SPECIFICATIONS

A specification set is the ensemble of drawings, text, bills of materials, and directions that constitutes the decision record in a form that enables the builder or user to realize function safely, reliably, competitively, and useably, the product having been fabricated and serviced to the customer's satisfaction.

The specification set for a water pumping system can be provided in text format to a contractor (builder), to procure and install the pump and pipeline, as shown below:

**PIPELINE SPECIFICATION SET**
- **MATERIAL**: UPVC
- **PRESSURE CLASS**: PN10
- **SIZE**: PIPE DIAMETER 280 MM
- **LENGTH**: 4 km

**PUMP SPECIFICATION SET**
- **PUMP TYPE**: CENTRIFUGAL
- **DISCHARGE FLOW CAPACITY**: 220 M3/HOUR
- **TOTAL PUMPING HEAD GENERATED**: 70 METRES OF WATER
- **OPERATIONAL SPEED**: 1450 RPM
- **OVERALL PUMP EFFICIENCY**: 65 %

**DESIGN ANALYSIS AND REPORT**

What the specification set does not reveal is which of its elements are addressing, singly or in combination, matters of function, safety, reliability, and competitiveness. A designer needs an alternative (equivalent) set that shows each necessary decision, allows bifurcation (division) into a priori and design decisions, allows tagging to show which variable (function, safety, reliability, or competitiveness) is addressed, and reveals the dimensionality of the problem.

Note that these statements (Specifications) are required by the contractor to replicate the unique pumping system desired. It is not clear how, or if, the various statements (specifications) addresses function, safety, and so on, nor does the contractor care. However, the designer does, and therefore organizes the equivalent decision set as discussed below.

**DECISION SET**

A decision set is a list of decisions required to establish the specification set. The decision set is equivalent to the specification set. Either may be deduced from the other on the basis of convenience to clear thinking. The decision set is expressed in terms of the designer's thinking parameters, and it easily focuses on function, safety, reliability, and so on. For example, the specification set for a pumping system can be displayed as follows:

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PIPELINE SPECIFICATION DECISION SET

In the list below, decision sets (1-8) lead to pipeline specification set (9)
1) Water demand volume required-Addresses function
2) Operating duty hours per day-Addresses function, namely demand volume
3) Guideline flow velocities for water pipelines that yield economic competitiveness-competitiveness
4) Pipe size (theoretical) applies a priori decisions 1,2,3- Addresses function and competitiveness
5) Available pipe materials and standard-Available technology that addresses function and competitiveness
6) Pipe size (available pipe materials and standards), addresses function and competitiveness
7) Pumping pressure generated in the pipe selected at stage 6-Addresses function and pipe safety
8) Pressure class or capacity of pipe required to withstand total pumping pressure predicted at 7- Addresses pipe safety
9) Specification of pipe selected (material, size, pressure capacity, length)

PUMP SPECIFICATION DECISION SET

In the list below, decision sets (10, 11) lead to pump specification set (11)
10) Total pumping head predicted for the actual pipe selected at 9 (pipeline’s characteristic curve shows operating point for desired flow)
11) Smallest Pump that will deliver the required demand and head is selected- Addresses function and competitiveness
12) Specifications of pump: Type, size (flow and head), efficiency, manufacturers designation

Note that these statements are used by the designer to identify decisions, what they address, and the dimensionality of the problem.

Composing a decision set to be properly revealing and useful is a skill developed through knowledge and practice. There is some duplication between entries in the specification set and decision set, but observe the explicit appearance of thinking parameters in the decision set

A PRIORI DECISIONS, DESIGN VARIABLES, AND DECISIONS

The first three decisions in the previous decision set example can be made a priori (they are called a priori decisions).

a) Water demand volume required-Addresses function
b) Operating duty hours per day-Addresses function, namely demand volume
c) Guideline flow velocities for water pipelines that yield economic competitiveness-competitiveness
The ninth decision (Specification of pipe, namely, material, size, length, pressure capacity), and twelfth decisions, (Specifications of pump, namely, type, size (flow and head), efficiency); are called design variables before the decision is made, and the design decision after decision is made.

It is through this variable that the designer attends to issues of preserving function, safety, and reliability, specifically using it to address competitiveness through optimality. In, this case, knowledge that there is an independent variable influences selection of the methodology used to establish the pipe and pump size.

STANDARD TECHNICAL SPECIFICATIONS3: WATER SUPPLY PROJECTS

The special specifications required for a particular defined problem can be elaborated by standard specifications, which are adopted by a particular body or organisation, such as the Ministry of Water and Irrigation. The section on pumps is reproduced below.

9.8 Pumps

1) The pumps shall be of the centrifugal type with Cast Iron casings. The shaft shall be prepared for direct connection via flexible coupling of the motors.
2) Pump casing shall have interchangeable, bronze wear rings. The impellers shall be of bronze or high grade cast iron dynamically balanced to ensure smooth running.
3) The propeller shaft shall be of steel and fitted with renewable bronze protecting sleeves wherever it is in contact with the pumped water.
4) Mechanical seals shall be provided unless approved otherwise.
5) It shall be stated in the tender documents if other materials are offered. For horizontal type pumps, the propeller shaft shall be carried by oil or grease lubricated ball or other bearing if heavy duty type.
6) The pump casing bearing, shaft, impellers and gaskets must be executed of materials suitable for many years continuous operation in water system.
7) If materials other than cast Iron, bronze or stainless are included in the pump, it cannot be approved unless a written guarantee for 10 years performance is produced, giving free checking and replacement in case of fault.
8) The performance curves, efficiency curves, and power demand curves (characteristics curves) shall accompany the tender with clear indicator of the capacity and efficiency of the pump with the specified head.

Standard specifications are those that are general and can be applied to several situations as shown above

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3 Standard Technical Specifications, Ministry of Water and Irrigation, Republic of Kenya, Director, Water development, Pages 79
STANDARD TECHNICAL SPECIFICATIONS

6 PIPE WORKS

6.1 Materials

6.1.1 Concrete Pipes

General

Precast concrete pipes and fittings shall comply with BS 5911: Part 100.

Minimum crushing test loads shall be as specified in Table 7 of the said standard.

Where plot chambers are connected directly to the main sewer, the connection shall be done by oblique-angled junctions with an angle of 45°.

Concrete pipes with flexible joints

The joints of pipes and junction shall be of a type which is able to maintain a maximum angular and straight movement as shown in the following table, without loss of water tightness under the pressure stated in clause 7.7 Testing.

<table>
<thead>
<tr>
<th>Internal Diameter</th>
<th>150</th>
<th>225</th>
<th>300</th>
<th>375</th>
<th>450</th>
<th>525</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angular movement</td>
<td>1.67</td>
<td>1.19</td>
<td>0.89</td>
<td>0.72</td>
<td>0.60</td>
<td>0.504</td>
</tr>
</tbody>
</table>

Concrete pipes with rigid joints

The joints of pipes and junctions shall be sealed with mortar mix 1:3.

6.1.2 Unplasticised Polyvinyl chloride (UPVC) Pipes

All UPVC pipes and fittings shall comply with ISO-standard 4435 or BS 4660:1973/78 and BS 5481:1977.

Nominal outside diameter and nominal wall thickness of the PVC pipes are shown in the following table:

<table>
<thead>
<tr>
<th>Class 41</th>
<th>Nominal Outside diameter in mm</th>
<th>160</th>
<th>200</th>
<th>250</th>
<th>315</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal wall thickness in mm</td>
<td>3.9</td>
<td>4.9</td>
<td>6.1</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>Class 34</td>
<td>Nominal Outside diameter in mm</td>
<td>4.7</td>
<td>5.9</td>
<td>7.3</td>
<td>9.2</td>
</tr>
</tbody>
</table>

Pipes and fittings shall be golden brown approximately to colour 414 of BS 381 C.

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4 Ministry of Water and irrigation, Republic of Kenya, Director, Water development, Pages 59-91
6.1.3 Ductile Iron Pipes

Ductile iron pipes and fittings shall comply with BS 4772 or ISO 2531. The pressure rating of the pipe shall be for a minimum working pressure of 2.5N/mm².

Joints in pipe bridges are flanged, spigot-socket or Viking Johnson Couplings.

Pipes and fittings shall be coated inside and outside with a hot pipes material complying with the requirements of BS 4164 "Coal Tar based hot applied coating materials for protecting iron and steel" or with a cold applied material complying with BS 3416 "Black bitumen coating solutions for cold application", Type 1 material.

6.1.4 Sluice Valves

Sluice valves shall comply with BS 5163, PN 10. They shall be flanged in accordance with BS 4772, PN 10.

6.1.5 Precast Concrete Covers

Concrete covers to be manufactured according to the detailed drawings.

6.1.6 Cast Manhole Covers

Covers in traffic areas: Standard Triangular Heavy Duty Frame and cover according to BS 497. Ref. A2-19 1/2.

Covers for plot chambers: Grade C(Light Duty) single seal recessed type inspection cover and frame according to BS 497 ref. C8-24/18.

6.1.7 Manhole Step Iron

To be manufactured according to the detailed drawing.

6.1.8 Steel Work

All steel to be hot dip galvanized according to BS 729. All steel surfaces exposed to sewage shall be coated with black bitumen coating to BS 3416, TYPE 1 material.

6.2 Handling and Storing Materials

6.2.1 General

The method of transportation, handling and storing of pipes and fittings shall be in accordance with the manufacturer's recommendations.
Pipes, valves, specials and other materials shall be handled, moved, lifted or lowered with the least possible impact. Handling equipment shall be of approved type. In slinging pipes, only flat slings shall be used and the use of chain slings, hooks or other devices working on scissors or grab principles shall not be permitted. Pipes shall be slung from two or more points as the Engineer may direct and the slinging, lifting and lowering shall be in the hands of a competent and experienced man. Care shall be taken to keep pipes and fittings clean and free from soil, mud, dirty water, solvents chemicals etc.

Subject to the requirements of inspection before acceptance, protective bolsters, caps or discs on the ends of flanges of pipes or specials shall not be removed until the pipes or specials are about to be lowered into the trench. Every precaution shall be taken to prevent damage to internal linings of external coatings.

Pipes in storage shall be supported clear of the ground on approved supports and adequately braced to prevent rolling. They shall not be stacked more than four tiers high without the approval of the Engineer.

**Materials of different classification shall be stored separately.**

All pipes and associated material shass at all times be protected from sun and weather to the satisfaction of the Engineer.

**No valves shall be lifted by the spindle.**

No valves, fittings or specials shall be stacked more than one tier high without the permission of the Engineer, and they shall not be stored in a dirty place or condition and shall not be allowed to become embedded in earth, sand, stone, aggregate, water, fuel, or any other deleterious matter.

Valves and their ancillary equipment shall be protected before and after erection against collapse of earthworks, falls of materials, concrete and cement droppings, wood and other matter.

Shortly before the laying or fixing any valve, pipe or fitting the contractor shall in the presence of the Engineer or his representative carefully examine each valve, pipe and fittings during loading, unloading, handling, storage and transportation. All damage and all defects revealed by this examination shall be repaired and remedied by the contractor.

**6.2.2 Transport of PVC pipes**

The full length of the pipe shaft shall rest on the loading area of the lorry. Overhanging of pipes, to prevent sagging and deformation shall be avoided. Rough handling and dragging of pipes and fittings shall be avoided.

**6.2.3 Storing of PVC pipes**

PVC pipes shall not be stored on each other to a height exceeding 1.5m. Pipes shall be staggered to prevent the sockets to rest on the shaft of the pipes. The first tier shall be placed on a well
drained layer of sand. All pipes and fittings shall be protected from sunlight by use of tarpaulins. Grass cover will not be accepted.

6.3 Excavation of Trenches

6.3.1 Trench Width

The minimum trench width shall be according to the detailed drawings, corresponding to the minimum width indicated below:

<table>
<thead>
<tr>
<th>Concrete Pipes</th>
<th>150</th>
<th>225</th>
<th>300</th>
<th>375</th>
<th>450</th>
<th>525</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of Trench</td>
<td>805</td>
<td>890</td>
<td>970</td>
<td>1060</td>
<td>1140</td>
<td>1220</td>
</tr>
<tr>
<td>PVC Pipes</td>
<td>160</td>
<td>200</td>
<td>250</td>
<td>315</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Width of Trench</td>
<td>460</td>
<td>500</td>
<td>550</td>
<td>615</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

6.4 Laying and Jointing

6.4.1 General

All laying and jointing of pipes except jointing of PVC and Polythene pipes shall be in conformity with CP 301 and CP 2010.

The bottom of the trench or surface of the bed shall be finished to a smooth even surface at the correct level to permit the barrel of the pipe to rest on the surface throughout its whole length between joint and sling holes. If considered necessary by the Engineer, fine screened material shall be placed and consolidated in the trench bottom to provide such a bed. The bottom of the trench and pipe bed shall be inspected by the Engineer, and only when passed as satisfactory shall pipe laying commence.

Each pipe shall be laid accurately to line, level and gradient so that, except where otherwise directed, the finished pipe line shall be in a straight line both in horizontal and vertical plans.

The levels and gradients shown on the drawing shall be rigidly adhered to unless otherwise ordered by the Engineer.

Where lines of pipe are to be constructed, the contractor shall provide and fix, at such points as may be directed, properly painted and securely positioned sight rails, the levels and positions of which shall be examined and checked by the Engineer before the rails are used and as often thereafter as may be necessary.

There shall at no time be less than three sight rails in position on each length of pipeline under construction to any one gradient, and the sight rails shall be situated vertically above the line of pipes, or immediately adjacent thereto.

Pipes shall be lowered singly into the trench, brought to the correct alignment and inclination bedded throughout their length, and properly jointed strictly in accordance with the
manufacturer's instructions. Unless otherwise approved by the Engineer, pipes shall be laid in an upstream direction and the socket of the pipes shall face upstream and every pipe shall be concentric with the previous.

Notwithstanding any flexibility provided in pipe joints, pipes must be securely positioned to prevent movement during and after the making of a joint. On screw and socket joints threads shall be coated with an approved tape to ensure watertightness.

Long radius curves in the pipeline shall be negotiated by deflections taken up in the joints or pipes of one or more lengths of pipes. The deflection at each of the various types of joint of pipes used in the works shall not exceed the manufacturer's specifications.

The contractor shall take care that all pipes and couplings are clean and free of foreign matter before subsequent sections are jointed.

The contractor shall obtain from the manufacturer or other approved supplier the necessary tackle required for the proper jointing of the pipes.

The contractor shall make himself and his employees acquainted with and comply with the instructions issued by the manufacturers of the various types of proprietary joints and couplings for incorporation in the works. The contractor shall be responsible for obtaining copies of such instructions.

Pipes shall not be cut without the permission of the Engineer. The cut shall be made with an approved mechanical pipe cutter and the edges of the cut shall be clean, true and square.

Threading of steel pipes shall be done with an approved device.

Subject to the permission of the Engineer, pipes shall be covered over with approved fill material upon successful completion of laying and joining. Joints shall be left exposed until completion of the pressure test.

Fill for surrounding and cushioning shall consist of uniformly readily compatible material free from tree roots, vegetable matter, building rubbish and excluding clay lumps retained on a 75mm sieve and stone retained on a 25mm sieve.

Adequate precautions shall be taken by way of back-filling or other means to anchor each pipe securely to prevent flotation of the pipeline in the event of the trench being flooded or during concreting.

Upon successful completion of the pressure test, the pipeline shall be back-filled as specified.

6.4.2 Concrete Pipes

(a) General
Each concrete pipe or joint, immediately before being laid, shall be carefully brushed out and tested for soundness by striking with a hammer, and any pipe or joint which does not ring true or which shows in any way other way any sign of being defective, shall be rejected.

Concrete pipes will be laid either in sand, gravel or concrete bedding.

In cases of a sand or gravel bedding, the contractor shall ensure that each pipe is supported throughout it's length by the barrel according to the bedding factor. The pipe is to be supported at least by the quarter of the barrel for bedding factor 1.9.

The pipes has to be bedded on a firm foundation of sand gravel which does not contain any hard lumps.

Joint holes are to be formed in the sand to enable joints to be made and inspected but they are to be as short as practicable.

In cases of concrete bedding the contractor shall lay the pipes on precast concrete stools of the same quality of concrete used for bedding, and the stools should have the same curvature as the pipes barrel. The pipes should be adjusted to the required levels and after checking jointing and testing them, concrete for bedding will be poured and compacted well at the underside of the barrel and socket of the pipes.

(b)Concrete pipes with flexible joints

Concrete pipes with flexible joints will be laid in sand gravel or concrete bedding.

(c)Concrete pipes with rigid joints

Concrete pipes with rigid joints will always be laid in concrete bedding with the appropriate bedding factor.

The rigid joints for concrete spigot and socket pipes shall be made as follows:-

(1)Before commencing the jointing operation, the socket of the previously placed pipe and the spigot of the new pipe shall be cleaned and thoroughly soaked with water.

(2)The spigot shall be wrapped one complete lap with tarred hempen spun yarn and the new pipe shall be carefully drawn towards the previously laid pipe so that the spigot enters the full depth into the socket of the previously laid pipe. The new pipe shall then be adjusted and fixed in its correct position in line, level and gradient and the tarred yarn shall be caulked tightly home into the socket.

On completion of this operation, the yarn shall not fill more than one quarter of the total depth of the socket.
(3) The remainder of the socket shall be completely filled with cement mortar consisting of one part of cement to three parts of sand. The mortar filling shall terminate flush with the socket and shall be neatly trowelled to a smooth finish around the pipe.

(4) To assist the curing of the mortar, the contractor shall cover the joints immediately after they are made with a layer of hessian which shall be kept continuously wet during daylight hours and he shall further adopt such other measures as the Engineer may direct.

Provided the contractor has the Engineer's written consent other means of jointing may be adopted.

(d) PVC Pipes

The pipes shall be laid on smooth soil and must never be surrounded with concrete. The soil must not contain hard lumps.

In road reserves, all PVC pipes should be protected by concrete slabs, when the distance from road surface to top of pipe is less than 1200mm.

(e) Steel Pipes

Steel pipes and fittings shall conform to the relevant BS or KBS standards.

6.5 Concrete Manholes and Plot Chambers

Manholes shall be constructed on sewer lines in the positions indicated on the plan drawings or wherever ordered by the Engineer.

Manholes on pipe sewers shall be constructed with an in-situ base as detailed on the drawings which shall be raised to form the benching and channels shall be carefully formed to shape according to the number, diameter and positions of the incoming and outgoing pipes. The channels in the manhole bases shall have circular inverts. The benching shall be sloped towards the channels at a gradient of 1 in 5.

Benching shall be carried out in concrete mix 1:3:6 and rendered with 10mm 1:3 cement mortar. The ends of all pipes entering and leaving the manholes are to be carefully cut to shape to suit the internal dimensions of the manholes.

Precast concrete chamber rings shall have a wall thickness of at least 150mm. The lowest chamber ring shall be bedded in 1:2 cement mortar.

Adjacent chamber rings shall have ogee joints, chamber rings bearing on manhole bases shall have the appropriate edge square. This edge shall contain a shallow u-chase to assist the bedding of the rings or slabs.
Plot chambers of blockwork shall be carried out as specified on the drawings and reinforced with hoop irons in every shift. The blockwork shall be rendered internally with 10mm cement mortar, 1:3. Step irons as detailed on the drawings shall be provided in manholes deeper than 1.20m.

6.6 Testing

A water test shall be applied for concrete pipes as specified in B.S., C.P. 301 after laying and jointing the pipeline and before backfilling or placing concrete surround or bedding concrete, to reveal cracked or porous pipes and faulty joints. Any leakages including excessive sweating which causes a drop in the test water level, will be visible, and the defective part of the work shall be rectified.

Should the Engineer so direct, manholes shall be tested by completely filling with water, and there shall be no appreciable loss over a period of 2 hours.

On completion of works, or at suitable intervals during construction, infiltration tests shall be carried out. The permissible amount of infiltration shall be 2 litres of water per minute per kilometre of sewer line of any diameter.

The test should be carried out by inserting suitable strutted plugs in the low end of the pipelines and in the connections, if necessary, and by filling the system with water. For small pipes, a knuckle bend may be temporarily jointed in at the top and a sufficient length of vertical pipe jointed to it in order to provide the required test head. Alternatively, the required test head may be applied by means of a small bore pipe leading from a suitable container and connected to a plug.

Precautions should be taken by strutting or otherwise to prevent any movement of the pipeline during the test.

A test pressure of 1.2m head of water above the soffit of the drain should be applied at the high end but not more than 2.4m. at the low end. Steeply graded drains should be tested in stages where the above maximum head would be exceeded if the whole section were tested at once.

The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular intervals of 10 minutes and noting the quantity required to maintain the original water level in the standpipe. The average quantity of water added for drains up to 300mm nominal bore should not exceed 0.06 litre per hour per 100 linear metres per millimetre of nominal bore of the drain.

A water test shall be applied for P.V.C pipes as specified in DIN 4033 paragraph 7.2 after laying and jointing the pipeline and before backfilling to reveal faulty joints. No backfilling of the trench will be allowed before the water test has been carried out successfully.

The water test for P.V.C. pipe shall be carried out as follows:
The pipeline shall be filled with water and air pockets shall be removed. The pipeline shall for at least 1 hour be exposed for an internal pressure of 5m water column. Eventually water losses occurring during that time shall be restored. Testing is to be carried out for a period of 15 minutes where the pipes are exposed under internal pressure of 5m water column. During that time there must be no loss of water.

6.7 Refilling of Trenches

6.7.1 Refilling in common Excavation

The back filling of trenches shall be carried out expeditiously so as to reduce lengths of trenches open at any one time. The back filling to a depth of 250mm above the top of the construction shall be placed immediately the work is ready to receive it, in order to protect the construction from the sun.

Backfill to a depth of min. 300mm above the top of the pipe shall be suitable fine material with max. particle size 20mm, placed in layers of 50mm kept at the same level on each side of the pipe and rammed to a density of 90% modified AASHO.

Further back filling shall be executed with selected materials in 150mm layers (300mm layers if a mechanical rammer is used) each layer being well rammed and watered to obtain the maximum compaction. Care shall be taken to ensure that no stone or other material which could damage pipes or other work is placed within 500mm of such work.

If the original soil is not water bearing, the cohesionless material used for refilling should at intervals be interrupted by barriers of impermeable material in order to prevent a flow along the trench.

6.7.2 Refilling in Rock

The fill material in rock excavation shall consist of soil of friable nature not exceeding 20mm and approved by the Engineer. Rock fill must only be used when a layer of minimum 500mm sand, gravel or soil of friable nature has been carefully compacted by hand over the top of the pipe and then only when approved by the Engineer.

9  MECHANICAL INSTALLATION

9.1  General

The workmanship and the materials covered by this section shall include the supply and installation of all pumps, mortar and chemical doser and ancillary equipment.

All materials and equipment shall be obtained from reputable manufacturer who have well established agents in Kenya, local agents shall be able to provide an efficient service of equipment and must have ample stocks of all expendable items such as gaskets, filters fuses, indicator lamps etc.
The Engineer reserves his right to reject any manufacturer or agents who does not fulfill the above requirements.

It is the responsibility of the Contractor to provide evidence that the equipment is in compliance with this specification and that the equipment will operate satisfactorily, under the conditions under which it is installed.

All equipment offered shall comprise of a complete installation kit such as Bolts, gaskets, Screens, belt guards etc or the satisfaction of the Engineer.

Details of concrete plants for pumps and mortar shall be supplied by the Contractor at least six weeks before he intends to install the equipment.

9.2 Spare Parts

The Contractor shall submit with his tender a guarantee from the supplier that will hold for sufficient number of spare parts for the maintenance of the equipment.

9.3 Storage of Material

The Contractor shall provide weatherproof lock-up sheds for the safe storage and custody of material for the works, and shall move such sheds and make good damage of disturbed surfaces upon completion to the satisfaction of the Engineer.

9.4 Description of Services

The Contractor shall supply, transport, deliver, install, connect, commission and hand over all equipment and materials specified in the specification, drawing and bill of quantities in a clean complete and in every detailed working conditions.

He shall carry out all tests specified in this specification or in a relevant standard together with any test which might be requested by the Engineer in connection with the use of special materials or equipment.

Further more, the Contractor shall provide guarantee initial free maintenance, instruction manuals and careful instructions of the Employers staff.

9.5 Maintenance Manual

Upon completion, the Contractor shall furnish the Engineer with six copies of a manual size A4 of loose leaf type containing all the foreign items.

1) Description of equipment
2) Full operation and maintenance instructions
3) Valves operation
The manual shall be specially written and not a standard manufacturers manual unless approved by the Engineer.

All instructions shall be written into the manual with reference to the drawings.

All valves, terminals, controls of the plant shall be labelled to correspond with maintenance and operation manual.

The work shall not be considered to be complete for purposes of taking over until such instructions and drawings has been supplied to the Employer.

9.6 Motors

All motors shall unless otherwise stated be suitable for 415/240 volts 3 phase 50 cycles 4 wire power supply and shall be executed for star-delta starters as specified.

The motors shall be constructed in accordance with CP 1015 and shall be protected as specified in section 10 - Electrical works.

The motor speed shall not exceed 2900 RPM. The motor shall be foot mounted squirrel cage, dump proof or totally enclosed suitable for an ambient temperature of 30oc.

The motor shall be designed for continuous running. Each motor shall be capable of an overload of 10% above its rated output and the rated voltage for a period of 1 hr without sustaining damage.

The rated output of motor shall be the maximum horsepower absorbed by the pump under the described conditions of head and discharge plus an allowance for loss of power in coupling. Etc.

Electrically driven pump shall unless otherwise stated be directly coupled via flexible coupling to the motor and motors and pumps shall be fitted to common rigid steel frames bolted to concrete plains. Proper alignment of mortar and pumps must be guaranteed.

9.7 Engines

The engines shall be of diesel type with a maximum speed of 3000 RPM designed for continuous running.
The Engines shall be directly coupled via flexible coupling to the pumps. Engine and Pump must be fitted to a common rigid steel frame bolted to concrete plinth. Proper alignment of engine and pump must be guaranteed. The engine shall be supplied with hand starter couplings, tachometer, hand throttle control, hand stop control, silencer, fuel tank for at least 300 hours running of the engines and necessary tool kit for minor repair.

9.8  Pumps

The pumps shall be of the centrifugal type with Cast Iron casings. The shaft shall be prepared for direct connection via flexible coupling of the motors.

Pump casing shall have interchangeable, bronze wear rings. The impellers shall be of bronze or high grade cast iron dynamically balance to ensure smooth running.

The propeller shaft shall be of steel and fitted with renewable bronze protecting sleeves wherever it is in contact with the pumped water.

Mechanical seals shall be provided unless approved otherwise.

It shall be stated in the tender documents if other materials are offered. For horizontal type pumps, the propeller shaft shall be carried by oil or grease lubricated ball or other bearing if heavy duty type.

The pump casing bearing, shaft, impellers and gaskets must be executed of materials suitable for many years continuous operation in water system.

If materials other than cast Iron, bronze or stainless are included in the pump, it cannot be approved unless a written guarantee for 10 years performance is produced, giving free checking and replacement in case of fault.

The performance curves efficiency curves and power demand curves (characteristics curves) shall accompany the tender with clear indicator of the capacity and efficiency of the pump with the specified head.

9.9  Chemical dosing Equipment

The chemical dosing equipment shall consist of gravity dosers, tube and connection as shown on the drawing.

9.10  Pressure Gauges

The pressure gauges shall be wall-mounted gauges in metric unit completed with connection to delivery side of pumps, copper pipe from pipe to gauge supplied with isolating cock.

10  ELECTRICAL WORKS
10.1 General

The quality of material and workmanship specified in his section is for all items forming part of Electric Installation as shown in the drawing, bill of quantities and these specifications.

10.2 Regulations

All the electrical works carried out strictly in accordance with the following:


ii) The Licenses by-laws

The Government Electrical Specification/GES No. 1 and No. 2

The power act

The Relevant British standard Specifications and codes of practice published by the British Institution here-in after referred to as BS an CP respectively).

Specification

The contract drawing and the working drawing produced by the Contractor and approved by the Engineer.

The Engineers Instructions.

The Contractor shall undertake all modifications demanded by the authorities in order to comply with the regulation and produce all certificates if any from the authority without change. After completion of the work the Contractor shall deliver a complete set of as built drawings showing the complete installation including all alterations and modifications. The set of drawings shall include but is not limited to all floor plans and diagrams.

10.3 Material

All materials, fittings and accessories are to be new and in accordance with the requirement of the current rules and regulations where such exist with the relevant KBS standards, BS or others.

The Contractor shall be required by the Engineer to submit samples for his approval before placing an order.

The Contractor will be entirely responsible for all materials apparatus, equipment etc furnish by him in connection with his work and shall take all special care to protect all parts of finished work from damage until handed over to the Employer.

Competent workmen under skilled and experienced supervision shall carry out the work.

The Engineer shall have the right to have any part of the work taken down or changed at the Contractors expense which is executed in an unsatisfactory manner.

10.4 Workmanship
The routes of services and approximate positions of operator are shown on the contract drawings but the exact positions shall be determined by approved dimensional detail on working drawing or on site by the Engineer in consultation with the Contractor.

10.5 Main Switchboard

The main switchboard shall be free standing type switchboard with front access.

The switchboard shall be constructed fully wired and checked out at the factory and shall require a minimum of installation work on site, Modular construction shall be used wherever practicable, and provision shall be made for simplified servicing replacement and maintenance throughout without major dismantling.

The enclosure shall be suitable for containing circuit breakers motor starters and metering equipment from KP&C where spaces on the switchboard are provided for future circuit components, all ancillary ports shall be installed initially. Full safety precautions shall be provided in all cases.

10.6 Switchgear

The switchgear for others apart from boreholes will be as per clause 2 where applicable.

10.7 Motor Starters

Motor starters for the backwash pumps shall be automatic direct on line. Contractor type fitted wire double pole incoming mechanically interlocked circuit breaker housed in a damp and dust proof steel enclosure.

10.8 Wiring

All wiring must be carried out in PVC single core copper cables to BS.

10.9 Cable and Conductors

All cables shall conform to relevant BS. No cable dimensions shall be smaller than 1.5sq. mm for light and control circuits shall be used.

All low voltage cables shall be thoroughly soldered or joined with connectors of absolutely reliable type which hold the conductors in a firm grip, without damaging the wire and without any possibilities of the vibrating loose.

10.10 Conduits

Plastic conduits shall be of the best quality new super high impact grade, heavy gauge class "A" rigid PVC, suitable for plain connection.
In no case shall conduits smaller than 20mm shall be used.

10.11 Boxes

All conduit boxes in connection with plastic Conduit shall be of plastic. All boxes shall match to the equipment installed in the box.

10.12 Light fitting

All light fittings shall be cleared and installed in complete working order before handing over.

10.13 Light Switches

Light switches shall be 5 or 20 Amperes according to the load switches

10.14 Power Installation

The installation for power shall be concealed in wells and floors in PVC conduits. All adaptors shall be solid bronze or brass pattern with standard thread.

10.15 Earthing and Bonding

Earthing and bonding shall be carried out to the requirement of the current 14th edition of the TEE regulation and GES 1 and 2. In particular attention is drawn to IEE regulation D5, D6, D7 and D29.

10.16 Testing

All tests prescribed in the 14th Edition of the regulations for the electrical equipment of the Institution of Electrical Engineers, together with all amendments as applicable, shall be carried out by the Contractor on the completed installations.

10.17 Handing Over

The Contract works shall be considered complete and the maintenance and defects liability period shall commence only when the contract work and supporting services has been tested, commissioned and operated to the satisfaction of the Engineer and officially approved and accepted by the Employer.

11 BOREHOLES

Application for drilling of a borehole shall be submitted by the client to the relevant authority upon which hydrological survey will be carried out by a qualified hydrogeologist.

The survey report will include among other things the geophysical site, expected water level, yield, quality and soil formations etc.
11.1 Drilling

Drilling shall be done by a registered Borehole drilling contractor with the relevant authority (MENR).

11.1.1 Diameter of Boreholes

All boreholes shall be straight, vertical and shall be drilled to provide for a finished borehole of at least 152mm cased diameter after allowing for 50mm thick gravel pack and temporary casing as found necessary.

11.1.2 Materials

Gravel pack and tests (copy)

All materials used in the borehole construction other than temporary works shall comply with the relevant standards specifications. A tolerance dimensions will be permitted provided that the material quality is not inferior to specification and the works is in no way impaired.

11.1.2.1 Borehole Casing (Steel)

Borehole casing shall be made from steel pipe manufactured to API specifications 5L or BS 3601 and of internal diameter 152mm and 4.0mm thick.

Casing shall be epoxy coated and lined to American standard WWAC 213/C 210 or BS BGC/PS/CW6 or German standard DIN30671 or any other Internationally recognized standard to resist underground colosion

Casing shall have self-centering sockets and spigot ends for fillet to prevent damage to the internal epoxy lining and supplied in 6m length.

11.1.2.2 Borehole Screens

Screens shall be slotted steel pipes manufactured to API specification 5L or BS 3601

11.1.3 Borehole Construction

The contractor shall install plain steel casing and screens to the required depth, install gravel pack of 2 - 4mm thickness to annular thickness of 50mm around the casing or as specified by the Engineer. The bottom of the production casing shall be sealed by welded steel plug of 6" diameter and 4mm thickness.

The Contractor shall be responsible for the provision of temporary casing as necessary, insertion and removal of which shall be at his cost.
11.1.4 Borehole Development

After insertion of the casing, screen and gravel pack each borehole shall be developed to clear gravel pack and clean and develop the aquifer method of development and time spent as proposed by the Contractor must be approved by the Engineer.

The methods of development shall be chosen among the following;

- Surging and pumping
- Hydraulic jetting, single pipe system open to atmosphere.

11.1.5 Test Pumping

After development of the borehole is complete, test pumping for yield shall be carried out. The Contractor shall provide and install the necessary pumping equipment capable of pumping the estimated yield against the estimated head below ground level but with suitable throttling devises so that the discharge may be reduced.

The pumping unit shall be complete prime mover and all auxiliaries shall be capable of being operated for a period of 24 hrs uninterrupted. It shall also have all discharge pipework and suitable discharge measuring devices subject to approval of the Engineer.

On completion of the test pumping the borehole shall be caped by a welded cap of 6” diameter and 4mm thickness.

11.1.6 Water Sample

The Contractor shall be responsible for taking samples of water at the end of test pumping of boreholes for bacteriological and chemical testing to a competent and authorized laboratory. The water samples shall be supplied in sterilized containers of not less than 300ml for bacteriological test and a five litres clean container for chemical tests.

11.1.6.1 Boreholes Disinfection

The boreholes are to be disinfected after development and test pumping, additionally wherever a borehole for human consumption has been temporary out of use the Borehole shall be disinfected before production resumes.

The Contractor is supposed to keep his drilling equipment in normal hygienic condition and the Engineer can demand the equipment to be disinfected.

11.1.7 Borehole Civil Works

11.1.7.1 Gantry
Gantry of 7.1 m height above the ground shall be provided and fabricated from DN 150mm flanged class B water pipes they shall have a hook on the top beam for chain block under ascending steps made from DN13mm GS water pipes on both column. The Gantry shall be finished in a heat resistant non-peeling of Aluminum paint.

11.1.7.2 **Storage Tank**

A suitable storage tank as approved by the Engineer will be constructed with a capacity of at least 50% of the daily water demand as required in standard design manual of the MENR shall be provided.

11.1.7.3 **Pump House**

A standard pump house as approved by the Engineer shall be constructed. The standard drawing of pump house shall be provided upon request by the MENR.

11.1.7.4 **Water Trough**

Livestock water troughs as approved by the Engineer will be constructed at 50m from the borehole.

11.1.7.5 **Communal Water Point**

A Communal water point as approved by the Engineer shall be constructed at 10m from the Borehole with a standpipe and proper drainage shall be allowed.

A concrete approx. of 2x3m shall be provided around the borehole.

Security fencing shall be provided by the Contractor as approved by the Engineer.

11.2.0 **Borehole Equipment**

11.2.1 **Pumping set and associated switch gear**

The pumping sets shall be multistage centrifugal type running a full load speed of not less than 2850RPM. The entire pump set body (Dump and Mortar), including the Impellers, Strainer, Cable guard, non-return valve shall be made of heavy duty stainless steel material.

AISI 316 or equivalent heavy duty grade stainless material grade. The bearing shall be water lubricated type, water resistant.

The pump efficiency at the duty point shall not be less than 58%.

The motor shall be a two pole canned asynchronous three phase, 415 VAC squirrel cage Induction type. It shall be continuously rated and of minimum class B insulation.
The pump set shall be supplied complete with the Cable, water tight cable, connector splicing unit.

11.2.2 Switch gear

Switchgear shall be 3 phase, 415 VAC, 50 HZ. It shall be in water tight, front access hedged door colosion, resistant, lockable metal enclosure, comprising of the following components among other fully wired and labeled.

The starter shall be of high quality durable type e.g. ASEA, MEM, CRABTREE, SIEMENS, etc

- Appropriate rating Contactor
- Appropriate thermal over load.
- Start stop/resist push button
- Integral TPN MCCB (MCB) type 3
- Over/under voltage and phase failure protection relay set at 380 and 450 VAC
- Water level control relay
- Pilot indication light (green marked pump run red marked overload - Tripped yellow marked borehole low
- Hours run counter range 0 - 99999 hrs
- Cable terminal blocks

All switch gear enclosures shall be fabricated from heavy gauge spangled galvanized glass protected sheet steel of minimum thickness of 1.5mm they shall be finished to tone heat resistant impeeling of stove grey enamel paint or epoxy powder coating.

11.2.3 Electrical generating set and associated switch gear.

Generating sets and switch gear shall comply with the following conditions:

Generating sets and switch gear shall be tropicalised able to operate continuously at their full load at the stated site climate and geographical conditions.

The generating set upto and including 22.4 KVA shall be air cooled and hand crank started and those above 22.4 KVA shall be both electric and hand crank started and water cooled.

The engine and the alternator shall be directly coupled and mounted on a robust vibration less steel base frame with coupling protection guard lifting eyes and mounting holes, fuel and terminals connected to the engine fuel pump. The set shall be supplied with appropriate strength size bolts, washer and nuts.

The generating set shall have a full load speed of 1500 RPM.

11.2.3.1 Engine

The engine shall be heavy duty 4 stroke direct injection cold starting type under the stated site conditions of latitude ambient temperature and humidity, the engine shall be able to operate for continuously and efficiently at the rated power
11.2.3.2 Electrical Starting System

This is recommended for Generating set of rated 22.5 KVA and above. The electric starting up system shall either be 12VDC or 24VDC completely wired labeled and comprising of the following components among others;

   a) Heavy duty starter mortar
   Terminal and associated cables
   Full charged heavy duty batteries (load acid or Nickel cadminium)
   Trickle charge unit
   Automatic cut-off device full charge

The engine key start switch system and charger panel comprising of DC battery charger ammeter, DC voltmeter, battery low indication lights, charger fault indication light.

On sudden application of full load rated at 0.8 laging PF (power factor) the voltage recovery to within 3% of the steady state value shall be within the range of 0.2 seconds.

The alternator shall be able to sustain overload equivalent to a full voltage current of 3 times full load rated volume for 5 seconds depending on voltage and output.

The phase sequence shall be red, yellow, blue for clockwise rotation when viewed from the dry end.

The alternator shall be protected against radio frequency interference.

The alternator stator core assembly shall consist of insulated low loss electrical sheet steel lamination jig build and welded under controlled pressure to withstand Engine vibrations and load/fault induced forces, pressed into the frame and torque pinned. The frame shall be cast steel type

Head treated monitoring steel brackets at least 3 Kg of fine resistant heat laying wire material.

11.2.3.3 Exhaust System

   The Exhaust system shall comprise of the following: -

   Exhaust silencer
   Flexible/rapid heat treated steel exhaust piping (minimum 2m), flexible bellows, 1m of heat treated steel pipe and shall be able to deliver power in excess of 10% higher its rated value for 1 hr in any period of 24 hrs consecutive running.

   The specific fuel consumption shall not exceed 0.3l per kW/h.

   The fuel system shall be gravity feed type and fuel tank shall be constructed from rust protected steel material of minimum thickness 1.75mm and zinc coated. All surfaces shall be cleaned primed and finished in gloss enamel.

   Fuel tank shall be of a capacity to last 12 hrs of continuous operational at full load complete with wall mounting GS bracket (wall mounting type, fuel content gauge, fuel cap, drain cork, vent pipe, 3m of steel/copper fuel feed and leak return line complete with fittings.

   The engine starting system shall be either manual hand crank, electric or both.
Hand crank starting shall be applicable to generating sets rated upto 22.5 KVA and shall comprise of a high quality, durable hardened steel crank tool with handle.

11.2.3.4 Alternator

Alternator shall be heavy duty industrial 4 pole 3 phase 415/240VAC 50/60Hz 4 wire series-star connected type.

It shall be brushless self exiting. Self regulating drip proof screen protected continuous related at full load class H insulation. The alternator shall meet the following conditions among others.

Voltage regulations shall be maintained within the limits of +– 2.5% from low load to full load including cold and hot variations at any power faction, between 0.8 lagging and unit inclusive of speed variation of + or - 3%.

The total RMS wave form distortion (line to line and line to Neutral) shall be of order 2% on open circuit and the corresponding on load figure of 3.5% and the bearing shall be ball bearing type sealed for life.

11.2.3.5 Instrumentation and switch gear Cubicle

The generating and switch gear cubicle shall be mounted on a vibration less frame and will comprise of the following components among others fully wired and labeled;

1No. 75x75mm flash mounting AC voltmeter range 0 - 500VAC couple with phase selector switch and protection fuses.
3No. 75x75mm flash mounting AC meters with 3No. current transformer (for generating sets rated 20 KVA and above).
415 VAC TPN type 3 MCCB (MCB) type Dorman MEM, SIEMEN, ASEA or any other as recommended by the Engineer.
Frequency range meter 45 - 65 HZ.
Hours run Counter (240 VAC) range 0 - 99999 hrs.
Engine low pressure, Engine high oil temperature, Engine high water temperature, radiator water level low, Over/low speed automatic shutdown protection devices with associated ED or CRYSTAL LIQUID indicator lights cable terminal blocks.
12  SHALLOW WELLS

12.1.1 Diameter and Depth

The diameter of a dug well shall be at least 1.2m to allow two men to work together during the digging. Slightly smaller diameter may be used if digging is to be done by one man only.

The wells shall be dug at least 3m below the expected water level.

12.1.2 Lining

Most dug wells needs an inner lining of materials such as Brick, stone masonry, concrete rings, cast in-situ or pre-cast concrete rigs. Backfilled dug wells with 100 - 150mm can also be a good solution.

- Sinking a dug well by excavation from the inside is very often a good and safe technique however in very loose soil (fine or medium sand) in thick layers over 3 m other methods for instant hand drilling shall be used.
- In consolidated ground (e.g. Rock) the well may stand unlined but the upper part should always have a lining.
- The section of the well penetrating the aquifer requires a lining with opening or perforations to allow the groundwater to enter.
- Any backfilling at the same level as the aquifer should be made with the gravel.
- However, in fine and sand aquifers, the lining should be without perforations and the groundwater should enter only through the bottom of the well.
- The bottom should be covered with graded gravel e.g. 3 layers each 150mm thick with grain sizes 1 - 2mm for the deepest layer than 4 -8 mm and 20 - 30mm effective size at the top.

12.1.3 Protection

The space between the walls of the dug well and the lining should be sealed with puddled clay or with cement grout. The sealing should be between the ground surface and the aquifer or down at least 2m below the ground surface.

- The wall lining should be extended approximately 0.5 m above the ground to form a wall round the well.

- A concrete apron should be constructed on the ground surface about 2m all round the well.
  - The well top should be sealed with watertight slab.
- A manhole that can be tightly and securely locked shall be provided for Inspection and Disinfection.