

# TECHNICAL SPECIFICATION FOR CONSTRUCTION OF WATER SUPPLY AND SEWERAGE SYSTEMS

## PART I – GENERAL WORKS

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# SECTION 1 - SCOPE OF WORKS

## 1.1 Scope of Works for the sewerage System

### 1.1.1 Sewer Reticulation System

Construction of Sewer reticulation system including supply and installation of pipes, manholes, other fittings & specials.

### 1.1.2 Pump Stations:

Supply / Construction & Installation of Pump stations, based on approved design & drawings.

### 1.1.3 Sewer Outfall

Supply & Installation of Sewer Outfall based on detailed design report (approved from design phase), drawings, including Installation of Mechanical & Electrical Equipment.

### 1.1.4 Sewer Jetting machine

Supply and delivery of Sewer Jetting equipment as per specifications provided in this Employer's Requirement.

### 1.1.5 Testing and commissioning

Testing and commissioning of the facilities including trial run, for a period of three (03) months.

## 1.2 Scope of Work for the water distribution system

### 1.2.1 Reverse Osmosis Plant

Supply / Construction & Installation of Reverse Osmosis plant, groundwater intake boreholes and associated works, permeate & brine reject lines, based on production capacity and flow rates given on detailed design report (approved from design phase), drawings, including Installation of Mechanical & Electrical Equipment.

### 1.2.2 Storage Tanks

Supply / Construction & Installation of storage tanks for desalinated water, feed water and brine, based on detail given on detailed design report, ( approved from design phase), drawings, including Installation of Mechanical & Electrical Equipment.

### **1.2.3 Rainwater Collection and Treatment system**

Supply and Construction of Rainwater collection network from all public buildings to treatment location as per the approved designs and supply and installation of Ultrafiltration plants.

### **1.2.4 Chlorine Dosing System**

Installation of Chlorine Dosing System based on detailed design (approved from design phase), drawings, including Installation of Mechanical & Electrical Equipment.

### **1.2.5 Degasification Unit**

Supply and installation of Degassifier, including Degassifier foundation and other ancillary works.

### **1.2.6 Administrative and Plant building**

Construction of administrative buildings and laboratories required for testing water samples.

### **1.2.7 Water Distribution Pumping System**

Supply / Construction & Installation of Water Distribution Pumping System, based on approved designs (from design phase). Also includes the Supply and Installation of Pumps and Other accessories including Control panel, electrical works and accessories including Valves and Fittings.

### **1.2.8 Water Reticulation System**

Construction of Water reticulation system including supply of pipes, Fittings & Specials, house connections with flow meters.

### **1.2.9 Brine Discharge Outfall**

Supply & Installation of brine discharge line along with ballast blocks including brine well, as per Employer's Requirements.

### **1.2.10 Photovoltaic System**

Supply / Construction & Installation of Photovoltaic equipment that would be used in the Water Supply Admin/Reverse Osmosis Plant building.

### **1.2.11 Water quality testing laboratory equipment**

Supply and delivery of Water quality testing laboratory equipment as per the list provided in this Employers Requirement.

### **1.2.12 Testing, Commissioning and Trial Run**

Testing and commissioning of the facilities including trial run, for a period of three (03) months.

### 1.3 Summary of Standards

A summary of standards referred to in various Sections of the Technical Specifications

<b>Section 2 - General Requirements</b>	
<b>ASTM E1417 / E1417M - 11</b>	Standard Practice for Liquid Penetrant Testing
<b>Section 4 - Earthworks</b>	
<b>2013/R-1697</b>	EPA Dewatering regulation
<b>BS 6031:2009</b>	Code of Practice for Earthworks
<b>BS 8004:2015</b>	Code of Practice for Foundations
<b>BS 1377-1:1990</b>	Methods of test for soils for civil engineering purposes. General requirements and sample preparation
<b>T147</b>	AASHTO Standard Method of Test

## Section-5 Structural Specifications

<b>BS 8500-1:2015</b>	Concrete. Complementary British Standard to BS EN 206. Method of specifying and guidance for the specifier
<b>ASTM C150 / C150M - 15</b>	Standard Specification for Portland Cement
<b>BS EN 12620:2002+A1:2008</b>	Aggregates for concrete
<b>ASTM C94 / C94M - 15a</b>	Standard Specification for Ready-Mixed Concrete
<b>BS 812-103.2:1989</b>	Testing aggregates. Method for determination of particle size distribution. Sedimentation test
<b>BS 4449:2005+A2:2009</b>	Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification
<b>BS 4483:2005</b>	Steel fabric for the reinforcement of concrete. Specification
<b>BS 8666:2005</b>	Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete
<b>BS EN 197-1:2011</b>	Cement. Composition, specifications and conformity criteria for common cements
<b>BS 1199 and 1200:1976</b>	Specifications for building sands from natural sources
<b>BS 8000-0:2014</b>	Workmanship on construction sites. Introduction and general principles
<b>BS EN 845-2:2013</b>	Specification for ancillary components for masonry. Lintels
<b>BS EN 13914-2:2005</b>	Design, preparation and application of external rendering and internal plastering. Design considerations and essential principles for internal plastering
<b>BS EN 1008:2002</b>	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete

## Section 6 Electrical Specifications

<b>Design criteria and technical Specifications for Conventional Gravity System.</b>	Water and Sanitation Unit -Environmental Protection Agency Ministry of Environment and Energy
<b>IEC 60502:2012 SER Series</b>	Power cables with extruded insulation and their accessories for rated voltages from 1 kV ( $U_m = 1,2 \text{ kV}$ ) up to 30 kV ( $U_m = 36 \text{ kV}$ ) - ALL PARTS
<b>BS 6004:2012</b>	Electric cables. PVC insulated and PVC sheathed cables for voltages up to and including 300/500 V, for electric power and lighting
<b>BS EN 60228:2005</b>	Conductors of insulated cables
<b>BS 5467:1997+A3:2008</b>	Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V
<b>BS 7671:2008+A3:2015</b>	Requirements for Electrical Installations. IET Wiring Regulations
<b>BS EN 50363-4-1</b>	P.V.C. Insulation and sheath of electric cables
<b>IEC 60228:2004</b>	Conductors of insulated cables
<b>IEC 60811-100:2012</b>	Electric and optical fibre cables - Test methods for non-metallic materials - Part 100: General
<b>BS EN 50525-1:2011</b>	Electric cables. Low voltage energy cables of rated voltages up to and including 450/750 V ( $U_0/U$ ). General requirements
<b>BS 6724:1997+A3:2008</b>	Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V, having low

	emission of smoke and corrosive gases when affected by fire
<b>IEC 60034-1:2010</b>	Rotating electrical machines - Part 1: Rating and performance
<b>BS EN 60529:1992+A2:2013</b>	Degrees of protection provided by enclosures (IP code)
<b>BS EN 60034-5:2001, IEC 60034-5:2000</b>	Rotating electrical machines. Degrees of protection provided by the integral design of rotating electrical machines (IP code). Classification
<b>IEC 60034-5:2000+AMD1:2006</b>	Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification
<b>IEC TS 60034-2</b>	Rotating electrical machines - Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors
<b>IEC 60072-1:1991</b>	Dimensions and output series for rotating electrical machines - Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080
<b>IEC 61111:2009</b>	Live working - Electrical insulating matting
<b>BS EN 3-7:2004+A1:2007</b>	Portable fire extinguishers. Characteristics, performance requirements and test methods
<b>BS EN 60754-1:2014</b>	Test on gases evolved during combustion of materials from cables. Determination of the halogen acid gas content
<b>BS EN 50396:2005+A1:2011</b>	Non electrical test methods for low voltage energy cables
<b>BS EN 60730-1:2011</b>	Automatic electrical controls for household and similar use. General requirements

<b>BS EN 61048:2006</b>	Auxiliaries for lamps. Capacitors for use in tubular fluorescent and other discharge lamp circuits. General and safety requirements
<b>BS EN 61049:1993</b>	Specification for capacitors for use in tubular fluorescent and other discharge lamp circuits. Performance requirements
<b>IEC 61049:1991</b>	Capacitors for use in tubular fluorescent and other discharge lamp circuits. Performance requirements
<b>BS EN 61347-1:2015</b>	Lamp controlgear. General and safety requirements
<b>IEC 60598-1:2014</b>	Luminaires - Part 1: General requirements and tests
<b>BS EN 60923:2005</b>	Auxiliaries for lamps. Ballasts for discharge lamps (excluding tubular fluorescent lamps). Performance requirements
<b>BS EN 60269-1:2007+A2:2014, BS 88-1:2007+A2:2014</b>	Low-voltage fuses. General requirements
<b>IEC 60269-1:2006+AMD1:2009+AMD2:2014</b>	Low-voltage fuses - Part 1: General requirements
<b>IEC 60898-1 Ed. 2.0</b>	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for A.C. operation
<b>BS 7430:2011+A1:2015</b>	Code of practice for protective earthing of electrical installations
<b>BS EN 60921:2004</b>	Ballasts for tubular fluorescent lamps. Performance requirements
<b>BS EN 60662:2012</b>	High-pressure sodium vapour lamps. Performance

	specifications
<b>BS EN 60188:2001, IEC 60188:2001</b>	High-pressure mercury vapour lamps. Performance specifications
<b>BS EN 61347-2-8:2001+A1:2006</b>	Lamp controlgear . Particular requirements for ballasts for fluorescent lamps
<b>BS 3988:1970</b>	Specification for wrought aluminium for electrical purposes. Solid conductors for insulated cables
<b>IEC 60811-409:2012</b>	Electric and optical fibre cables - Test methods for non-metallic materials - Part 409: Miscellaneous tests - Loss of mass test for thermoplastic insulations and sheaths

## Section 7 -Instrumentation Specifications

<b>BS EN 60654-1:1993, IEC 60654-1:1993</b>	Industrial-process measurement and control equipment. Operating conditions. Climatic conditions
<b>BS EN ISO 9001:2015</b>	Quality management systems. Requirements
<b>BS EN 60529:1992+A2:2013</b>	Degrees of protection provided by enclosures (IP code)
<b>PAS 5308-1:2009</b>	Control and instrumentation cables. Specification for polyethylene insulated cables
<b>PAS 5308-2:2009</b>	Control and instrumentation cables. Specification for PVC insulated cables
<b>BS 1646-2:1983</b>	Symbolic representation for process measurement control functions and instrumentation. Specification for additional basic requirements
<b>BS 5863-1:1984, IEC 60381-1:1982</b>	Analogue signals for process control systems. Specification for direct current signals
<b>BS 5863-2:1980, IEC 60381-2:1978</b>	Analogue signals for process control systems. Specification for direct voltage signals
<b>BS EN 60051-1:1999, IEC 60051-1:1997</b>	Direct acting indicating analogue electrical measuring instruments and their accessories. Definitions and general requirements common to all parts
<b>DIN IEC 61554:2002-08</b>	Panel mounted equipment - Electrical measuring instruments - Dimensions for panel mounting (IEC 61554:1999)
<b>BS 90:1975</b>	Specification for direct-acting electrical recording instruments and their accessories

## **SECTION 2    GENERAL REQUIREMENTS**

## **Section 2 - General Requirements**

### **2.1 General**

The Conditions of Contract, BOQ and the Detailed Design approved from the initial phase shall be read in conjunction with the requirements. Matters referred to, shown or described in any one of these documents are not necessarily repeated in others. Notwithstanding the subdivision of the specifications in various headings, every part is to be deemed supplementary to every other part and various parts are to be read with each other, so far as it may be practical to do so or when the context so warrants.

The words “Consultant” and “Engineer” must be constituted to be the same thing

### **2.2 Standards and Codes**

In various places throughout this requirements and bidding documents, reference is made to the Standards, Specifications and By-Laws issued by the British Standards Institution or ASTM. These references shall in every case be deemed to include the latest edition or issue of such Standards. Specifications and By Laws including all revisions, amendments and addenda subsequently issued. Where materials are not specified to be to a particular Standards and a British or American Standard exists in respect of such materials, and then the materials shall in all respects comply with the relevant and current British or American Standards. In such cases where British or American Standards do not exist, the Contractor shall indicate the relevant international Standards and produce the same for the approval of the Engineer.

### **2.3 Drawings and Specifications**

*Drawings:* Drawings, activity schedule/Bill of Quantities and Specifications provided as part of the employer’s requirements are intended to complement each other, so that if anything is shown on the Drawings, but not mentioned in the specifications or vice versa, it is to be furnished and built as though specifically set forth in all three. If any discrepancies, errors, ambiguities or omissions occur in the Drawings or activity schedule or Specifications, the same shall be referred to the Employer before proceeding with the Works, and the Employer Engineer’s decision on such discrepancies, errors, ambiguities or omissions shall be final.

In addition to the Drawings, activity schedule and Specifications attached hereto, the Employer will during the progress of the Works furnish additional Drawings, Specifications, and instructions as may be necessary, in the opinion of the Employer, for the purpose of the proper and adequate execution and maintenance of the Works, and the Contractor shall make his work conform to these. Such drawings and instructions shall be deemed to be part of the Contract Documents.

## **2.4 Transportation to the Site**

The Contractor shall provide all necessary transport, handling and storage of all materials, components and the like to their points of installation on site including transport to and from storage. The Contractor shall provide all necessary transport of labour to and from the site. The contractor shall use routes specified by the island authorities for transporting heavy goods to the site as mentioned in the Clause 2.39

## **2.5 Schedule and Execution Plan**

The Contractor shall prepare and submit to the Employer for approval the construction schedule and an execution plan of temporary facilities, stock yards, etc., before the start of the Works.

## **2.6 Repairing and Correction**

Any breakage(s) or defect(s) of existing buildings, roads utilities, or part(s) of them caused by the Works including transportation for the works shall be repaired or corrected by the Contractor with his responsibility.

## **2.7 Materials, Goods and Workmanship**

Materials, goods and workmanship shall be of the best quality of their respective kinds and, as far as applicable, shall comply in every respect with the requirements of the quoted Standards, Codes of Practice and Specifications or any other National Standard approved by the Employer. Preambles and descriptions of materials, goods and workmanship given in any one section of the specifications shall apply throughout the whole of these specifications unless otherwise described. The substitution of materials, goods, workmanship and the like from that specified shall only be permitted with the written approval of the Consultant.

The Contractor shall submit for the approval of the Consultant a list of names and addresses of the manufacturers and trademarks or names of all the various types of materials and goods he proposes to use the Works. This list shall include reference to the specifications Clause or Article to which the materials and goods apply. All materials used in the Works shall be new and of the appropriate quality all to the Employer's approval.

Materials shall be obtained from approved sources and used in accordance with the manufacturer's printed instructions. In the absence of a specification all materials shall comply with a relevant standard. The Employer shall order the removal of any materials, which he has not approved.

No orders for materials and goods shall be placed until approval has been obtained for the materials and goods from the Consultant.

The Contractor shall note that it is his responsibility to include in his price for the cost of the materials and products as specified and no adjustment will be allowed should the alternatives be rejected by the Employer.

All workmanship shall be of the best standard. All goods and materials to be incorporated in the Works must 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.

## **2.8 Approved Manufacturers & Manufacturer's Instructions**

Reference to proprietary items or approved manufacturers shall be construed as establishing standards of quality and not as limiting competition.

The Contractor may offer alternatives to the materials specified provided that such materials meet or exceed the required minimum standards. The final decision on this matter rests with the Employers.

All items or materials shall be delivered to the Site in the manufacturer's original unopened containers with the manufacturer's brand and name clearly marked thereon.

All items or materials shall be assembled, mixed, fixed, applied, or otherwise incorporated in the Works in accordance with the printed instructions of the manufacturer of the items or materials unless specifically instructed otherwise by the Employer.

## **2.9 Samples**

The Contractor shall furnish for approval with reasonable promptness, all samples as directed by the Employer. The Employer shall check and approve such samples with reasonable promptness only for conformance with the design concept of the Works and for compliance with the information given in Contract Documents. The work shall be in accordance with the approved samples.

All samples shall be delivered to the Employer with all charges in connection therewith paid by the Contractor and deemed to be included in the contract price.

Duplicate final approved samples, in addition to any required for the Contractor's use, shall be furnished to the Employer, one for office use and one for the Site.

Samples shall be furnished so as not to delay fabrication, allowing the Employer reasonable time for consideration of sample submitted.

Each sample shall be properly labelled with the name and quality of the material, manufacturer's name, name of the project, the Contractor's name and date of submission, and the specification article number to which the sample refers.

## **2.10 Ordering Materials**

The activity Schedule shall not be used as a basis for ordering materials and the Contractor is entirely responsible for assessing the quantities of materials to be ordered. Upon completion of the design phase the contractor should provide a detailed BOQ brfeaking down and detailing the activities in the activity schedule. The Contractor should also provide detailed breakdown of Master material list which will be verified by the engineer. Upon receipt of the Employer's order to commence the Works, the Contractor shall immediately place orders for all required materials and will be held responsible for any delays occurring due to the late placing of such orders. Prior to finalizing material orders, the Contractor shall advise the Employer and await the Employer's written approval to complete the same. The Contractor shall pay all expenses, taxes and dues etc. incurred on the procurement of materials from abroad.

## **2.11 Defective Work**

Any defective work materials and also deviations from the working details in respect of setting out, correct lines and levels, verticality, sizes thickness of members and/or any other dimensional variation of any kind whatsoever, shall be removed and reconstructed or otherwise rectified without undue delay to the approval of the Employer and the Contractor shall be responsible for all additional costs incurred due to rectification of any defect work or material.

## **2.12 Disposition of Existing Utilities**

Before commencing any construction work the Contractor shall obtain from the Employer, Island Council and relevant utility providers the location of any existing utilities on the Site. Active utilities on the site shall be carefully protected from damage, relocated or removed as required by the work. When an active utility line is exposed during construction, its location and elevation shall be plotted on the Record Drawings and Employer notified in writing.

Active utility lines damaged during the course of construction operations shall be repaired or replaced as determined by the Employer at the Contractor's expense. If an active utility line is damaged the Contractor shall notify the Employer by telephone and in writing immediately.

## **2.13 Protection**

The Contractor shall have the Works and adjoining properties protected from inclement weather. Any loss or damage caused by weather, carelessness or lack of skill of workers, accident or otherwise shall be of such property that is affected. The Contractor shall provide all necessary dust sheets, barriers and guard rails and clear away at completion.

The work shall be suspended for such time as may be directed and/or approve by the Consultant if the specified quality of work is difficult to maintain during inclement weather.

## **2.14 Scaffolding**

The Contractor shall provide, erect, maintain, dismantle, and clear away at completion proper and adequate scaffolding including that required for Sub-Contractor and Suppliers. Putlog holes shall be made good to match the adjacent surface as the scaffolding is dismantled. The Contractor shall be entirely responsible for all safety precautions in connection with the

scaffolding including the provision of all bracing, scaffold boards, toe boards and the like and for its entire sufficiency for the work.

If in the Engineer's opinion scaffolding is considered dangerous then the Contractor shall rectify the same at his own expense. All work utilizing scaffold shall be halted until the scaffold is corrected all to the Employer's written approval.

The contractor is responsible and pays for all necessary permits to erect and dismantle the scaffolding, use of cranes and other machinery on site and on the roads around the work site.

## **2.15 Cutting and Patching**

The Contractor shall be responsible for all cutting and patching and making good required for all trades for all work and his prices will be deemed to include for all such cutting and patching and making good.

## **2.16 Water for the Works**

The Contractor shall make all necessary arrangements and provide all water for the proper execution of the Works, together with all transport, temporary plumbing, storage and distribution, pay all charges and alter, adapt and maintain temporary work as necessary and remove and make good at completion.

Water for execution work such as construction works, Concreting, Curing, Pressure testing, Leak testing, Disinfection, Cleaning and other construction activities shall be clean, potable fresh water and shall not contain any injurious amounts of harmful impurities which may adversely affect quality of water. Saline water shall not be allowed to use for above purposes. Contractor shall provide for the above purposes at their own expenses.

## **2.17 Electricity for the Works**

The Contractor shall make all necessary arrangements and provide all artificial lighting and power (maintaining a generator if necessary) for the proper execution and security of the Works and its protection, with all meters, temporary wiring and fittings, pay all charges and alter adapt and maintain the temporary work as necessary and remove and make good at completion.

## **2.18 Construction Machinery**

All necessary construction machines shall be provided and maintained by the Contractor and shall be approved by the Employer. Prior to commencement of works contractor must provide the employer with master machinery list which will be used during implementation.

## **2.19 Safety of Adjoining Existing Buildings**

The Contractor shall take all necessary precautions during the excavation for the Works particularly those excavation which are adjoining existing buildings and shall protect such buildings from the damage or collapse by means of temporary or permanent shoring, strutting, sheet piling or underpinning or excavation in short lengths and/or other methods as he deems fit also he shall properly support all foundations, trenches, walls, floors, etc. affecting the safety of the adjoining existing buildings.

The Contractor shall alter, adopt and maintain all such works described above for the whole period of the Contract and shall finally clear away and make good all damages done.

The construction and efficiency of the shoring, underpinning, strutting and the like for the purpose for which it is erected shall be the responsibility of the Contractor, should any subsidence or any other damage occur due to the inefficiency of the shoring, underpinning, strutting and the like or any other support provided. The damage shall be made good by the Contractor at his own expense and responsibility.

The shoring, strutting, piling and the like, shall be executed in such a manner as to cause as little inconvenience as possible to adjoining owners or the public and the Contractor shall be responsible for negotiating with the adjoining owners the means to safeguard their property and for the use of any portion of their land for the purpose of executing the excavations and no claims submitted on this ground will be entertained.

The Contractor shall be held solely responsible for the safety of the adjoining existing buildings, the sufficiency of all temporary or permanent shoring, underpinning, piling, and the like.

Contractor shall keep the Employer informed as to manner in which he intends to proceed with the execution of the excavations and obtain his approval. Such approval if given shall not absolve the Contractor of his responsibility under this Clause.

The Contractor shall save harmless and indemnify the Employer in respect of all claims, demands, proceedings, damages, costs, charges and expenses whatsoever arising out of or in relation to any such matters in so far as the Contractor is responsible under this Clause.

## **2.20 Demolitions**

Demolition includes the complete demolition including grubbing up of foundations and the proper termination of all services as required by the Drawings including the removal and disposal of all demolished materials. The demolition work shall be executed in a systematic manner.

Demolition operations and the removal of debris shall be carried out to ensure minimum interference with roads, streets, footpaths and other adjacent occupied or used facilities

The Contractor at his own expense shall repair damage caused to adjacent facilities by demolition operations. The Contractor shall arrange and pay for the disconnecting, removing and capping of utility services, notify the affected utility agency in advance and obtain written approval before commencing work.

## **2.21 Levels and Reference Points**

The Contractor shall satisfy himself that the existing ground levels as indicated in Contract are correct. Should there be any dispute regarding any levels, Contractor shall submit to the Employer a schedule of the levels considered to be in error, together with the values he believes to be correct. The ground relevant to the disputed levels shall not be disturbed until the Employer's decision as to the correct levels is given.

The Contractor shall supply to the Employer details of the value and location of the temporary benchmarks and reference points he proposes to use. Temporary bench marking should be carried within the line of sight.

## **2.22 Interference with Access to Properties and Apparatus**

Before interfering with access to any property, the Contractor shall make adequate alternative arrangements for the occupiers.

The Contractor shall not obstruct access to any apparatus or utilities of any service or utility.

## **2.23 Procedure for Complaints and Damage Claims**

Details of complaints received by the Contractor as a result of work he is carrying out shall be passed to the Employer without delay. The Employer shall likewise pass to the Contractor details of complaints, which may be submitted directly to him.

A similar exchange of information shall be made in relation to all claims and intended claims, which may be received.

## **2.24 Protection against Damage**

The Contractor shall avoid causing unwarranted damage to streets, pathways, land, property, trees and other features. He shall deal promptly with any complaints from owners or occupiers.

The Contractor shall avoid damage to apparatus or utilities of other undertakers and shall temporarily support or work around any such apparatus, which crosses or runs alongside his works. In the event of damage, the Contractor shall notify the Employer and the Undertaker.

## **2.25 Apparatus of Statutory Undertakers**

The Contractor shall liaise with all relevant statutory Undertakers before commencing any excavations, and shall satisfy himself of the exact position of existing apparatus, which may be affected by the works.

The Contractor shall notify the Employer in advance of any diversion or removal of apparatus or utilities required for his own convenience or proposed method of working and shall comply with any requirements of the Employer with respect to them.

## **2.26 Work Standard**

Works should be carried out according to professional standard acceptable to Employer. The contractor shall reimburse Employer the cost of material lost or damaged due to faulty installation.

Contractor shall carryout the Works in a hygienic and professional manner to ensure that no leakage of sewage to the ground takes place. In case the ground is contaminated with sewage, the affected area shall be chlorinated & decontaminated.

## **2.27 Tidiness of the Site**

The Contractor shall be responsible for the proper up keeping and maintenance of the site and the works and shall remove from the site rubbish and other waste as it accumulates. Materials and equipment shall be positioned, stored and stacked in an orderly manner.

## **2.28 Care of Works**

The Contractor shall take all necessary and reasonable precautions to protect the existing utilities, properties, and structures etc. in which his is carrying out his activities and make good, at his own cost, any loss or damage that he might cause.

## **2.29 Security**

The contractor shall ensure that the site is secure during the period of work and shall be liable for any loss or damage sustained as a result of their failure to comply with this condition.

Where the works are in close proximity to buildings, walls or other existing structures, the contractor shall take adequate measures to prevent any damage to such structures. In addition before commencing work the Contractor shall submit details in writing to the Engineer of his proposed method of carrying out these measures and shall not commence operations until these are approved in writing.

## **2.30 As-Built Drawings / Shop Drawings**

The Contractor should note that the Drawings and Quantities in the Tender Documents have to be considered as preliminary, and only provide an indication of the locations, layouts and scope of works. Detail design drawings must include longitudinal sections showing ground level, mean sea level {MSL}, pipe invert level, depth of pipe, slope, manholes, distance between manholes, and changes in slope for all pipes in the network. The contractor should produce all the relevant as built drawings including the profiles. The locations, layout and scope of works may be altered and in such cases the Contractor shall not be entitled to any claim whatsoever for such alterations over and above the measured works or measured variations at the tendered rates except in accordance with the provisions of relevant Clauses of the Conditions of Contract.

Subject to the above limitation, design detail will be provided by the Engineer in advance of the Contractor's intended commencement of construction as indicated in his approved construction programme or as otherwise agreed with the Engineer.

Should any Contractor's proposals for the any specialised items differ in entirety or substantially from that of the Engineer's or should it affect another component of the element or item of work beyond permissible variations from it, then the Contractor shall, at his own cost, be responsible for redesign to provide a complete acceptable system before approval of any part thereof. For such works, the Contractor shall furnish, at his own expense, the Engineer with copies of all design calculation, sketches, working drawings and similar information in as much detail as the Engineer may reasonable require for his full information and subsequent approval.

Such approval of the Contractor's design shall not relieve the Contractor from any of his duties, responsibilities or obligations under the Contract.

The above work to be undertaken by the Contractor or his approved subcontractor shall be in accordance with current practice generally using accepted design techniques in accordance to international standards or as specified in the relevant Tender Document all to the approval of the Engineer.

Contractor shall prepare the working drawings/shop drawings and documents, including diagrams and schedules shall show the details of proposals for the execution of the works and shall include everything necessary for the following purposes:

- To illustrate in detail the arrangement of the various section of the works and to identify the various components.
- To integrate the various sections of the works.

The shop drawings required shall include but not be limited to the following:

- (a) Layout of house connections showing locations approved by the house owner
- (b) Detailed layout drawings all pump stations and treatment plant, showing the connection of mechanical and electrical services, ducting, conduit, cable tray and trunking together with earthing system

- (c) Detailed layout drawings showing sections such as through ceiling voids and vertical shafts.
- (d) System diagrams, circuit diagrams and wiring diagrams for all installations and equipment.
- (e) The drawings, specifications and technical information for materials and equipment of building components such as doors, windows etc.

Working drawings and documents shall be made available sufficiently early so that the Engineer gets sufficient time to check and correct them.

The Contractor shall liaise with the Engineer for the period required for any approval, which shall be a maximum of two weeks. Delay in obtaining approval of working drawings shall not be a reason for requesting extension of time.

The Contractor shall ensure that all items to be ordered by him can be accommodated in the positions shown on the drawings and for taking all necessary dimensions on site together with any supporting information which may be necessary for preparing working drawings.

Materials or equipment shall not be ordered nor the construction of the associated works be commenced until such approval has been obtained from the Engineer.

The Contractor shall be deemed to have obtained a full and proper understanding of the Engineer's design and design intents and to have satisfied himself with their accuracy and suitability. In this respect, the Engineer will meet all reasonable requests made by the Contractor in furnishing design information and other information to the Contractor. No claim in respect of lack of knowledge will be admissible.

## **2.31 Site office for the engineer**

The contractor shall provide a site office for the use of the Engineer inside the site.

### **2.31.1 Furnishing of the Site Office for the Engineer**

The offices shall be fully furnished with new, good standard office furniture and equipment approved by the Engineer for the sole use of his and other site supervisory staff for their efficient operation.

Providing and furnishing the site office shall be completed within 30 days from the commencement of the contract.

The office shall be kept clean and guarded at all times and shall be supplied with office stationery etc. as required by the Engineer.

## **2.32 Surveying Equipment**

The Contractor shall provide at the site, at his own expense, one approved set of surveying and measuring equipment. The set shall be used by the Contractor for requirement at site and be made available from the commencement of contract for the use of the. The set shall consist of the following instruments:

<b>ITEMS</b>	<b>QUANTITY</b>
<b>Total Station</b>	1
<b>Pogo with Reflector</b>	1
<b>Big Tripod</b>	1
<b>Small Tripod</b>	1
<b>Fibre glass type (Cased 30m)</b>	2
<b>Steel Pocket Tape, 3m</b>	4
<b>Surveying Umbrellas</b>	2
<b>Ranging Poles, 2.5m Long</b>	10
<b>Level Books – as required</b>	
<b>Field Books – as required</b>	

All equipment shall be supplied with their tripods, staff and such other equipment/item as the Engineer may require for the measuring, or setting -out of the work.

The Contractor shall be solely responsible for the maintenance of all such instruments and equipment and shall ensure they are, at all times, in good repair and adjustment. All equipment other than expendable items shall revert to the Contractor upon completion of the works.

The Contractor shall provide the Engineer, throughout the Contract period, with all necessary assistants and chainmen to assist with surveying work. The assistant shall keep the survey equipment in good order.

## **2.33 Laboratory and Laboratory Testing**

### **2.33.1 Description**

Testing of materials and completed work shall be carried out by a site laboratory established and allocated exclusively for that purpose; all testing shall be carried out under the direction and supervision of the Engineer's staff. All tests shall be performed in strict accordance with the appropriate British Standards or other standards as approved by the Engineer.

Any testing relating to the Works as required by the Engineer which cannot be carried out in the site laboratory shall be carried out at the Contractor's expense, at an independent laboratory approved by the Engineer.

The provision of laboratory facilities on site, as specified, shall in no way relieve Contractor of the responsibility for providing additional laboratory space and testing equipment as necessary in order to control materials at mixing plants and elsewhere and enable him to fulfil his obligations under the Contract.

If for any version a laboratory cannot be setup at site, all the tests shall be got done in a laboratory approved by the Engineer.

### **2.33.2 Laboratory Building**

The Contractor shall provide, furnish, equip, keep clean and maintain to the satisfaction of the Engineer a laboratory building of a floor area not less than 30 sq.m. The building shall be provided with electrical power, potable water, drainage, and shall have adequate daylight and artificial lighting.

The Laboratory shall be adequately staffed by the contractor with materials technicians and assistants in the numbers deemed necessary by the Engineer so that no interruption of unnecessary delay shall occur to construction activities due to delays in sampling or testing, in-site or in the laboratory, as required by the Contract. The testing equipment provided in the laboratory shall be sufficient to carry out the following tests;

- (a) Modified Proctor compaction tests
- (b) Field Density tests using core cutter and sand replacement methods

- (c) Crushing strength of 150mm size concrete cubes.
- (d) Sieve analysis

The Contractor shall, at the Commencement of the Contract, submit a detailed list of the equipment he is proposing to provide showing for each item its type and model, serial number, manufacturer's name and year of manufacture for the Engineer's approval.

The testing of the works by the Engineer, in no way, absolves the Contractor from his responsibilities to carry out his own testing of the quality of his works and the materials used.

The laboratory building and equipment shall be used exclusively for the purposes for which they are intended and shall, together with all equipment, all samples and records, be open to inspection by the Engineer during all working hours.

The laboratory shall be fully operational within 15 days of commencement of Contract and remain so until all work in the opinion of the Engineer is complete. At the end of Construction the laboratory building with furniture and equipment shall revert to the Contractor. The laboratory shall not, however, be removed from site without the prior consent of the Engineer.

If in case the tests are to be done in an approved laboratory, such an approval shall be obtained from the Engineer within 15 days of commencement of Contract.

Vernier Callipers and 2 Screw Gauges having 0.01 mm least count shall be made always available at site by the Contractor.

After removal of the laboratory the Contractor shall clean and level the site removing all foundations, drain water pipes and other services installed for the laboratory and return the ground to its original condition.

### **2.33.3 Sample**

The Contractor shall submit samples of all materials and goods for inclusion in the works to the Engineer and only those approved by the Engineer and to the standards specified elsewhere in the Contract may be ordered for supply. Samples shall be submitted promptly in order not to delay the works.

All work executed shall be of equal standard in all respects to the approved samples and the Engineer may reject any work which, in his opinion, does not comply with the approved samples.

## **2.34 Site surveys, setting out and design detailing**

### **2.34.1 Description**

The Contractor shall be responsible for the true and proper setting-out of the works in relation to the lines and levels of reference given by the Engineer or shown on the Drawings and for the correctness of the position, levels, dimensions and alignment of all parts of the works and for the provision of all necessary instruments, appliances and labour used in connection therewith. This also includes the survey of each plot and preparation of site layout and identifying household catchpits, and obtaining Homeowner & Contractor agreement for each house. This survey should be carried in accordance with guidelines set by the client.

The Contractor shall carry out a detailed survey of the site in advance of his commencement of Construction work, and shall supply full details to the Engineer as specified in the following sub clauses.

Contractor shall carry out a detailed level verification survey. These levels should be taken from each location of the Cleanouts, Manholes, valve chambers, or any other specific locations placed on roads for systems. The contractor should submit this survey for approval by the engineer.

All setting out and levelling shall be based on permanent Benchmarks obtained from the Local Authority.

### **2.34.2 House Connection Survey**

Contractor shall request client to provide the current guidelines on provision of house connections. Additionally, immediately after mobilisation contractor shall obtain the approved list of households from island councils. The Contractor shall then carry out a joint inspection survey for the list of houses provided as per the guideline and finalise the list of house connections with island council and client. Upon finalisation of this list contractor shall prepare layout drawing indicating the existing location of the septic tanks, levels (in MSL), requested location of the catchpit with levels ( if applicable) and requested location of the

water meter. If the invert level of the catchpit to be placed is lower than the invert of the sewer main pipe on the road, contractor shall notify engineer. The contractor shall prepare homeowner agreements as per guidelines and complete the house connection survey requirements within the mobilisation period.

The house connection list for water meters must include the following locations,

I. Harbour kiosks

II. All public buildings

III. All sewerage facility locations including pump stations, STPs or discharge pump Stations.

### **2.34.3 Setting out Survey for Facilities**

After carrying out the site clearance works at facility locations (water treatment plant, rainwater collection buildings, lift/pump stations (if applicable), discharge pump station/STP (if applicable)) the contractor shall carry out a setting out survey of the location. This survey shall provide existing road levels surrounding the facility, levels within the plot at 2m-by-2m grid and all structures (admin buildings, sumps, sheds, vents, lights etc) locations within the site. The layouts produced should be submitted to engineer/consultant for approval prior to carrying out any of the works.

### **2.34.4 Detailed Level Survey (where applicable)**

The contractor shall carry out a detailed level survey of the network components. This includes level survey of each Manhole/cleanout location, facility location. This should be submitted to Engineer for verification. Any substantial change in the elevation that could result in pipe cover loss changes in critical profile invert levels at PS should be taken addressed prior to commencement of works.

### **2.34.5 Existing levels, Reclaimed Areas and Layouts**

Before commencing operations of any section of the works including reclaimed areas, the Contractor shall survey all existing detail in that section, in plan and in level and shall plot the results in such detail and to such scales as shall be to the satisfaction of the Engineer. These survey plots shall be supplied to the Engineer at least four weeks before the intended commencement of construction on the section. Unless otherwise instructed by the Engineer the detailed survey plots will be supplied in 1:200 scale.

In addition to the requirements above, horizontal control lines shall be marked out by pegs at intervals of not more than 20m and the lines traversed with the theodolite, by steel band or by any other method acceptable to the Engineer. The alignments established shall be referenced by pegs offset at suitable distance on each side of the horizontal control lines. These offset pegs shall be painted in a conspicuous colour.

Cross sections of the existing ground and of the ground after completion of earthworks shall be taken at intervals not exceeding 20m along the horizontal control lines in an approved and acceptable manner. Demarcation of roads on reclaimed areas shall be carried with assistance from island council.

Based on the levels of the reclaimed area, Contractor may need to revise the designs of the reclaimed areas and should be submitted to Engineer for approval.

#### **2.34.6 Bench Marks and Survey Points**

As the work proceeds, the contractor shall establish, at suitable location, substantial permanent benchmarks, clear of the works, from which, all subsequent setting out and levelling shall be carried out. The location of the benchmarks, one at every 200m, shall be agreed with the Engineer before they are established.

Benchmarks shall be constructed in class 20/20 concrete, with minimum dimensions of 0.3m x 0.3m, the upper surface being approximately 50mm above ground level. A 20mm diameter mild steel rod, not less than 300mm in length, shall be cast into the concrete so that it projects about 10mm above the centre of the surface of the concrete. The concrete surface shall be clearly engraved with the reference number of the benchmark. The co-ordinates and level of each benchmark shall be determined in metres to 3 decimal places.

The Contractor shall check co-ordinates and levels of benchmarks at monthly intervals and immediately notify the Engineer of any discrepancies.

### **2.35 Soil Investigation and Report**

limited soil investigation is required in the Design phase. If the contractor intends to do any further investigation, then he has to inform the Engineer so that the approval of Island Authorities could be obtained.

## **2.36 Progress Photographs**

The Contractor shall submit to the Engineer before the fifth day of each month, throughout the period of the Contract, one set of progress photographs comprising 2 copies of 12 A4 size photographs selected by the Engineer from not less than 24 exposures of views of the works taken at the direction of the Engineer. The arrangements for the progress photographs are subject to the approval of the Engineer and shall be discussed at as early a date as possible so that complete coverage can be assured.

The Contractor shall submit to the Engineer each month, a videograph of the progress of works, one video tape not more than 30 minutes duration showing the progress during every month.

## **2.37 Notice Boards**

The Contractor shall provide, erect and maintain for the duration of the contract, Notice Boards 3m x 4m size as per drawing and specification in a location approved by the Island authorities / the Engineer, including complete cost and conveyance of materials and labour charges,

Notice Boards shall have a block board panel size of around 3m as detailed on the Drawings or equally approved. The Contractor is responsible for obtaining all necessary approvals for the erection of these notice boards.

Under no circumstances, shall sub-contractor's or supplier's name boards be fixed on hoarding or elsewhere on site.

## **2.38 Advertising**

Neither the Contractor nor any of those in his employment shall give information concerning the works for publication in any form without the written approval of the Engineer.

Neither the Contractor nor any of his sub-contractors shall erect placards or advertisements within the site other than the notice boards mentioned before

## **2.39 Traffic Management and Site Safety**

### **2.39.1 Site Safety and Traffic Management**

In order to improve the general vehicular traffic condition and to guarantee public safety from and around the work the Contractor shall provide all labour, and materials, and construct and maintain temporary traffic diversions throughout the construction activities, to the directive and approval of the Engineer. It is therefore recognised that there is a particular responsibility placed upon the Contractor to take special precautions for public safety and to minimise the scale and extent of disruption to public and commercial life. Plans for traffic diversion shall always be submitted to the Engineer and to the traffic police for their prior approval.

### **2.39.2 Safety on Site**

The Contractor shall ensure that the works are carried out in a safe manner, according to internationally accepted guidelines on safe working procedures and to the satisfaction of the Engineer.

The following requirements shall be complied with by the Contractor:

- (a) Excavation - All excavations shall be adequately supported to avoid collapses and effective safety barriers shall be erected with warning signs and devises around all open excavations to the satisfaction of the Engineer.

Struts and walling shall not be used as ladders and for the purpose of access to the base of excavation the Contractor shall provide proper ladders which shall be suitably secured.

Reflective wearing shall be worn by all workmen on or close to a highway and, where necessary, temporary road signs and cones shall be provided to ensure a safe working area.

- (b) Protective Clothing - The Contractor shall ensure that all personnel on site are supplied with the necessary protective clothing such as safety helmets, goggles, face masks, ear muffs, gloves, boots, etc. which are required for the operations being performed.

(c) Scaffolding - Suitable and sufficient scaffolds shall be provided and properly maintained for all work that cannot safely be carried out from the ground or from part of the structure or from a ladder.

Every scaffold shall be of good construction, of suitable and sound material and of adequate strength for the purpose for which it is used. Unless designed as an independent structure, every scaffold shall be rigidly connected to a part of the structure which is of sufficient strength to afford safe support. Protective headgear shall always be worn.

(d) Lifting Device - Every rope, chain, pulley, bloc, hook, winch, crane or other lifting gear used for raising or lowering loads or as a means of suspending them shall be of good construction, sound material, adequate strength and free from defects. They shall be properly maintained and tested at regular intervals by a competent person, who shall be to the approval of the Engineer.

(e) Working in manholes etc. , - Checks shall be carried out before entry to ensure that the atmosphere is fit for respiration and no smoking naked lights or flames are to be permitted in any sewer, manhole or chambers or adjacent to them when these are open.

The safety equipment which shall be made available shall include but not limited to:

- Gas detector lamps with lead acetate papers.
- Lifting harness with ropes Hand lamps with spare batteries
- Protective head gear.
- Rubber Gloves.
- Breathing apparatus.
- Wooden First Aid Boxes
- Fire Bucket sand with round bottom buckets.
- Rubber mat of 1.1kV grade of size 6mm thickness
- Fire Safety Rules charts
- Shock Treatment Charts

Throughout the period of the Contract, the Contractor shall provide safety helmets and high reflectivity jackets to all Consultant's staff and visitors. Barriers must be provided to all

excavations for the safety of the public and flagmen must be used for all items of plant for the safety of the operatives, supervision staff and members of the public.

### **2.39.3 Traffic Management**

Before commencing the works, the Contractor shall consult with and obtain from the Traffic Police, Employer and the Engineer their requirements for temporary traffic signs, road markings, lighting and other measures necessary to ensure the safety of the public. The Contractor shall also take a No Objection Certificate from Consultants supervising other Contracts in the area, get details of newly installed and temporary services and obtain access requirements for other contractors.

The Contractor shall deploy, as a full time member of his site staff for the duration of the contract, whose duties shall include the production and implementation of traffic management schemes and the safety of vehicular and pedestrian traffic. Qualification and experience of the traffic management staff shall be subject to the approval of the Engineer.

Throughout the Contract, the Contractor shall maintain vehicular and pedestrian access to all properties adjacent to and within the site at all time. The contractor is solely responsible for obtaining the necessary permissions and approvals from the Traffic Police, service authorities and all other concerned authorities for the diversions and closure of sections of the existing roads and footpaths. Details of all proposed traffic management schemes shall be prepared well in advance of their intended implementation and shall be submitted to the Engineer and to other interested parties for approval.

Approval by the Engineer of a scheme will not relieve the Contractor of his responsibility to gain approval from the Traffic Police or other concerned authorities. Ignorance of any restrictions as to the timing and /or placing of diversions imposed by the Traffic Police or other authorities will not be accepted as a basis for claims for additional costs or delays arising from such restrictions. Adequate warning and direction signs are to be erected wherever necessary and diversions are to be maintained in good condition to the satisfaction of the Engineer.

Temporary diversions shall be constructed and maintained to the standards approved by both the Traffic Police and the Engineer. Upon completion of the Permanent works, the temporary diversions shall be removed and the site restored to the satisfaction of the Engineer.

The Contractor shall arrange with the appropriate authorities for any additional land required for temporary diversions.

All traffic diversions must be constructed and maintained to the highest standards with regular washing of cones and daily maintenance of flashing lights. The signs and cones should be self-stabilising, and if extra stability is required only small sandbags should be used.

All stockpiles of material to be used in the works must be fenced off and all unsuitable material must be removed from site on a daily basis and not stockpiled on site.

## **2.40 Services**

Before the Contractor may proceed with the Works in any given area he is required to establish the precise location of all services in that area.

The contractor will therefore be required, acting in strict co-operation with the Engineer, and other concerned authorities, to open up hand excavations, at points to be agreed, in order to establish the precise location of the existing services. The Contractor is required to make adequate allowance in his programming for this process and may be required to adapt his programme to accommodate the service protection and /or relocation works ordered as a result of these investigations.

## **2.41 As Built Records**

Upon completion of work as in the stages of the Programme of Works, at the direction of the Engineer, the Contractor shall prepare detailed drawings and other records, as required, of the works executed. The Contractor is required to submit the soft copy as well as three hard copies of the as built records to the scale advised by the Engineer.

## **2.42 Programme of Works**

The following specific requirements shall apply to the Programme of Work

The works shall be programmed in such a way as to minimise disruption to public traffic

Works shall not be carried out simultaneously over large areas of the site but shall be sequenced so that all operations likely to cause disruption to public traffic shall be undertaken and completed in discrete area before commencement of operations in other areas.

Works which, by their nature, will create disruption and / or obstructions to vehicular or pedestrian traffic, such as pavement rehabilitation or trench – work shall be programmed to be undertaken in a continuous sequence of events from the initial disruption until the restoration of access without and significant delay between operations.

The programme submission shall be accompanied by outline traffic management plans in sufficient detail to indicate to the Engineer that the Contractor has considered this aspect the work in his programme. Notwithstanding, acceptance of the Contractor's programme will not in any way relieve of his responsibilities for traffic management.

The Contractor's Programme shall, insofar as it is practicable to do so, take into consideration the commercial interest of individual shopkeepers e.g. operations should not be sequenced so as to disrupt access to those individual shops having access from more than one street, from more than one of those streets at a time.

Weekly programmes of work shall be prepared at least one week in advance and submitted to the Engineer, who will in turn brief the Island authorities.

The Contractor's Programme of Works, submitted in accordance with the Conditions of Contract, shall be subject to the approval of the Engineer and of Employer, the Contractor has not properly achieved the objectives of the programme, then they may require the Contractor to revise his Programme and the Contractor shall do so forth, for this reason the Contractor is advised to liaise closely with the Engineer during the production of his Programme.

The Contractor should note that when a phase or phases of the works is/are programmed to be completed before commencement of another phase, the Contractor may not commence work on the later phase until the former phase is completed, even if the former phase overruns its allocated construction time, without the specific permission of the Engineer.

In addition to the Works Programme required under the Conditions of Contract, the Contractor shall produce individual programmes for each element of the works likely to cause significant disruption to public and vehicular traffic, for the approval of the Engineer and

prior to commencement of the element of the works, clearly showing the sequencing of construction operations in such a manner as to minimise the duration of the disruption.

The Contractor shall note that different work in various parts of site by other contractors may be in progress or may commence during the Contract Period. It will be the Contractor's responsibility to liaise with contractors on adjacent sites in order to ensure the detail progress. The Contractor's Programme will be phased and will make full allowance for the need for a co-operative timing with adjacent contractors.

### **2.43 Contractor's Offices, Yard, Stores and Plant Area**

The Contractor's main office shall be located in an area identified by the Island Authorities for the purpose. The Contractor's main office shall be used for the purposes of administering the Project. An adjoining area could be allocated by the Island Authorities for storage of materials.

The Contractor's other offices, yard, stores and plant area shall be provided, by the Contractor, at location(s) to the approval of the Employer. The Contractor shall be responsible for all associated expenses including rents, assessments or temporary occupation license fees, establishment, running and maintenance costs, the supply of all services, as well as the obtaining of any appropriate No Objection Certificates.

Within 7 days of the Commencement date of the Contract, the Contractor shall submit, for the approval of the Engineer, a drawing showing detailed plans for the offices, yard, stores and plant area, together with all sanitary arrangements, and for the supply of water and electricity. Until the Engineer has given his approval in writing, no construction of any of the Contractor's buildings, fences, services or roads shall commence. The area shall be fenced in accordance with Municipality regulations.

The Contractor shall not be permitted to erect temporary building or structures elsewhere without the specific permission in writing of the Engineer, including approval of the dimensions and specifications of such buildings or structures and their location.

The Contractor shall take all steps necessary as directed by the Engineer to minimise or eliminate dust, noise or any other nuisance, which may occur. Plant emitting dust, smoke, excessive noise or other nuisance shall not be permitted to be sited at any location which shall

cause nuisance to any building or other installation, whether complete or under construction, site offices, camps, or other similar buildings.

Under no circumstances shall overnight accommodation be permitted on site except for Site watchman in carrying out their duties.

Throughout the period of the Contract, the Contractor shall maintain the area of his operation within the limits of the site in a clean, tidy and safe condition by arranging materials and the like in an orderly manner. All rubbish, debris, waste materials and the like shall be systematically cleared from the site as it accumulates.

The Contractor shall satisfy himself as to the means of access to the site and other relative items affecting him, his sub-contractors and suppliers.

Upon completion of the Contract, or, in the case of facilities required by the Contractor during the Period of Maintenance, on completion of the period of maintenance the Contractor shall remove all buildings and other facilities from the site including all foundations and services, clean and level the site and restore the ground to its original condition.

## **2.44 Protection of Environment**

The contractor shall, in compliance with the EIA report for the project and based on the environmental management plan described therein, prepare an Environmental Management Plan prior to commencement of work and get the same approved by the Engineer.

The contractor shall be responsible for the protection of the environment in the area where he works. All mitigation measures identified in his Environmental Management plan shall be strictly adhered to by the Contractor during the period of construction

## **2.45 Training of Operator's Staff**

The contractor must also provide training and instructions for the operation and maintenance of the plants including all mechanical/electrical components. The scope of training shall fall into two main types which are 'off the job' and 'on the job'. The Contractor must provide a detailed plan and documentation including the training programme and provision of training personnel.

### **2.45.1 Training Objectives**

- providing training for all operating personnel
- the chemistry and processes involved in the operation
- raise awareness about occupational health and safety standards and emergency procedures

### **2.45.2 Training Requirements**

The programme should cover training procedures as well as on the job training for the following personnel:

- Operators
  - on the operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure;
  - on the day to day operation of the Works and procedures;
  - on a comprehensive list of 'what if scenarios dealing with the actions to be taken in the event of potential process problems, alarms, plant failures overflows, power failures etc.;
  - on first line mechanical maintenance;
  - safe methods of work general;
  - on safety procedures to be followed in operating, maintaining and cleaning the plant;
  - under operational conditions on the operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure;
- Electrical Maintenance Staff
  - on the configuration, construction and operation of the electrical Plant;
  - on the electrical maintenance requirements of the Works;
  - on the switching and safety procedures to be followed;
  - safe methods of working;
  - on fault finding and repair procedures
- Control and Instrumentation Maintenance Staff
  - on the configuration, construction and operation of the Plant;
  - on the control and instrumentation maintenance requirements of the Works;

- on fault finding and repair procedures;
- safe methods of working;
- Mechanical Maintenance Staff
  - on the routine mechanical maintenance requirements of the Works;
  - on lubrication requirements of the Works;
  - on fault finding, repair and overhaul procedures;
  - safe methods of working.

## **2.46 Testing, Commissioning & Trial Operation (03 Months)**

Prior to start of any commissioning activity, the contractor shall prepare and submit commissioning plans, outlining schedule, sequence, detailed methodologies and checklists for all commissioning activities to be undertaken. No Commissioning activity shall commence before approval of the commissioning plans by the Engineer. The commissioning of the system should be carried within the contract period to demonstrate the successful operation of the system before handover of the system to client.

### **2.46.1 Stage 1: Pre-Commissioning Tests**

Pre-commissioning tests include Factory Acceptance Tests, Site Acceptance Tests and functional tests of individual components of the works to demonstrate that each item/component can safely undertake the subsequent stages of commissioning (wet commissioning & trial operation). The following tests shall be carried out as part of pre-commissioning;

- Hydrostatic Testing of Structures and pipelines including Pumping/Lifting Stations STP structures, rainwater collection network, water distribution network, water storage tanks, gravity sewer network including pumping mains.
- Visual inspection of equipment/components to ensure correct installation.
- Functional Tests, including calibration Tests for all instruments and Electrical and Mechanical Equipment.

### **2.46.2 Stage 2: Commissioning**

Water Supply facilities: Process commissioning of water supply facilities including RO plant and Ultrafiltration unit etc to demonstrate the correct operation of the system and its components. Water quality tests should be undertaken to demonstrate that the RO plant and Ultrafiltration Plants produce drinking water to the standards specified in the design.

Sewerage facilities: Wet commissioning of sewerage facilities will be carried out using ground water to demonstrate reliable operation of the components in accordance to the requirements of the design and contract documents.

### **2.46.3 Stage 3: Trial Operation & Process Commissioning of Facilities**

#### **2.46.3.1 Sewerage facilities**

Upon completion of the preceding commissioning activities, sewage will be introduced into the system by connecting the septic tank inlet pipe to the household catchpit in each house. The contractor shall undertake trial operation of the sewerage facilities and conduct process commissioning of the sewerage system. Process commissioning and trial operation shall include the following;

- Commissioning of sewerage facilities as a complete process on sewage and testing of continuous operation.
- The operation of Mechanical, Electrical and control systems including Pumping/Lifting Stations and Sewage Treatment Plant Equipment.
- Performance testing of STP to demonstrate compliance with the approved design.
- Final adjustment of equipment and control settings for pumping/lifting stations and sewage treatment plant.
- Monitoring/Inspection of connections to the house hold Inspection Chambers, to ensure correct installation.
- Conduct effluent quality testing to demonstrate compliance with effluent quality standards of EPA.

- Conduct ground water quality at the premise of pump stations to the requirement of EPA.
- During the trial operation, the contractor should take full responsibility for the entire sewerage facilities, including any routine and immediate maintenance required.
- The contractor shall complete the final training of Operation and Maintenance staffs during this period and ensure the staffs are ready to undertake functional operation of the facilities.
- The Contractor should keep documentation of operational and maintenance logs for the entire period of trial operation.

#### **2.46.3.2 Water Supply facilities**

Upon completion of stage 02 commissioning activities, water will be supplied to the network. The contractor shall undertake trial operation of the water facilities and conduct process commissioning of the system. Process commissioning and trial operation shall include the following;

- The operation of Mechanical, Electrical and control systems.
- Performance testing of RO plant to demonstrate compliance with the approved design.
- Final adjustment of equipment and control settings for pumps and accessories.
- Monitoring/Inspection of connections to houses ensuring no cross connection is made.
- During the trial operation, the contractor should take full responsibility for the entire RO plant system and water network facilities, including any routine and immediate maintenance required.
- The contractor shall complete the final training of Operation and Maintenance staffs during this period and ensure the staffs are ready to undertake functional operation of the facilities.
- Conduct Daily and Monthly water quality testing in line with the requirements of Environmental Protection Agency (EPA).

- RO plant and UF plants shall be operated at fixed times (to not waste water) and log sheets should be maintained for all recordable equipment (pressure gauges, rotameters, flow meters, conductivity meters, pH meters, etc and maintenance activities.

## 2.47 Environmental Monitoring & Reporting

The Contractor shall undertake Environmental monitoring & reporting, as identified in the Environmental Impact Assessment (EIA) reports, to the requirements of Environmental Protection Agency (EPA). A Generic list of monitoring measures required under water and sewerage infrastructure projects is listed below. In addition to these monitoring parameters, the contractor shall also include any additional parameters identified in the EIA and submit the reports to EPA as required. The reports should be prepared by a registered Consultant at EPA.

Component	Indicators	Methodology	Locations and samples	Frequency
<b>Marine Water Quality</b>	The following parameters must be tested: Temperature, pH, Salinity, conductivity, Total suspended solids (TSS) turbidity, nitrates, phosphates, ammonia, Dissolved Oxygen, Biological Oxygen Demand (BOD) and fecal coliform, total coliform	Laboratory Analysis	Installed outfall locations	Immediately after construction
<b>Ground Water Quality</b>	The following parameters must be tested: Temperature, pH, Salinity, Total Dissolved Solids (TDS), Total Petroleum Hydrocarbon (TPH), Fecal coliform and Total coliform	Laboratory Analysis	From borehole site	Immediately after construction of borehole
<b>Terrestrial modifications</b>	Location of trees that need to be removed, type and number of trees that need to be removed and location of replantation	Logs from contractor, and photographic evidence	Project sites, proposed RO plant, sewerage main building	Continuous during vegetation removal and replantation
<b>Benthic Cover/Marine Survey</b>	Coral cover( bottom morphology) , fish census	Marine Survey using Transects	Discharge locations and alternative locations	Every 6 Months during

				construction
<b>Noise Level</b>	Noise level in decibels  Noise complaints received from businesses	Spot measurement during work hours.  Logs from contractor of complaints	Project site, accommodation and residential areas close to the construction site	Monthly during construction
<b>Labor force</b>	Number of laborer Accommodation units Valid work visa and passport PPE provision Fire safety Pay slips	Logs from Contractor	Project site	Bi-annually during construction
<b>Waste management</b>	Waste type and quantity  Method of disposal	Observation, logs and photographic evidence	Project site	Once every Four months during construction phase

## **SECTION 3 SITE PREPARATION**

### **3.1 General**

The Contractor shall maintain close liaison with all Service Authorities and shall obtain their approval prior to removal of any service installation. Where Service Authority installations are to be removed, they shall be removed after the existing facilities have been relocated and commissioned or after they have been redundant and after any electrical supply has been made safe by the Authority or the Contractor whichever is appropriate.

“Site clearance” shall include the demolition/removal of all plants, bushes, underground structure, foundations, manholes, chambers, drains, septic tanks, cesspits, soak away, pipelines, under growth, trees (of any girth), tree stumps, buildings, services, rubbish and debris which are required to be cleared to construct the Works. Site clearance as directed by the Engineer shall include clearing and grubbing for the road corridor. The rate shall include for backfilling with suitable material all voids created by the removal of above mentioned items.

All areas of the Site specified for clearance or from which material is to be excavated or upon which filling is to be deposited shall be cleared of all obstructions walls and the like and bushes, hedges, and the like. The contractor shall remove material so cleared from Site.

The Site shall be cleared of all vegetation, rock, boulders, etc. and surface soil shall be removed as directed by the Employer. The trees, which are to be retained, shall be protected from damage.

Spreading, levelling and consolidating on site where required, shall be made with suitable surplus excavated material obtained from the Site. Imported soil used for filling shall be approved by the Employer.

The Contractor shall dispose all unsuitable and surplus excavated material. The Contractor shall tidy up and leave the Site in a clean and sanitary condition at all times during the execution of the Works.

It is deemed that except for the items mentioned in this technical specification, cost of all other works in connection with site clearance is included in various pay items of the BOQ.

### **3.1.1 Locating all existing services**

The contractor, with the assistance of utility service providers and island council must locate all existing services by cutting trenches across the road's right of way at least at an interval as reasonably required or as instructed by the Engineer. The trench shall be excavated manually without the use of machinery, so as not to damage any service. The width of the trench shall be decided at site. Once the service is located, its position, location and depth together with any other significant details, shall be marked up on a layout drawing, provided to the Engineer, and got approved by the Engineer. After collecting the details the trench shall be backfilled with the permission of the Engineer. The backfilling shall follow the specification for earthwork excavation.

Locating of the services has a bearing on the subsequent works and also on the safety of services during construction of the project by the Contractor.

The Item shall be measured by the volume of trench excavated and the rate would include for obtaining permission from the various authorities for exposing the services, excavation, backfilling and preparation of drawing.

### **3.1.2 Removal of Concrete Structures**

#### **A) General**

The Contractor shall remove wholly or in part and satisfactorily dispose of all structures (manhole, slabs, walls, buildings, pillars and any other structure constructed of brick or coral stone masonry or cement concrete) as indicated on the Drawings or directed by the Engineer, and which are not specifically described under a separate Clause of this Specification. This section also involves clearing grass, bushes, shrubs, saplings, uprooting rank vegetation along the pipeline route and removal & disposal of rubbish to approved disposal areas anywhere in the island as directed by the Engineer in-charge.

All material removed and all structures demolished shall be removed from the Work Site, hauled away and disposed of in approved disposal area and as approved by the Engineer. The Contractor will also have to carry out the cutting of trees, including trunks, branching and

removal of stumps, roots, stacking of serviceable materials with all lifts and up to all lead within project area and earth filling in the depression/pit, including excavation & backfilling.

The voids or depression which are the result of the demolition of structures shall be backfilled with borrow material as approved by the Engineer. Backfilling material shall be placed in horizontal layers of over 15 cm in depth and compacted to not less than 98%. The Contractor shall also sort out dismantled material, dispose of unserviceable material and stack the serviceable material.

### **3.1.3 Removal and Decommissioning of Existing System**

The Contractor shall remove wholly or in part and satisfactorily dispose of all existing water supply or sewer system (if the existing system becomes redundant) upon completion and testing and commissioning of new system. This will also include the removal of all the existing sludge from the septic tanks and soak wells using proper equipment such as sucker truck; and transfer the contents to the sewage treatment plant. Once all the content has been thoroughly removed the septic tanks should be backfilled with adequate material and compacted.

### **3.1.4 Mobilising to site and maintaining water bowsers**

The contractor shall mobilise at least two water bowsers of 3000 litre capacity in the island to cater for the needs of the community affected by the dewatering of trenches for sewer mains. The water bower shall have a pumping arrangement for pumping water to the temporary sump in each household. The pump and hose shall be suitable to cover all affected houses from an adjoining road. The rate for the item shall encompass all activities mentioned above

### **3.1.5 Pumping saline water from trenches to sea.**

The contractor shall maintain a close watch on the salinity of the water that is pumped out of the trench. When the salinity reaches 2000 micro Siemens, the water is no longer suitable for recharging. It should then be directed to the sea. The Contractor should mobilise hose pipes long enough to reach the sea for carrying out this operation. The rate for the item shall encompass all activities mentioned above.

## SECTION 4 – EARTHWORKS

### 4.1 Scope

This section specifies the requirements for the excavation, dewatering, Backfilling and other earth works.

### 4.2 Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

### 4.3 Reference Standards

The following standards are referred to in this section and the drawings relevant to this section;

<b>2013/R-1697</b>	EPA Dewatering regulation
<b>BS 6031:2009</b>	Code of Practice for Earthworks
<b>BS 8004:2015</b>	Code of Practice for Foundations
<b>BS 1377-1:1990</b>	Methods of test for soils for civil engineering purposes. General requirements and sample preparation
<b>T147</b>	AASHTO Standard Method of Test

### 4.4 Excavation

Excavation work shall be carried out in a safe and proper manner with appropriate precautions being taken to safe guard workmen and existing structures and utilities against all hazards. Notwithstanding these provisions, if damage to existing utilities results from the

contractor's operations, such damage shall be repaired without delay by the contractor or some other agency approved by the engineer, and the cost of such repairs shall be borne by the contractor.

*Equipment:* Mechanical equipment shall not be used in locations where its operation would cause damages to trees, buildings, culverts or other existing property, utilities or structures above or below ground. In all such locations hand-excavating methods shall be used. Where necessary contractor shall use hand tools to excavate test pits prior to excavation to determine the exact location of existing utilities. Test pits shall be refilled by hand as soon as practicable after the necessary information has been obtained. No extra payment will be made for the excavation of test pits.

*Adjoining Structures:* Excavation shall be performed to the required depth as shown in the Drawings. Excavation area shall be protected from any water flowing in. Sides of excavations shall be shored or inclined to retain excavation unless otherwise specified. Excavation near adjoining structures shall be executed with care so as not to damage those structures. The method of protecting the adjoining structures shall be proposed in writing to the Employer and approved by the Employer before starting excavation. The contractor shall devise a method of disposing the excess water from excavation. Approval must be obtained from the Employer and the relevant local authority before the beginning of excavation.

*Excavated material* shall be deposited within specified areas as directed unless otherwise specified. The Contractor is deemed to have inspected the site and to have ascertained for himself as to the nature of the soil, etc. and also the areas where to collect and stack the materials for which necessary site clearance shall have to be made at his own cost. Stacking or excavated materials shall be done at places approved by the Employer and the original ground levels of such places shall have been recorded by him jointly with the Contractor before commencement of stacking operation. Extra excavation and allied lead/lift required

specifically for providing working space to workmen or shuttering to walls of basement etc. shall be measured for payment, no extra claim being allowed for such work incidental to development and executions of allied jobs. Only authorized excavation approved by the Employer shall be paid for.

Excavated material shall not be piled along sides of excavations in a manner that will overload or increase danger of collapse of excavation sides. All excavated material shall be neatly piled in stockpiles but where this is not practicable the excavated material shall be removed from site. Excavated material shall be separated into those suitable for fill and those unsuitable for fill as directed by the Engineer. Materials unsuitable for fill shall, as soon as practicable, be removed from site.

Sufficient clear working space shall be left all around excavated area. The disposal of waste/unserviceable materials may be in filling and/or in embankment according to nature of place of disposal. The appropriate specifications for filling and/or embankment shall apply.

*Depth of Excavation:* All foundation trenches shall be excavated to the full widths and depths shown on the drawings or to such greater or smaller depths as may be found necessary in the opinion of the Employer and so ordered by the Engineer. Should any excavation be taken down below the specified levels, the Contractor shall fill in such excavation at his own cost with cement concrete specified for foundations, well rammed in position until it is brought up to the level.

*After Excavation:* The Contractor shall notify to the Employer or Engineer when the excavation is completed and no concrete or masonry shall be laid until the Employer has approved of the soil for each individual footing. All foundation pits shall be refilled to the original surface of the ground with approved materials, which shall be well consolidated as directed by the Employer. The Contractor shall erect temporary barricades around the excavations and if necessary make provisions of red lamps (warning Lamp)

Wherever Necessary, the Contractor shall remove/maintain/restore all service lines like telephone, water supply, electricity etc. without any extra charges.

*Adhere to drawings:* The Contractor shall perform all excavation as required for all work under this contract as indicated on the drawing. No Blasting of any kind will be permitted. Footings and foundations shall rest on firm undisturbed soil from loose materials. Excavation shall be carried out using materials and by whatever means are necessary accurately to the lines and levels shown on the Drawings, or as ordered by the Employer.

Except where indicated, the drawings are to remain undisturbed.

*Extension of Excavation:* The Contractor shall remove all topsoil, plants, roots, vegetation, rubbish, rocks, etc. from areas lying within limits of structures and from areas to receive fill, embankment, surfacing, road construction, concrete or other construction. Excavation shall extend a sufficient distance from walls, footings, etc. to allow space for placing and removing shoring and formwork, for performing all work in the excavations and for the inspection of same at the contractor's own expenses. Slopes and formation surfaces shall be trimmed true to line and the required profiles shall be left well consolidated, neat and smooth. Any additional excavation occasioned by slips, falls, wash-ins, etc., shall be made good at the Contractor's expense with mass concrete or approved filling materials as ordered by the Engineer.

*Inspection:* The Engineer shall inspect all the excavations before commencement of further work and the Contractor shall notify the Engineer when excavations are ready for inspection. The Engineer may instruct the Contractor to test the bearing capacity of the soil in the bottom of excavations. Upon receipt of such instructions, the Contractor shall forthwith carry out such tests as the Engineer may instruct at the Contractor's expense. Should the bottoms of excavation be found to be unsuitable as bearing surfaces as a result of such tests or inspection by the Engineer and the Contractor shall excavate further as directed until a satisfactory

bearing surface is achieved. No excavation shall be refilled nor any permanent work commenced until the formation has been inspected by the Engineer and his permission to proceed given. If required by the Engineer the bottom 150mm of excavation shall not be removed until just before the commencement of construction of permanent work.

Material suitable for fill shall be put to immediate use or stockpiled at the option of the Contractor. Under no circumstances shall material declared to be suitable for fill be stored next to materials declared to be unsuitable for fill. Stockpiles of materials suitable for fill shall be located in areas as approved by the Engineer in the vicinity of the work, located so as not to interfere with the progress of the works. Stockpiles shall be kept in a neat, well drained workable condition at all times. Footings and foundations shall rest on firm undisturbed soil free from loose materials. The bottom of excavations shall be thoroughly compacted by a mechanical compactor.

#### **4.5 Dewatering, Sheet piling and Trenching**

*Sheet piling:* Excavation for foundation or trenches or for any other work shall be sheeted, braced and shored as necessary to prevent caving or sliding and to ensure complete safety against collapse of soil at side of excavation and to prevent damage to adjacent property structures, paving and utilities.

*Dewatering:* This section includes the provision of all labours, materials, plant, equipment and appliances and performance of all necessary operations required to execute the work of this section. All Dewatering work undertaken must follow the EPA guidelines, Dewatering regulation (Regulation no: 2013/R-1697), by ensuring that all water removed during excavation for trenching and construction should be disposed of inland given that the salinity of water is not above 2000 microsiemens

The Dewatering rate must include all charges levied by regulatory authorities including any cost for supplying water to affected households

The excavations shall at all times be kept free from storm water, percolating water or subsoil water by any means necessary. The Contractor shall provide, maintain and clear away on completion any equipment necessary together with temporary drains and the like. Under no

circumstances shall concrete be poured, fill placed, pipes laid or appurtenances installed in excavations containing water.

The trench shall be kept dry during sub-grade preparation and continually thereafter until the pipe to be installed therein, is completed to the extent that no damage from hydrostatic pressure, floatation, or other cause will result. The contractor is welcome to propose methods of laying pipelines to the required gradient without dewatering or the least amount of dewatering.

All saline water dewatered shall be pumped out to the sea. Under no circumstances saline water shall be allowed to recharge the fresh ground water aquifer. Surface water shall be diverted or otherwise prevented from entering excavated areas or trenches to the greatest extent practicable without causing damages to the adjacent property.

Where the excavation level is below the natural water table and it is necessary to pump continuously from the excavation or to install a specialist form of dewatering equipment around the perimeter of the site or excavation, the Contractor will be responsible for ensuring the safety and stability of all adjoining structures and services or utilities above or below ground level. It will also be the responsibility of the Contractor that the equipment installed shall ensure that the excavation and subsequent construction is carried out in dry conditions.

The Excavation process shall follow the standards given below.

**BS 6031:2009 Code of Practice for Earthworks**

**BS 8004:2015 Code of Practice for Foundations.**

Continuous or permanent dewatering of the excavation or Site may not be undertaken without the written approval of the Employer to the work and the methods to be employed which shall also comply with Codes of Practice and Local Authority requirements. The water pumped from the excavations shall be pumped to disposal points or sumps as approved by the Employer and/or Local Authority and if so required be passed through settling tanks before disposal.

The contractor shall provide and maintain adequate de-watering equipment to remove and dispose of all surface and ground water or seawater entering excavations. However, contractor is restricted to minimize dewatering or extraction of ground water. Any extraction or dewatering of ground water could be carried out, only if Employer approved. The contractor must also provide all equipment necessary for the site dewatering.

The Contractor is responsible for following the shop drawings approved by the Engineer while installing the dewatering systems and ensuring that the Engineer is notified of any modifications made to the shop drawings.

*Observation and Monitoring:* The Contractor must ensure that the monitoring process involves observing and recording the drawdown levels in stand pipes, water discharge quantities and the effects of dewatering on existing structures.

## **4.6 Backfilling**

Backfilling shall be undertaken as soon as practical after the specified operations preceding it, have been completed. Backfilling should not be commenced until the works to be covered have been completed to the extent required by the Employer.

*Compacted backfilling* will be required for the full depth of the trenches. The backfill shall consist of uniform, readily compatible materials and shall not contain materials deemed unsuitable as directed by the engineer. At least up to 300mm above the top of the pipe only selected soil or fill materials shall be deposited in 150mm layers and thoroughly compacted using an appropriate mechanical compactor. Particular care shall be taken to avoid damages to the pipe. The remainder of the refilling may consist of course materials, which shall be spread in layers of not more than 250mm and compacted as above. Where the excavations have been supported and the supports shall be removed these shall be withdrawn progressively as backfilling proceeds in such a manner so as to minimize the danger of collapse. All voids behind the supports shall be filled and compacted.

*Commencement:* Backfilling shall commence as soon as the work of constructing the pipeline has been completed, but not before the work has achieved sufficient strength to withstand all loads imposed by backfilling. All excavation and backfilling shall be coordinate

with construction of the pipeline so as to expedite completion with minimum disruption. Backfilling of a trench shall be carried out after inspection of the trench by the Engineer (Employer). For pipes bedded on the trench bottom, or on a sand or granular bed, selected backfill material free from vegetable matter, building rubbish, stones, etc. shall be placed in unconsolidated layers of 150 mm thickness, and then uniformly compacted. Backfill used above the selected backfill layer shall be to the approval of the Relevant Authority, or others responsible for the upkeep of roads, and will usually be the excavated material.

*Inspection:* Well compacted back filling shall reach at least 95%- 98% of maximum dry density. All pipes connecting to an inspection chamber shall be properly covered with the correct selected material up to the thickness of 300 mm compacted above the crown of the pipe, or otherwise protected as specified in the specification or as directed by Employer. Backfilling around manholes and inspection chambers shall be undertaken in such a manner that will avoid damage or uneven loading. Backfilling shall be undertaken as soon as practicable after the specified operations preceding it, have been completed. Backfilling should not be commenced until the works to be covered have been completed to the extent required by the Employer.

All earth used for filling shall unless otherwise stated, be selected hard dry material from the excavation. The backfill of excavations shall be placed in horizontal layers not exceeding 150mm in thickness. Each layer shall be compacted by hand or other mechanical means to the required density before the next layer is added. The Contractor shall de-water the excavations and maintain them dry for stability and especially at the time of backfilling, concreting or any other construction work. The scheme of de-watering shall be approved by the Employer. Bailing, pumping out or otherwise removing all water which may accumulate in the excavation from all causes. Provision of adequate barriers, lighting, gangways across open trenches, etc. for protection of workmen and public. *Filling material* shall contain no perishable or organic rubbish and no particles in excess of 100mm in diameter. The maximum dry density of the material shall be not less than 1600 kg/m<sup>3</sup>. The surface of the sub-grade shall be compacted at optimum water content to the same percentage of maximum dry density required of subsequent layers.

Filling and backfilling shall be placed in layers not exceeding 150mm thick (after compaction). Each layer shall be uniformly spread and shall be moistened or dried by aeration when required to ensure the optimum water content and shall be compacted uniformly by hand or machine methods of specified density as follows:

Filling under footings of water tanks, concrete Beds, sidewalks and other bearing situation.	At least 98% maximum dry density.
Fill within 300mm; measure horizontally, of foundation walls, retaining walls, and edges of footings, and other below grade vertical surface. When machine compacted, compaction shall be	At least 95% maximum dry density.
Filling in Trench	At least 95% Maximum Dry Density

*Devices:* The Engineer shall have the right to disapprove and compacting device of inadequate capacity or in his opinion, of type unsuited to the character of the material being compacted. Heavy equipment for spreading and compacting fill and backfill shall not be operated closer to walls than a distance to the difference in height between the top of the footings and the layer being compacted. The Engineer may determine that testing may be required, if in his opinion compaction does not match the level required, to determine the density of in place soil shall be by means of **AASHTO Standard Method of Test T147** or in accordance with **BS 1377-1:1990** the number of density tests per layer shall be as instructed by the Engineer.

*Protection:* When backfilling behind retaining walls, basement walls and the like the said structures shall be kept propped during the complete operation. The hydraulic compaction of fill shall not be permitted and the backfilling shall be carried out in layers not exceeding

150mm thick. Each layer shall be compacted to 95% of the modified compaction. No backfilling shall be carried out until the wall concrete has achieved its full works cube strength and care shall be exercised so as not to damage the external tanking membrane and its protection.

*Trenches* shall not be fully backfilled until all required pressure tests have been performed and until the utility systems, as installed, conform to the requirements of the Specifications governing mechanical, electrical, and utility work. If the excavated material is not suitable for filling, then the contractor shall provide suitable filling materials at the Contractor's own cost... Filling material shall contain no perishable or organic rubbish and no particles in excess of 150mm in diameter.

Filling and backfilling shall be placed in layers not exceeding 150mm thick (after compaction). Each layer shall be uniformly spread and shall be moistened or dried by aeration when required to ensure the optimum water content and shall be thoroughly compacted uniformly by hand or machine methods as required.

#### **4.7 Disposition of Excavated Materials**

Subject to any specific requirements of the Contract, the disposition of excavated material shall be at the Contractor's discretion but shall be so arranged as to suit the overall requirements for the construction of the Works.

The Contractor shall ensure that no excavated material which is suitable for or is required for re-use in the Works is disposed of outside of the site. Temporary spoil tips may be used to store excavated material as required, and shall be arranged by the Contractor.

Excavated material which is surplus to requirements or is unsuitable for re-use in the Works shall be disposed off-site either to locations to be found by the Contractor (Contractor's tip) or to locations designated by the Engineer (Engineer's tip). Materials ordered to be disposed of to the Contractor's tip shall become the Contractor's property and he shall be entirely

responsible for its disposal. Material ordered to be disposed of to the Engineer's tip shall remain the property of the Employer.

#### **4.8 Reinstatement of Trenches and Road Surfaces**

Upon completion of backfilling operations as specified above the street shall be opened for usage and the trench should be left without reinstating for the period set by Employer, if any, else for not less than 14 days, to allow for its consolidation. As soon as the road has been satisfactorily consolidated the contractor shall carry out the reinstating works

Kerbs, channels, edgings and quadrants disturbed by the works shall be re-laid with existing units, provided that they are not damaged. Where existing units are not suitable for reuse the Contractor shall provide replacement units of similar texture, colour and type consistent with those adjacent and comply with the relevant requirements of the Employer.

Reinstatement of trenches with paving blocks or materials of the original surface shall be carried out in accordance in all respects, with the relevant requirements and to the satisfaction of the Employer. If a reinstated trench was found sunken within a period of three months, the contractor shall make good the trench with his own expenses. Road surfaces shall be properly reinstated to the requirements of the Employer.

## SECTION 5 - STRUCTURAL SPECIFICATIONS

### 5.1 Scope

This section specifies the requirements for structural components of the sewerage system.

### 5.2 Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

### 5.3 Reference Standards

The following standards are referred to in this section and the drawings relevant to this section;

<b>BS 8500-1:2015</b>	Concrete. Complementary British Standard to BS EN 206. Method of specifying and guidance for the specifier
<b>ASTM C150 / C150M - 15</b>	Standard Specification for Portland Cement
<b>BS EN 12620:2002+ A1:2008</b>	Aggregates for concrete
<b>ASTM C94 / C94M - 15a</b>	Standard Specification for Ready-Mixed Concrete
<b>BS 812-103.2:1989</b>	Testing aggregates. Method for determination of particle size distribution. Sedimentation test
<b>BS 4449:2005+A2:2009</b>	Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification
<b>BS 4483:2005</b>	Steel fabric for the reinforcement of concrete. Specification

<b>BS 8666:2005</b>	Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete
<b>BS EN 197-1:2011</b>	Cement. Composition, specifications and conformity criteria for common cements
<b>BS 1199 and 1200:1976</b>	Specifications for building sands from natural sources
<b>BS 8000-0:2014</b>	Workmanship on construction sites. Introduction and general principles
<b>BS EN 845-2:2013</b>	Specification for ancillary components for masonry. Lintels
<b>BS EN 13914-2:2005</b>	Design, preparation and application of external rendering and internal plastering. Design considerations and essential principles for internal plastering
<b>BS EN 1008:2002</b>	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete
<b>BS EN 13658-1:2005</b>	Metal lath and beads. Definitions, requirements and test methods. Internal plastering
<b>BS EN ISO 1461:2009</b>	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
<b>BS 1202-1:2002</b>	Specification for nails. Steel nails
<b>BS EN 206:2013</b>	Concrete. Specification, performance, production and conformity
<b>BS 8500-2:2015</b>	Concrete. Complementary British Standard to BS EN 206. Specification for constituent materials and concrete

## **5.4 Concrete Works**

### **5.4.1 Concrete**

#### **5.4.1.1 Cement for Admin buildings other than the Sewerage treatment plant**

Cement shall, be Ordinary Portland Cement of an approved brand with reference to BS EN 197-1:2011 , BS 8500-1:2015, BS EN 206:2013 and ASTM C150 / C150M - 15. Cement shall be of recent manufacture and shall be used within a period of 6 months of manufacture.

The Contractor shall with each fresh consignment of cement delivered to the site furnish the Consultant with a copy of the Manufacturer's statement of compliance with the above Standard Specifications together with the date of manufacture, certified by an independent agency in the country of origin and its date of delivery to Site.

Check tests will be required by the Consultant. These tests shall be carried out at the Contractor's expense. Any cement failing to meet the required standards will be rejected and replaced at the Contractor's expense.

#### **5.4.1.2 Cement for the Sewerage treatment plant or any below the water table works**

Cement shall, be Sulphate resistant Portland Cement (SRPC) of an approved brand with reference to BS EN 197-1:2011 , BS 8500-1:2015 and ASTM C150 / C150M - 15. Cement shall be of recent manufacture and shall be used within a period of 6 months of manufacture.

The Contractor shall with each fresh consignment of cement delivered to the site furnish the Consultant with a copy of the Manufacturer's statement of compliance with the above Standard Specifications together with the date of manufacture, certified by an independent agency in the country of origin and its date of delivery to Site.

Check tests will be required by the Consultant. These tests shall be carried out at the Contractor's expense. Any cement failing to meet the required standards will be rejected and replaced at the Contractor's expense.

### **5.4.1.3 Normal Weight Aggregate**

Fine aggregate for use in the production of concrete shall be of river sand and shall conform to the requirements of BS EN 12620:2002+A1:2008.

Coarse aggregate for use in the production of concrete shall be composed of crushed gravel or stone. It shall conform to the requirements of BS 812-103.2:1989 and shall have a maximum size of 25 mm.

Sources of aggregate shall be to the approval of the Consultant and samples of aggregate from the proposed sources shall be submitted to the Consultant at least 28 days before intended use. Manufactured sand and blast furnace slag to be used in concrete shall not be used unless otherwise specified or approved by the Consultant. No new sources of aggregate will be permitted without prior approval of the Consultant.

The aggregates shall be free from salt, rubbish, dirt, other foreign matters and other organic impurities and shall contain not more than 0.03% by weight of chlorides or 0.4 % by weight of sulphates. In case of using fine aggregate of 0.01% or more water soluble chloride content, the necessary measures for corrosion inhibiting of reinforcement shall be instructed by the Consultant Any aggregates which fail to meet these requirements shall be rejected and removed from the site, following which the Contractor's sources of supply shall be re-examined for suitability. Aggregate to be used in concrete shall possess the qualities indicated in the following tables

### Quality of Aggregates

Aggregate type	Open dry specific gravity	Percentage of water absorption (%)	Percentage of solid volume for the evaluation of particle shape (%)	Clay lump (%)	Loss in washing test (%)	Organic impurity (%)	Water soluble chloride (%)
Coarse aggregate	≤ 2.5	≤ 3.0	≥ 55	≤ 0.25	≤ 1.5	0	≤ 0.25
Fine aggregate	≥ 2.5	≤ 3.5	-	≤ 1.0	≤ 3.0	0	≤ 0.01

\* Colour of test solution not to be darker than standard solution

### Grading requirements for aggregates

Percentage passing each sieve by weight (%)

Agg.	Max. size (mm)	Nominal sieve size (mm)											
		40	30	25	20	15	10	5	2.5	1.2	0.6	0.3	0.15
Coarse	25			90	60		20	0	0				
		100	100	-	-		-	-	-				

				10	90		50	10	5				
				0									
	20				90		20	0	0				
				100	-		-	-	-				
					100		55	10	50				
Fine								90	80	50	25	10	2
							100	-	-	-	-	-	-
								100	100	90	65	35	10

#### 5.4.1.4 Water

Water used for mixing and curing concrete or washing aggregate shall not contain vegetable matter, acid, sulphates, chlorides or other salts in such quantities as to cause efflorescence on the face of the concrete nor to effect adversely the setting time or strength of the concrete nor to instigate electrochemical corrosion of the reinforcement. Ground water shall not be used for concrete works and water shall be obtained from a public supply or another source approved by the Consultant. Potable water containing not more than 10 parts per million dissolved solids shall be used for all reinforced concrete work. Only water of approved quality shall be used for washing out formwork, curing concrete and similar surfaces

#### 5.4.1.5 Mix Proportions

The Contractor, having knowledge of the source and type of cement, aggregates, plant and method of placing he intends to use for the aggregate/cement ratios and water/cement ratios which he considers will achieve the strength requirements specified and will produce a workability which will enable the concrete to be properly compacted to its full depth and finished to the dimensions and within the tolerances shown on the Drawings, shall be responsible for designing his concrete mixes within the following limitations. The aggregate/cement ratios and the water/cement ratio shall not exceed the upper limits specified

below. Furthermore, the quantity of cement per cubic metre of concrete shall in no case be less than the minimum specified:

<b>Class Nsq.mm/mm</b>	<b>Min. SRPC content Kg/cu.m</b>	<b>Min. 28 day trial mix test. N/sq.mm</b>	<b>Works test N/sq.mm</b>
<b>30/20</b>	315.00	40.00	30.00
<b>25/20</b>	310.00	35.00	25.00
<b>20/20</b>	305.00	30.00	20.00

As soon as possible after commencement of the Contract, the Contractor shall prepare such trial mixes as required to satisfy the Consultant that the specified concrete strengths will be obtained using the materials and mix proportions in accordance with the above clauses. The proportion of cement shall be increased if necessary to obtain the strengths required.

From each trial mix, six preliminary Test Cubes shall be made and tested two at 7 days and four at 28 days, the test at 7 days being intended to give an early indication of possible variation from the required strength. If the difference between the highest and lowest results from any one trial mix is more than 15 per cent of the average of the strength test results, the test is to be discarded and a further trial mix made, unless all test results so obtained are above the required strength.

Mix ratio for reinforced concrete shall be in the proportion 1:2:3 (cement: fine aggregate: coarse aggregate) by dry volume. Mix ratio for lean concrete shall be in the proportion 1:2:6 (cement: fine aggregate: coarse aggregate) by dry volume. Water-cement ratio for concrete shall be 0.4% to 0.45% and the specified design strength of reinforced concrete shall be 25 N/mm<sup>2</sup>. The required slump of concrete shall be 100 mm and mix proportion must be designed to obtain required the workability, consistency and durability.

#### **5.4.1.6 Batching and Mixing Of Concrete**

All concrete shall be batched by weight and mixed mechanically. Hand mixing shall be allowed if written permission has been given by the Consultant. Concrete may either be batched and mixed on Site or outside the Site and transported thereto when mixed outside the Site and transported to it, batching and mixing shall be in accordance with ASTM Specification C94 "Standard Specification for Ready Mixed Concrete".

When mixed on Site, batching and mixing shall be as follows:

##### **5.4.1.6.1 Batching by Weight**

The cement and each size of aggregate shall be measured by weight. The water may be measured by weight or volume. The weight batching machines used shall be of an approved type, and shall be kept in good condition while in use on the Works. Checks are to be made as required to determine that the weighing device are registering correctly.

##### **5.4.1.6.2 Batching Aggregate by Volume**

When batching aggregates by volume is allowed, as and when required, the cement shall be batched by weight and the water by weight or volume. Each size of aggregate shall be measured in metallic containers the depth of which is at least equal to their greatest width. The containers shall be of such shape that their volume can be easily checked by measurement.

##### **5.4.1.6.3 Mixing Concrete**

Mixing shall be done in a mechanical mixer. The mixer drum shall be free of hardened mortar adhering to its inner surface. Before mixing commences the drum shall be primed by washing with rich cement grout. A measured quantity of dry course aggregate shall be first placed in the hopper. This shall be followed with the measured quantity of sand and then cement. The skip shall be raised and the dry material slipped into the drum.

The dry materials shall be mixed for at least four turns of the drum after which the correct quantity of water shall be added gradually while the drum is in motion, to ensure even distribution of the materials.

The total quantity of water for mixing shall be introduced before 25% of the mixing time has elapsed and shall be resulted to achieve the specified water cement ratio. The complete contents of the mixer shall be emptied before recharging. When the mixer is closed down for the day or for any period exceeding 20 minutes, the drum shall be flushed clean.

Concrete mixture shall be constantly controlled to obtain required workability and mix strength. Mixing time for each batch shall be not less than 3 minutes.

The Contractor shall conduct tests for quality control toward insuring that concrete of the required quality is constantly produced and the Contractor shall have all quality control tests report ready for submission as required by the Consultant

#### **5.4.1.6.4 Placing**

Concrete shall be conveyed from the mixer to its final position in any suitable manner, provided there is no segregation, loss of ingredients or contamination. Concrete placing shall be proceeded to keep the surface of placed concrete as horizontal as possible. It shall be placed in its final position before initial setting takes place and within 20 minutes of the addition of the water to the mixer. However, when agitating equipment is used to convey concrete such as in ready-mixed concrete, the elapsed time between the addition of the water and placing may be increased to 45 minutes.

The order of placing concrete shall be such as to prevent water from collecting at the ends, corners and along the faces of forms. It shall not be placed in large quantities at any given point and allowed to run or be worked over a long distance in the form.

Vibrating of concrete and tapping of formwork shall be performed to wall, column and other places difficult for concrete to proceed. Proper number of workers for placing and compacting concrete shall be arranged. Vibrator shall be operated for concrete in the cases of water tightness, portions where it is difficult for concrete to proceed and other cases directed by the Consultant. However, vibrator shall not touch reinforcing bars and shall not be operated more than 30 seconds at same spot. Concrete shall be placed 300 - 600 mm thickness at once in case vibrator is performing. The layer thickness will depend on the width of forms, the amount of reinforcement and the need to place each layer before the previous one stiffens.

Concrete shall not be allowed to drop freely for more than 1.50 m. To convey the concrete as near as possible to its final positions, drop chutes of rubber or metal shall be used for small sections and bottom dump buckets or other suitable vessels for large sections.

Concrete shall be carefully compacted when placed to ensure a dense and uniform mass free from air holes and cavities. Concrete shall be compacted by vibrations as mentioned earlier. Vibration shall be performed by mechanical or electromechanical vibrators. The vibrators shall be of the plunger (poker) type for insertion in the concrete.

The poker type vibrators shall have a diameter compatible with spacing of reinforcement, a sufficiently high frequency and be properly handled by experienced personnel. They shall be immersed at regular intervals close enough to vibrate all the concrete, but not so close as to affect previously vibrated and partially set concrete. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete.

The vibrators shall be withdrawn gradually to ensure that no air pockets are formed. All vibrations, compaction and finishing operations shall be completed within 15 minutes from the time of placing the concrete in its final position.

Concrete shall be placed at the speed suited for the workability of the concrete and condition of the place of placement, which insures proper consolidation of concrete.

Concreting for any one part or section of the work shall be carried out in one continuous operation, and no interruption of concreting work will be allowed. Where beams and slabs together form an integral part of the structure, they shall be poured in one operation, unless provision is made to form a construction joint. A record is to be kept by the Contractor on Site of the time and date of placing the concrete in each portion of the works..

#### **5.4.1.7 Testing**

The Contractor must provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent, for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the

Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture according to this Specification. If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected notwithstanding any previous certificates, which may have been provided. Notwithstanding the above, the Contractor will be required to rectify any deficiencies which are attributable to defects in the workmanship or quality during the Defects Liability Period specified in the contract.

The Works Test Cubes shall be made at least once for each individual part of the structure as agreed with the Consultant. At least six cubes shall be made at one time. Three of the six cubes are to be tested at 7 days. The remaining three cubes are to be tested at 28 days, and their average strength must not fall below the minimum strength specified and the lowest test result shall not be more than 20% below the average of the four cubes.

When the result of the 7-day test is unsatisfactory, The Contractor may elect to remove and replace the defective concrete without waiting for the 28-days test. If the result of the 28-days test is unsatisfactory, all concreting shall be stopped at the Contractor's expense and shall not proceed further without written permission from the Consultant.

The contractor shall be required to conduct all tests according to BS method and procedure. The tests, as a rule, should be conducted at the locations directed or at the testing institutions approved by the Consultant. The Consultant shall conduct test, as a rule and in the case of failure in test, measure shall be taken as instructed by the Consultant. The Contractor shall keep test records during the work and for 2 years after completion of the contracted work. The following tests should be carried out.

If concrete is unsatisfactory, and where requested by the Consultant, the Contractor shall remove and test cores or conduct in-situ load tests from/on suspect portions of the works. Concrete found to be defective shall be cut out, removed and replaced by the Contractor at his own expense.

#### Cement Test

1. Setting test.
2. Soundness test.
3. Compressive strength test.

In order to assume estimated strength of concrete in structure, compressive strength test shall be conducted for prepared test pieces on the 7th day and 28th day and those test pieces shall be made for sampling at placing of concreting. Strength test shall be conducted for each of the following conditions: each days pour, each class of concrete, each change of supplies or source and each 100 cubic meter of concrete or fraction thereof. The number of test pieces to be used in a test shall be not less than 3 for each test of the 7th day and the 28th day unless otherwise instructed by the Consultant. Test pieces shall be made in accordance with British Standards, and sampling shall be taken as near as possible at the point of placement. Test pieces shall be stored without being disturbed and shall be covered during the first 24 hours, and carefully transported specimens to the testing laboratory. Test pieces shall be cured in water after de-moulding. The temperature of test pieces shall be kept as close as possible to the temperature of the concrete in structure until the time of testing. The test results shall be expressed in the average value by calculating the average compressive strength of all test pieces. The average value must be equal to or greater than the specified strength.

Note: Item (1) shall be conducted once in every manufacturer.

Item (2) & (3) shall be conducted once in every 2,000 bags.

Aggregate test:

- Grading and fineness modules

#### **5.4.1.8 Curing**

Freshly placed concrete shall be protected from rain, dust, chemical attack and the harmful effects of heat, wind, flowing water, vibrations and shocks. The concrete surface shall be kept moist by sprayed with water or by other appropriate methods, and the top surface of slabs shall be kept flooded with water at all times after concreting for the duration of curing period. This protection shall continue until the concrete is sufficiently set such that it can no longer be damaged by these factors which shall not be less than 24 hours after the time of placing. Concrete shall be cured for at least 7 days or longer if instructed.

Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period.

Honeycombed surfaces shall be made good or on the instruction of the Consultant be cut out by the Contractor and make good at his own expense. Concealed concrete faces shall left as from the formwork except honeycombed surfaces shall be made good. Faces of concrete to be rendered shall be roughened by approved means to form a key. Faces of concrete that are to have finished other than those specified shall be prepared in an approved manner as instructed by the Consultant

#### **5.4.1.9 Formwork**

The Contractor shall supply, design, erect, strike and remove the formwork and be entirely responsible for its stability and safety so that it will carry the wet concrete and all incidental loadings and preserve it from damage and distortion during its placing, vibration, ramming, setting and curing. Formwork shall be used to obtain accurate concrete in accordance with the designated drawings and to obtain and a material capable of providing the surface finish specified. Formwork shall be firmed and secured to bear the force of concreting and tightened to avoid cement paste seeping and the loss of any liquid from the wet concrete and to be removable without shock to the partially set concrete.

The dimensional tolerances in location and cross section of concrete member used for designing and construction of formwork shall conform to the following table.

## Standard Values of Dimensional tolerances

Item	Tolerance (mm)
Tolerance in distance from datum line of each floor to respective members	+ 10
Tolerance in cross section of columns, beams and walls	- 5 , + 10
Tolerance in thickness of floor and roof slabs	0, +10

Supports shall be provided with the adequate horizontal and diagonal bracing and/or stays to prevent collapsing, heaving and twisting of formwork due to horizontal loads working during concrete placing. Fastening hardware to be used shall be those with allowable tensile strength guaranteed by manufacturer through strength tests. Form oil shall not have injurious effects on quality of concrete nor to bonding of surface finishing materials and shall be subject to approval of the Consultant. Formwork shall be of timber and/ or metal and shall include all temporary concrete moulds and their supports. Sheathing for formwork shall be waterproof plywood of not less than 12 mm thick. Joint of sheathing shall be butt joint and firmly assembled. In case of using wood board for sheathing, boards shall be 15 mm thick and applied planer. Joint shall be tongued and grooved unless otherwise approved by the Consultant. For concrete surfaces which are to be plastered, clean sawn boards should be used. For concrete surfaces which are to remain exposed wrought formwork shall be of timber framing lined with 12mm thick smooth polyurethane faced plywood or an equal approved lining or of metal, suitable to obtain a fair-faced finish on the concrete. Form liners shall be sound and suitable materials to accurately and safely cast the in-situ concrete structure as shown on the Drawings. Timber form boards for sheathing where used for fair-faced concrete shall be of such new materials as not to cause any defects to the surface of the concrete. Special care shall be taken in fabrication, storage and protection of these boards.

Where columns or beams are shown as chamfered wrought hardwood fillet shall be planted in the angles of the formwork. Except where shown otherwise on the drawings, all exposed concrete corners and arises shall have a 10 x 10mm chamfer.

All formwork is to be thoroughly cleaned of any concrete or any other deposits. Immediately before concreting, formwork shall be thoroughly hosed down with water, temporary openings being provided to permit the escape of sawdust, shavings etc., with the water.

Wherever required and prior to placing of the reinforcement the internal surfaces of all formwork shall be treated with an approved mould oil.

Erection of formwork, and transportation and storage of materials should be started only after previously placed concrete has reached an age which acceptance of these loads will not have any adverse effect on the concrete. Sheathing should be fabricated and installed accurately to match the locations, shapes and dimensions of members called for in the Drawings. Sheathing should be installed tightly so as not to permit cement paste or mortar to escape from joints. Pipes, boxes and other embedded hardware shall be properly secured to sheathing or others so that they will not move during concrete placing. In addition to this, supports shall be erected plumb. Supports at any two vertically consecutive floors shall be erected as near as possible to identical locations on a common plane and shoring shall be erected paying special attention to safety. If sheathing is reused, the surface in contact with the concrete shall be thoroughly cleaned off and sufficiently repaired before reuse. In case of using for fair-faced concrete, the same sheathings shall be used twice after approval of the Consultant.

Forms shall be removed in such a manner as to ensure the complete safety of the structure, so that there is no shock or vibration that would damage the reinforced concrete. Formwork shall be removed gently, after its removal has been approved by the Consultant. Inspection and approval by the Consultant shall be obtained immediately after the removal of sheathing and defects shall be immediately remedied according to instruction of the Consultant. After shoring has been removed, members shall be carefully observed for cracking and deflection, when found, they shall be reported immediately to the Consultant. Unless otherwise specified, the minimum period before striking formwork shall be as follows:

<b>STRUCTURAL MEMBER</b>	<b># OF DAYS</b>
<b>Columns</b>	1
<b>Beams,side</b>	1
<b>Beams, soffits</b>	21
<b>Beam props</b>	21
<b>Suspended Slabs, soffits</b>	21
<b>Cantilever Soffits</b>	28

Formwork shall be inspected by the Consultant prior to placing of concrete. Any work showing signs of damage due to premature loading is to be entirely reconstructed at the Contractor's expense. The Contractor is entirely responsibility for the safe removal of formwork and all other temporary works.

#### **5.4.2 Construction Joints**

Whenever placing of concrete is discontinued within a bay or prior to completing a member, a construction joint shall be formed. Construction joints are to be made only along a horizontal or vertical plane except that in the case of inclined or curved members they shall be at right angles to the principal axis. Care shall be taken to prevent offsetting of the joint and to ensure water tightness.

Unless otherwise shown on the Drawings, construction joints will not be allowed in the unsupported sections of slab, beams and beamlike members. At construction joints the laitance film and porous layer of the already set concrete shall be removed and the surface keyed by hacking and then wire brushed and thoroughly cleaned. Immediately before adding the fresh concrete, the surface is to be thoroughly wetted and a 10 mm thick coating of a fresh cement/sand mortar (having the same proportion of cement/sand as concrete in the mix) applied to the surface. The new concrete is then to be well compacted against the old.

Joint surfaces shall be cleaned, made free of laitance and other foreign matters, and wetted prior to concreting. The locations of shapes of construction joints shall be consulted and approved by the Consultant.

### **5.4.3 Reinforcement**

All structural reinforcement steel shall be epoxy coating of non-pre-stressed reinforcement to ASTM A775/A775 M for the sewerage treatment plant/Lift Stations. In other cases, reinforcement shall be epoxy coated high yield deformed bars or epoxy coated mild steel complying with BS 4449:2005+A2:2009 (with coating requirements stated in BS ISO 14654:1999) or welded wire fabric complying with BS 4483:2005. <sup>2</sup>. Reinforcing steel shall be of the dimensions given in the approved Drawings.

Reinforcing bars are to be stored clear off the ground and shall be truly straight. Suitable covering shall be provided to protect against windblown sulphates, chlorides and other deleterious matter.

Specimens sufficient for three tensile tests and three cold-bending tests per ten tonne of bars or fraction thereof and for each different size of bars shall be sampled. Testing shall be in accordance with BS 4449:2005+A2:2009 and batches shall be rejected if the average results for each batch are not in accordance with BS 4449:2005+A2:2009.

All steel is to be totally free from dirt, paint, loose rust or scale and is to be thoroughly brushed and cleaned after positioning and immediately prior to concreting.

The bars are to be accurately bent to the shapes indicated, and the bending must, wherever possible, be completed before the steel is fixed in position. Straight portions of bars must be true and bends must be kept out of winding. The internal radius of bends shall not be less than four times the diameter of the bar, except for stirrups and column binders. Great care is to be taken to bend stirrups and column binders to fit closely around the main bars. In the absence of reinforcement bending schedules the bending requirements of BS 8666:2005 “Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete. Specification “or other similar approved standard shall govern.

Except where agreed by the Consultant all bars are to be bent cold in an approved bar bending machine. Lengthening of bars by welding and re-bending of incorrectly bent bars will not be permitted. Unless otherwise stated splices in reinforcing bars shall be formed by lapping. Such laps in bars in any member shall be staggered. Except as otherwise indicated on the

Drawings, the minimum overlap of lapped splices shall be 40 bar diameters or 300mm, whichever is greater.

The steel is to be fixed in position exactly as indicated and the bars are to be securely wired together with 1.6 or 1.4mm soft iron binding wire or approved spring steel slips wherever necessary to prevent any displacement during concreting. Binders and stirrups shall tightly embrace the longitudinal reinforcement to which they shall be security bound or spot welded. Binding wire shall be turned in from the formwork and shall not project beyond reinforcing bars. Spacers, chairs and the like, temporary or permanent, are to be used as required to ensure that the steel has the exact amount of cover indicated. No permanent spacers may show on a surface where a fair faced concrete finish or brushed aggregate finish is required.

Unless otherwise indicated, the minimum cover to the reinforcing bars and to binding wire shall be as follows:

<b>POSITION</b>	<b>COVER mm</b>
<b>Main bars in columns</b>	40-45
<b>Main bars in floor slabs and soffits of roof slabs</b>	30
<b>Main bars in top of roof slabs</b>	30-35
<b>Bars in top ground slabs</b>	30-35
<b>Bars in foundation/below ground level</b>	50-55
<b>Clear cover in beams soffit</b>	30-35

The Contractor is to ensure that no steel is displaced from its position during the placement of concrete.

All reinforcement to be sprayed with water two hours before concreting commences.

All reinforcing steel and binding wire shall be stored under cover and shall be at least 250mm above the ground.

#### **5.4.4 Admixtures**

No admixtures of any type shall be used in the preparation of concrete or concrete products unless so directed. In this event, the rates and methods of application shall be strictly in accordance with the manufacturer's written instructions.

#### **5.4.5 Watertight Construction**

All concrete work below ground level shall be designated as watertight. The Contractor shall include in his rates for such waterproof additives as he deems to be necessary, subject to the prior approval of the Consultant, or as instructed on the drawings. The Contractor shall install slurry type waterproofing to top surfaces of balcony slabs and external surfaces of underground concrete work. The Contractor shall also apply free mastic G-316 or equivalent epoxy water proofing to all internal surfaces of water tanks in strict accordance with the drawings.

When in the opinion of the Consultant, damp patches or leakage of water in the finished work are due to failure of the Contractor to comply with the specification, the affected work shall be made good at the Contractor's expense.

Water bars shall be provided as shown on the drawings and at all construction joints and the type of water bar will be as specified or to the approval of the Consultant. All water bars shall be jointed and supported strictly in accordance with the manufacturer's instructions.

##### **5.4.5.1 Surface preparation**

In general all surfaces shall be examined for form tie holes and defects such as honeycombing, rock pockets, cracks, etc. These areas shall be repaired in accordance with these specifications and the manufactures printed instructions. For concrete finishes, concrete surfaces shall have an open capillary system to provide tooth and suction shall be clean; free from scale, excess form oil, laitance, curing compounds and other foreign matter. Smooth surfaces or surfaces covered with excess form oil or other contaminants shall be washed lightly sandblasted, water blasted, or acid -etched with muriatic acid, as required to provide a clean absorbent surfaces. Horizontal surfaces shall not be troweled or power - troweled, and shall be left with a rough float finish or a broom finish. Vertical surfaces may have a sacked finish. Comply with manufactures specifications for requirements pertaining to minimum 'age' of concrete deck surface scheduled to receive water proofing. To avoid surface

moisture, water proofing shall be applied to 'green' concrete as soon as possible after forms have been stripped or to older pours which have been thoroughly moistened with clean water prior to application. Free water shall be removed prior to application. Mixing of crystalline water proofing compound should comply with manufactures specification for installation.

#### **5.4.5.2 Application**

In general the Contractor must apply all materials under the direction of the manufacturer's representative. For constructions joints and surface defects the waterproofing works must comply with waterproofing material manufacturer's printed directions in the preparation, and treatment of construction joints and surface defects. After all repair, patching and sealing strip placement has been prepared in accordance with manufacturer's recommendations and approved by manufacturer's representative, treat concrete surface with first coat slurry mix of crystalline waterproofing compound. The Contractor must use a short bristle or broom to work the slurry well into the concrete, filing all hairline cracks and surface pores.

#### **5.4.5.3 Curing**

In general curing shall begin as soon as the waterproofing materials have set up sufficiently so as not to be damaged by a fine spray. Treated surface shall be sprayed three times a day for a three-day period. Allow material to set 12 days before filling the structure with liquid

The contractor must utilise methods to protect treated surfaces from damage due to wind, sun, rain and temperatures below 1.67 degrees C. For a period of 48 hours after application, arrange protections to permit proper curing conditions for waterproofing material.

The contractor must remove all surplus materials from the premises and leave all areas broom-clean. In the case of temporary protections remove all such items carefully to avoid damage to treated surfaces.

### **5.4.6 Mortar**

#### **5.4.6.1 Description**

Mortar for bedding kerbs, channels, cover frames etc shall be 1:3 cement: sand mortar. Mortar for grouted stone pitching shall have 5% by weight of hydrated lime added to it. Mortar for use with block work shall be 1:4 cement: sand mortar.

### 5.4.6.2 Materials

Cement shall be as specified in sections 5.4.1.1 and 5.4.1.2 to BS EN 197-1:2011 and sand shall be natural sand or crushed natural stone or a combination of both as specified in BS 1199 and 1200:1976. Materials used for plastering shall conform to those specified in the concrete works section. Grading of sand, however, shall be as in table below

Grading of sand	Mortar plastering	Plastering
5mm sifting thorough 100% 0.15mm sifting less than 10%	for first coat  for finish coat	for first coat and dubbing out
2.5mm sifting through 100% 0.15mm sifting less than 10%	for finish coat	for second coat

### 5.4.6.3 Mixing

Mortar shall be mixed thoroughly either by hand or mechanically until its colour and consistency are uniform. The constituent materials shall be accurately gauged, allowance being made for bulking of sand. Mortar shall be made in small quantities only as and when required. Mortar which has begun to set or which has been mixed for a period of more than one hour shall be discarded. Mixing volume ratio of mortar shall be as in table below:

Base	Area of application	First coat cement:sand	Dabbing out cement:sand	Finish coat cement:sand
Masonry blocks	Floor	-	-	1:4
	Interior wall	1:4	1:4	1:4
	Exterior wall	1:4	1:4	1:4

Mortar plasticisers may be used with the Consultant's approval, but in no circumstances shall calcium chloride be permitted.

#### 5.4.6.4 Thickness of coating

Standard thickness of coating (mm)

Base	Area of application	First coat	Dubbing out	Second coat	Finish coat	Total
Masonry block	Floor	-	-	-	as per dwg	as per dwg
	Interior wall	8	-	8	4	15
	Exterior wall	8	-	8	4	15

Thickness of coating shall be standard thickness of coating unless otherwise indicated on the Drawings.

### 5.5 Masonry and Rendering

#### 5.5.1 Materials

##### 5.5.1.1 Cement

Cement shall be used as described under concrete work. White or coloured cement shall comply with the physical requirements of BS EN 197-1:2011.

##### 5.5.1.2 Water

Water shall be as described under Concrete Works.

##### 5.5.1.3 Sand

Sand shall be imported river sand, free from silt, quality to be approved by the Consultant. For use in plastering, sand is to comply with the requirements of BS 1199 and 1200:1976.

##### 5.5.1.4 Blocks

Blocks shall be solid cement blocks 125 mm thick for external walls and hollow cement blocks 100 mm thick for internal walls. The blocks must be manufactured with cement and sand with no defects and samples shall be submitted to the Consultant for the approval before ordering the material. The average compression strength should be not less than  $2.8\text{N/mm}^2$  and shall comply with physical requirements of BS EN 771-5:2011

### **5.5.2 Mortar**

Mortar shall be mixed using the ratios provided in section 5.4.6.3. For work not in contact with earth or sand, one part lime may be added to the mix. Mortar for pointing facing concrete blocks shall be prepared using white cement. When block work is constructed below ground level sulphate resisting cement shall be used.

Should the Contractor wish to use a plasticiser with mortar, then the mortar shall consist of 1 part cement to 4 parts sand with plasticiser added and used strictly in accordance with the manufacturer's instructions. The plasticiser must be approved by the Consultant before use.

Mixing shall be carried out by means of an approved mechanical mixer. The mortar shall be mixed dry until a uniform mix is obtained. Sufficient water shall then be added and the mixing continued until a homogenous mix is obtained. Excess water shall not be used in the mix. All mortar shall be used before the initial set has taken place and on no account shall mortar which has commenced to set be remixed with water or new batches and used.

### **5.5.3 Workmanship**

Generally in accordance with BS 8000-0:2014. Block-work shall be set out and built to the respective dimensions, thicknesses and heights shown on the Drawings and/ or as instructed in writing by the Consultant.

Unless otherwise ordered, hollow blocks shall be used in all closures, end blocks such as at door jambs, window openings, etc. Blocks of special lengths or size, shall be solid. The blocks shall be well soaked before being used and the tops of walls left off shall be wetted before work is recommenced.

Blocks shall be laid in true and regular courses on a full bed of mortar of 10 mm average thickness, exclusive of any key in the jointing surfaces of the blocks. Bonding mortar shall be used immediately after mix, and mixed mortar left for more than one hour shall be rejected. Sufficient mortar shall be used in bedding and jointing to ensure that all keys are solidly filled. Where blocks abut against concrete each third course shall be tied thereto by means of approved galvanised steel ties.

All horizontal joints shall be properly level. The Vertical joints shall be properly lined and quoins, jambs and other angles plumbed as the work proceeds. All walls shall be plumbed vertical.

Standard sized block shall be used wherever possible. Broken blocks shall not be used except where required for bonding purposes. Walls and partitions shall be bonded to one another at angles and junctions.

Joints of faces of block walls which are to be rendered or plastered shall be raked out for depth of 10 mm as the work proceeds. Walls shall be carried up regularly without leaving any part more than one metre lower than another unless the permission of the Consultant is first obtained. Work which is left at different levels shall be racked back.

Vertical and horizontal joint of blocks shall be filled completely and suitable with mortar on line shall not be moved or rearranged. Joint and surface of block of exposed finished block wall shall be cleaned immediately after joint is filled. In case concrete block wall is attached to structural concrete, block wall shall be placed before concreting structure. Mortar for joint shall be touched with steel trowel before hardening and exposed joints shall be finished with uniform width and planned without roughness or cavity. Height for placing block per day shall be maximum 1.2 m unless otherwise specified and blocks shall be placed with cavity side under.

The Contractor shall cut and fit blockwork as required, leave or form chases for edges of concrete slabs, steps, ends of partitions, etc cut chases for pipes, conduits, etc., and generally perform all cutting away for all trades. Wooden plates and door and window frames shall be bedded and exposed edges pointed in mortar and cramps shall be built in.

#### **5.5.4 Protection Of Finished Blockwork**

The Contractor shall ensure that the finished blockwork walling is not damaged by subsequent operations. The Contractor is to protect newly or partially built walling against it being dried out too rapidly by the sun's heat or from any other adverse climatic effects and is to follow the Consultant's instructions in this matter.

The Contractor shall in all cases cover all newly erected walling with hessian or other material approved by the Consultant and shall keep the same wet for at least three days.

### **5.5.5 Compressible Joint Fillers**

Compressible joint fillers shall be used where specified at joints on drawings or requested by the Consultant. Filler shall be cut to exact widths and shall have all edges neatly trimmed. All fixing shall be strictly in accordance with the manufacturer's printed instructions.

### **5.5.6 Polysulphide Sealant**

Gun quality sealant shall be used where specified on the drawing or where requested by the Consultant including external joinery and metal work bedded against blockwork or concrete. The colour shall be to the approval of the Consultant.

The primer shall be supplied by the same manufacturer as the sealant. The joints will first be thoroughly cleaned to the satisfaction of the Consultant and shall be primed before sealing with sealant. Application of these materials shall be strictly in accordance with the manufacturer's printed instructions.

### **5.5.7 Lintels**

Lintel shall be reinforced concrete as approved or directed by the Consultant. Main reinforcing bar shall be anchored more than 40D ( 40 x diameter of the bar) at both ends. In case lintel is prefabricated, shop drawing shall be submitted for approval of the Consultant. Prefabricated lintels shall comply with the requirements of BS EN 845-2:2013. All lintels shall be bedded on cement and sand mortar and the Contractor shall allow for a minimum bearing at each end of 150 mm.

### **5.5.8 Metal Mesh Lathing/Reinforcement for Plastering/Coatings**

Wire mesh reinforcement shall be used for every connection to concrete. Lathing must be provided as reinforcement for plastering in columns, walls or specified in drawings products.

Plain expanded metal lathing must comply with BS EN 13658-2:2005 with a minimum weight of 1.9 kg/mm<sup>2</sup> and wire ties must be annealed iron, galvanized to BS EN ISO 1461:2009 unless other material is specified. The Contractor must ensure that clout nails are made from galvanized steel or stainless steel nails to B.S 1202: Part 1, table 3 and that staples are galvanized steel wire staples to the relevant British Standards

The type of reinforcement, method and the sample shall be approved by the Consultant.

### **5.5.9 Storage of Materials**

Cement shall be stored in a weatherproof ventilated housing off the ground and away from any source of water and dampness. These materials shall be stored in such a manner that they are used in rotation in order of delivery.

Sands shall be stored separately according to type, on clean concrete hard standings and protected from contamination.

Blocks shall be delivered to Site stacked and stored to permit ventilation and protected from rain, dampness and the like.

In the event that any materials for use in this Section deteriorate and become unusable due to inadequate and poor storage they shall be removed from Site as instructed by the Consultant and replaced at the Contractor's expense.

### **5.5.10 Preparation of Surfaces for Plastering**

Surfaces to receive plastering, beds and the like are to be dry brushed to remove all loose particles, dust, laitance, efflorescence and the like, any projecting fins on concrete surfaces shall be hacked off. All traces of mould oil shall be removed from concrete surfaces by scrubbing with water containing detergents and rinsing with fresh water.

Surfaces are to be wetted and re-wetted as required to equalise suction before the first coat of plaster or the like is applied. Particularly dense, hard concrete surfaces are to be wetted and rewetted as required before bonding plaster is applied.

In-situ Concrete Surfaces must be scrubbed with water containing detergents to ensure complete removal of mould oil, surface retarders and other materials in compatible with coating. Rinse with clean water and allow it to dry unless specified otherwise. Organic growths must be treated with fungicide to manufacturer's recommendations and brushed off.

The Contractor must roughen specified surfaces thoroughly and evenly by removing the entire surface to a depth of 3mm by scabbling, bush hammering or abrasive blasting, clean surfaces by washing and brushing.

Where surfaces are out of line, they are to be brought to level by hacking or dubbing out in similar mix to the undercoat prior to commencement of finishing. Irregularities in surfaces to

be plastered shall be filled with mortar (without lime) twenty four hours before plastering commences.

Joints in blockwork and the like shall be well raked out before replastering to form a good key. Smooth concrete surfaces to be plastered shall be treated with an approved proprietary bonding agent. Plastering shall not be commenced until all mechanical and electrical services, conduits, pipes and fixtures have been installed.

The Contractor shall satisfy himself as to the suitability of all surfaces prior to the commencement of the application of the finishing material.

#### **5.5.11 Plastering**

Internal plastering is to comply with BS EN 13914-2:2005. Accuracy of plaster must be 15mm thick or more and the maximum permissible gap between an 1800mm straight edge and any point on the surface is to be 3mm. If necessary to correct inaccuracies, the Contractor must dub out in thickness of not more than 10mm in same mix as first coat. The Contractor must allow each coat to set before the first is applied and cross scratch surface of each dubbing out coat immediately after set.

The plaster for use internally is to be mixed using the ratios provided in section 5.4.6.3. The render for use externally is to be composed of 1 part cement and 4 parts of sand, and is to be applied in 2 coats to the finished stated thickness externally. The plaster shall have waterproofing quality by adding approved waterproofing additives into the mix.

Plaster or render is to be mixed in clean buckets and gauge boxes. All tools are to be kept clean and fresh plaster or render is not to be contaminated with set plaster or render.

The ingredients for the plaster or render are to be mixed three times dry and three times while water is added. Alternatively mixing may be done by approved mechanical mixers, which are to be cleaned before use.

The working time permissible after the addition of water to the plaster or render mix is to be 30 minutes. Mixed plaster or render that has exceeded this limit is to be removed from the site and not re-tempered and used in the works.

The Contractor is to ensure that before plastering or rendering commences the junctions between differing base materials or between plastered rigid sheet and plastered solid backgrounds are cut through with a fine blade in a neat, straight line at the junctions

All surfaces to be plastered or rendered are to be sprayed with water, which is to be allowed to dry out before a key coat of cement slurry is applied. All undercoats are to be scratched to form an adequate key for the next coat. The setting coat is not to be applied until the floating coat has been left in a moist condition for at least three days.

All plastering shall be executed in a neat workmanlike manner and made good to wood frames, skirting, pipes, fittings and the like. Plasterwork is to be finished with a smooth, trowelled face, free from blemishes and fit to receive decoration. Render is to be finished with a wood float. Any blown, cracked or otherwise damaged plaster or render shall be condemned by the Consultant and is to be hacked off and made good with quick setting plaster at the Contractor's expense.

Full use is to be made of grounds, rules and angle trowels to ensure that all wall faces finish plane and true to line in all directions and that all angles are straight, true and plumb. Prices for plastering and rendering are to ensure that work to walls and ceilings are effectively 'cut' at the joint so as to minimize damage due to movement.

#### **5.5.12 Sand Cement Screed**

Floor screeds are to be composed of one part cement and three parts sand and are to be smooth and level. Final difference in levels in any part of the building shall not exceed 2 mm, otherwise the Contractor shall be required to apply an approved self-levelling screed to finish the surface.

Where beds are to be laid direct on to a concrete sub-floor that has set, the surface of the subfloor is to be thoroughly cleaned and prepared to ensure a good bond, the surface being chipped with a pick if necessary, brushed well and washed out to remove all dust and dirt, and thoroughly soaked with water left on overnight. Surplus water is to be mopped up and immediately prior to laying the bed, the sub-floor is to be coated with a grout of neat cement wash well brushed on as the work proceeds. The grout must not be permitted to set before the bed is laid.

Alternatively the Contractor may use a bonding agent applied in conformity with the manufacturer's instructions. Pipes, conduits and the like to be embedded in a screed or topping shall be securely fastened to the concrete subbase, then apply cement and sand haunch to the side of pipes/conduits and a layer of chicken wire mesh overlaid at least 200 mm wide at each side. When these operations have been completed the Contractor may commence the laying of screed/toppings.

The Contractor shall lay screeds or toppings in bay sizes as instructed by the Consultant including filling joints between bays as directed. Joints in the concrete subbase shall be continued through the screeds or toppings.

The screeds or toppings shall be finished to give the surface stated using either a hand trowel, mechanical power float or the like. All finishes shall be uniform, smooth and free from ridges, trowel marks and other blemishes. For a non-slip finish apply carborundum particles between successive trowelling operations to give a smooth surface.

The beds shall be protected from excessively rapid drying out by means of tarpaulins or polythene sheeting for a minimum of 7 days after laying. Laying beds is preferably to be carried out when the building is fully protected from adverse weather, however, the Contractor is to protect all beds as necessary from damage by wet weather. In the terrace the screed shall have a gradient as shown in the plan about 1% in the directions indicated by the arrows.

## **5.6 Finishes**

### **5.6.1 Cement**

The cement shall be as described in 'Concrete work'.

### **5.6.2 Water**

All water used in the completion of the finishes as specified herein shall be clear, clean, potable, fresh water, free from all deleterious matter or chemical impurities, which may adversely affect the finishes and shall comply with BS EN 1008:2002.

### **5.6.3 Sand**

The sand is to be clean, sharp, river sand free from earth, loam, saline materials or other impurities and well graded from coarse to fine.

For use in beds, granolithic finishing, tile bedding and jointing, etc., sand is to comply with the requirements of BS 1199.

### **5.6.4 Admixtures And Plasticisers**

All additives and the like shall only be used when approved in writing by the Consultant and in strict accordance with the manufacturer's written instructions.

### **5.6.5 Workmanship Generally**

Workmanship shall conform to the recommendations of the appropriate Codes of Practice. The Contractor is responsible for the provision of all labour, scaffolding, materials, tools, plant, etc., required for the completion of the execution of the Works, to the full satisfaction of the Consultant.

### **5.6.6 Defective/Damaged Work**

All defective or damaged work shall be cut out and patched as directed by the Consultant. All patched surfaces shall match the consistency and finish of the original surface and shall be level with adjoining surfaces.

Damaged or deteriorated materials and manufactured items shall not be used in the Works. Any materials or manufactured items damaged during and after bedding or setting in position shall be removed and replaced by and at the Contractor's expense.

### **5.6.7 Storage**

All branded materials delivered to site are to be properly stored in a watertight shed on a dry floor, or in equivalent conditions to avoid deterioration prior to use. Any materials which deteriorate or become damaged before use are to be removed from site and replaced at the Contractor's expense.

## SECTION 6 - ELECTRICAL SPECIFICATIONS

### 6.1 Scope

This part specifies the requirements for Electrical equipment in all the pumping stations, STP, Central control room, all buildings and roads inside the administration building premises and the STP areas.

Following clauses specify General Electrical requirements and standard of workmanship for the equipment and installations. General Specification classes shall apply where appropriate except where particularly redefined in the appropriate Special Specification Clauses

### 6.2 Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

### 6.3 Reference Standards

The following standards are referred to in this section and the drawings relevant to this section;

<b>Design criteria and technical Specifications - design and Construction of water treatment And supply system</b>	Water and Sanitation Unit -Environmental Protection Agency  Ministry of Environment and Energy
<b>IEC 60502:2012 SER Series</b>	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - ALL PARTS
<b>BS 6004:2012</b>	Electric cables. PVC insulated and PVC

	sheathed cables for voltages up to and including 300/500 V, for electric power and lighting
<b>BS EN 60228:2005</b>	Conductors of insulated cables
<b>BS 5467:1997+A3:2008</b>	Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V
<b>BS 7671:2008+A3:2015</b>	Requirements for Electrical Installations. IET Wiring Regulations
<b>BS EN 50363-4-1</b>	P.V.C. Insulation and sheath of electric cables
<b>IEC 60228:2004</b>	Conductors of insulated cables
<b>IEC 60811-100:2012</b>	Electric and optical fibre cables - Test methods for non-metallic materials - Part 100: General
<b>BS EN 50525-1:2011</b>	Electric cables. Low voltage energy cables of rated voltages up to and including 450/750 V (U0/U). General requirements
<b>BS 6724:1997+A3:2008</b>	Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V, having low emission of smoke and corrosive gases when affected by fire
<b>IEC 60034-1:2010</b>	Rotating electrical machines - Part 1: Rating and performance
<b>BS EN 60529:1992+A2:2013</b>	Degrees of protection provided by enclosures (IP code)

<b>BS EN 60034-5:2001, IEC 60034-5:2000</b>	Rotating electrical machines. Degrees of protection provided by the integral design of rotating electrical machines (IP code). Classification
<b>IEC 60034-5:2000+AMD1:2006</b>	Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification
<b>IEC TS 60034-2</b>	Rotating electrical machines - Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors
<b>IEC 60072-1:1991</b>	Dimensions and output series for rotating electrical machines - Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080
<b>IEC 61111:2009</b>	Live working - Electrical insulating matting
<b>BS EN 3-7:2004+A1:2007</b>	Portable fire extinguishers. Characteristics, performance requirements and test methods
<b>BS EN 60754-1:2014</b>	Test on gases evolved during combustion of materials from cables. Determination of the halogen acid gas content
<b>BS EN 50396:2005+A1:2011</b>	Non electrical test methods for low voltage energy cables
<b>BS EN 60730-1:2011</b>	Automatic electrical controls for household and similar use. General requirements
<b>BS EN 61048:2006</b>	Auxiliaries for lamps. Capacitors for use in

	tubular fluorescent and other discharge lamp circuits. General and safety requirements
<b>BS EN 61049:1993</b>	Specification for capacitors for use in tubular fluorescent and other discharge lamp circuits. Performance requirements
<b>IEC 61049:1991</b>	Capacitors for use in tubular fluorescent and other discharge lamp circuits. Performance requirements
<b>BS EN 61347-1:2015</b>	Lamp controlgear. General and safety requirements
<b>IEC 60598-1:2014</b>	Luminaires - Part 1: General requirements and tests
<b>BS EN 60923:2005</b>	Auxiliaries for lamps. Ballasts for discharge lamps (excluding tubular fluorescent lamps). Performance requirements
<b>BS EN 60269-1:2007+A2:2014, BS 88-1:2007+A2:2014</b>	Low-voltage fuses. General requirements
<b>IEC 60269-1:2006+AMD1:2009+AMD2:2014</b>	Low-voltage fuses - Part 1: General requirements
<b>IEC 60898-1 Ed. 2.0</b>	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for A.C. operation
<b>BS 7430:2011+A1:2015</b>	Code of practice for protective earthing of electrical installations

<b>BS EN 60921:2004</b>	Ballasts for tubular fluorescent lamps. Performance requirements
<b>BS EN 60662:2012</b>	High-pressure sodium vapour lamps. Performance specifications
<b>BS EN 60188:2001, IEC 60188:2001</b>	High-pressure mercury vapour lamps. Performance specifications
<b>BS EN 61347-2-8:2001+A1:2006</b>	Lamp controlgear . Particular requirements for ballasts for fluorescent lamps
<b>BS 3988:1970</b>	Specification for wrought aluminium for electrical purposes. Solid conductors for insulated cables
<b>IEC 60811-409:2012</b>	Electric and optical fibre cables - Test methods for non-metallic materials - Part 409: Miscellaneous tests - Loss of mass test for thermoplastic insulations and sheaths

## 6.4 Requirement of Statutory Authorities

The electrical equipment/installations shall comply with the requirements of Rules /Regulations as amended up-to-date, required by Statutory Acts or Authorities in Male, Republic of Maldives including those related to power supply, fire safety etc. Design of electrical control panels and other electrical components must be provided and must be approved by Maldives Energy Authority. In the case of any ambiguity or lack of suitable provisions in the rules safety provisions laid down by corresponding British or International Electro technical Commission statutes /regulations /codes shall apply.

According to the EPA's Design criteria and technical Specifications for conventional gravity system, guideline all cables and wires used in the electrical installations should comply with the following standards:

- PVC insulated non-armoured cables with copper conductor for voltages up to and including 450/750v, for electric power, lighting and internal wiring has to comply with BS 6004 and BS EN 60228:2005 standard. [BS 6004 is equivalent to IEC 60227-3]
- Electric cables. Thermosetting insulated, armoured cables for voltages 600/1000 V and 1900/3300 V has to comply with BS 5467 and BS 6360 (class 2 stranded) standard. [BS 5467 is equivalent to IEC 60502]

## **6.5 Voltage Regulation and Operating Conditions**

Equipment shall be suitable for operation with, 415 V, three phase 50 Hz AC, supply available at the various locations. The tolerance for Voltage must be between +10% and -15%. The limits for frequency shall be plus or minus 5%. Equipment offered shall be suitable for continuous operation under high ambient temperature up to 45°C. During starting of heavy equipment the voltage may drop by a maximum of 15% for a period of 45 to 60 seconds. All electrical equipment shall be suitable for trouble free and uninterrupted operation during such voltage dips. Motors used in areas where inflammable gases or liquids exist shall be explosion proof with associated wiring also explosion proof. Motors for outdoor installation shall be weatherproof.

Switchboards shall not be exposed to moisture or corrosive gases. Contractor shall submit layout drawings, clearly indicating the location of switchboard and other equipment proposed to be installed, for the approval of local Electricity supply authority.

## **6.6 Power Factor**

Suitably rated capacitors shall be provided to each individual motor above 1.5 KW rating along with discharge device having appropriate rating to improve the power factor up to 0.95.

## **6.7 1100 Volts Grade Armoured Lt Power and Control Cables**

### **6.7.1 Technical Specifications**

#### **6.7.1.1 General**

The LT power, control and special cables to be supplied are required for the LT power distribution, control and protection connections in the pump stations. These shall be 1100 volts grade, heavy duty multi core, annealed stranded high conductivity copper conductor for power cables and tinned copper conductor for control and special cables, H.R. PVC insulated armoured, overall sheathed by extruded PVC.

The cable conductor shall be made from stranded copper for power cables and stranded annealed copper for control cables and special cables to form compact conductor having a resistance within the limits specified in IEC 60228:2004. The minimum number of strands for conductor shall be 7 (seven). The minimum conductor size for copper LT power cable shall be, 2.5 sq.mm.. For LT power cables, following sizes of copper conductor shall be used: 4 core, 6 sq.mm; 4 core 10 sq.mm; 4 core/3.5 core 25 sq.mm 3.5 core 50 sq.mm; 3.5 core 95 sq.mm and 3.5 core 300 sq.mm. Control cables of 2.5 sq.mm copper conductor with suitable number of cores shall be used. Wherever long runs are involved 4 sq.mm control cables should be used to limit the voltage drop within limits. Wherever cables carrying signals /instrumentation are involved they shall be armoured twisted and individually shielded.

#### **6.7.1.1.1 Insulation**

The cable insulation shall be of best quality H.R. PVC compound suitable for 85 degree C operation as per IEC 60502 the insulation shall be designed and manufactured for the specified voltage grade. The insulation shall fit closely in the conductor and shall be free from voids, foreign particles and burnt material etc., to ensure good insulation properties throughout the cable length.

#### **6.7.1.1.2 Sheath**

The laid up cores in cable shall be inner sheathed by extruded PVC covering, which shall be suitable to withstand the site conditions and the desired temperature. The sheath shall be of

adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects.

#### **6.7.1.1.3 Armour/Shield**

The control cables shall be armoured with galvanized round steel wire as per IEC 60502.

#### **6.7.1.1.4 Outer Sheath**

Extruded PVC sheaths shall be applied over the armouring with suitable additives to prevent attack by rodent and termites. All sheaths must be given anti-termite treatment.

#### **6.7.1.1.5 Fillers**

Fillers shall not be used. However, if they are absolutely essential, they shall be chemically inert, rat proof, non-absorbent pollution free and not prone to any environmental influences. They shall be suitable for the operating temperature of the cable and compatible with the insulating material.

#### **6.7.1.1.6 Identification**

The cores in the control cables shall be identified by a colour scheme as per IEC 60502. Over and above this, the cores shall further be identified by indelible printing of serial number on the cores at equal distance not exceeding 75 mm. All cables shall carry the manufacturer's data in a permanent and legible manner at an interval of at least three meter run. The manufacturer's data shall include the name, the cable size, type and voltage rating together with any other information which the manufacturer considers appropriate.

#### **6.7.1.2 Cable Drums**

The cables covered by this specification shall be supplied in drum length (continuous length) of 1000/500 meters.

The cables shall be supplied in non-returnable wooden drums of robust construction. The wood used for construction of the drum shall be properly seasoned, sound and free from defects and wood preservative shall be applied to the entire drum.

### **6.7.1.3 Packing**

All cables shall be wound on substantial logged wooded non-returnable drums. A layer of water-proofed paper shall be applied to the surface of the drums and over the outer cable layer. A clear space of at least 40m shall be left between the cable and the logging.

Each drum shall carry the manufacturer's name, the Employer's name, address and order number, item number and type, size and length of cable, net and gross weight stencilled on the drum.

### **6.7.1.4 Cable Segregation**

The control cables are proposed to be laid on racks in covered trenches, cable tunnels and along ceiling and walls in substation, and building areas. The control cables will run on separate racks from the power cables. In the case of control cables from the various pumping stations to the Central control room/STP shall be installed in underground rigid PVC conduits with a minimum diameter of 2 inches with the necessary supports. In the case of cables from Motor control centre to motors and other Cables buried in ground they shall be installed in rigid PVC conduits and cables above ground shall be laid in Rigid aluminium pipes subject to provisions in the standards. For final runs into the instrumentation equipment flexible steel liquid tight conduit with high tensile strength and copper ground built into the core shall be used not exceeding 18 inches in length.

The cables shall have heat and moisture resistant Properties for satisfactory operation under tropical humid conditions.

### **6.7.1.5 Tests**

The Contractor must provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent, for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture according to this Specification. If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected notwithstanding any previous certificates, which may have been provided. Notwithstanding the above, the Contractor will be required to rectify any deficiencies which are attributable to defects in the workmanship or quality during the Defects Liability Period specified in the contract.

Type test: Type test in each type and size of the cable shall be conducted as per applicable standards. The following shall be performed as type tests:-

- Annealing test (IEC 60228:2004)
- Conductor resistance test (IEC 60228:2004)
- Test for armour wires/ strips (IS 3945)
- Per sulphate test (IEC 60228:2004)
- Test for thickness of insulation and sheath (IEC 60502)
- Tensile strength and elongation test for insulation and sheath (IEC 60502) Ageing tests for insulation and sheath (IEC 60502)
- Loss of mass test for PVC insulation and sheath (IEC 60811-409:2012) Shrinkage test (IEC 60502)
- Hot deformation test (IEC 60502)
- Cold bend test (IEC 60502)
- Cold impact test (IEC 60502)
- Heat shock test (IEC – 540, IEC – 502)
- Thermal stability (IEC – 540, 540A)
- Test for bleeding and blooming of pigments for PVC (IEC 60502)
- Fire resistance test (IEC 60502)
- Measurement of insulation resistance (IEC 60502)
- High voltage test (IEC 60502).

- Test for rodent and termite repulsion property of sheath are to be performed by the manufacturer. The details of tests are to be given by the manufacturer.
- Routine tests and acceptance tests:- The following test shall constitute routine tests and acceptance tests.
  - Annealing test
  - Conductor resistance test
  - Insulation resistance test
  - Test for thickness of insulation and sheath.
  - High Voltage test

The test methods, condition of test and test requirement shall comply with those given the type tests. The high voltage test shall, however, be performed as per the methods specified under relevant clause for routine test in IEC 60502. Apart from these, conductor examination, check of dimensions etc., shall be carried out as routine tests.

## **6.8 Installation, Testing and Commissioning**

### **6.8.1 General**

The scope shall cover the complete installation of all equipment and accessories covered under this contract. Installation work pertaining to equipment, cabling, lighting, earthing, lightning protection etc. shall comply with the applicable standards, safety Codes etc. Installation shall be carried out strictly in accordance with the approved drawings. Modifications, if any, required suiting the site conditions shall be carried out only with the prior approval of the Employer. All such changes shall be incorporated in the “As built” drawings to be furnished by the Contractor. It shall be the total responsibility of the Contractor to move/transport from stores/storage yard/shed etc. relevant items and accessories to the place of installation and where necessary assemble all parts of equipment.

## **6.9 Motors for Distribution Pumps**

### **6.9.1 General Characteristics of Motors**

All MV motors shall be squirrel cage induction type and suitable for the following.

- Supply voltage: 415 Volts, 3 Phase, 50 Hz AC supply Voltage variation: +10% , -15%

- Frequency variation:  $\pm 5\%$
- Combined variation of Voltage & Frequency: 10%

All motors shall be foot / flange mounted squirrel cage induction type and shall be capable of developing at least 10% more power than demanded by the pump or driven equipment over its entire range of safe operation.

Motors shall be continuous maximum rated as per IEC 60034-1 and preferably be designed for low starting current and smooth acceleration except for cases where the driven equipment characteristic demands otherwise. Motors shall be of 4/6/8 pole design fitted with ball/ roller bearings and provided with one or more terminal boxes large enough to accommodate armoured PVC insulated copper conductor of appropriate ratings.

### **6.9.2 Motor Winding**

Motor winding shall be insulated with Class F insulation with temperature rise limited to Class B rating as per IEC 60034-1 over an ambient temperature of 45°C. The pull out torque of the motors at rated voltage and frequency shall preferably be 200% of FLT in each motor above 5.5 KW rating. Motors shall be suitable for auto transformer, star-delta / or Direct On line starting depending on capacity.

### **6.9.3 Starting current for motors**

When LT motors are switched on with full voltage applied onto their terminals, the starting current shall be limited to 550% of full load, current for squirrel cage induction motors. All LT motors shall be squirrel cage type.

### **6.9.4 Motor enclosure Protection**

All motor shall be provided with protection to IP 65 under BS EN 60529:1992+A2:2013. For Hazardous location flame and explosion proof enclosures shall be provided.

Appropriate water proof enclosures shall be provided to outdoor Electric panels and starters, to provide sufficient protection from rains, dust, vermin etc.

Degrees of protection provided by enclosures for rotating electrical machinery shall conform to the requirements of BS EN 60034-5. Flame proof motors shall comply with relevant

specification of mine safety requirements and other applicable specifications for this type motors.

#### **6.9.5 Motor Testing**

Testing of motors shall comply with the requirements of IEC TS 60034-2 . Dimensions of foot mounted motors shall comply with the requirements of IEC 60072. Generated values of efficiency and power factor at full load and 3/4 load shall be furnished by the tenderer.

#### **6.9.6 Motor Starting arrangements**

Individual Motor starters / panels for 415 volt 3 Phase 50 Hz Motors shall be as below:

- For Squirrel cage motors up to 3.7 KW : Direct-on-line

Squirrel cage motors above 3.7 to 18 kW : Star-delta starters

Motors exceeding 18 KW: Auto transformer or any other soft type of starters acceptable to the Employer.

Each control panel / starter shall incorporate isolator, HRC fuse contactors, timing relays, Thermal overload relays, single-phase preventor, Hour meter (for pump running hours) etc. appropriate for the scheme of control. Contactors shall be of AC 3 duty (minimum).

Contactors rating for each motor shall be at least 25% higher than the full load current of the motor and contactor shall comply with the requirements of IS 2959, IS 4237 and IS 10118. Reversible starters shall be provided wherever necessary. Motor starter rated 30 kW and above shall be provided with auxiliary relay for motor space heater.

## **6.10 Cables and Cable Laying**

### **6.10.1 Types of cables**

The following type of cables shall be used:

1. For HT Power Supply: 3C core X LPE, 11kV, Armoured Copper cable.
2. For LT Power Supply : 3½ core, 4C, 3 core or 2 core 1100 / 600 v PVC insulated PVC sheathed armored copper cables.
3. For control cables: Multi-core Cu cable minimum 2.5 mm<sup>2</sup> with PVC insulation, armored and PVC sheathed. Wherever signal for remote instrumentation are involved the cables have to be twisted and shielded in addition to the above requirement.

The minimum size of control cable shall not be less than 2.5 mm<sup>2</sup>. Sizes should be increased for long runs to avoid voltage drops exceeding limits. All cables shall be suitably de-rated for grouping and higher ambient temperature. For selecting cable sizes, 45 °C ambient temperatures shall be taken as the basis. The LT cables shall conform to IEC 60502.

### **6.10.2 Cable Accessories**

All accessories like cable glands, lugs and terminal markings etc. shall be used conforming to relevant standards / as specified. End termination for HT cables shall be heat shrinkable type. For 1100V grade cables, Siemens type gland and crimping type lugs or approved equivalent shall be used.

### **6.10.3 Cable Laying methodology**

Cable laying and termination shall be such that chances of cable damage are remote. LT cable shall be laid in cable tunnel on racks, trays, or buried underground in rigid PVC conduits with appropriate protection as per the requirements stated in elsewhere. Black shall indicate the neutral, while red, yellow and blue for three different phases. All LT cables when laid on the cable racks shall be properly dressed and clamped as required without crisscrossing and unnecessary overlapping. Cables shall be properly dressed and clamped.

#### **6.10.3.1 Laying of Underground cables**

The laying UG cables on ground is done by excavating a trench of 1.2 meter depth for HT cable and 0.75m depth for LT cable, and cables laid in areas. The cables shall be protected by

good quality bricks on the sides and top of the cables and fill up top layer with sand. Power cables, Control/measurement cables from (remote) control room to sewage pump stations shall be enclosed in rigid PVC pipes and laid in trenches with appropriate supports wherever they are laid underground.

In routing, necessary barriers and spacing shall be maintained for cables of different voltages in case they lie side by side. Telephone cables shall cross the power cables only at about right angles and these two shall not run in close proximity.

LT cables shall be bent in radius not less than 12 times their individual overall diameters, while HT cable shall have bends not less than 15 times their individual overall diameter. Route markers have to be provided for underground cables at periodical intervals.

Routes of these cables shall be arrived at on the basis of the relevant drawings and after consulting the Engineer.

#### **6.10.4 Drawings and Schedules**

Sizes of cables shall be given in single line power diagrams. A cable schedule shall be prepared on the basis of relevant drawings. All cable and wires shall be adequately sized to carry continuously the normal currents expected on the relative circuits. All trenches for electrical cables shall be separate from water pipeline trenches.

#### **6.10.5 Splicing and Termination**

Straight through joints shall be avoided. In case, these are absolutely necessary they shall be made at convenient locations suitably protected as approved and sanctioned by the Engineer but in no case within the conduit pipes or ducts. Branch circuit wiring shall be spliced only in switch boxes, panel switch socket outlet boxes light fixtures outlets and junction boxes. They shall be made only with approved porcelain connectors.

Compression type cable and glands shall be used for cable connections. Double compression cable end glands shall be used for flame proof switch gears. Cable glands shall be of brass with cadmium or nickel plating. Tinned copper lugs shall be used for cable termination.

#### **6.10.6 Testing**

Cables shall be tested in accordance with IEC 60502

### **6.10.7 Control Switches**

Control and instrument switches shall be of rotary type flush mounting having enclosed contacts which are accessible by the removal of cover and shall be provided with properly designated escutcheon plates clearly marked to show the operating positions. Control switches shall have momentary contacts, spring return to center with pistol grip handle. Instrument and selector switches shall have oval knob.

### **6.10.8 Push buttons**

Push Buttons shall be momentary contact type with rear terminal connections. The colour of the push buttons shall be “Green” for start and “Red” for stop. Wherever required, the push button shall be suitably shrouded to prevent inadvertent operations. They shall be provided with integral inscription plates engraved with their functions. The contact element shall have at least 1 No. and 1 NC contacts. The contacts shall be able to make and carry at least 6A continuously at 415 AC.

### **6.10.9 Indicating lamps**

Indicating lamps shall be panel-mounting type with rear connection. The lamps shall be provided with the built-in series resistors on the lamp holder. The lamp shall have translucent lamp cover, of suitable colour. The cover shall be oil and dust proof of polycarbonate lenses. The bulb and lenses shall be interchangeable and replaceable from front of the panel. Long life high brightness LED type lamps satisfying the requirements of visibility can also be used in place of lamps subject to electrical and mechanical compatibility.

## **6.11 Safety Equipment to Be Provided**

The Contractor shall provide the following safety equipment as per safety rules, on the HV panels, Generator panels, control panels and main MV panel-rooms.

- Rubber mat conforming to IEC 61111 in-front of all the HT and MV panel for their entire length 1m wide
- Sufficient pairs of electrically tested rubber gloves. These are to be kept in a suitable wooden box.
- A first aid treatment instruction chart for electric shock in local language and English duly framed and displayed.
- The nearest medical facility available with phone number shall also be kept.

- First aid box containing full compliments of medicines for treatment of electrical burns in the main switch-room.
- Adequate number of portable fire extinguishers of dry Chemical powder (store type) as per BSEN 3 to suit the individual substation/ pumping station requirement.
- Adequate number of caution notices in local language and English shall be fixed permanently on the equipment to comply with the requirement of safety provision in the form of danger notices for vigilance against electrical accidents
- Adequate number of fire buckets with MS angles stand 4 Nos. round bottom fire buckets marked “Fire” shall be provided.

## **6.12 Lighting & Small Power**

### **6.12.1 Definitions and Conventional Symbols**

The wiring and the equipment shall comply in all respects with the requirement of IEC regulations there under as amended from time to time. The wiring and other electrical equipment shall be suitable for trouble free operation at variation of voltage and frequency prescribed in IEC rules /regulations.

### **6.12.2 Point Wiring**

Point wiring shall include all work necessary to complete wiring from switch circuit of any length from the tapping point on the distribution circuit Switchboard to the following:

- Ceiling rose for fans, lighting etc.
- Socket outlet (in the case of socket outlet points).
- Lamp holder (in the case of wall brackets, batten points, bulk head and similar fittings).
- Call bell buzzer (in the case of the works “via the ceiling rose/ socket outlet or bell push where no ceiling rose /socket outlet is provided”).

### **6.12.3 Circuit wiring**

Circuit wiring shall mean the length of wiring from the distribution board up to the tapping point of the nearest first points of that circuit, viz., up to the nearest first switchboard measured along the run of wiring. Such wiring shall be measured on linear basis.

#### **6.12.4 Systems of Wiring**

The wiring shall be carried out on such a system as may be specified in the tender schedule or otherwise specified in the Special Specification (“Power” and “Heating” wiring shall be kept separate and distinct from “Lighting” and “Fan” wiring). Recessed conduit wiring shall be done on distribution system main and branch distribution boards at convenient physical and electrical centers and without fuses at isolated places. All conductors shall run, as far as possible, along the walls and ceiling so as to be easily accessible and capable of being thoroughly inspected. In no case, the open wiring shall be run above the false ceiling without the approval of the Engineer. In all type of wiring, due consideration shall be given for neatness, good appearance and safety.

#### **6.12.5 Balancing of Circuits**

The balancing of circuits in three phase installations shall be arranged beforehand to the satisfaction of the Engineer.

#### **6.12.6 Drawings**

All wiring diagrams shall indicate clearly in plan, the main Switchboard, the distribution fuse board, the run of various mains and sub-mains and the position of all points with their classification

#### **6.12.7 Cables**

##### **6.12.7.1 Scope**

This specification covers the design, manufacture, testing at work, inspection and delivery at site of PVC insulated cables for power and light wiring.

##### **6.12.7.2 Conductors**

The conductors shall be of copper. The conductors shall be smooth, uniform in quality and free from scale, inequalities, splits and other defects. The stranded conductor shall be clean and reasonably uniform in size and shape and its conductor shall conform to the specification given in the relevant standards. The conductors shall be either circular or shaped.

##### **6.12.7.3 Insulation**

The cable for power distribution shall be insulated for 1100V and Suitable for 415V, solidly earthed system. The insulation shall consist of the following:

Compounded polyvinyl chloride, suitable co-polymers, of which the major constituent shall be vinyl chloride. Mixture of polyvinyl chloride and suitable co-polymers which have been suitably compounded and processed must comply with the requirements of the relevant standards.

#### **6.12.7.4 Inner Sheath**

For all cables having two or more cores, the individual cores shall be laid up and then be surrounded by common covering applied either by extrusion of wrapping or filling material containing a thermoplastic material. A proofed or plastic tape may be applied over the common covering employed. It must be ensured that the circularity of the cable is maintained.

#### **6.12.7.5 Armouring**

Armouring shall be arranged over the inner sheath .The armour of cable shall be of Galvanized steel wires or Galvanized steel strips.

#### **6.12.7.6 Outer Sheath**

A tough outer sheathing of PVC insulating material in standard colours shall be provided over the armoring to offer a high degree of mechanical protection against abrasion.

#### **6.12.7.7 Manufacturer's Identification**

The manufacturer shall be identified throughout the length of the cable by manufacturer's name or trademark, voltage grade and year of manufacture of the cable indented; embossing shall be done only on the outer sheath.

#### **6.12.7.8 Packing and Marking**

The cable shall be wound on a drum of suitable size, packed and marked. The marking done on the drum shall have the following information:

- Trade name, if any
- Name of the manufacturer

- Number of cores and nominal area of the conductor Type of the cable and voltage for which it is suitable Length of the cable on the drum Direction of rotation of drum (an arrow) Drum No.
- The outer ends of the cable shall be sealed by means of non-hygrosopic sealing materials.

### **6.12.7.9 Testing**

#### **6.12.7.9.1 Type Tests**

The successful bidder shall submit two (2) sets copies of the following type test reports conducted on similar equipment for the approval of the Employer

- Annealing test Conductor resistance test
- Test for thickness of insulation and sheath
- Physical tests for insulation
- Physical tests for PVC sheath
- Fire resistance Cold-impact
- Bleeding and blooming
- Partial discharge test
- Bending test
- Dielectric power factor tests
- Heating cycle test Impulse withstand test
- High voltage tests.

#### **6.12.7.9.2 Acceptance Tests**

- Conductor resistance test
- Test for thickness of insulation and sheath
- Partial discharge test (for screened cables only)
- High voltage tests

#### **6.12.7.9.3 Routine Tests**

Conductor resistance test

Partial discharge test (for screened cables only) High voltage tests

### **6.12.7.10 Recommended Makes**

Cables shall be manufactured by Unistar / Incab / CCI or approved equal

### **6.12.8 Rating of lamps and fans**

Socket Outlet Points and Fans, Incandescent lamps installed in pump stations & other areas shall be rated at 60 watts and 100 watts respectively. Exhaust fans shall be rated according to their capacity. 5 A socket outlet points and 15 amp. socket outlet points shall be rated at 100 and 1,000 watts respectively, unless the actual values of load are known or specified.

### **6.12.9 Joint and Looping back**

Unless otherwise specified the wiring shall be done in the “Looping System”. Phase of live conductors shall be looped at the switch box and neutral conductor can be looped from the light, fan or socket outlet. In non-residential buildings, neutral conductor and earth conductor and earth continuity wire shall be brought to each switchboard situated in room and halls. These shall be terminated inside the switchboards with suitable connectors and the switchboard shall be of adequate size to accommodate one number 6A socket outlet and control switch in future. For 1 6A socket outlet separate cables shall be drawn from the main distribution board with suitable protection.

### **6.12.10 Control at point of supply**

There shall be a linked main switch gear with fuse on each live conductor of the supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of a linked switch gear. The neutral shall also be distinctively marked. The main switch gear shall be installed as near as practicable to the termination of service line and shall be easily accessible without the use of any external aid. Indication Identifying Earthed Neutral Conductors On the main switch gear, where the conductors include an earthed conductor of a two wire system or a conductor which is to be connected thereto, an indication of a permanent nature for earth conductor has to be provided.

### **6.12.11 Main switch gear and Switch board**

#### **6.12.11.1 General**

All main switch gear shall be of metal clad and shall be fixed at close proximity to the point of entry of supply and shall have easy access. Open type Switchboards shall not be permitted.

#### **6.12.11.2 Installation and arrangement of Switchboard**

A Switchboard shall not be installed so that its bottom is within 1.25 m above the floor unless the front of the Switchboard is completely enclosed by a door, or the Switchboards, is located in a position to which only authorized personnel have access.

Switchboard shall be recessed in the wall if so specified in the schedule of work or in the special specifications. Equipment which is on the front of Switchboards shall be so arranged that inadvertent personnel contact with live part is unlikely during the manipulation of switch gears, changing of fuses or like operations.

#### **6.12.11.2.1 Screening of Live Parts**

The various live parts unless they are effectively screened by substantial barriers of nonhydroscopic, non-flammable, insulating material, shall be so placed that an arc cannot be maintained between such parts and earth.

#### **6.12.11.2.2 Danger Notice Plate**

All Switchboards connected to medium voltage and above shall be provided with “Danger Notice Plate, conforming to relevant Indian Standards.

#### **6.12.11.3 Type of Switchboards**

Metal clad switchgear shall preferably be mounted on any of the types of boards mentioned above.

##### **6.12.11.3.1 Hinged Type Metal Boards**

Such boards shall be suitable for mounting of metal clad switch gear consisting of not more than one switch gear and ICTP 4 way or 6 way. Metal Box shall consist of a box made of sheet not less than 3 mm thick and shall be provided with a hinged cover to enable the boards to be swung open for the examination of the wiring at the back. The joints shall be subsequently welded. Metal boards may be made of suitable size angle iron of maximum size of 25 mm x 35 mm x 6 mm or channel iron of minimum size of 25 mm x 25 mm x 6 mm frame work suitably mounted on front with a 3 mm thick M.S plate and on back with 1.5mm M.S. sheet. The front sheet shall be provided with suitable hinges to enable the board to be swung open for examination of the wiring. The joints shall be substantially welded.

The boards shall be securely fixed to the wall by means of rag bolts and shall be provided with a locking arrangement and earthing stud. All wires passing through the metal boards shall be bushed. There shall be a clear distance of 30 mm between the front and back sheets. More space shall be allowed wherever necessary. A hylam board to thickness not less than 6 mm. may be provided at the back, if so required in the special specification in any particular

case No part shall project beyond any edge of panel. No fuse body shall be mounted within 25 mm of any edge of the panel.

#### **6.12.11.3.2 Fixed Type Metal Board**

Such boards shall be suitable for large Switchboards for mounting large numbers of switch gears and/or higher capacity metal clad switch gear. These shall consist of an angle of channel iron frame fixed on the wall at the top. There shall be a clear distance of 1 m. in front of the Switchboard.

The connections between switch gear mounting and the concerned cable up to the wall shall be enclosed in a protection pipe.

The detailed dimensions and design of metal boards and angle frame work for switch gears including the disposition of the various mountings which shall be symmetrically and neatly arranged for arriving at the overall dimensions shall be prepared and submitted beforehand and have the prior approval of the Engineer.

#### **6.12.11.4 Marking of Apparatus**

When a board is connected to voltage higher than 250 volts all the terminals or leads on the apparatus mounted on it shall be marked in the following colours to indicate the different phases to which the apparatus or its different terminals may have been connected.

AC Three Phase: Red, Blue and Yellow Neutral: Black

When four wire three phase wiring is done, the neutral shall preferably be in one colour and the other wires in another colour.

Where a board has more than one switch gear each such switch gear shall be marked to indicate which section of the installation it controls. The main switch gear shall be marked as such. Where there is more than one main Switchboard in the building, each Switchboard shall be marked to indicate which section of the installation and building it controls. All markings required for the above shall be clear and permanent. All distribution boards shall be marked 'Lighting' or 'Power' as the case may be and also marked with the voltage and number of

phases of the supply. Each shall be provided with a circuit diagram and the current rating of the circuit and size of the fuse element.

#### **6.12.11.5 Main and Branch Distribution Boards & Locations**

Unless otherwise specified in the Special Specification main and Branch distribution fuse boards shall be the metal clad type. Main distribution Boards shall be controlled by a linked fuse unit and a circuit breakers. Each outgoing circuit shall be provided, of MCB with SP / TP as per requirement. Branch Distribution boards shall be controlled by a MCCB / MCB. Each outgoing circuit shall be provided with a fuse or ELCB / MCB. The earthed neutral conductor shall have provision for Disconnecting individually for testing purpose. At least one Spare circuit breaker of the same capacity shall be provided on each branch distribution board.

#### **6.12.12 Capacity of Circuits**

Lights and fans may be wired on a common circuits, such circuit shall not have more than a total of ten points of light, fan and socket outlet or a load of 800 watts whichever is less.

Power circuits on buildings shall be designed with a maximum of two outlets per circuit, based on the loading. Where load is not specified the load shall be taken as 1 kW per outlet. Wherever the load to be fed is more than 1 kW it shall be controlled by an isolator switch or miniature circuit breaker and directly fed from the DB with separate wires and it should not be looped to any other outlet.

#### **6.12.13 Wall penetrations**

When conductors pass through walls, any one of the following methods shall be employed. Care shall be taken to see that wires pass very freely through protective pipe or box and that wire pass through in a straight line without any twist or cross in wires, on either end of such openings.

A conductor shall be carried in an approved heavy gauge solid drawn or lap welded conduit or in a porcelain tube of such a size that it permits easy drawings in. The ends of conduit shall be neatly bushed with porcelain, wood or other approved material.

Where a wall tube passes outside a building so as to be exposed to weather, the outer end shall be well mounted and turned downwards and properly bushed on the open end.

#### **6.12.14 Fixing to Walls and Ceiling**

Plug box for ordinary walls or ceiling shall be of well-seasoned teak or other approved hard PVC not less than 5 cm. long by 25 cm. sq. on the inner and 2 cm. sq. on the outer end. They shall be cemented into walls within 6.5 mm of the surface the remainder being finished according to the nature of the surface with plaster. Where owing to irregular coursing or other reasons the plugging of the walls or ceiling with wood plugs present difficulties, the wood casing, wood batten or metal conduit shall be attached to the wall or ceiling in an approved manner. In all such case approved type of asbestos or fibre fixing plug with correct size of tees shall be used to finish the work neatly without leaving any voids. Where this cannot be done, wooden plugs as described can be used with special permission of the Engineer.

#### **6.12.15 Accessories**

All switches shall be placed in the live conductor of the circuit and no single pole switch or fuse shall be inserted in the earth or earthed neutral conductors of the circuit.

#### **6.12.16 Socket outlets**

A socket outlet shall not have embedded terminal as integral part of it. But the fuse may be embedded in plug in which case plug shall be non-reversible and shall be so arranged and connected that the fuse is connected to phase, live conductor or the non-earthed conductor of the circuit. Every socket outlet shall be controlled by a switch. The switch controlling the socket outlet shall be on the 'Live' side of the line. 6 Amps and 16 Amps socket outlet shall normally be fixed at any convenient space 23 cm above the floor level or near such levels in special cases as desired by the Engineer. 16 Amps switch and socket should have an integral provisions of an indicator lamp/ light emitting diode. The switch for 6 Amps socket outlet shall be kept along with socket outlet. However, in special case, if desired by the Engineer the 6 Amps. Socket outlet shall be kept at normal switch level and that for 16 Amp along with the socket outlet. However, in special case, if desired by the Engineer the 6 Amp socket outlet shall be placed at the normal switch level. 16 A sockets shall have MCB/fuse with neon lamp /LED indicator.

Where socket outlets are placed at lower levels, they shall be enclosed in a suitable metallic box, as the case may be to harmonize with the system or wiring adopted. In an earthed system of supply a socket outlet and plug shall be of the three pin type. The third terminal shall be connected to earth.

Conductors connecting electrical appliance with a socket outlet shall be of flexible twin cord with an earthing core which shall metallic body of the electrical appliance.

#### **6.12.17 Attachment of fittings and accessories**

In case of conduit wiring, all accessories like switches sockets, outlets, call bell pushes and regulators shall be fixed in flush pattern inside metal boxes. Accessories like ceiling roses, brackets, battens, stiff pendants, etc. shall be fixed on metal outlet boxes. Aluminium alloy or cadmium plated iron screws shall be used to fix the accessories to their bases. The blocks/board shall normally be mounted with their bottom 1.25 m from floor level. The Boards shall have a hylam finish.

#### **6.12.18 Exhaust Fans**

Exhaust fans shall conform to the relevant British Standards.

Exhaust fans shall be fixed at the places indicated by the Engineer. For fixing an exhaust fan, a circular hole shall be provided in the wall to suit the size of the frame, which shall be fixed by means of rag bolts embedded to the wall. The hole shall be neatly plastered to the original finish of the wall. The exhaust fan shall be connected to exhaust fan point which shall be wired as near to the hole as possible by means of a flexible cord, care being taken to ensure that the blades rotate in the proper direction. In the case of Exhaust fans installation in corrosive atmosphere the same shall be painted with a special PVC paint or chlorinated rubber paint (Chloro rubber paint). Installation of exhaust fans at locations requires careful consideration. Metal enclosures of regulators of ceiling/exhaust fans shall be connected to earth by loop earthing.

#### **6.12.19 Luminaries**

##### **6.12.19.1 Emergency Light**

Emergency light unit must work on 230 volts. A.C. supply shall be Self-containing unit with 20 watts 300 mm long fluorescent lamp type 'SWITCH ON MAIN FAILURE'. It shall have electronic automatic switch of facility with electronic inverter, battery, battery charger with full load charging provision along with trickle charge circuit, which shall prevent overcharging of battery. The battery shall be maintenance free. The unit shall provide 4 hours illumination following power failure. The units shall generally conform to IEC 60598-2-22 or IS 9583.

## **6.12.20 Wiring Systems**

### **6.12.20.1 Surface Conduit Wiring System**

Rigid PVC conduits pipes of approved gauge thickness shall be used. The maximum number of PVC insulated 250 volts grade copper/aluminium conductor cable that can be drawn in one conduit of various sizes and the number of cables per conduit prescribed in the standards shall not be exceeded. In any case the area occupied the cables inside the conduit shall not exceed 40% of inner area of conduit. The minimum size PVC conduit dia. shall not be less than 25 mm. In long distance straight run of conduit, inspection type junction box at reasonable intervals shall be provided.

### **6.12.20.2 Fixing of Conduit**

Conduit pipes shall be fixed by heavy gauge clamps, secured to suitable wood plugs or other approved plugs with screws in an approved manner at an interval of not more than one metre but on either side of the couplers bends, or similar fittings, saddles shall be fixed at a distance of 30 cm from the centre of such fittings. The saddle should not be less than 24 gauge for conduits up to 25 mm dia and not less than 20 gauge for larger diameter. Where conduit pipes are to be laid along the trusses, steel joints etc. the same shall be secured by means of ordinary clips or girder clips as required by the Engineer. Where it is not possible to drill holes in the truss members, suitable clamps with bolts and nuts shall be used. The width and the thickness of the ordinary clips or girders clips and clamps shall be as in the code of practice for wiring.

### **6.12.20.3 Switch Box**

Switch box shall be made of metal on all sides, except on the front. In the case of cast boxes, wall thickness shall be at least 3 mm and in case of welded mild steel sheet boxes the wall thickness shall not be less than 18 gauge for boxes, up to a size of 20 cm x 30 cm and above this M.S. boxes shall be used. Except where otherwise stated 3 mm thick phenolic laminated sheets, like hylum, shall be fixed on the front with brass screws. Clear depth of the box shall not be less than 60 mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern. All fittings shall be flush pattern. Only a portion of the above box shall be sunk in the wall, the other portion being projected out for suitable entry of conduit pipes into the box.

#### **6.12.20.4 Recessed Conduit Wiring System**

Recessed PVC conduit wiring system shall comply with all the requirements of surface conduit wiring system specified in clauses above and in addition to the requirements spelt in the following clauses:

The chase in the wall shall be neatly made out of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, special care shall be taken to fix the conduit and accessories in position along with the building work, to avoid damage to the finished wall etc. All outlets such as switches, wall sockets etc. shall be flush type. The outlet box shall be same as above and shall be mounted flush with the wall. The metal box shall be efficiently earthed with conduit by an approved means of earth attachment. To facilitate drawings of wire in the conduit, G.I mesh wire of 10 SWG shall be provided while laying of recessed conduit.

## **6.12.21 Street lighting**

### **6.12.21.1 General**

1. Street lighting needs to offer good illumination. The materials used in street lighting should have good resistance to atmospheric condition and at the same time shall be appealing enough to add to the beauty of roads.
2. In tune with growing consciousness of society about energy conservation, street lights need to be energy efficient also.
3. Lighting system has to adequately take care of the Security concerns of pedestrians and motorists at night.
4. The basic purpose of illumination are as follows:
  - a. Clear Visibility
  - b. Drivers Comfort
  - c. Traffic Safety
  - d. Ease of traffic flow
5. Besides the conventional High Pressure Sodium Vapour (HPSV) and High Pressure Mercury Vapour (HPMV) Luminaries Metal halide. (HM) Street light Luminaries may also be used.
6. CFL and FLT Luminaries shall be preferred for access and minor roads. 7. The light sources used generally are high-pressure sodium vapour lamp.
  - a. The exact choice of light source is governed by functional, economic and aesthetic considerations.
8. The spacing between the luminaries should be uniform. Light sources may be mounted on one side or on both sides in parallel or staggered arrangement or on the median depending upon the width of the road and required recommended intensity of the lighting.
9. Special attention should be paid to the lighting of road junctions and crossings so that the kerbs and obstructions are clearly visible.
10. The pole, bracket and luminaries shall be of good integrated design and it should appear to have been designed as one unit.

### **6.12.21.2 Scope of Work**

The supply and installation of lighting equipment for lighting schemes shall include all of the following:

- a. Lighting units of required height and type as specified elsewhere in the Contract/shown in the drawings, with lanterns, lamp control gear, fuse links, cable service units, earthing, wiring, and sundries to complete the unit.
- b. Lighting cabinets.
- c. Service cable (Copper/XLPE/SWA/PVC) of size stated in the Contract including terminations.
- d. Earthing of electrical equipment including supply of earthing material consisting of earth electrodes and earth continuity conductors.
- e. Termination work.
- f. Excavation and backfilling of trenches, laying of cable access ducts, sealing of ducts, laying of protective tiles over cable etc.
- g. Civil works associated with equipment erection and installation.
- h. All labour, plant and materials for the complete erection, adjustment, testing, painting and commissioning of all equipment supplied and the system installed.
- i. All material which is not expressly specified but which is necessary for the successful installation and commissioning of the street lighting system.
- j. Providing computerized lighting calculations, luminance and illumination charts / diagrams for selected areas required by the Engineer.
- k. Maintaining the system during the defect liability period as stipulated in the contract.

#### **6.12.21.2.1 Design Requirements**

All the electrical installations shall be designed to provide safety to personnel, reliability, provision for possible future requirements, a graded system of protective devices, equipment and material and adequate interrupting capacity, continuous current carrying capacity and insulation levels, all as required by systems voltages, capacities and short circuit levels.

Where lighting columns are to be in the vicinity of overhead power lines the Contractor shall ensure that the Engineer is informed and satisfied with the clearances provided and that warning notices are permanently fixed to the columns affected, prior to erection.

The Contractor shall investigate and ascertain the presence of existing or new services at the intended locations of new lighting units, cabinets, cables etc. and shall make minor adjustment, as required with the approval of the Engineer, to the location of the new equipment, in order to avoid the existing utilities. d) Except where otherwise indicated, all the electric and electronic material, apparatus, machinery, equipment and installation must comply with the latest edition of the British Standards,/Indian standards codes of practice and local regulations. Any general or particular regulation issued by local authorities, such as Fire Brigade, Safety Inspectorate, Municipality, Public Telephone Company etc. shall also be complied with by the contractor.

### **6.12.21.3 Power Supply**

The contractor shall obtain power supply from the local Electricity Authority, for lighting cabinets at locations approved by the Engineer. The Contractor will arrange to install and connect lighting cabinets at the agreed locations and co-ordinate this item of work with the Authority. Power supply will be at 415/240 volts 3- phase, 4-wire, 50 Hz. The Contractor shall be responsible for the supply, installation and for terminations of the power supply cables as required by the Engineer.

### **6.12.21.4 1100 Volts Grade Armoured LT Power and Control Cables**

#### **6.12.21.4.1 Power Cables**

The cables shall comply the following: -

650/1 100V grade with standard copper conductor from 4 mm<sup>2</sup> and above Colour coded PVC insulation applied over conductor by extrusion. PVC inner and outer sheathed applied by extrusion. Steel armouring between inner and outer sheathed. Size of cables must be chosen to suit duty and load sections. While selecting PVC insulated armoured cables for street lights not only the current carrying capacity of the cable but also the voltage drop shall be taken into account, which depends on number of lights and resistance of cable. Manufacturer's identifications (Name of trade mark) and voltage grade shall be embossed as the outer sheath.

Cable wound drum shall have the following information.

- Name of the manufacturer.
- Direction of rotation

- Type of cable, voltage grade, size and number of cores.
- Length of cable.

The Supplier shall ensure the following;

- Cable ends shall be sealed by means of non-hydroscopic sealing materials.
- Necessary test certificates as approved in British or international standards shall be delivered along with cable drum.

#### **6.12.21.4.2 Conductor**

The cable conductor shall be made from stranded copper for power cables and stranded annealed copper for control cables and special cables to form compact conductor having a resistance within the limits specified in IEC 60228:2004. The minimum number of strands for conductor shall be 7 (seven). The minimum conductor size for LT power cable shall be 4sq.mm copper. However, 2.5 sq.mm copper conductors may be used for small power distribution. For LT power cables, following sizes of conductor shall be used:

4 core, 10 sq.mm; 3.5 core 25 sq-mm; 3.5 core 35sq.mm 3.5 core 50 sq.mm; 3.5 core 105 sq.mm and 3.5 core 300 sq.mm.

Control cables of 2.5 sq.mm copper conductor with suitable number of cores shall be used.

#### **6.12.21.4.3 Insulation**

The cable insulation shall be of best quality H.R. PVC compound Suitable for 85°C operation as per IEC 60502. The insulation shall be designed and manufactured for the specified voltage grade. The insulation shall fit closely in the conductor and shall be free from voids, foreign particles and burnt material etc. to ensure good insulating properties throughout the cable length.

#### **6.12.21.4.4 Sheath**

The laid up cores in cable shall be inner sheathed by extruded PVC covering, which shall be suitable to withstand the site conditions and the desired temperature. The sheath shall, be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects.

#### **6.12.21.4.5 Armour/Shield**

The control cables shall be armoured with galvanized round steel wire

#### **6.12.21.5 Serving/Outer Sheath**

Extruded PVC serving as per IEC 60502 shall be applied over the armouring with suitable additives to prevent attack by rodent sand termites. All serving must be given anti-termite treatment.

#### **6.12.21.5.1 Fillers**

Fillers shall not be used. However, if they are absolutely essential, they shall be chemically inert, rat proof, and non-adsorbent and resistant to environmental influences. They shall be suitable for the operating temperature of the cable and compatible with the insulating material.

#### **6.12.21.5.2 Identification**

The cores in the control cables shall be identified by a colour scheme as per IEC 60502. Over and above this, the cores shall further be identified by the indelible printing of serial numbers on the cores at distances not more than 75mm.

All cables shall carry the manufacture's data in a permanent legible manner at an interval of at least three metre run. The manufacturer's data shall include the name, the cable size, voltage rating, together with any other information which the manufacturer considers appropriate.

#### **6.12.21.5.3 Drum Length and Cable Drums**

The cables covered by this specification shall be supplied in drum length (continuous length) of 1000/500 metres+5%. The cables shall be supplied in non-returnable wooden drums of robust construction. The wood used for construction of the drum shall be property seasoned, sound and free from defects and wood preservative shall be applied to the entire drum.

#### **6.12.21.5.4 Packing**

All cables shall be wound on substantial logged wooden nonreturnable drums. A layer of waterproofed paper shall be applied to the surface of the drums and over the outer cable layer. A clear space of at least 40mm shall be left between the cable and the logging. Each drum

shall carry the manufacturer's name, the Customer's name, address and order number, item number and type, size and length of cable, net and gross weight stenciled on the drum.

#### **6.12.21.5.5 Cable Runs and Operation**

1. The control cables are proposed to be laid on racks in covered trenches, cable tunnels or along ceiling and walls in substation.
2. The control cables will run on separate racks from the power cables.
3. The cables shall have heat and moisture resistant properties for satisfactory operation under tropical humid conditions.

#### **6.12.21.5.6 Tests**

The Contractor must provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent, for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture according to this Specification. If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected notwithstanding any previous certificates, which may have been provided. Notwithstanding the above, the Contractor will be required to rectify any deficiencies which are attributable to defects in the workmanship or quality during the Defects Liability Period specified in the contract.

#### **6.12.21.5.7 Type Tests**

Type test in each type and size of cable shall be conducted as per applicable standards. The following shall be performed as type tests as per standards already mentioned:

- Annealing test
- Conductor Resistance Test
- Test for Armour wires/strips
- Persulphate Test
- Test for thickness of insulation and sheath
- Tensile strength and elongation test for insulation and sheath
- Ageing Test for insulation and sheath
- Loss of mass test PVC insulation and sheath Shrinkage test
- Hot deformation test
- Cold bend test
- Cold impact test
- Heat shock test
- Thermal stability test
- Test for bleeding and blooming of pigments for PVC Fire resistance test
- Measurement of insulation resistance
- High voltage test

All the tests shall be as per relevant British standards

Test for rodent and terminate repulsion property of sheath are to be performed by the manufacturer. The details of the tests are to be given by the manufacturer.

#### **6.12.21.5.8 Routine test and acceptance tests**

The following tests shall constitute routine tests and acceptance tests which shall be performed on samples collected from materials ready for dispatch:

- Annealing Test
- Conductor Resistance Test
- Insulation Resistance Test
- Test for thickness of insulation and sheath
- High voltage test.

Apart from these, conductor examination, check of dimensions etc. shall be carried out as routine tests. The test methods, condition of test and test requirement shall be as per the IS/

British Standards identified for the Type Tests. The high voltage tests shall, however, be performed as per the methods specified under relevant clause for routine test.

#### **6.12.21.5.9 Laying of PVC Insulated Armoured Cable**

The cable shall be laid in ground in one length without any jointing after cutting trench 0.6m wide and 0.76m deep, levelling the bottom of the trench properly, making the trench free of stone and other hard materials to avoid damage of cables, giving brick (full size – 2nd class) protection to the cable by placing brick longitudinally on two sides and at the top at the rate of 12 nos. brick per m, filling of the space between the brick protection layer and the surface of the ground level with excavated soil and ramming by excavated soil to make the surface level with the adjoining area. The ground surface of the whole trench route shall be cleared. The width of the trench should be increased by 0.23m, for each of the additional cable in the same trench. The depth and other condition will remain same as stated in the paragraph above. For lighting along bridges, the cable shall be laid through 150mm PVC pipe inserted in the bridge structure during construction. The pipe shall connect the spaces kept for housing loop box near each light pole on the bridge.

While selecting PVC insulated armoured cables for street lights not only the current carrying capacity of the cable, number of lights to be connected and the total power requirement shall be considered, but also the voltage drop shall be taken into account. The voltage drop depends upon current consumed by the light and the resistance of the cable. The cable shall be terminated through heavy duty single compression cable glands of corrected size. Crimping type sockets shall be used for all cable termination. Entry and outgoing cables to loop box shall be protected by metallic pipes.

#### **6.12.21.6 Wiring and General Fixing**

1. The wiring between the lantern and auxiliary gear to the cut-out in the column bases shall be carried out and tested by a qualified electrician and be in accordance with the code of practices laid down in the standards and regulations to the entire satisfaction of the Engineer. All wires shall be PVC insulated. The whole of the wiring shall be fully bonded for earthing. Size and make of wires shall be approved by the Engineer.
2. Unless otherwise described in the Contract wiring between the terminal block in the luminaire and components in the base of the light unit shall be PVC insulated and

sheathed single, multi-core or composite cable satisfying BS 6004:2012. Single phase 3 core copper conductors shall be not less than 2.5 sq.mm in cross section area except that where the vertical unsupported length does not exceed 6 metres their cross sectional area can be reduced to 1.5 sq.mm. Where electronic ignitors are used with remote control gear single core cable shall be used.

The final connection between the lamp and equipment mounted in the base compartment shall be made using PVC insulated and sheathed 2 core and earth and minimum rated at 85 C.

3. All cables shall be correctly colour coded and labelled.
4. Unsupported lengths of cable shall be kept to a minimum and shall not be allowed to come in contact with components by their freedom of movement. Where there is more than one cable they shall be secured together at one metre intervals throughout the unsupported length.
5. Wiring shall wherever possible be housed inside columns, wall brackets and posts or stiffening members. Where it is external it shall be as described in the Contract. Connections between conduit and sign housings, switch boxes and other components shall be waterproof and be smooth internally.

#### **6.12.21.7 Cut-Outs**

1. Cut-outs shall be dust and damp protected made of hot dip galvanized steel without rubber gasket, totally enclosed with MCB for Pole Circuit. The design of the cut-out shall permit withdrawal of the fuse carrier without exposing live connections. A separate fuse shall be provided for each and every lamp.
2. The cut-outs shall be provided with an earthing terminal and shall accept cables up to 25 sq.mm. The fuse carrier shall accept HRC fuses upto 20 Amp rating or C.B. All terminals shall be securely fixed within the cut-out enclosures. The cut-out shall be fitted with a suitable Brass Compression Cable Gland Type "CW" in accordance with BS 6121 and with Earth Tag and PVC Shroud. The cut-out shall be sized for looping in and out of the service cable.
3. Minimum thickness of body of the cut out box shall be 2.5mm and that of cover shall be 1.5mm.
4. Cut-outs should not have more than 2 incoming cable termination.

#### **6.12.21.8 Control Gear**

The control gear shall be designed to operate the lamp at the specified power rating indicated in the design criteria and shall be able to start the lamp and control it continuously for ambient temperatures ranging from 15 deg C to + 50 deg C. The control gear shall be capable of accepting of supply voltage of 240V. The following specifications shall be met by the control gear Control gear shall be suitable for 50 Hz, 240V  $\pm$  10% operation. For input voltage fluctuations of +10% ,15% from the nominal specified voltage, it shall regulate the lamp watts to  $\pm$  5%. Control gear shall have an overall power factor of at least 0.9 when operated under rated lamp load. Control gear shall operate the lamp without adversely affecting the lamp life and performance as specified herein. Control gear shall withstand a 2500V dielectric test between core and windings for one minute. The permissible voltage dip without causing the lamp to extinguish shall be 40 to 50%. The ballast shall be impregnated, tropicalized with compact winding and insulation Class "H". The maximum permissible winding temperature rise shall not exceed 130 deg C.

#### **6.12.21.9 Auto Switch**

1. For conservation of energy and on economical consideration auto switching is preferred in place of conventional manual switching.
2. Auto change over switch unit shall be complete with analogue / digital time switch with auto manual switching mode and following. Suitable rated air break contractor.

Incoming cable terminal with MCB protection at point of entry. On – Off indicating lamp. Pollution free Lithium cell. Internal wirings with stranded PVC insulated copper conductor cable.

3. The above unit shall be incorporated in MS box made of 5mm thick MS plate slightly rounded shape at corner and of solidly welded joints at the corners. It will have type double door to be opened in front. There shall be ventilation arrangement at top duly protected by canopy and close mesh brass net. The top hood of the box shall be sufficiently projected on four sides to prevent ingress of rain water inside the box. Railway type locking and additional arrangement of pad locking is also to be made in front side. Suitable base structure shall be provided with MS channel and angle with suitable G.I. Nut, bolt and washers. Bases shall be duly grouted with cement concrete in ground. The bottom of the box shall be 750mm height above ground level and shall be complete with earth terminal and lifting hooks. All components along with provision of housing KWH meter to be done on hylum sheet at the back side of the box. The box is to be painted both inside and out side with two coats of red oxide primer after finishing the surface properly. For convenience the switching unit is to be identified by marking in black Japan.

4. Over and above preset timers, photo electric controls may be used to turn light equipment on and off automatically at dusk and dawn if specifically required in the Contract. This will operate as soon as the ambient light level drops to a desired level This will switch on the system during cloudy weather.

5. The command of photo electric cell will supersede the timer setting. Analogue time switches shall conform to IEC 60730-1/BS EN 60730-1.

#### **6.12.21.10 Lamp**

1. The 250-Watt mercury vapour lamp shall comply with the following requirements:

Power rating of lamp:250 watts (mercury vapour)

Total luminous flux: 14,000 lumens

Average life to burn out to exceed:24,000hrs

At half life, the maintained luminous flux shall be a minimum of 80 percent of the initial luminous flux.

2. The 250 watt mercury vapour ballast shall be designed to operate the specified lamp of the power rating in these standard specifications and shall be able to start the lamp and control it continuously for ambient temperatures ranging from 0 degree to 55 degree C. The ballast shall be of high power factor for starting. The ballast shall be capable of accepting a supply voltage of 240V. The following specifications shall be met by the ballast:

- Ballast shall be suitable for 50Hz, 240 V AC+10% operation.
- For input voltage fluctuations of + 1 0%, from nominal specified voltage, it shall regulate the lamp watts to +5 percent.
- Ballast shall have an overall power factor of at least 0.9 when operated under rated lamp load.
- Ballast shall operate the lamp without adversely affecting the lamp life and performance as specified herein.
- Ballast shall withstand a 2000 V dielectric test between core and windings for one minute. The permissible voltage dip without causing the lamp to extinguish shall be minimum 40 percent when the lamp is new. Line starting amperes shall be not more than the operating amperes.

3. The 250 watt high-pressure sodium lamp shall comply with the following requirements:

- Power rating of lamp : 250 watts ( high pressure sodium)
- Total luminous flux : 31,000 lumens
- Average life to burn out to exceed:24,000hrs
- At half life,the maintained luminous flux shall be a minimum of 90 percent of the initial luminous flux.
- The contractor shall submit spectral distribution information for the Engineer's approval.

4. The 250 watt high pressure sodium ballast shall be designed to operate the specified lamp of the power rating in these standard specifications and shall be able to start the lamp and control it continuously for ambient temperatures ranging from 0 degree C to 55 degree C. The ballast shall be high of power factor for starting. The ballast shall be capable of accepting a supply voltage of 240 V.

The following specifications shall be met by the ballast:

- (i) Ballast shall be suitable for 50Hz, 240 V AC+10 % operation.
- (ii) For input voltage fluctuations of + 5% from nominal specified voltage, it shall regulate the lamp watts within lamp volt- watt trapezoid per ANSI Standard.
- (iii) Ballast shall have an overall power factor of at least 0.9 when operated under rated lamp load.
- (iv) Ballast shall operate the lamp without adversely affecting the lamp life and performance as specified herein.
- (v) Ballast shall withstand a 2000 V dielectric test between core and windings for one minute.
- (vi) The permissible voltage dip without causing the lamp to extinguish shall be minimum 25 percent when the lamp is new.
- (vii) Line starting amperes shall be not more than the operating amperes.

#### **6.12.21.11 Ballasts**

- 1. Unless otherwise specified ballasts shall comply with BS EN61347-2-9 or BS EN 60923:2005 as appropriate and be for 240V operation.
- 2. The terminals shall be indelibly marked to indicate all wiring connections.

#### **6.12.21.12 Igniters for Discharge Lamps**

- 1. Unless otherwise specified, igniters shall not be incorporated in the lamps.
- 2. Compatibility between igniters, lamp and ballast shall be established to the satisfaction of the Engineer.

#### **6.12.21.13 Capacitors**

- 1. Capacitors shall comply with BS EN61048 and BS EN61049 or IEC 61049:1991 and be supplied complete with fixing clips, discharge resistors, and either sealed-in cable tails or shrouded terminals.

2. Capacitors shall correct the lamp circuit power factor to not less than 0.90 lagging unless otherwise agreed in writing by the Engineer.

#### **6.12.21.14 Fuse Holders, Fuses and Miniature Circuit Breakers (MCBs)**

1. Cut-outs fuse holders and MCB's shall have mould drip proof housings.
2. Terminals shall be sufficient for the conductors as specified. These shall be clearly labelled to differentiate circuits and phases.
3. When fuse holders are intended to be used as isolating devices, special tools or protective measures shall not be necessary to extract them.
4. Fuse links shall comply with the requirements of BS EN 60269-4 or I IEC 60269-1. They shall be of high breaking capacity type and be of a value specified to protect the circuit.
5. Miniature circuit breakers shall be in accordance with IEC 60898-1 Ed. 2.0 for use on 240V single phase supply or 415V three phase supplies. Their short circuit current rating and type shall be specified in the offer. Thermal or magnetic excess current tripping devices shall be provided with a mechanism to ensure that the contact cannot be held closed against a fault.(FAIL SAFE).
6. Where MCBs are intended to be used as isolating devices, a 'lock off' facility should be provided.
7. All devices shall be rated for 50 deg C ambient temperature.

#### **6.12.21.15 Specification of Road Light Fixtures**

The street light luminaries will be supplied with IP-66 protection and conforming to IEC 60598-1 with following technical specifications:

- Housing: High-pressure die-cast aluminium body/or with nylon plastic, powder coated.
- Reflector: Deep drawn high grade aluminium, electro chemically brightened and anodized.
- Glass: toughened heat resistant glass sealed with silicon gasket.
- Lamp holder: E-40 adjustable for various optics.
- Control gear: Integral with electromagnetic copper wound ballast, ignitor and capacitor wired with heat resistant wire.

#### **6.12.21.16 Street Light Luminaries**

1. Street light luminaries housing and cover shall preferably be made in single piece die-cast LM6 aluminium.
2. The housing and cover shall be epoxy powder coated finish from outside.
3. Clear acrylic glass cover to be used.
4. The lamp compartment to be fitted with an innovative electro chemically brightened and anodized aluminium reflector for better uniformity and high optical efficiency.
5. The glass covering to be held in position by stainless steel toggles.
6. Synthetic rubber gasket and toggles to be provided to make the luminaries dust and water proof.
7. Lamp replacement and accessories maintenance to be undertaken by opening the toggles.
8. The Luminaries shall be complete with the following components:
  - Copper wound Ballast
  - Power factor improvement capacitor Electronic Igniter.
  - The main connector to receive incoming power.
  - End mounting on pipe of suitable diameter.
9. Out door Industrial Luminaires for fluorescent lamp (corrosion proof) may be used for access and minor roads.
10. The Unit shall comprise of deep drawn CRCA M.S. sheet housing in epoxy powder coated finish as top canopy.
11. Reflector cum control gear tray will be fabricated from CRCA MS Sheet, finished in epoxy powder coated white.
12. The unit shall be pre-wired with vacuum pressure impregnated copper wound ballasts, P.F. improvement capacitors, Lamp Holder and main connector to receive in coming power source.
13. An acrylic perspex and gasket have to be provided to make the luminaries weather proof.
14. The perspex should be held in position by toggles.

15. Re lamping can be done easily by releasing toggles and opening the acrylic cover. The contractor has to arrange inspection of pole and streetlight luminaries at manufacturer's premises to carry out necessary tests

16. The wires shall be rated for 600 volt AC, XLPE insulated and shall be capable of withstanding high temperatures. The terminal block / connectors shall be high temperature grade porcelain or equivalent approved and be easily accessible and suitable for 2.5 sq.mm conductor. A suitable earthing terminal shall be provided in the lantern. Care is to be taken in positioning the terminal block such that whilst being readily accessible there is no possibility of accidental contact during maintenance.

17. All new lanterns and lamps shall be assembled fixed, focused, adjusted and wired in accordance with the manufacturer's instructions.

#### **6.12.21.17 Feeder Pillar**

The Contractor shall have to get the control panel fabricated.

#### **6.12.21.18 Street Light Poles**

1. The steel tubular poles shall be made of steel, swaged and welded type having ultimate tensile strength 42 kg. per sq mm.). The steel tubular poles are of three sections(telescopic) with reduction in diameter for each section. The swaged and welded length at two points shall be over lapped with minimum of 200 mm length. The top portion of the steel tubular poles shall be bent in the shape of swan neck for fixing luminaries with the pole by getting a suitable length of E.R.W. pipe welded/ or separated fabricated brackets to be fixed on the pole top.

2. Plantation depth of steel tubular poles shall be as per length and local condition. The plantation depth of steel poles to be used on bridge is nil as it will be erected over the deck.

3. Cables shall be terminated through heavy duty single compression Cable glands of corrected size.

4. Crimping type sockets shall be used for all cable terminations.

5. Entry and outgoing cables to loop box shall be protected by metallic pipes.

6. Poles shall be erected on the ground first after making foundation pit for at least 150mm more than the planting depth, the placing the pole on a 600 mm x 600 mm x

150 mm thick cement concrete (4:2:1) and then making metal concrete foundation (6:3:1) for 300 mm on all sides of the pole for the total planting depth and additional 300mm for muffing above ground level. The foundation pit beyond concrete consolidation shall be filled with excavated earth as and where necessary and duly rammed. G.I. Earth bolt shall be provided after making drilled holes etc. on pile. The bottom portion of the poles before placing in the foundation pit shall be painted with two coats of black japan bitumen based paint. Extra cement concrete foundation (6:3:1) with dimension 600 mm x 600 mm x 750 mm above ground level with 3 mm thick neat cement finish shall be provided. There shall be opening for loop box.

7. Poles shall be painted with the two coats of paint having colour to the choice of Engineer– in-Charge over basic primer paint of two coats of red lead after cleansing the surface of the pole with sand paper/emery cloth.

8. Poles may be numbered in black letters and digits within a circle as required with the black Japan paint of approved make and brand. The size of the letter should be 45 mm and pole numbers shall be written with respect to pillar box as per direction of Engineer – in-Charge.

9. Following dimensions shall be measured

- Overall length (m).
- Length of sections (m)
- Outside dia. of sections (mm)
- Thickness of sections (mm)
- Weight of pole (kg)
- Results shall be well within the limits specified in the above IS.

10. Following tests are to be carried out at manufacturers works as per

- Deflection test (mm)
- Permanent set test (mm)
- Drop test

11. Following observations to be made before dispatch of poles from manufacturer's works:

- General workman ship
- Straightness
- Freedom from defects

- Earthing arrangement
- Protection against corrosion

#### **6.12.21.19 Fluorescent Lamps**

Starters for fluorescent lamps shall comply with BS 3772 and shall be incorporated in the electrical equipment where applicable. Lamps for all similar applications shall be identical, of the same colour temperature and from the same manufacturer.

## 6.13 Earthing

### 6.13.1 Description

Earthing in general shall comply with BS 7430 Code of practice Earth electrode either in the form of pipe electrode or plate electrode should be provided at all premises for providing earthing system. As far as possible, all earth connection shall be visible for inspection and shall be carefully made.

Except for equipment provided with double insulation all the non-current carrying metal parts of electrical installation are to be earthed properly. All metal conduit trunking cases, sheets, switch gears, distribution fuse boards, lighting fittings and all other parts made of metal shall be connected to an effective earth electrode.

The main earth electrode should be G.I perforated pipes driven into the soil as per standard practice. Continuous looped earthing should be provided with adequate size G.I. wire / flat. Earthing work should conform to codes of practices and safety regulations and rules. The electrodes shall be situated at a distance not less than 3.0 m. from the building fencing structure and equipment foundations. The earth pit shall conform to BS 7430 and GI earth electrodes of not less than 100 mm external dia shall be driven to a depth of at least 3m in the ground below the ground level. The surrounding the electrodes, soil shall be treated up with salt, coke and charcoal.

Earth electrode shall be installed near the main supply point and shall comprise a copper / GI earth of appropriate diameter and driven to depth of 3 meters below ground level, or to a greater depth, if so required to obtain a sufficiently low earth resistance value. Alternatively copper plate may be used as the main earth electrode conforming to standards The electrodes shall be driven at least 3 m away from the building or any other earth station. Minimum requirement of earth pits as per I.E. rules are as under:

- Two numbers independent for transformer body
- Two numbers independent for transformer neutral
- Two numbers independent for four pole structure
- One number for lightning arrestors
- Two numbers for L.T. panel at sub-station and at pump house.

The main earth electrodes after being driven into the ground shall be protected at the top by constructing a concrete or block masonry chamber of size 300 mm x 300 mm x height 300 mm. and shall be provided with CI cover. The resistance of any point in the earth continuity system of the installation to the main earth electrode shall not exceed 1.0 ohm. The remaining space in the bore hole shall be filled with bentonite. The bentonite will hold the earth rod in position. The neutral conductor shall be insulated throughout and shall not be connected at any point to the consumers earthing system.

An earth continuity conductor shall run continuously from the farthest part of installation to the main earth electrode and shall be connected by branch conductor to all metal casing and sheathing housing electrical apparatus and/or wires and cables. All branches shall be connected to earthing. The earth continuity conductors shall have a cross-sectional area at least half to the size of the phase conductor and in no case less than 1.5 mm<sup>2</sup> of Cu/GS. All earth wires and earth continuity conductor shall be galvanized MS flats of appropriate size. Interconnections of earth continuity main conductors and branch wires shall be brazed properly, ensuring reliable, permanent and good electrical connections. The earth lead run on structures must be securely bolted. Neutral earth leads shall be run on a separate supports without touching the body of the transformers. Earth wires shall be protected against mechanical damage and possibility of corrosion particularly at the junction points of earth electrodes and earth wire interconnections. Earth electrodes shall be connected to the earth conductors using proper clamps and bolt links. It shall not be allowed to use the armour of the incoming feeder's cable to the sub-distribution board as the only earthing system. Sheathed lugs of ample capacities and size shall be used for all underground conductors for sizes above 3 mm<sup>2</sup> whenever they are to be fitted on equipment. Alternatively flat copper conductor of suitable shall be used for the purpose. The lugs shall be fitted on equipment body to be grounded or flat copper only after the portion on which it is to be fixed is scrubbed, cleaned of paint or any oily substance on a subsequently tinned surface. No strands shall be allowed to be cut in case of stranded ground round conductors. G.I embedded conduits shall be made electrically continuous means of good continuity fixing and also be rounding copper wires and approved copper clamps.

### 6.13.2 Earthing of Lighting Poles

All external poles are to be looped together with continuous 8 SWG GI earth wire clamped at dollies provided on every fuse box of poles and looped onwards to the other pole. Every fifth pole shall be connected to earth through an earth electrode.

### 6.13.3 Earthing for Lighting Installation

This shall be common grid system, the main grounding conductor laid and embedded in concrete being grounded at earth pits outside the buildings at approved locations or other places. The earthing of L.T panels shall be connected to two main grounding conductors each of which along with main cables shall run with cables to distribution boards in each floor. This shall run along with the cable and at the top floor be connected same section completing the grid.

### 6.13.4 Sizes of Earthing Conductors

System Earthing conductor size and Material

Buried in ground / concrete above ground	40 x 10 mm MS
Main Earthing Grid	40 x 10 mm
11 kV outdoor sub-station	
And 11 kV switchgear	
415V switchgear, transformer, Suitable to rating	50 x 6 GS
DG set, Capacitor Control Panel	
Battery charger	25 x 3 mm GS
415V LT Motors	
Valve motors	10 SWG GS wire
0 - 15 HP	8 SWG GS wire
15 - 40 HP	4 SWG GS wire

40 - 50 HP 25 X 3mm GS flat

50 HP and above 25 X 6 mm GS flat

Lighting distribution Board, 30V DC Tripping Unit. 25 X 3mm GS flat

Local push Button Stations, Junction Boxes. 14 SWG GS wire

Lighting and receptacle system 12 SWG GS wire Earth Electrode 50  
mm dia. 3000 mm long heavy duty GI pipe

Street lighting poles 8SWG GS wire

Notes:

- Conductors above ground shall be galvanised steel.
- Conductors buried in ground or embedded in concrete shall be mild steel.

## **SECTION 7 Instrumentation Specifications**

### **7.1 Scope**

This section covers the general requirements for design ,supply installation and Commissioning of all instrumentation ,control , data monitoring equipment complete (ICDM) in every detail as specified in the remaining parts of this section. The complete ICDM shall be furnished by a single subcontractor to ensure system uniformity, subsystem compatibility and co-ordination of all system interfaces.

The Contractor must provide all tools, equipment , materials and supplies and perform all labour required to complete the supply, installation ,including all instrumentation Signal and power conduit not shown on the electrical drawings, validation, Start up and commissioning of a complete and operable ICDM system as Indicated in the project specifications in respect of all the pumping stations

The Contractor must provide all necessary equipment components and interconnections and the services of the manufacturers, engineering representatives for the engineering, implementation, installation, calibration, validation commissioning operation and instruction to ensure that the end user receives a completely integrated and operational ICDM as herein specified. It shall also be within the scope of the subcontractor to ensure that any incidental items/work specified in other parts of this specification which has relevance to the control ,instrumentation, data acquisition or automation aspects has also to be arranged by him even though the same is not expressly covered by the specification herein.

### **7.2 Definitions**

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

### 7.3 Reference Standards

The following standards are referred to in this section and the drawings relevant to this section;

<b>BS EN 60654-1:1993, IEC 60654-1:1993</b>	Industrial-process measurement and control equipment. Operating conditions. Climatic conditions
<b>BS EN ISO 9001:2015</b>	Quality management systems. Requirements
<b>BS EN 60529:1992 +A2:2013</b>	Degrees of protection provided by enclosures (IP code)
<b>PAS 5308-1:2009</b>	Control and instrumentation cables. Specification for polyethylene insulated cables
<b>PAS 5308-2:2009</b>	Control and instrumentation cables. Specification for PVC insulated cables
<b>BS 1646-2:1983</b>	Symbolic representation for process measurement control functions and instrumentation. Specification for additional basic requirements
<b>BS 5863-1:1984, IEC 60381-1:1982</b>	Analogue signals for process control systems. Specification for direct current signals
<b>BS 5863-2:1980, IEC 60381-2:1978</b>	Analogue signals for process control systems. Specification for direct voltage signals
<b>BS EN 60051-1:1999, IEC 60051-1:1997</b>	Direct acting indicating analogue electrical measuring instruments and their accessories. Definitions and general requirements common to

	all parts
<b>DIN IEC 61554:2002-08</b>	Panel mounted equipment - Electrical measuring instruments - Dimensions for panel mounting (IEC 61554:1999)
<b>BS 90:1975</b>	Specification for direct-acting electrical recording instruments and their accessories

All the components of the system shall satisfy BS EN60654, Operating conditions for industrial process measurement and control and quality procedures as per BS EN 9001. Besides they shall satisfy the requirements of ingress protection as laid down in BS EN 60529. Protection from Radio frequency interferences as brought out in the various British standards shall also be ensured. Instrumentation cables shall satisfy PAS 5308 requirements and in respect of symbolic representation of process control functions and instruments BS1646 shall be applicable.

All equipment shall operate with 240 V +10% , -15% 50 HZ ac The Contractor shall obtain all Instruments/sensors and controllers/accessories from manufacturers of international standing and repute and they shall generally Confirm to the relevant British standards

The design and quality of all instruments sensors and controllers and other equipment shall be fully suited to the conditions, which will be met in service. All instruments shall be capable of carrying their full load currents without undue heating. They shall not be damaged by the passage of fault currents within the rating of the associated MCB or through the primaries of their corresponding instrument transformers and shall be provided with protection against power supply transients , disturbances and lightning surges as also radio frequency interferences. All instruments shall be back connected and the metallic cases shall be earthed. Approved means shall be provided for zero adjustment, span or range and configuring of instruments without dismantling.

All voltage circuits to instruments shall be protected by MCB's in each unearthed phase of the circuit placed as close as practicable to the main connection. Metal oxide varistors and surge arrestors shall be provided to protect against abnormal voltages.

Control voltages used shall be selected to suit the particular application of the instrumentation equipment. Unless otherwise agreed by the Engineer, control and instrumentation supply voltages shall not exceed 24 volts D.C.

Analogue signals shall be 4-20 mA DC to BS 5863: Part 1:1984. They shall operate over two wires and be isolated from earth. 1 -5V DC signals shall only be permitted within the main instrument enclosure. Analogue signals shall be so connected that the failure of a remotely transmitted signal to another panel will not affect other readings on instruments operated by the same signal. Instrumentation cables shall satisfy the requirements of BS 5308 Part1 and part2 and shall be armoured and shielded with twisted pair for noise immunity.

Indicating instruments shall be designed to measure and indicate the quantities using the following units:

- Flow : l/s (Litres per second)
- Level : m (Metres)
- Pressure: m.hd (Metres head of water) Temperature: °C (Degree Celsius)
- Concentration:p.p.m (Parts per million Current)
- Amp : A (Amperes)
- Voltage: V (Volts)
- Power : W (Watts)
- Electrical Energy: W-hr (Watt-hours)
- Frequency: Hz (Hertz)
- Speed : r.p.m (Revolutions per minute)

All instruments, gauges and control equipment shall be subject to the Engineer's approval, and those which perform similar duties shall be of uniform type and manufacture throughout the scheme in order to facilitate maintenance and the stocking of spare parts. Moving parts and contacts shall be adequately protected from the ingress of dust, and all instruments shall be protected by moisture and dustproof cases including those mounted in panels. All

equipment shall be suitable for its environment. Panel mounted receiving instruments shall be of the electrically operated miniature flush mounting type unless otherwise stated.

Where applicable each instrument chassis shall be easily withdrawable from its housing for maintenance without interrupting its signal.

All instrument bezels shall be finished to a British Standard colour to be specified by the Engineer. Scales shall be clearly marked with black lettering and graduations on a white background. Instruments of the same type and range shall have identical scales.

The Subcontractor shall provide instruments and equipment to interface with auxiliary contacts provided under other contracts, for alarms, status inputs, interlocking and control inputs and other functions as indicated and specified in the project specification.

#### **7.4 Field Mounted Instruments**

Field mounted instruments shall, where possible, be hermetically sealed. If this is not possible they shall be of weatherproof construction with heavy cast cases. Transmitters and similar equipment shall be further enclosed in weather proof; glass reinforced fire-retardant polyester resin cabinets. Particular regard shall be paid to the ease of access to all instruments. Serial number/calibration plates shall be visible when the instrument is in its cabinet.

Locally mounted indicating instruments shall be mounted in viewable positions. Field mounted instruments shall be complete with all mounting brackets, pillars, fittings and fixings to complete the installation.

#### **7.5 Panel Mounted Instruments**

Panel mounted instruments shall wherever possible be hermetically sealed. If this is not possible they shall be enclosed in moisture and dust proof cases.

## 7.6 Indicators

All indication instruments shall have performances in accordance with BS EN 60051, dimensions to DIN 61554 and scale markings to DIN 43802. Class index shall be between 1.0 and 5.0 depending on the scale length.

Level indicators shall be scaled vertically, alarm levels being indicated by red areas. Motor current ammeters shall have red lines or movable pointers to indicate motor full load current. Ranges shall be arranged so that the normal working point is between 50% and 75% of full-scale deflection.

## 7.7 Chart Recorders

All chart recorders for use in control and instrument panels desks, consoles, etc., shall comply with the following unless stated otherwise in the specific application Clause.

All chart recorders shall:

- Comply with BS 90:1975 (1993) to measured quantity accuracy Class 1 and time keeping accuracy Class 0.05.
- Have a separate scale plate for each signal channel.
- Have a linear scale not less than 100mm long with clear graduation and markings for each signal channel.
- Have the units of the measured variable and any multiplying factor clearly marked on the scale plate.
- Be flush mounting with matt or semi-matt black bezel.
- Be designed so that the chart may be withdrawn from the front and replaced without interrupting the indicating section.
- Have a plug-in chassis, which may be withdrawn from the front leaving the housing in position, without interrupting its signal.
- Have a minimum chart speed of 20 mm per hour and minimum chart duration of 4 weeks.
- Have charts with printed calibration of 0-100% and 24 hr. time marks.

- Have a window of anti-glare or low reflectivity glass in a hinged, lockable door, which opens a full 180 degrees, with adequate window and door sealing to prevent the ingress of dust and moisture.

Matching with all other meters and instruments (including indicating meters, meter relays, integrators etc.) on the same panel, and on similar panels in the same room, as regards style, finish and appearance is a must.

The Contractor shall ensure that the accuracy of all meters on inclined surfaces will be maintained over the whole range. Sufficient charts shall be provided for two year operation at the time of take-over.

## **7.8 Digital Indicators**

Digital indicators shall be panel mounted type with dimensions of 96x48 mm , 41/2 Digit electronic digital display type colour LCD /LED / FLUOROSCENT Precaution shall be taken such as the use of snubbers or other means to ensure that fluctuations in the signal, however caused, does not cause the last figure to flicker and become unreadable during normal running. Input shall be 4-20 ma dc or pulse input/potential free contact. At least two Programmable alarm contacts shall be provided for high or low alarms. Steadiness of readout is more important than high speed accuracy and updating of figures is not required more than once in three seconds. In addition, the indicator must read zero at zero (process) input.

Readings shall be direct without using conversion factors other than multiples of ten, which shall be clearly indicated. Figures shall be 14mm gauge visible up to 12 metres.

## **7.9 Integrators (Totalizers)**

Totalizers shall be 8 figures non-resettable mechanical impulse counters or stepper drive with a minimum figure size of 9 x 4.5 mm. Electronic counters may be employed provided precautions are taken to retain the figures in the event of power failure by memory back up. Integrators must not "tick over" if there is no process input. Readings shall be direct without using conversion factors other than multiples of ten, which shall be clearly indicated.

## 7.10 Transmitters

Transmitters shall be manufactured from materials suitable for use with the process medium and for the site ambient conditions and this shall be subject to approval by the Engineer.

The materials of construction shall be suitable for the climatic conditions described in the specification and where necessary suitable heavy duty GRP weatherproofs enclosures with viewing windows shall be provided.

Transmitters shall provide 4mA to 20 mA output signals proportional to the measured conditions. They shall operate on a 2 wire system forming a loop. They shall be fitted with output meters to give an approximate indication of transmitter output scaled 0 - 100%.

Differential pressure transmitters which shall have capacitance or inductive type sensing elements shall be fitted with direct mounted, stainless steel, 3 valve manifolds. Pressure and level transmitters shall be fitted with two valve manifolds.

Pipe work shall be of copper or stainless steel pipe as appropriate with a minimum gradient of 1 in 12 after an initial rise (gas) or fall (liquid) of 300mm.

Transmitter equipment should be supplied and installed complete in all detail including pipe work, stop clocks, drain clocks and any similar ancillary items of equipment and capable of easy removal and maintenance. Process data, calibrated span, range, output, protection, accuracy and connection details shall be as necessary to satisfy the particular specification requirements.

The transmitter shall have non-interacting external zero and span adjustment and shall have facility for an optional external damping adjustment. Each transmitter shall be equipped with a stainless steel nameplate, permanently attached, indicating the following specified data as a minimum:

- Transmitter tag no.
- Purchase order no.
- Name and address of manufacturer Type/Model no.
- Serial no.

- Calibrated range
- Range and maximum working pressure, temperature, speed, vibration level etc.  
Materials of construction
- Electrical protection classification

### **7.11 Signal Modifying Cards**

Cards which are required to modify the signal, e.g. square-root extractor, scaling and bias, alarm set-point, analogue isolator etc. shall be mounted within a separate enclosure inside the instrumentation panel. The enclosure(s) shall contain all necessary terminals and rack positions for an additional 20% signal modifying cards.

### **7.12 Mimic Display**

The mimic diagram shall be based on the mottled effect mosaic tile principle, with all artwork design etc carried out by the contractor. Colours and symbols and lay out shall be based on the relevant British standards.

The surface of the diagram shall be flat with no projections, free of box, and scratch resistant. The colours used shall be change and fade resistant. Adjacent mimics shall fit closely together with only a hairline crack exposed.

The whole diagram shall be surrounded with a bezel to ensure neat and tidy Overall appearance. The lay out diagram shall be approved by the engineer before manufacture. All the pump operations, controls, status indications for pumps, status indication for power supply availability, generator status and alarms shall be shown on the mimic display along with discharge output flow/totalizer shall be indicated in the mimic panel.

### **7.13 Indicating Lamp Test Facility**

A lamp test facility shall be provided on all instrument panels displaying more than four indicating lamps. The lamps test shall be initiated by means of a suitably located "LAMP TEST" pushbutton, operating via auxiliary relays or lamp test diodes as appropriate. The operation of the lamp test facility shall not affect the monitoring or successful operation of the plant.

Each light shall be of the L.E.D. type with either a descriptive label affixed beneath the light fitting or an engraving on the screen of the fitting.

## **7.14 Alarm Annunciator**

Each alarm condition shall be indicated on an alarm annunciator having the following basic features. An audible alarm shall sound upon the initiation of any alarm condition. The audible signal shall be muted upon depression of "ALARM MUTE" pushbutton, automatically after an adjustable delay of 1-5 minutes, or upon the depression of the "ALARM ACCEPT" pushbutton.

The appropriate annunciator shall flash with an equal mark/space ratio at approximately 230 flashes per minute (fast flash) upon the initiation of any alarm condition. Upon depression of the "ALARM ACCEPT" pushbutton the alarm annunciator shall change to steady indication.

Upon the clearing of the initiating alarm contact, the appropriate annunciator shall flash with an equal mark/space ratio approximately 70 flashes per minute (slow flash). Upon the depression of the "ALARM RESET" pushbutton, any annunciator whose initiating contacts have cleared, the appropriate annunciator shall be reset and the lamp shall be extinguished.

Depression of the "ALARM RESET" pushbutton shall not reset any alarms which have not been accepted and shall only reset alarms whose initiating contacts have cleared. Any subsequent alarm that occurs after the "ALARM ACCEPT" pushbutton has been depressed shall be considered as a new alarm condition, irrespective of the state of other alarm legends. Depression of the "ALARM TEST" pushbutton shall simulate the effect of an alarm condition occurring on all channels into audible alarm and fast flash mode. After a preset adjustable period of between 110 seconds, the test facility shall simulate the clearing of the initiating condition to allow resetting of the annunciators.

All annunciators shall be sized to permit an adequate unambiguous description to be engraved in letters no smaller than 3.5mm high. The legends shall be black on an amber background and shall not be visible unless illuminated. The flashing of more than one annunciator shall be synchronous to minimise confusion between fast and slow flashing of multiple alarms. For each annunciator provided under the project the Contractor must provide spare parts for two

years operation. These spare parts must as a minimum include one module or PCB of every type used in the annunciator including the CPU.

### **7.15 Clocks**

A digital 24 hr. synchronous clock having numerals no less than 100mm high shall be fitted at the top centre of the Main Instrument Panel.

### **7.16 Pushbuttons and Switches**

Pushbuttons for operational circuits shall be provided with a shroud, guard or other suitable means to prevent inadvertent operation. They shall be in accordance with the high standard generally required by the Specification as a whole and by the equipment with which they are associated.

Illuminated pushbuttons where used shall be of a design that allows easy replacement of the lamps from the front of the panel. If legends are engraved on the pushbuttons they shall be clear and concise and shall be approved by the Engineer before manufacture.

Control switches shall be in accordance with the high standard generally required by the Specification as a whole and by the equipment with which they are associated.

### **7.17 Mechanical Tilt Float Switches**

The float shall be with Non mercury switch with sealed neoprene jacketed cable impact and corrosion resistant and of robust construction with ABS shell with change over contacts tether method of tie wrap nylon of suitable weight. with the tilting action the contacts shall changeover with a dead band between opening of one contact and closing of the other during which period contacts shall remain open. This dead band shall operate over an arc of approximately 20 degrees on either side of horizontal. Means for preventing the float from movement due to draft or liquid turbulence should be provided as also a means for raising the units for maintenance and repair.

## **7.18 Magnetic Switches**

Magnetic level switches shall be of two magnets, glandless construction snap action type. Wet side materials shall generally be stainless steel, gun metal Aluminium bronze, PTFE AND EBONITE. When used in conjunction with stilling tubes they shall be installed in float chambers supplied by the level switch manufacturer and be provided with flanged connections to suit the stilling tube.

## **7.19 Ultra-Sonic Equipment**

Ultra-sonic level measurement shall be accomplished by the use of non-contact, echo-time measuring equipment operating at ultrasonic frequency. The equipment shall transmit pulses, which are reflected back to the sensor from the surface of the liquid whose level is being measured.

The equipment shall consist of a sensor incorporating both transmitter and receiver, together with a separate control unit. The equipment shall be provided with automatic temperature compensation, shall be suitable for operation in the designated application under the specified climatic conditions.

The sensor shall be suitable for mounting in the open, or within an enclosed tank, and shall be totally enclosed and hose proof with environmental protection to IP67.

The control units shall incorporate:

- (i) Facilities for independently adjusting dead band zero and span, and shall have an output of 4-20mA proportional to level.
- (ii) A 4 digit read out in metres to indicate liquid level.
- (iii) An entry for operating parameters without the need to physically measure the distance to water level or to remove the sensor head.
- (iv) Potential free changeover contacts to provide a minimum of 5 control points.
- (v) Secure access for parameters via a removable /fixed keypad.

- (vi) A common potential free alarm signal for system faults, echo loss and memory failure.
- (vii) An LED display to the level control unit shall illuminate on receipt of acceptable echoes and extinguish when echoes are not received. A LED for indication for dc power availability shall also be provided.
- (viii) A level control unit that shall be automatically checked for availability and any faults shall be signaled back to the main control panel.

The overall accuracy of the level measurements shall be within  $\pm 1.0\%$  of the instrument span. The connection between the sensor and control unit shall be via commercially available twisted and screened cable, and the equipment shall operate with up to 150 metres of such cable.

The Contractor shall ensure that each part of the equipment is suitable for the application, particularly with regard to the blocking distance and transmitted beam angle or cone. Where more than one device is used means should be adopted to prevent interference of one unit with the other where a number of level units are to be installed, a suitable rack system shall be provided for panel mounting the control units. Programming shall be by a remote key pad. Units in the rack shall be connected by means of a multipin connector such that they can be removed easily.

Where ultra-sonic equipment is specified in the application clauses for measuring flow in open channels, the equipment shall be supplied and installed in accordance with the above Clause, except that in this application the control unit shall be micro-processor based incorporating algorithms for converting level to flow in accordance with BS 3680:Part 4, as appropriate and shall provide a 4-20 mA output proportional to flow. The system accuracy shall be within  $\pm 1.0\%$  of the instrument span over the range 5% to 100% flow.

Each ultrasonic level sensor shall be installed on a robust and rigid structure provided for the purpose under this Contract. The structure shall include a means of leveling the sensor so that the transmitted beam is perpendicular to the liquid surface and shall provide a safe and easy access to the sensor for servicing and maintenance.

The Contractor shall, where applicable, provide a canopy around and/or above the sensor and/or the control unit to provide a protection from direct sunlight.

## **7.20 Pressure Sensors for Level Measurement**

Level measurement shall be accomplished by the use of a hydrostatic level measurement transducer. The equipment shall consist of a chrome/nickel-measuring cell together with a separate control unit.

The equipment shall be provided with automatic temperature compensation and shall be suitable for operation in the designated application under the specified climatic conditions.

If the sensor is mounted in an enclosed sewage wet well it shall conform to zone 1 for methane gas and IP 68. Otherwise it shall be suitable for the environment in which it is installed.

The sensor shall comprise of a Hastelloy C diaphragm in contact with the liquid and a chromenickel thin film measuring element, completely isolated from the media. The cell shall be filled with silicon oil free liquid. Any seals in the cell shall be Viton or similar.

The transmitter shall incorporate the following features.

- i) Calibration elements for insitu dialogue.
- ii) Digital LED/LCD indication of measurements and parameters entered.
- iii) Mode indication of set point controllers.
- iv) LED fault indication on input signal.
- v) Galvanic isolation between input signal and switching functions.
- vi) Display indicating level.
- vii) Means for configuring parameters
- viii) Any outputs shall be 4-20 mA.

A programmer shall be provided for programming the instrument. Any components used in the wet well or tank shall consist of stainless steel or non-corrodible materials. Flow Measurement

## 7.21 Magnetic Flow Measuring Equipment

Generally the flow meter shall be as follows:

### Flow metering System

i) Each flow metering system shall consist of the primary transducer (sealed to IP68), earthing rings, the necessary signal converter and power supply unit and all cabling between the primary transducer and signal converter and power supply unit. ii) Each of the signal converters/power supply units shall be supplied for remote mounting and sealed to IP65, unless otherwise specified.

iii) The signal converters/power supply units shall be provided with a 4-20 mA output signal, linear with flow and suitable for retransmission to remote instrumentation. The outputs shall be capable of supplying a load of 1000 ohms under all conditions. The above units shall operate from a 240V 50 Hz mains Supply.

The supply voltage may vary by  $\pm 15\%$  and frequency between 48 and 52 Hz. The flow element of magnetic flow meter shall be Pulsed dc electromagnetic type with a linear output and should have inherent (zero) stability.

1. Flow meter should have the following physical specifications:
2. The metering tube of the flow meter shall be of carbon steel unless otherwise indicated
3. Flow meter flanges shall be ANSI 150 pound carbon steel unless indicated otherwise the liner shall be polyurethane or fusion bonded epoxy

Flow meter shall be housed in below grade vaults and shall be designed to withstand accidental submergence in 10 m of water for 24 hours.

The Contractor shall provide sufficient suitable cable to allow for the primary transducers to be situated up to 25 metres from their signal converters, unless a longer length is specified. The Contractor shall provide full details of the cable he proposes to use.

### **7.21.1 Accuracy**

The flow meter accuracy shall be  $\hat{A}\pm 0.2\%$  or reading in the velocity range of 10 metres/sec down to 0.5 m/s and  $\hat{A}\pm 0.05\%$  of reading down to 0.2 m/s orbiter. The repeatability of the flow meter shall be  $\hat{A}\pm 0.05\%$  down to 0.5 m/s velocity increasing progressively to  $\hat{A}\pm 1\%$  at 0.25 m/s or better. All flow meters to be calibrated on NEMAS accredited flow calibration rigs and calibration certificates are required for each flow meter.

### **7.21.2 Signal Output**

The following output formats are required and must be isolated from any common connection to the instrument to prevent common mode interference.

#### **7.21.2.1 Analogue output**

The signal output shall be a 4-20 mA direct current loop. The output shall be short circuit protected and capable of supplying a load of up to 1000 ohms.

The Contractor shall state to what limit over-scale currents may be guaranteed to represent flow to  $\hat{A}\pm 5\%$  in the event of pipeline bursts occurring downstream of the meter (i.e. to what current is the circuit reasonably linear for over scale flows).

#### **7.21.2.2 Integration**

One pulse shall be generated for a specific volume of water passing to the meter. This shall be achieved by the closure of potential free contacts or through opto couplers. This function need only be applied to forward flows, unless available bi directionally as a standard feature. A socket shall be provided such that a portable data logger may be connected to the flow meter.

#### **7.21.2.3 Interference**

Electrical noise may occur from sources such as electromagnetic induction, electrostatic or capacitive coupling and electrical coupling or electrical conduction. The signal to noise ratio should be sufficiently high to prevent spurious signals affecting the signal and the instrument and associated cables must be so screened as to operate without degradation of performance in the following conditions:

- Radio Frequency
- Portable or mobile radio
- Power 0-25 watts
- Frequency 49-150 MHz, AM and FM
- Proximity >5 metres

In addition they shall be not prone to interference from TV or mobile phone signals.

The flow meter shall incorporate electrode(s) to detect when the pipe is not full. The flow meter converter shall display the “ pipe not full” signal.

*Electrodes:* The flow meter shall be of a type that prevents polarization of electrodes. The electrodes shall be 316 stainless steel bullet nosed or elliptical self cleaning type unless otherwise indicated

ii)The primary transducer electrodes shall be capable of being removed for cleaning. The Contractor shall provide details of the working space required allowing the electrodes to be removed. iii)The Contractor shall advise on the suitability of cleaning the electrodes and if it is required for the flowmeter application, and shall provide it if he deems it necessary.

*Vibration:* The flowmeter shall be able to endure vibration,when in service, without any degradation in performance.

*Wetted Parts:* All wetted parts shall be non-toxic and suitable for use with sewage, or potable water, as appropriate, at the specified ambient temperatures.

### **Plant Labeling and Nameplate**

The primary device shall be marked in a permanent manner with the following information:

- Manufacturer's name Serial number
- Nominal internal diameter
- Maximum operating pressure
- Calibration factors
- Type of enclosure
- Forward flow direction

- Weight Power
- Installation
  - i) The flow sensor shall be suitably flanged to meet the plant maximum operating pressure. Each flow meter should be individually pressure tested by the manufacturer to at least 1.5 times its flange pressure rating. A Certificate of Conformity for pressure testing will be required.
  - ii) The flow meter shall be fitted with permanent lifting lugs (minimum 25mm internal diameter) and be supplied with all relevant test certificates.
  - iii) The Contractor shall include a dimensioned arrangement drawing showing details of length, clearance dimensions and any special support arrangement. A flange adaptor shall be incorporated to allow removal of the flow meter.
  - iv) The flow meter shall have flanges in conformity with the pipeline.
  - v) The flow meter head shall be protected from direct sunlight if installed in an exposed location.

## **7.22 Pump Controllers**

Pump controllers shall be microprocessor based or microcontroller based and be purpose designed to meet pumping station requirements having the following features;

Automatic pump sequencing shall be determined by the specified level detection system.

Monitoring and protection from over voltage, under voltage and phase imbalance, pump motor over current etc. Front panel consisting of the following:

- LCD readout screen which shall show the system status i.e. pump running, level, line voltage, pump motor current and pump starting sequence.
- Operating Log which displays number of starts and total running hours for each pump.
- Fault log which displays all active alarms e.g. all parameters detailed. Set points which displays the level of the parameters detailed. Configuration i.e., number of pumps level sensor type etc. this screen shall be pass-word protected to prohibit unauthorised changes to the system. Indicator lights for power on, auto off and processor fault.

- A membrane key pad to set system configuration and operating set points. It shall be provided with contacts of suitable rating to interface with the relevant pump motor to operate in auto mode. Also, it shall accept potential free contact from the MCC to activate the auto mode from Pump auto/manual selector switch.

### **7.23 Inspection and Testing**

Tests shall be carried out on all equipment in accordance with the appropriate BS unless otherwise specified.

### **7.24 Works Tests**

The Contractor must provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent, for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture according to this Specification. If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected notwithstanding any previous certificates, which may have been provided. Notwithstanding the above, the Contractor will be required to rectify any deficiencies which are attributable to defects in the workmanship or quality during the Defects Liability Period specified in the contract.

All control, interlock and alarm circuits shall be checked with simulated loads or links as necessary. Milliamp input signals shall be applied as necessary to check the operation of recorders, control loops etc. All indicating instruments shall be checked for correct operation. High voltage and insulation resistance tests shall be carried out using applicable voltages.

Calibration tests shall be carried out on all flow, level, pressure, and other instruments and controllers, at the Manufacturer's works.

## **7.25 Submittals**

The following documents have to be submitted by the contractor

1. Overall general arrangement of Instrumentation panels and devices and Process Instrumentation diagram
2. Interconnection drawings showing interconnections between MCC and Central control room and instruments
3. Shop drawings, product data and detailed manuals
4. Complete description, specifications schematic drawings and descriptive literature
5. Conduit routing/lay out and wire pulling schedules
6. Grounding schemes
7. Panel supports
8. Enclosures and junction boxes
9. List of spare parts to be provided for two years operation
10. Details of training to be imparted to plant personnel for successful Operation and maintenance of the plant

The submittals are subject to approval by the engineer. Final Documentation shall be submitted based on the Engineers' comments.

## **SECTION 8      PHOTOVOLTAIC GRID-CONNECTION SPECIFICATIONS**

### **8.1 Scope**

This part specifies the requirements for photovoltaic equipment that would be used in the Water Supply Admin/Reverse Osmosis Plant building, 3 Storage Tanks, Sewage Treatment Plant Admin Building and both Vacuum Stations.

Following clauses specify general requirements and standard of workmanship for the equipment and installations.

### **8.1 Definitions**

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

### **8.2 Reference Standards**

The following standards are referred to in this section and must be complied with during the design, selection, installation and operation of the PV system;

<b>Guidelines on Technical Requirements for Photovoltaic Grid-connection</b>	Guidelines on Technical Requirements for Photovoltaic Grid-connection by the Maldives Energy Authority
<b>BS EN 62446:2009</b>	Grid connected photovoltaic systems. Minimum requirements for system documentation, commissioning tests and inspection
<b>BS EN 61730-1</b>	Photovoltaic module safety qualification-

	Requirements for construction
<b>BS EN 61730-2</b>	Photovoltaic module safety qualification- Requirements for testing
<b>IEC 60904 Parts 1 to 10</b>	Photovoltaic devices
<b>IEC 60891, 2009, IEC 60891</b>	Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics
<b>IEC 60904-1, 2006</b>	Photovoltaic devices-Part 1 Measurements of PV current-voltage characteristics
<b>IEC 60904-2, 2007</b>	Photovoltaic devices – Part 2 Requirements for reference solar devices
<b>IEC 60904-3, 2008</b>	Photovoltaic devices – Part 3 Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data
<b>IEC 60904-4, 2009</b>	Photovoltaic devices – Part 4 Reference solar devices - Procedures for establishing calibration traceability
<b>IEC 60904-5 2011 IEC 60904-5</b>	Photovoltaic devices – Part 5 Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method
<b>IEC 60904-7 2008</b>	Photovoltaic devices – Part 7 Computation of the spectral mismatch correction for measurements of photovoltaic devices

<b>IEC 60904-8 1998 IEC 60904-8</b>	Photovoltaic devices - Part 8 Measurement of spectral response of a photovoltaic (PV) device
<b>IEC 60904-9 2007</b>	Photovoltaic devices – Part 9: Solar simulator performance requirements
<b>IEC 60904-10 2009</b>	Photovoltaic devices – Part 10: Methods of linearity measurement
<b>IEC 61215 2005</b>	: Scope of the work in progress includes design qualification and type approval for crystalline silicon terrestrial PV module Ed 3
<b>IEC 61345 1998</b>	UV test for photovoltaic (PV) modules
<b>IEC 61646 2008</b>	Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval
<b>IEC 61701: 1995</b>	Salt mist corrosion testing of PV modules for Edition 2
<b>IEC 61730-1: 2004</b>	PV module safety qualification requirements for construction for Part 1/Amendment 1
<b>IEC 61730-2 2004</b>	Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing
<b>IEC 61829 1995</b>	On-site measurement of I-V characteristics for crystalline silicon PV array Ed 2.
<b>IEC 61853-1</b>	Irradiance and temperature performance measurements and power rating for PV module performance testing and energy rating.

<b>IEC 61853-2</b>	Spectral response incidence angle and module operating temperature measurements for PV module performance testing and energy rating
<b>IEC 62716</b>	Ammonia corrosion testing of photovoltaic (PV) modules.
<b>IEC 61194 1992</b>	Characteristic parameters of stand-alone photovoltaic (PV) systems
<b>IEC 61683 1999</b>	Photovoltaic systems - Power conditioners – Procedure for measuring efficiency
<b>IEC 61702 1995</b>	Rating of direct coupled photovoltaic pumping systems
<b>IEC 61724 1998</b>	Photovoltaic system performance monitoring – guidelines for measurement data exchange and analysis
<b>IEC 61725 1997</b>	Analytical expression for daily solar profiles
<b>IEC 61727 2004</b>	Photovoltaic (PV) systems – Charact. of the utility interface
<b>IEC 62124 2004</b>	Photovoltaic (PV) stand alone systems – Design verification
<b>IEC 62446 2009</b>	Grid connected photovoltaic systems – Minimum requirements for system documentation commissioning tests and inspection
<b>IEC 62253</b>	Equipment and safety specifications for direct

	coupled photovoltaic (PV) pumping systems
<b>IEC 61683 1999</b>	PV systems – Power conditioners – Procedure for measuring efficiency.
<b>IEC 62093 2005</b>	Balance-of-system components for photovoltaic systems - Design qualification natural environments.
<b>IEC 62109-1</b>	Safety of power converters for use in photovoltaic power systems -- Part 1. General requirements.
<b>IEC 62109-2</b>	Requirements for inverters for safety of power converters for use in photovoltaic power systems Part 2. Particular requirements for inverters.
<b>IEC 62509</b>	Performance and functioning of photovoltaic battery charge controllers.
<b>IEC 62109-X</b>	Safety of power converters for use in photovoltaic power systems – Part X. Controllers.
<b>IEC 62109-X</b>	Safety of power converters for use in photovoltaic power systems – Part X. Particular requirements for combiner box.
<b>IEC 62116: 2008</b>	Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters
<b>IEC 62108 2007</b>	Concentrator photovoltaic (CPV) modules and assemblies - Design qualification and type

	approval
<b>IEC 62670-1</b>	Concentrator photovoltaic (CPV) module and assembly performance testing and energy rating - Part 1: Performance measurements and power rating - Irradiance and temperature.
<b>IEC 62670-2</b>	TS Concentrator photovoltaic (CPV) module and assembly performance testing and energy rating - Part 2: Energy rating by measurement.
<b>BS 7671</b>	Requirements for electrical installations .Part 7-712 Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems)
<b>IEC 62109-1</b>	Safety of power conversion equipment for use in photovoltaic power systems -Part 1: General requirements.
<b>IEC 62109-2</b>	Safety of power conversion equipment for use in photovoltaic power systems -Part 2: Particular requirements for inverters.
<b>IEC 62548</b>	Installation and Safety Requirements for Photovoltaic (PV) Generators.
<b>BS EN 62759-1:2015</b>	Photovoltaic (PV) modules. Transportation testing. Transportation and shipping of module package units
<b>PD IEC/TS 62804-1:2015</b>	Photovoltaic (PV) modules. Test methods for the detection of potential-induced degradation.

	Crystalline silicon
<b>BS EN 50548:2011+A2:2014</b>	Junction boxes for photovoltaic modules
<b>BS EN 50521:2008+A1:2012</b>	Connectors for photovoltaic systems. Safety requirements and tests

### 8.3 Requirement of Statutory Authorities

The photovoltaic equipment/installations shall comply with the requirements of Rules /Regulations as amended up-to-date, required by Statutory Acts or Authorities in Male, Republic of Maldives including those related to power supply, fire safety etc. Design of photovoltaic panels and other components must be provided and must be approved by Maldives Energy Authority. In the case of any ambiguity or lack of suitable provisions in the rules safety provisions laid down by corresponding British or International Electro technical Commission statutes /regulations /codes shall apply.

### 8.4 System documentation requirements

The Contractor must submit an application form along with the technical documentation for the equipment, warranty information on components and complete system, system installation and checkout procedures, single line diagram of the PV system showing the necessary connections, safety devices, connection points, etc. for the technical screening by the Consultant and Grid owner and subsequent screening and approval by the Maldives Energy Authority. The documentation must comply with the requirements of IEC 62446 / BS EN 62446 Clause 4.

#### 8.4.1 One line Diagram

The single line diagram must have the following details

- The electrical components
- Wire types
- Sizes of Wires

- Number of Conductors
- Conduit Type
- Sizes of Conduits
- PV module specification
- Utility disconnecting means

## **8.5 Electric System and other technical requirements for the grid connection**

The rated frequency of the electric system must be 50 Hz and the electric system of the power generation facilities shall be the same as the electric system of the grid to be connected. Electrical cables and other general electrical components must comply with the requirements of Guidelines on Technical Requirements for Photovoltaic Grid-connection by the Maldives Energy Authority (MEA) and Section 6 - Electrical Specification of this technical specification. All electrical components installed outside or in a location that may be subject to UV exposure should be UV and water resistant. Metering method, power factor, allowable voltage fluctuations, protection relays, islanding operation detection and other technical components shall comply with the MEA guideline above.

## **8.6 Installation**

Standard health and safety practice and conventional electrical installation practice must apply to the installation of a PV system.

## **8.7 Testing**

The Contractor must provide Quality Assurance Certificates, established according to the Quality Assurance System of the international standard series ISO 9001/2 or equivalent, for the supply items have been subjected to the tests performed as per applicable standards. The certificate shall be valid for a period covering the manufacture of the certified items. If the Contractor is not the manufacturer, the Contractor will provide the Quality Assurance Certificates of the original manufacturer. The materials shall be suitably marked to enable them to be identified from references on the certificates.

If Certificates are not provided or if the Engineer determines that testing is required, the Contractor shall arrange for inspection, testing and obtaining of such information as may be required to be carried out at the place of manufacture as specified below.

If there are no facilities in Maldives for carrying out the prescribed tests the Contractor shall bear the cost of carrying out the tests elsewhere at no extra cost. Any materials or workmanship which is shown by such tests not to be in accordance with the specifications shall be rejected notwithstanding any previous certificates, which may have been provided. Notwithstanding the above, the Contractor will be required to rectify any deficiencies which are attributable to defects in the workmanship or quality during the Defects Liability Period specified in the contract.

#### **8.7.1 Testing on the A.C. Side**

Testing of the completed system to the requirements of BS 7671 must be carried out and documented.

### **8.7.2 Testing on the D.C. Side**

The testing of the D.C. side of the PV system shall be in accordance with the requirements of BS 7671 and BS EN 62446. The following tests must be carried out on the DC circuit(s) forming the PV arrays.

- Continuity of protective earthing and/or equipotential bonding conductors
- Polarity test
- String open circuit voltage test
- String short circuit current test
- Functional tests stipulated in IEC 62446
- Insulation resistance of the DC circuits

## **8.8 Inspection**

Upon the installation of the PV system the Contractor must submit the “Notification of work completion” (from the MEA website) for the inspection of the PV system by the Consultant, Grid Owner and Maldives Energy Authority.

## **8.9 Operation and maintenance**

The Contractor should provide, as a minimum, the information as described in BS EN 62446. The following information must be included in the documentation and operation manual provided after the completion of Works.

- Basic system information (parts used, rated power, installation dates etc)
- System designer information
- System installer information
- Wiring diagram, to include information on:
  - Module type & quantities
  - String configurations
  - Cable specifications – size and type.
  - Over-current protective device specifications (where fitted) - type and ratings.
  - Array junction box locations (where applicable).
  - D.C. isolator type, location and rating

- Array over-current protective devices (where applicable) – type, location and rating
- Details of all earth / bonding conductors – size and connection points.
- Details of any connections to an existing Lightning Protection System (LPS).
- Details of any surge protection device installed (both on a.c. and d.c. lines) to include location, type and rating.
- AC isolator location, type and rating.
- AC overcurrent protective device location, type and rating.
- Residual current device location, type and rating (where fitted).
- Module datasheets
- Inverter datasheets
- Mounting system datasheet
- Operation and maintenance information, to include:
  - Procedures for verifying correct system operation.
  - A checklist of what to do in case of a system failure.
  - Emergency shutdown / isolation procedures.
  - Maintenance and cleaning recommendations (if any).
  - Considerations for any future building works related to the PV array (e.g. roof works).
- Warranty documentation for PV modules and inverters - to include starting date of warranty and period of warranty.
- Documentation on any applicable workmanship or weather-tightness warranties.
- Test results and commissioning data