be calculated using the graph in Figure D1 below

When testing asbestos cement or concrete pipelines the following procedure shall be adopted:

When all air has been expelled and not less than 24 hours after filling has been completed, the pressure shall be raised at a rate not exceeding 15 metres head (1,5 bars) per minute by pumping water into the section of pipeline being tested, and shall be maintained at the required pressure for not less than 3 hours or for such longer period as the Engineer may require for inspection. During the period of the test there shall be no visible pipe or anchor movement, fissure, leakage or sweating through pipe coupling or flange; if any pipe or anchor movement, fissure or leakage is observed the test shall be discontinued and the defect or defects made good and the test repeated.

During the sequential hourly testing:-

- (a) a reduction in make-up water in accordance with the permissible figures calculated from the graph (Fig D1) indicates a self-correcting state;
- (b) a constant or increasing quantity of make-up water indicates a fault which must be investigated, rectified and the Field Hydraulic Test repeated.

Figure D1: Make-up water in field testing of pressure pipes

See overleaf

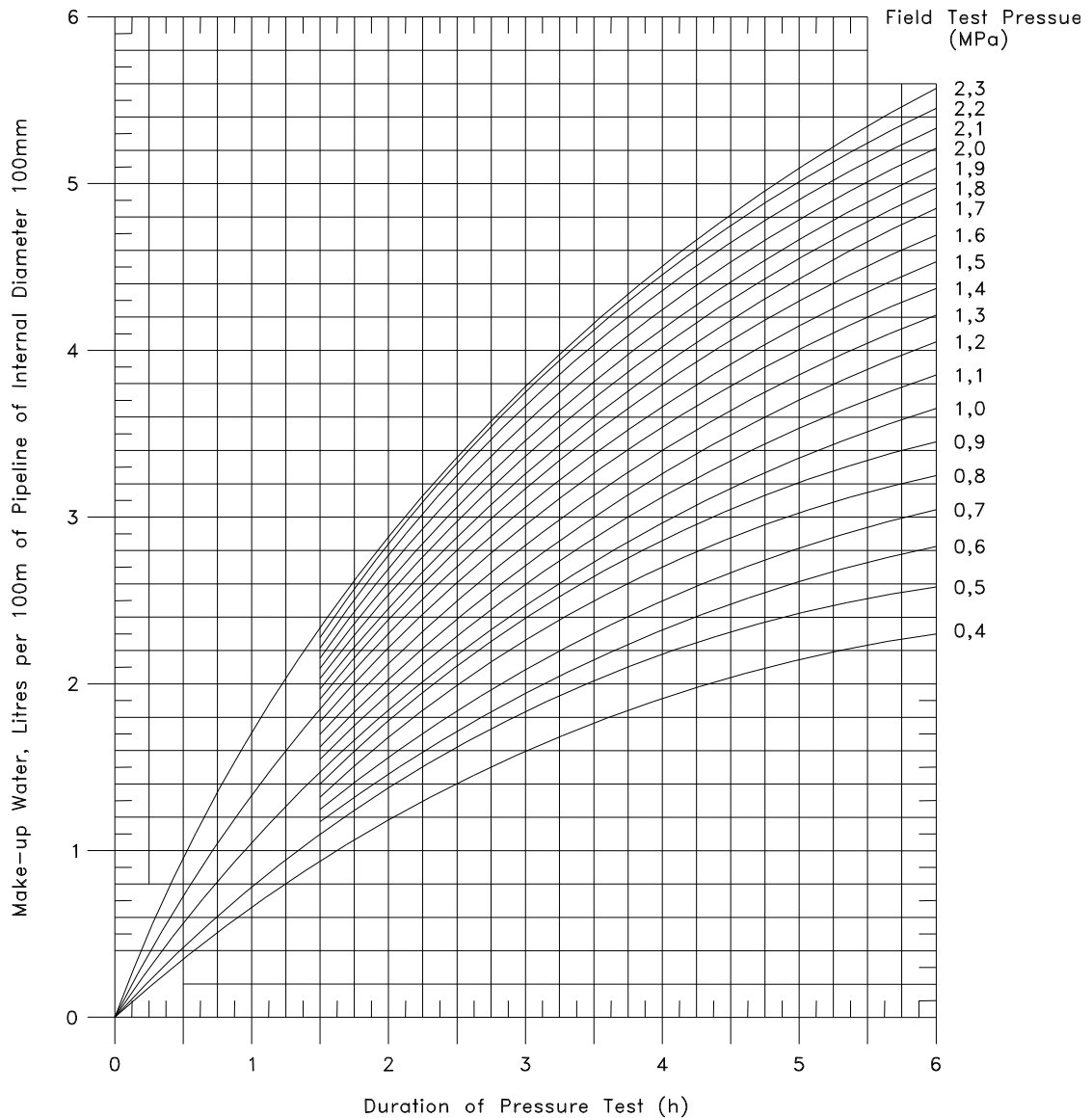


Figure D1: Make-up water in field testing of pressure pipes

7.17.2.3 Field Testing Continuously Welded Steel Pipes with bitumen or epoxy linings

As for asbestos cement, etc pipelines above except that no make-up water shall be permitted.

7.17.2.4 Field Testing jointed pipes in Steel, Cast iron, Polythene, HDPE and PVC

As for asbestos cement, cement mortar lined etc pipelines above except that make-up water shall not exceed 10% of the permissible value calculated from the graph (Fig.D1).

7.17.2.5 Failure to Pass Test

If the specified pressure is not attained or maintained, or if the rate of pumping or leakage is excessive, or in the event of any weakness, defect, leakage or fracture occurring in the pipes under test, the Engineer may order the test to be discontinued or repeated, and the Contractor shall thereupon search for and rectify any weakness or defect in the pipes under test.

The work of rectification is to consist of repair or replacement or both to the order and satisfaction of the Engineer; the pipework shall thereafter be refilled with water and retested in the manner specified. This process shall be repeated until a satisfactory test is obtained, and no section of a pipeline will be accepted unless it has withstood the hydraulic test under the specified conditions. Where the work fails test due to the act or omission of the Contractor, all the work of rectification shall be done entirely at his expense.

7.18 FAILURE TO TEST PIPEWORK

Until pipework has been tested and accepted by the Engineer, payment for pipes laid in excess of 2km will only be made as "Materials on Site". In addition to these provisions for ensuring that the Contractor tests pipework promptly, the Engineer is empowered to forbid all further excavation for or laying/installation of pipework when the untested length of pipeline, or of open or partly open trench, exceeds 5 kilometres. No claim for additional payment or extension of time shall be founded upon such an order or the Contractor's compliance with it.

The same provision shall apply to any sewer but for an untested length of 400 metres.

Bid rates for testing pressure pipelines shall cover all temporary arrangements required for passing or pumping water through from one section of the pipeline to the next, and the filling and testing of the pipeline including the supply and use of all the plant, pipework, pumps, tanks, labour and supervision required.

Backfilling over joints may be done only after the completion of a satisfactory hydraulic test.

7.19 CLEANLINESS AND STERILISATION OF POTABLE WATER MAINS

The interior of bitumen lined pipes and fittings are to be kept spotlessly clean and free from all contamination and the Contractor is to take every precaution to ensure this. Temporary end covers and caps are to be applied to these pipes at all times and contamination by windblown dust or careless handling avoided.

All watermains shall be sterilised before commissioning or connection to mains in use. After the pipeline has been tested, cleaned and flushed, it is to be filled with a chlorine solution having a strength of 20 milligrams of chlorine per litre, introduced by injection pump as a concentrated solution at a rate proportional to the inflow of water filling the main which is to be accurately measured to ensure uniform and correct solution strength. The solution is to remain in the mains for 24 hours, when a sample is to be taken and checked for chlorine residual. Provided the residual is not less than 10 mg/l, the pipework shall remain charged for a further three days after which the potability of the water is to be checked at every point along the main at which a sample can be drawn. If the Engineer finds the chlorine content excessive, sufficient water shall be run to waste to ensure a reasonable

dilution and the sterilised section then connected and commissioned with every care to avoid contamination.

Any valves, pipes or fittings inserted in the system to make a connection shall be thoroughly cleaned and swabbed internally with a solution of 25 mg/l chlorine.

If it is proved convenient in practice, the Engineer may require the tests for chlorine residual to be done by the Government Analyst, or some other specified laboratory, transport and testing costs then being met by the Employer. The Contractor's rates shall be deemed to allow for any additional delay in obtaining the results from the laboratory.

With the Engineer's approval, sterilisation may be undertaken in conjunction with hydraulic testing.

All the equipment required for sterilisation including pumps, tanks, pipework, hoses and weighing scales, is to be provided by the Contractor. Granular chlorine or similar approved chemicals shall be used for disinfection. The Bill of Quantities contains an item to cover sterilisation (disinfection).

7.20 CATHODIC PROTECTION

The Bill of Quantities may include a Provisional Sum for cathodic protection which will be designed, supplied and installed by a specialist Subcontractor to the approval of the Engineer.

7.21 PAYMENT FOR PIPELAYING

Rates in the Bill of Quantities for the supply on pipes shall include to inspect, take delivery, load, transport to site, off load, store if necessary, handle, lay, joint, check for leakage, paint as specified on completion where necessary, and test, except that for pressure piping a separate item in the Bill covers the testing.

Laying and jointing of pipes will be measured and paid in linear metres of pipeline as laid, excluding valves and fittings contributing to the length of the pipeline. Additional payments will be made for the installation of valves and specials as provided for in the Bill of Quantities.

Payment for untested pipework in long pipelines will be limited to a total length of 2 km. If short lengths of pipework are to be tested, payment will be made only when the test is satisfactorily completed.

8 SANITATION FACILITIES

Sanitation facilities for persons with disabilities were designed based on the National Guidelines for WASH in Health Care Facilities in Uganda, 2021. The contractor shall follow the National Guidelines for WASH in Health care facilities in Uganda, 2021 while implementing this activity.

Special Facilities

Wooden worktop and shelves 20mm thick made from solid tropical hard wood timber and finished with formica sheeting or made from medium density fibre boards (MDF) completely secured to the toilet walls directed by the Project Manager.

Wheel chair access ramp at entrances.

Access Ramps

For all access ramps to be constructed the following specifications should be adhered to;

- i. The maximum slope of ramps should be 1:20 (5 cm per. m) with a minimum width of 1.3m and maximum width of 1.5m.
- ii. A flat landing area should be provided at the bottom and top of the ramp, and where direction changes, with minimum dimension of 1.3m X 1.3m and maximum dimensions of 1.5m X 1.5m.
- iii. Galvanized iron Handrails should be provided on both sides, with double handrail; at heights of 0.6m and 0.9m from the ramp floor level. Rails for wheels should be placed at the bottom of the rails at a height of 0.15m.
- iv. The ramp surface should be finished with a hard and non-slip terrazzo finish with tactile markings/patterns/ texture in contrasting colour at the beginning and end of the ramp.

9 ENVIRONMENTAL SPECIFICATIONS

9.1 GENERAL REQUIREMENTS

9.1.1 Site Establishment and Management

Every precaution shall be taken, in accordance with this specification, to prevent pollution of air, soil, ground and surface water as a result of construction or associated activities at all locations (including borrow pits) of the contract.

Traffic routes to working areas: no indigenous site vegetation shall be destroyed by construction vehicles, unless authorised by the Engineer.

Staff ablution facilities: only chemical toilets flush or/toilets discharging into approved septic tanks and soakaways will be allowed on site so as to limit potential groundwater pollution caused by other forms of ablution facilities.

Stormwater control measures: care should be taken not to alter natural stormwater drainage during construction activities resulting in potential pollution.

Pollution control:

- Discharge of hazardous chemicals on the site or to the stormwater system is prohibited.
- Soil erosion caused by construction activities shall be kept to a minimum. Care should be taken in the siting of facilities and materials.
- All wastewater leaving the site shall be contained and treated before release to the streams, to comply with Government standards for wastewater/effluent discharge.

Management of waste: litter and solid waste, associated with construction activities, shall be confined to areas designated for that specific use by the Engineer.

The Contractor shall draw-up a plan of all parts of the construction site, showing the layout of site establishment, topsoil stockpiles, planned access and circulation routes, borrow pits, etc. The plan shall be submitted to the Engineer for comment and approval before site establishment commences.

Where the Environmental Specification is in conflict with other sections of the technical specification, the Environmental Specification shall apply.

9.1.2 Housekeeping

The Contractor shall ensure that the Contractors camp and working areas are kept clean and tidy at all times. The Engineer shall inspect these areas on a regular basis.

9.1.3 Demarcated areas and fencing

Routes for temporary access and haul roads shall be located within the approved demarcated areas and vehicle movement shall be confined to these roads. Movement of vehicles outside the designated working areas shall not be permitted without written authorization from the Engineer.

All construction activities shall be restricted to designated working areas shown on the drawings and/or approved by the Engineer. Materials, including spoil, shall only be stockpiled on designated areas.

Fences as indicated on the drawings and tender specification shall be maintained throughout the construction period. All temporary fencing as indicated by the Engineer shall be removed on completion of the contract.

9.1.4 Fire risk and Burning

Burning of vegetation including tree trunks and stumps cut during site clearing and establishment shall not be permitted unless authorised by the Engineer. Woody material not required by the Contractor should preferably be given to the surrounding community. All vegetation not disposed of by means of the above nor retained for landscaping purposes shall be removed to a site designated by the Engineer.

The Contractor shall ensure that the risk of fire at any location on the site is kept to a minimum.

The Contractor shall supply firefighting equipment appropriate to the fire risk presented by the type of construction and other on-site activities and materials used on site. This equipment shall be kept in good operating order.

Open fires for heating and cooking shall only be permitted in protected areas designated by the Engineer for this purpose. The Contractor shall supply his labour force with wood, coal etc for cooking and heating purposes

No fires will be allowed adjacent to the boundary fence, either inside or outside the Works.

9.1.5 Storage of fuel and other materials

Fuel, lubricants, transmission and hydraulic fluids shall only be stored in the designated areas.

9.1.6 Control of damage to plants, trees and animals

The underlying requirement is to minimise damage to natural habitats within the designated area. In practice a certain amount of damage is sometimes unavoidable, in which case the aim is to rehabilitate the disturbed land according to a rehabilitation plan approved by the Engineer or the Engineer's instructions.

9.1.7 Destruction of plants and trees

Plants and trees within the designated area shall only be moved or removed with prior written approval of the Engineer to areas specified by the Engineer. Removal, damage or disturbance of any plant or trees outside the said areas is not permitted.

Gathering of firewood outside the designated area shall not be permitted.

9.1.8 Disturbance of animals

Any animals resident within the site shall not be killed nor unnecessarily disturbed. Where sensitive species occur these shall be relocated at the Employer's cost.

9.2 CONTROL OF DAMAGE TO SOIL AND WATER

9.2.1 Topsoil

Topsoil shall be stripped from the areas as indicated below prior to the commencement of site establishment and construction and stockpiled for use in reinstatement and rehabilitation:

- roads;
- any part of the site where berms are to be constructed from overburden, subsoil and excavated materials;
- any area upon which structures, buildings and hardstandings are to be constructed;
- any area which is to be used for temporary storage of materials including topsoil stockpiles;
- areas which could be polluted by any aspect of the construction activity; and
- areas designated for the dumping of spoil.

The Contractor shall ensure that subsoil and topsoil are not mixed during stripping, excavation, reinstatement and rehabilitation.

Stripping of topsoil shall be undertaken in such a way as to minimise erosion by wind or runoff. Areas from which topsoil is to be removed shall be cleared of any foreign material which may come to form part of the topsoil during removal including bricks, rubble, any waste material, litter, excess vegetation and any other material which could reduce the quality of the topsoil.

Topsoil shall be stockpiled in areas designated by the Engineer. Where required the stockpiles shall either be vegetated or covered by a suitable fabric to prevent erosion and invasion by weeds.

Topsoil shall be stripped from the above areas to a depth not exceeding 300 mm from the original ground level unless otherwise specified by the Engineer, after clearing and grubbing of the area is complete.

9.3 CONTROL OF POLLUTION

As a minimum requirement all waste emissions (hazardous, airborne, liquid and solid) from the site shall be kept within the limits of standards set in terms of relevant national and local pollution legislation and regulations.

9.3.1 General

No waste of a solid, liquid or gaseous nature shall be emitted from the site without approval by the Engineer.

Accidental pollution incidents shall be reported to the Engineer immediately after they occur and shall be cleaned-up (to the satisfaction of the Engineer) by the Contractor or a nominated clean-up organisation at the expense of the Contractor.

9.3.2 Soil

Vehicle and plant maintenance shall be confined to the areas demarcated for this purpose. Should any fuel, transmission oil or hydraulic fluids be spilled onto the soils the Engineer shall be informed immediately.

9.3.3 Water

The quality of water bodies on and/or adjacent to the site will probably be monitored before, during and after construction by the Employer.

9.3.4 Air

All reasonable measures should be taken to minimise air emissions in the form of smoke, dust and gases. e.g. by applying dust prevention techniques such as the sprinkling of water.

9.4 MANAGEMENT OF WASTE

All wastes arising from construction activities are to be handled, transported and disposed of in accordance with the relevant regulations. All efforts should be made to minimise, reclaim or recycle waste, and failing that, dispose of it in a manner licensed by the government for that purpose.

9.4.1 Sewage

The Contractor shall provide sanitation facilities in the form of chemical toilets or flush toilets at the camp, office, workshop and construction site for staff and visitors discharging to septic tank(s) and soakaway(s). The location, number and sizing of all such facilities shall be to the approval of the Engineer. No other form of sanitation will be permitted except with the written approval of the Engineer. No surface discharge of septic tank effluent will be permitted.

9.4.2 Wastewater

All runoff from both fuel tanks/drums, truck washing areas and wash water from concreting vehicles and other equipment shall be collected and directed through oil traps to settlement ponds and treated to comply with National standards for effluent disposal. The settlement ponds shall be suitably lined at the Contractor's expense, if required in the opinion of the Engineer, in order to minimise potential groundwater pollution.

Wastewater may not be disposed of directly into drainage lines, streams or the dam. The Contractor shall provide suitable retention and filtration structures (which shall be properly maintained) for the collection of wastewater. Wastewater from dewatering activities will be allowed to settle before the supernatant is pumped or gravitated to the streams.

Any water used for cleaning, testing and commissioning of equipment shall be contained in a retention structure and if necessary treated before discharge to one of the streams or Dam.

Washing and changing facilities shall be provided by the Contractor. All run-off from these washing and/or changing facilities shall be contained and treated to the satisfaction of the Engineer.

9.4.3 Solid Waste

Definition: "Refuse" refers to all construction waste (such as rubble, cement bags, waste cement, timber, cans, other containers, wires and nails), household and office waste.

Refuse shall be collected and stored in demarcated, fenced areas in skips and/or bins. The fenced areas or containers should be designed to prevent refuse from being blown out by wind and should be strategically and conspicuously placed throughout the site

Refuse shall not be buried nor burned on site unless prior written approval has been sought from and given by the Engineer

9.4.4 Hazardous Waste

Definition: Hazardous wastes are those which are proven to be toxic, corrosive, explosive, flammable, carcinogenic, radioactive, poisonous or as determined by the Hazardous Substances and Articles Act as amended.

Discharges of hazardous chemicals (such as paint, turpentine and oil) on the site or to the stormwater system are prohibited, as declared under the Hazardous Substances and Articles Act as amended.

Potentially hazardous raw and waste materials shall be handled and stored on-site in accordance with the manufacturer's specification and relevant legal requirements.

Hazardous waste products shall include, but shall not necessarily be limited to, the following:

- cement;
- diesel, petroleum, oil and lubricants;
- explosives;
- drilling fluids;
- pesticides;
- concrete additives; and
- water purification chemicals.

All hazardous waste products shall be removed from site and disposed of in a manner, and at a site, approved by the Hazardous Substances and Articles Control Board.

9.5 MANAGEMENT OF STORMWATER AND EROSION

The aim is to minimise soil loss from the site due both to wind and water.

9.5.1 Storm water

At all stages of the contract, stormwater control measures as specified by the Engineer shall be applied to keep soil on-site by minimising:

- erosion of temporary stockpiles of topsoil and permanent spoil dumps;
- erosion from construction roads, excavations and borrow pits;
- silt-laden run-off from all areas stripped of vegetation, including excavation surfaces and stockpiles of spoil and topsoil;
- contaminated run-off from storage areas;

thereby preventing it from entering water courses.

Natural stormwater run-off which is not polluted by site operations shall be diverted around spoil dumps and topsoil stockpiles.

Where uncontaminated stormwater has accumulated in the workings and needs to be pumped out, it must be disposed of into the side streams in such a way that erosion does not occur along the course of its passage.

9.5.2 Control of Erosion

At all stages of the contract, erosion of bare soil, other excavation surfaces and stockpiles of topsoil and spoil shall be prevented by the application of erosion control measures as specified by the Engineer.

Should erosion occur due to negligence on the part of the Contractor in applying the above measures, the Contractor will be responsible for reinstatement of the eroded area to its former state at his own expense. Any surface water pollution occurring as a result of this negligence will be cleaned up by the Contractor or a nominated clean-up organisation at the expense of the Contractor.

Cross and side stormwater drainage measures shall be constructed on access and haul roads to the site and on roads within the site.

The Contractor shall ensure that run-off from access and haul roads, and that diverted into cross and side drains, does not cause erosion.

9.6 REHABILITATION

At all excavation sites, the soil excavated shall be replaced after completion of the construction activity, and revegetated with indigenous grass and plants according to landscaping instructions within 30 days after completion of the construction activity, to the satisfaction of the Engineer.

All construction sites (including borrow pits) will be cleaned and rehabilitated to their original state and/or to the satisfaction of the Engineer.