**FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA**

**MINISTRY OF WATER AND ENERG**

**Section VII: Technical Specification**

**For**

***Design Review, Supply & installation of Electro-Mechanical Equipment, for Guradhamole CR- Multi-Village Water Supply Project in Somali Regional State***

***March 2025***

**Addis Ababa, Ethiopia**

PART 2 – Works Requirements

Section VII - Works Requirements

**Table of Contents**

[1.1. Scope of contract 9](#_Toc189228259)

[1.2. Definitions 9](#_Toc189228260)

[1.3. Design and Standardization 11](#_Toc189228261)

[1.4. Packing transport and storage of materials and plant 11](#_Toc189228262)

[1.5. Contract Period and Program 12](#_Toc189228263)

[1.6. Tender Drawings 13](#_Toc189228264)

[1.7. Working drawings 13](#_Toc189228265)

[1.8. Contract Drawings 14](#_Toc189228266)

[1.9. Record Drawings 15](#_Toc189228267)

[1.10. Ambient Conditions 15](#_Toc189228268)

[1.11. Date Schedules of Technical Information 15](#_Toc189228269)

[1.12. Copies of Orders 15](#_Toc189228270)

[1.13. Standardization 16](#_Toc189228271)

[1.14. Foundations and Building Works 16](#_Toc189228272)

[1.15. Inspection and Tests at Manufacturer's Works 16](#_Toc189228273)

[1.16. Erection and Checking of Work 17](#_Toc189228274)

[1.17. Supervision and Labour 17](#_Toc189228275)

[1.18. Specialist Subcontractors 17](#_Toc189228276)

[1.19. Special Tools 17](#_Toc189228277)

[1.20. Installation, Operating and Maintenance Manuals 18](#_Toc189228278)

[1.21. Spare Parts 19](#_Toc189228279)

[1.22. Labels and Plates 20](#_Toc189228280)

[1.23. Dust, Insect and Vermin Proofing 20](#_Toc189228281)

[1.24. Alternatives 20](#_Toc189228282)

[1.25. Testing and Commissioning 21](#_Toc189228283)

[1.26. Instructions and Training of Local Staff 26](#_Toc189228284)

[1.27. Works Executed by the Employer on by Other Contractors 26](#_Toc189228285)

[1.28. Sequence of Operations and Delays to Other Contractors 26](#_Toc189228286)

[1.29. Contractor's Site Offices, Workshops, Storage and Working Areas 27](#_Toc189228287)

[1.30. Use of Site 27](#_Toc189228288)

[1.31. Possession of Site 27](#_Toc189228289)

[1.32. Interference with the works 27](#_Toc189228290)

[1.33. Rejected Materials and Defective Work 28](#_Toc189228291)

[1.34. Existing Works and Services 28](#_Toc189228292)

[1.35. Overhead Power Lines 29](#_Toc189228293)

[1.36. Existing Access 29](#_Toc189228294)

[1.37. Excavation Across Roads and Tracks 29](#_Toc189228295)

[1.38. Liaison with Police and other officials 29](#_Toc189228296)

[1.39. Preservation of Trees 29](#_Toc189228297)

[1.40. Protection From Water 30](#_Toc189228298)

[1.41. Protection Against Fires 30](#_Toc189228299)

[1.42. Watching, Fencing and lighting 30](#_Toc189228300)

[1.43. Water and Power for Use on the Works 30](#_Toc189228301)

[1.44. Fuel Supplies 31](#_Toc189228302)

[1.45. Telephone and Communications 31](#_Toc189228303)

[1.46. Sanitation 31](#_Toc189228304)

[1.47. First Aid and Medical Services 31](#_Toc189228305)

[1.48. Inspection by Engineer During Defects Liability Period 31](#_Toc189228306)

[1.49. Sign Boards 32](#_Toc189228307)

[1.50. Reference Documents 32](#_Toc189228308)

[2.1. Introduction 44](#_Toc189228309)

[2.2. Materials and Workmanship 44](#_Toc189228310)

[2.3. Design Life 44](#_Toc189228311)

[2.4. Welding 45](#_Toc189228312)

[2.5. Castings 46](#_Toc189228313)

[2.6. Forgings 46](#_Toc189228314)

[2.7. Fixings 46](#_Toc189228315)

[2.8. Allowance for Wastage 47](#_Toc189228316)

[2.9. Lubrication 47](#_Toc189228317)

[2.10. Machinery, Lifting, Dismantling, Guards, Noise and Vibration 49](#_Toc189228318)

[2.11. Gear Boxes 50](#_Toc189228319)

[2.12. Bearings 50](#_Toc189228320)

[2.13. Pumps 50](#_Toc189228321)

[2.13.1. Pump Casings 51](#_Toc189228322)

[2.13.2. Impellers 51](#_Toc189228323)

[2.13.3. Pump Shafts 51](#_Toc189228324)

[2.13.4. Bearings 52](#_Toc189228325)

[2.13.5. Shaft Seals 52](#_Toc189228326)

[2.13.6. Pump sleeves 53](#_Toc189228327)

[2.13.7. Pumps Miscellaneous 53](#_Toc189228328)

[2.13.8. Performance 53](#_Toc189228329)

[2.13.9. Submersible Borehole Pumps 54](#_Toc189228330)

[2.14. Flanges 56](#_Toc189228331)

[2.15. Pipe work 56](#_Toc189228332)

[2.16. Valves and Penstocks 65](#_Toc189228333)

[2.17. Instruments and Ancillaries 73](#_Toc189228334)

[2.18. Painting and Protective Coatings 76](#_Toc189228335)

[2.19. Chemical Plant 86](#_Toc189228336)

[2.20. Floor Trench Covers, Chequer Plating and Egg Crate Flooring 87](#_Toc189228337)

[2.21. Foundation Bolts and Fixing Arrangements 88](#_Toc189228338)

[2.22. Brackets, Fixings, Anchor Points and Pipe and Valve Supports 88](#_Toc189228339)

[2.23. Guarding and Protection of Moving Parts 88](#_Toc189228340)

[2.24. Schedule of Test 88](#_Toc189228341)

[2.25. Standby Power Generating Plant 89](#_Toc189228342)

[3.1. Introduction 100](#_Toc189228343)

[3.2. Voltage and Supply System 100](#_Toc189228344)

[3.3. Cables 100](#_Toc189228345)

[3.4. Cable Installation 103](#_Toc189228346)

[3.5. Cable Terminations, Joints and Identification 112](#_Toc189228347)

[3.6. Switchgear and Control Equipment 115](#_Toc189228348)

[3.7. Motor Starters 123](#_Toc189228349)

[3.8. Switchboard and Control Panel Components 128](#_Toc189228350)

[3.9. Switchboard and Panel Wiring 136](#_Toc189228351)

[3.10. Electric Motors 137](#_Toc189228352)

[3.11. General Services 141](#_Toc189228353)

[3.12. Earthing 144](#_Toc189228354)

[3.13. Small Power and Lighting Distribution System 148](#_Toc189228355)

[3.14. Road Lighting 155](#_Toc189228356)

[3.15. Control and Monitoring Systems 155](#_Toc189228357)

[3.16. Civil Works Associated With Installation Of Services 157](#_Toc189228358)

[3.17. Schedule of Test 158](#_Toc189228359)

[1. TECHNICAL SPECIFICATIONS 162](#_Toc189228360)

[1.1 Introduction 162](#_Toc189228361)

[General 162](#_Toc189228362)

[Scope of the works to be conducted by Civil Contractor 165](#_Toc189228363)

[1.2 Scope of Work to Be Conducted by Electromechancal Contractor 167](#_Toc189228364)

[1.3 Ambient Conditions 168](#_Toc189228365)

[1.4 Tools and Workshop Equipment 169](#_Toc189228366)

[1.5 Spare parts 171](#_Toc189228367)

[1.6 Special tools 172](#_Toc189228368)

[1.7 Record Drawings 173](#_Toc189228369)

[1.8 Installation, Operating and Maintenance Manuals 173](#_Toc189228370)

[1.9 Tests After erection on Site 174](#_Toc189228371)

[1.10 Instructions and Training of Local Staff 175](#_Toc189228372)

[1.11 Employer’s & Engineer’s in Attending Factory Inspections 176](#_Toc189228373)

[2. MECHANICAL PARTICULAR SPECIFICATIONS 178](#_Toc189228374)

[2.1 Treatment Plant, Mechanical Particular 178](#_Toc189228375)

[2.2 Pumping Stations, Mechanical Particular 180](#_Toc189228376)

[2.3 Multi-stage vertical inline shaft pumps (turbine pumps) and Electric submersible Centrifugal Pumps and Associated Pipe Work 181](#_Toc189228377)

[Submersible Pump Technical specification 185](#_Toc189228378)

[Pump Casing 187](#_Toc189228379)

[Impellers 187](#_Toc189228380)

[Submersible Motor Specification 190](#_Toc189228381)

[Technical Specification for submersible motors: 190](#_Toc189228382)

[2.4 Pipe work and Valves 194](#_Toc189228383)

[2.5 Overhead travelling crane 195](#_Toc189228384)

[2.6 Chemical plant 195](#_Toc189228385)

[2.7 Surge Suppression Plant 196](#_Toc189228386)

[3. RAW WATER AND CLEAR WATER PUMP STATIONS AND TREATMENT PLANT PARTICULAR ELECTRICAL REQUIREMENTS 197](#_Toc189228387)

[3.1 Electrical General 197](#_Toc189228388)

[3.2 Electrical System – LV 199](#_Toc189228389)

[3.3 Instrumentation 210](#_Toc189228390)

[3.4 Building Electrical Installations 210](#_Toc189228391)

[3.5 Flood Lights Cables, Wiring and Accessories 211](#_Toc189228392)

[3.6 Standby Diesel Generating Plant 211](#_Toc189228393)

[Manufacturer Technical data of the alternator 225](#_Toc189228394)

[Technical information 226](#_Toc189228395)

[Documentation 227](#_Toc189228396)

[4. DATA SCHEDULES/DATA SHEETS 228](#_Toc189228397)

#### **Technical Specifications for Supply & Installation of Electromechanical Equipment**

**GENERAL TECHNICAL SPECIFICATIONS**

**A - GENERAL REQUIREMENTS**

## Scope of contract

The Contract shall include the design, manufacture, inspection and works testing, supply and delivery, unloading, supervision of erection, complete installation, commissioning, tests on completion, training of local operators, production of record drawings, installation, operating and maintenance manuals, setting to work of pumping plant, water treatment plant and all associated equipment, pipe work and fittings, electrical equipment and cabling at the Site, finishing, painting and remedying of defects for a period of one year, all as defined in Section VIII.

A general description of the Works is also given in Section VIII.

This Section of the Specification is to be read in conjunction with the other Sections of the Specification giving particular requirements for electrical and mechanical equipment.

The Contractor shall provide sufficient tools and lifting equipment to enable all installation work to be undertaken for completion of the Contract. These said tools should not be used as part of the supply of Special Tools specified elsewhere.

The Contract shall also include the supply of spare parts necessary for undertaking normal maintenance for a period of two years.

The Plant is required to be complete in all respects as specified herein and shall include all items of Plant, machinery, fittings, etc., necessary whether such items are specifically referred to in the Contract or not.

The Contractor shall prepare and submit to the Engineer, in addition to the specified Working Drawings, all details, drawings and technical data required by the Engineer to enable him to ascertain the foundation requirements, supports and fixings to be built into the Civil Works.

The Contractor shall give all facilities to the Engineer for inspection and testing, during manufacture and installation of mechanical and electrical Plant.

## Definitions

In construing the Conditions and the Specification relating to the Plant, the following words and expressions shall have the meanings herein assigned to them unless there is something in the subject matter or context inconsistent with such construction:

**"BS" and "BSCP"** shall mean the Edition of the relevant British Standard Specification and British Standard Code of Practice respectively current twenty-eight days prior to the date set for the submission of Tenders.

**"C.E.E."** shall mean the International Commission of Rules for the approval of Electrical Equipment

**"IEC"** shall mean the international Electro technical Commission

**"ISO"** shall mean the international Organization for Standardization

**"EEU"** shall mean the Ethiopian Electric Light and Power Corporation

**"IEE"** shall mean the Institution of Electrical Engineers (British)

**"Tender Drawing"** shall mean a drawing prepared by the Engineer for Tendering purpose

**"Working Drawing"** shall mean a working drawing submitted by the Contractor to the Engineer for acceptance, all as specified in the Conditions of Contract

**"Contract Drawing"** shall mean a drawing, which has been accepted by the Engineer and issued as part of the Contact

**"Certified Manufacturer's Drawing"** shall mean a drawing, which is prepared by the manufacturer, and certified by the manufacturer as showing the exact dimensions and details of the equipment as it will be supplied for the Contract

**" Special Tools"** shall mean both special tools and appliances necessary for the duties specified

* 1. **Regulation, Standards, Materials and Workmanship**

All work carried out under this Contract shall comply with the latest requirement of any duly constituted authorities having jurisdiction over the work.

All materials shall comply with the appropriate ISO, British Standard Specification, C.E.E Standards and the recommendations of the IEC as specified. Where an alternative specification to those from such standards and recommendation are to be used, these will be specifically referred to hereinafter.

All references to such standards shall be to the latest edition or revision thereof unless otherwise stated. Where a specific ISO, British or other Standard is referred to in this Specification, another Standard will be acceptable if it ensures an equal or higher quality of material and workmanship than the Standard referred to at no extra cost to the Employer. If the Contractor intends to use such alternative Standard, he shall notify the Engineer thereof, submitting with his notice two copies (in English), of the proposed Standard and shall not order any material or perform any work unless and until he has obtained the Engineer's approval of such Standard.

All materials and equipment incorporated in the Works shall be to the approval of the Engineer.

The names of the manufacturers of materials and equipment proposed for incorporation in the Works together with performance, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Engineer, who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the Specification. Such parts shall be replaced by the Contractor at no extra cost to the Employer.

All materials and equipment shall be the most suitable for the purpose specified and shall be new and of first class quality, free from imperfections and selected for long life and minimum maintenance.

No secondhand materials whatever will be acceptable. The Contractor may be required to produce certified invoices.

All articles and materials specified to conform to ISO, British or other standards shall be clearly and indelibly marked with the appropriate standard number specified, except where marking is impractical when the relevant advice/delivery notes shall include the ISO, British or other standard number with which they are to comply.

All set, fixing and wood screws, studs and the like used through the whole of the electrical installations shall be brass or serialized or other material resistant to corrosion.

## Design and Standardization

The Contractor shall be responsible for the design and submission of calculation of all Mechanical and Electrical works specified in respect of capacity, hydraulic consideration, strength, voltage drop, fault levels, protection and discrimination. The Contractor's design shall be subject to the approval of the Engineer, which approval shall not in any way affect the Contractor's responsibilities.

The Works in the Contract shall be designed to facilitate inspection, cleaning and repairs, where continuity of operation is the first consideration. All Plant supplied shall be designed to ensure satisfactory operation under working conditions. All plant containing rotating parts shall be capable of operating at speeds unto the maximum duty specified without vibration or excessive noise.

The plant shall be designed on the basis that all butt welds are made at the manufacturer′s work site. Welding shall only be used for fillet welding of loose flanges to make up pipe lengthen.

All motors, fluorescent lighting and other electrical plants shall have a power factor of not less than 0.85 lagging.

Correspondence parties throughout the contract works shall be the Engineer to prove interchangeability by actual interchanging of the various parts.

Suitable provisions by means of eyebolts or other means are to be provided to facilitate handling of all items with a mass greater than 70kg.

## Packing transport and storage of materials and plant

Before dispatch from the manufacturer's works the plant and equipment shall be thoroughly cleaned protected against damage, deterioration, corrosion and ingress of dirt. The packing shall be suitable for transport by sea and shall withstand prolonged exposure to a hot atmosphere and storage on site.

All packages shall be clearly and conspicuously marked with the contractor's identification mark and the Employer's reference mark.

All separate component parts of the Plant shall be identified by metal tags tied by wire and reference to drawings, installation instructions. Packing lists, etc. Detail of the referencing mark.

All separate component parts of the Plant shall be identified by metal tags tied by wire and referenced to drawings, installation instructions. packing lists, etc. Details of the referencing system shall be submitted to the Engineer for approval.

All items shall be adequately protected from damage and deterioration at all times, including the period of storage and erection at the Site.

All wooden cases and support timbers within cases shall be proofed with suitable anti-termite solution. Straw or similar organic materials shall not be used for packing.

## Contract Period and Program

As required by the Conditions of Contract, the Contractor shall provide within twenty-eight days of the Commencement Date, a fully detailed program for the completion of the Works. This program shall be based on Data Schedule A, and shall indicate the programmed dates for the commencement and completion of the following:

Submission of foundation drawings for approval

Submission of Working Drawings for approval

Placing orders with Subcontractors for materials, plant and equipment

Receipt by the Contractor from Subcontractors of ordered plant, materials and equipment.

Inspection and Testing by the Engineer

Delivery to Site

Erection on Site

Tests on Completion

Instruction Period

The above activities shall be scheduled for each individual plant installation. The programme shall also the planned rate of progress for each month.

The programmed dates shall be coordinated with the civil works contractor and the power supply authorities, and shall be subject to confirmation by the Engineer.

## Tender Drawings

It is the Contractor's responsibility to refer to and examine all Tender Drawings appropriate to any part of the Contract, and to provide and co-ordinate all work accordingly.

Positions of Plat, pipe work, cables, columns, outlets, and other items as shown on the Drawings are approximate only and the Contractor shall allow for minor adjustments to final positions as may become necessary during installation. It shall be the responsibility of the Contractor to verify dimensions and to liaise with the civil works contractor to establish agreed services routes and corridors at all compounds and sites.

Drawings shall, in general, not be scaled off. However, where the Contractor is measuring cable lengths or similar items, he shall determine the appropriate scale of the drawings and measure to suit his own requirements. The lengths, sizes and ratings of all cables shall be submitted for approval.

The Contractor is not at liberty to modify or alter the disposition of items supplied by others from that shown on Tender Drawings. A part from this reservation, the drawings are issued only to give general guidance and any proposed modifications will only be considered providing the general principles are followed.

The Engineer may supply to the contractor such further drawings as may appear to be necessary for the manufacture. erection completion and maintenance of the plant and the contractor shall execute. obey and be bound by the same and shall not be entitled to any extra payment in respect of any work shown or directed to be done by such further drawings unless the Engineer shall have given written instructions for the same.

## Working drawings

Where so required the contractor shall prepare fully dimensioned scale drawings of builder's work arising from the installation of mechanical and /or electrical plants, for approval of the Engineer before proceeding.

The Contractor shall give to the Engineer full particulars of loading, including moments, details of any anti-vibration measures. And dimensions and positions of foundations and plinths and /or fixings necessary for the support and accommodation of all such plant, so that adequate provision may be ensured.

The contractor must prepare full working drawings of all plant and services for the complete installation. Including cable layouts, diesel plant drawings, electrical layouts within buildings, road lighting and floodlighting column locations. All drawings must be submitted to the Engineer for approval before any works are commenced. Where possible service reserves shall be established such that a regular approved layout is achieved for all services, these being dimensioned from fixed points within each compound.

It is acknowledged that items of Plant offered by the Contractor may vary in size and/or configuration from that shown on the Tender Drawings. The Contractor shall submit for approval, the proposed layout for his particular Plant. In this regard, the Contractor is not at liberty to effect major alterations to structures, nor major relocations of Plant, but will be expected to arrange his installation within the space provided. All dimensions affecting accommodation of the Plant supplied under this Contract, and points at which services other than those covered under this Contract are required, shall be clearly indicated on drawings to be submitted to the Engineer by the Contractor. These drawings shall show such other details of Plant, not given in the Tender or Tender Drawings, as the Engineer may require for the purpose of preparing detailed drawings for installation of the Plant and for the purpose of making any necessary modifications to the Works being provided under other contracts.

Any proposed deviations from the arrangements shown on the Drawings herewith shall be clearly stated in the Tender, and will only be considered if the above principles are followed. The information under this Clause is required within 8 weeks of the award of the Contract.

The Contractor shall also, in accordance with his approved programme submitted with his Tender, commence to submit before proceeding with manufacturer's working drawings large scale Plant room layouts, ductwork detailed drawings, pipe work and pipe work support and expansion details "certified" fully dimensioned and detailed manufacturer's drawings of Plant including all necessary wiring diagrams detailing connections, current loading in cables and external wiring requirements, schematic diagrams of the electrical control systems. etc. These drawings shall show leading dimensions and design sizes of all Plant.

All these drawings shall either be cleared for general acceptance or commented on by the Engineer for amendment until finally accepted. The accepted drawings shall constitute Contract Drawings and the Plant shall be manufactured to these Contract Drawings in every particular case. The acceptance by the Engineer of any drawing does not relieve the Contractor of his responsibility under the Contract, and will not commit the Engineer or make the Engineer liable for any mistake of the manufacturer or deficiencies in strength of any part or in the capacity or efficiency of the Plant for carrying out, in accordance with this Specification, the work for which it is designed.

The Contractor shall supply to the Engineer two copies of all drawings in English, including associated electrical wiring diagrams for comment and four further copies of all accepted Contract Drawings.

## Contract Drawings

Following approval of Contractor's Drawings by the Engineer they shall constitute Contract Drawings and the Plant shall be manufactured in accordance with the approved drawings. The acceptance by the Engineer of any such drawings shall not relieve the Contractor of his responsibility under the Contract and shall not commit the Engineer nor make the Engineer liable for any mistakes or the manufacturer's deficiencies in strength or efficiency in operation of any part or item for its specified purpose.

The Engineer reserves the right to amend or add to the Contract Drawings as may be necessary or expedient as stated.

The Contractor shall keep available on site copies of all drawings on which he shall periodically update the details to facilitate the production of the Record Drawings at the completion of the whole of the works.

One hard copy and two CDs shall be provided by the Contractor after approval of the drawings and supporting information.

## Record Drawings

Record drawings shall be prepared and compiled by the Contractor after the Works have been completed and handed over and shall constitute a permanent record of the whole of the Works as finally built and installed. They shall be produced in the form of black lines on a durable translucent film from which paper prints can be taken by others as required.

A print of the appropriate wiring connection diagram shall be fixed to the inside of the hinged front of each control cabinet, switchboard panel or distribution switchboard. The print shall be protected by non-flammable transparent material. Where insufficient space is available, the print shall be reduced in size. A copy of the print shall also be provided with the Record Drawings and inserted in the Operating and Maintenance Instructions. In addition, block diagrams of the panel components shall also be fixed to the inside front covers so that operators and maintenance personnel are made aware of the function of each component.

## Ambient Conditions

All Plant, materials and installation techniques shall be suitable for the climate conditions and altitude prevailing at the Site. These conditions are given in Section 4 of this Specification.

## Date Schedules of Technical Information

The Contractor shall complete all the Data Schedules of technical information contained in the Tender Documents particularly any departure or deviations from the Specification and names of manufacturer's of supply of the Plant, Should he fail to do so, then the Tender may not receive full consideration, and may be liable to rejection.

## Copies of Orders

Copies of all orders for all major Plant items, materials and subcontract works placed with suppliers and subcontractors shall be provided in triplicate to the Engineer. The orders shall give or shall be accompanied by full details of the material, Plant or work ordered.

Copies of all orders shall be provided in the English language or with an English translation where the actual order is placed in any other language.

## Standardization

Corresponding parts and units shall be interchangeable wherever possible. Where required by the Engineer, the contractor shall demonstrate the parts can actually be interchanged.

## Foundations and Building Works

In general, all building, structures and foundation upon which plant will be erected will be constructed by others. The Contractor shall plan his work accordingly by:

* Submitting all his foundation requirements within the specified times, and
* Arranging for the supply of all foundation bolts, trench covers kerbs and other cast in components in advance of the delivery of Plant.

Where foundations and building works are specifically included under this Contract, the appropriate rates shall be entered in the Schedule of Prices.

## Inspection and Tests at Manufacturer's Works

The Engineers and his duly authorized representative shall have access to the Contractor's premises at all reasonable times to inspect and examine the material and workmanship of the mechanical and electrical. Place during its manufacture there and if part of the Plant is being manufactured on other premises, the Contractor shall obtain permission for the Engineer or his duly authorized representative, to inspect as if the Plant was manufactured on the Contractor's own premises. Such inspection, examination or testing, if made, shall not relieve the Contractor from any obligation under the Contract.

Where the Plant is a composite unit of several individual pieces manufactured in different places, it shall be assembled and tested as one complete working unit, at the maker's works, to the relevant British or other approved, equal standard where applicable.

The Contractor shall submit his proposed programme of tests for the Engineer's approval three weeks before the commencement of testing.

The Contractor shall give the Engineer at least seven clear days notice in writing of the date on any the place at which any Plant will be ready for testing as provided in the Contract and the Engineer shall thereupon at his discretion notify the Contractor of his intention to inspect such part of the Plant and shall then, on giving twenty four hours notice in writing to the Contractor, attend at the place so named within seven days of the date by which the Contractor has stated in his notice the said Plant will be ready for testing. The Contractor shall forward to the Engineer six duly certified copies of the test readings and characteristic performance curves for items such as pumps, fans, etc.

Whether at the premises of the Contractor, or of any subcontractor, the Contractor, except where otherwise specified, shall provide, free of chare, such labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonable demanded, to carry out efficiently such tests of the Plant, in accordance with the Contract, and shall give facilities to the Engineer, or to his authorized representative, to accomplish such testing. Where inspection or testing is to be carried out at subcontractors works a representative of the Contractor shall be present.

Works tests shall also be carried out such that due consideration is given to the site conditions under which the Plant is required to function. The test certificates shall give all details of such tests.

As and when any Plant shall have passed the tests referred to in this clause, the Engineer shall issue to the Contractor a notification to that effect.

The Contractor shall not pack for shipment any part of the Plant until he has obtained from the Engineer his written approval to the release of such part for shipment after tests required by the Engineer in terms of this clause have been completed to his satisfaction.

## Erection and Checking of Work

The Contractor shall be solely responsible for transport to the Site, handling and transport about the Site and the erection of the Plant. As each part of the Plant is erected, it shall be subject to approval by the Engineer.

All parts shall pass such tests on Site as required by the Engineer to prove compliance with the Contract irrespective of any tests, which may have been carried out at the manufacturer's works.

## Supervision and Labour

The Contractor shall provide all skilled and unskilled labour for the completion of the works. The Contractor is required to maintain a competent supervising Engineer and staff on site throughout the erection and instruction periods, and thereafter as may be required during the defects liability period.

## Specialist Subcontractors

Where Subcontractors are not nominated, the Contractor shall appoint specialist Subcontractors for any sections of the Works in which he himself is not an experiences, recognized and approved operator.

## Special Tools

The Contractor is to provide one complete set of any special tools and appliances necessary for the operation, testing, maintenance and dismantling of the various sections of the Plant whether of a mechanical or electrical nature.

Tools for each different type of equipment shall be new and unused and kept in a wall-mounted strongbox or boxes each fitted with a suitable lock and two keys. Such tools shall be provided for each and every separate location of the Works and shall not be used by the Contractor during the erection of the Plant. The cost of these tools shall be included in the Contractor's Tender. The strongbox is to be clearly marked or labelled with its description. Each tool shall be identified and a list of tools shall be affixed inside the box lid. Racks shall be provided as necessary to separate the various items.

A provision has been made for the Contractor to schedule such tools and appliances in the Data Schedules and for him to price for such tools and appliances in the Schedule of Prices.

## Installation, Operating and Maintenance Manuals

The Contractor shall supply to the Engineer illustrated operating and maintenance manuals. The manuals shall be in one or more volumes in order to separate literature from drawings, etc., as necessary.

The manuals shall have tests in English. They shall include the following information for the operating personnel:

1. Description of all systems installed, including electric lighting and power installation, electronic installations, mechanical installation, air systems, automatic controls systems, etc. An identification system should be established and shown on drawings and in the manuals.
2. Description of all Plant supplied including manufacturers' leaflets, which are to be scheduled for easy reference.
3. Schedule of all Plant supplied, giving duties, electrical loads, etc.,
4. Schedule of all equipment suppliers (and their local agents) including names, addresses, telephone, telex and Fax numbers.
5. Fully detailed instructions for the installation testing and commissioning of all plant, which will be undertaken by the contractor including detailed schedules of checks to be carried out prior to putting the equipment into operation.
6. The Start-Up Operation and shut down instructions for all equipment and systems,
7. Full maintenance instructions for all equipment including planned maintenance schedules or charts giving daily, weekly, monthly, quarterly, half yearly and annual maintenance instruction, together with recommended lubricants and spares. This should also include details of routine maintenance work that will be within the competence of the normal maintenance staff, and notification of maintenance work that will have to be done the manufacturer, his agent or other specialist operator.
8. Spare parts list.
9. Fault finding charts.
10. Record drawings of all systems installed including general arrangements, conduit and wiring trunking systems, Plant rooms details, air and water systems flow sheets, wiring diagrams, control schematics and valve charts, etc., to a reduced scale.
11. Certified supplier's drawings of all equipment supplied, which are to be scheduled for easy reference.
12. Copies of performance curves.

A copy of each manual at least in draft form shall be submitted four weeks before shipping the equipment to which it refers. The draft manual submitted shall include details of all items of plant and equipment unless the Engineer approves separate submission of details of particular items.

The final version, modified as necessary to accommodate any changes on site and all test results and certificates as specified, shall be presented as soon as possible thereafter.

Six copies of each set of manuals and two CDs shall be issued to the Engineer before the Plant is shipped.

Each manual shall be durable and permanently bound within a stiff binder. The cover of each binder shall be finished with a black waterproof and greaseproof material and the title printed in gold block lettering on the front and on the spine.

## Spare Parts

The Tender shall submit with his Tender the completed relevant Data Schedule, listing the recommended spares and their prices which are considered necessary for the maintenance of the Plant for two years normal operation. When considering the proposed list he must bear in mind the availability of such Plant in Ethiopia.

A sum has been allowed in the Schedule of Prices for the supply of spare parts. The Engineer shall decide on which of the recommended spare parts shall be supplied. The prices of the spare parts shall be valid for one year from the award of contract, and the Engineer will give instructions on which spares shall be provided within this period.

The spare parts shall at least include the following items;

* Complete set of spare fuses or MCB's as required
* Spare coils and contactors for starters
* Recommended spares for control systems
* Bearing for pumps, motors, etc.
* Spare overloads and contacts for starters
* Recommended spares for generator sets and control panels
* Any other spares recommended by manufacturers of specialized equipment

All spare parts shall be new, unused and strictly interchangeable with the parts for which they are intended as replacements and shall be treated and packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose, and when more than one spare is packed in a single case or other container, general description of its containers and other packages shall be marked and numbered in an approved manner for purposes of identification.

All cases, containers or other packages are liable to be opened for such examination as the Engineer may require and packing shall be designed to facilitate opening and subsequent repacking.

## Labels and Plates

Identification labels of "Traffolyts" or similar approved material engraved black on white unless otherwise agreed, with not less than 5 mm "lino" style letters shall be fixed on or adjacent to all equipment, valves, controls switches and distribution gear, by means of at least two brass screws or rivets or other approved means.

Danger or warning tables shall be engraved white on red.

Glue, as the only means of attachment is unacceptable.

All labels shall be in English.

The labels shall bear the identification shown on the drawings, such as indication, designation function and, where necessary, phase voltage, current, pressure and temperature.

Plastic adhesive strip labels or adhesive die stamped tapes will not be permitted.

## Dust, Insect and Vermin Proofing

All Plant, which is affected by ingress of dust, shall be effectively dust proofed.

All Plant shall be vermin proofed, where no protection is afforded in its normal manufactured form, to ensure that no mechanical breakdown shall occur due to interference or damage by vermin. All materials used in construction or for connections shall be resistant to attacks by insects, microbiological life or other local fauna and such materials shall be to the approval of the Engineer.

Where cables are laid in trenches, the trenches shall be treated with an approved additive to prevent termite activity, or a termite barrier provided.

Where cables are laid in trenches, the trenches shall be treated with an approved additive to prevent termite activity, or a termite barrier provided.

Where panels or components are sealed, adequate provision shall be made to dissipate heat so those electrical components are not subject to any form of dertaing resulting from unacceptable temperature rises.

## Alternatives

The Contractor's main Tender shall comply fully with the Specification.

The Contractor is however at liberty to include additional alternative items of Plant, which do not completely comply with the requirements of the specification, provided that the requirements of the following two paragraphs are fulfilled.

The Contractor shall submit manufacturer's detailed descriptions of alternatives and he shall draw attention to any aspect of each component, which does not fully comply, with the requirements of this specification. These detailed descriptions, including and departure from the requirements of the Specification may, after approval by the Engineer, be included among the Contract documents and each item shall be in accordance with the description of it. Approval of a manufacturer's description shall not include approval of any departure from the requirements of the Specification unless the departure is specifically approved by the Engineer in writing.

Where Plant differs from that specified the Contractor should submit with his Tender drawings showing any amendments of system design necessary to suit the Plant. The Engineer will either approve these drawings or issue others if he approves the components concerned.

The Engineer however, may not necessarily accept any alternative put forward.

## Testing and Commissioning

### General

As many tests as in the opinion of the Engineer are possible shall be arranged together. Four copies of the Contractor's records of all tests shall be furnished to the Engineer.

All material, which is specified for tests at the Manufacturer’s works, must satisfactorily pass such tests before being painted or otherwise coated.

All test instruments shall be to approval and shall be calibrated by a competent as may be approved by the Engineer.

Full witnessed testing and inspections will be carried out on our plant and equipment, including:

* All pumps
* All motors
* Valves, Actuators Penstocks
* Standby diesel plant
* Chemical dosing plant
* Electrical Switchgear and Motor Control Panels
* Electrical reticulation and installations
* Other items as may be required shall be inspected and tested.

All major items of plant shall be offered for inspection prior to their being dispatched from the manufacturer's or his Subcontractor's works.

The Engineer shall be given two weeks’ notice in writing to attend works tests. The Engineer may, at his discretion, forego the witnessing of any tests. In such instances, the Contractor shall have the required tests carried out, and shall supply test certificates to the Engineer. The Engineer's approval is required before shipment to site. Formal test certificates are required in triplicate in all cases. The Engineer will give at least twenty-four hours written notice of his intention to attend the tests.

The Engineer shall be entitled at all reasonable times during manufacture to inspect, examine and test on the Contractor's premises the materials, workmanship and performance of all plant to be supplied under the Contract. If the plant or any part thereof is being manufactured at a plant other than the Contractor's he shall obtain for the Engineer permission to inspect, examine and test such plant as is required. Any such examination, inspection or testing does not relive the Contractor of his obligation under the Contract.

Where the Contract provides for testing on the premises of the Contractor or any subcontractor, the contractor shall provide free of charge all assistance, labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be required and reasonably demanded for carrying out of the tests.

If after inspecting, examining or testing any plant the Engineer should decide that such plant thereof is defective or not in accordance with the Contract he may reject the said plant or part thereof by giving the Contractor, within a reasonable time, written notice of such a rejection, stating therein the reason for rejection.

### Tests at Manufacturers Works

All electrical plant shall be tested at the manufacturer's works in accordance with the requirements of the current relevant British Standards.

In particular the following tests shall be carried out for specific items:

***Control Panels and Switchgear***

The following tests shall be carried out for each control panel before the panel is dispatched from the manufacturer's works:

***Visual inspection***

Inspection of provisions for cable entries

Checking access, type of cable gland, etc.

High voltage power frequency pressure test at 2 kv for 1 minute, followed by an insulation test The relays with variable controlled supply to ensure relays close at 85% nominal voltage and hold closed down to 65% nominal voltage

Test tripping of relays occurs at 60% nominal voltage

Observe any special tests applicable to the installation

Injection testing of current transformers for correct polarity and ratio, and protection relays for correct operation.

Functional testing including simulation of operation of sequence controls (e.g. level controls, etc.)

Checking of time delay settings and protection relay setting

Checking of fuses, MCB's and MCCB's etc. for correct type and rating

Check inter-locks

Any other tests required by the Engineer or his Representative.

***Electric Motors***

Electric motors having a rating of 11 KW or less shall be tested in accordance with BS 4999 Table 60.3.1.4 column 5 designated "Routine Check".

Motors having a rating of more than 11 KW shall be tested in accordance with BS 4999 Table 60.3.1.4 column 3 designated "Basic".

All rotational and temperature rise tests shall be performed with the motor set up in normal working position, i.e. either horizontal or vertical in accordance with the particular drive application.

Motors shall not be dispatched for works assembly with associated mechanical plant until test certificates have been approved by the Engineer.

Electrical motors rated 11 KW and above shall be tested for vibration in accordance with the principles contained in ISO 3945, and BS 4999 Part 50.

As required by the British Standards, the tests shall include, as applicable:

* Detailed load tests or type tests on each motor to determine temperature rise, efficiency, speed and power factor, at different loads ranging from no-load to 110% of the continuous maximum rating of the motor.
* Open-circuit test
* Short-circuit or locked-rotor test
* Voltage or pressure tests
* Over-speed test
* Insulation test

High voltage and insulation resistance test shall be made when the apparatus are hot.

The power and power factor measuring instruments shall be connected in such a position as to allow for all losses in the complete system and not for the motor alone.

***Pump sets***

Each pump shall be tested individually with its own motor over its full working range.

Each pump shall be run and tests carried out in accordance with BS 5316 Part 1, or other standards as approved by the Engineer, to ensure that performance, power absorbed and efficiency meet the guaranteed characteristics as shown in the Data Schedules.

Each pump set shall be tested for efficiency at each head/ quantity/ speed duty/

The pumps shall be tested complete with all shaft bearings, thrust bearings and directly driven auxiliaries, or where this is impracticable, the Contractor shall state what allowances shall be made for the losses incurred by these items and shall demonstrate the accuracy of these allowances to the satisfaction of the Engineer.

The speed of the pump shall be stated when recording various readings of head/ quantity pertaining to the pump. Head/quantity curves and pump efficiency / quantity curves shall be drawn and may be necessary. In addition, the curve of overall efficiency of the pump set and power absorbed against the quantity shall be drawn. If necessary, the values of motor efficiencies obtained during the motor works tests may be used. The curve produced shall be used to demonstrate that the Plant will be capable of meeting the full range of operating conditions at site.

The pump set shall be free from cavitation and vibration over the whole working range.

Pump castings shall be subject to a pressure test of 1.5 times the maximum pressure obtained with the delivery valve closed. The positive suction head shall be taken into account in determining this pressure.

The Contractor shall satisfy the Engineer as to the mechanical reliability of the plant and its capability of fulfilling the whole of the conditions. The contractor shall detail the type of apparatus available for testing, and the method of measuring pump discharge. He shall satisfy the Engineer as to the accuracy of the instruments used in the tests and shall, if required, carry out calibration tests.

***Valves, actuators and penstocks***

All parts, which shall be subject to pressure in service, shall be subject to a hydrostatic test to a pressure not less than 1.5 times the maximum possible working pressure. Valves and actuators shall be tested at the "closed valve head" of the pump plus 10% on one side of the valve and zero pressure on the other. The valves shall be operated for two opening and closing cycles under the action of the actuators against the required pressure. Valves without actuators shall be similarly tested to ensure drop tightness. Penstocks shall be subjected to on and off seating tests where applicable.

***Diesel Generating Sets***

Each set shall be tested for output and performance in accordance with the requirements of BS 649 and BS 5000 Part 99. Tests shall include all function tests, operation of all safety devices, load tests and temperature tests.

***Cable and wiring***

All cable and wiring shall be fully factory tested. A sample of each cable rating/size shall be tested in the presence of the Engineer, the tests being those required by the British or other National Standards Institution.

### Test Certificates

Test certificates and reports shall be submitted in triplicate to the Engineer within three weeks of works testing of the following equipment:

* Motors
* Control Panels and Switchgear
* Armoured Cables
* Distribution Boards
* Motors
* Diesel Generating Plant
* Pumps
* Other as may be identified.

### Tests After erection on Site

All Plant shall pass such tests on site as are required by the Engineer to prove compliance with the contract independently of any tests which may already have been carried out at the Manufacturer's works. In particular, all electrical pressure tests made at the Manufacturer's works shall be repeated at voltages to be approved by the Engineer, and all pump performance tests shall be repeated on Site.

The Contractor shall prepare all on site test results and certificates for all items as required by the IEE Regulations and relevant British Standards. These certificates and test results shall be provided in triplicate with copies included within the operation and maintenance manuals.

The Contractor shall maintain on Site marked up copies of all changes to the installations as they proceed. These changes shall be agreed with the Engineer on a weekly basis and shall be included on the Record Drawings produced by the Contractor for all installed equipment as specified elsewhere.

All skilled labour, supervision, apparatus, electricity, water, fuel and the like for tests, and instruments required for carrying out the tests efficiently will be the responsibility of and at the expense of the Contractor. The accuracy of the instruments shall be demonstrated if required.

Tests on completion shall be carried out to ensure that the Plant is complete, has been correctly installed, is reliable in operation under the conditions at site and is able to operate over its whole working range. In addition, the efficiency and performance of the Plant shall be checked as far as possible over the whole works

Range and the values obtained will be compared with those obtained during the tests at the Contractor's premises.

The Contractor shall include for all tests that may be require by any statutory Authority.

On completion, all plant and pipe work systems shall be properly balanced, left in working order and instructions given on the efficient operation and maintenance of the plant to the Engineer satisfaction.

If, in the opinion of the Engineer, the Plant does not comply with this Specification, the defect shall be remedied at no cost to the Employer.

### Continuous Test Period

The Plant shall be tested, under normal operating conditions over a continuous period of 14 days. The Plant shall, at the discretion of the Engineer, be divided into sections for the purpose of these tests but each and every section shall be tested for the full period of 14 days continuous operation. Where sections of Plant form an integral operation the section of the Plant shall be tested together to ensure the correct and proper functioning of the water pumping, storage and flow systems,

The Contractor shall arrange to run all Plant before submission for final testing to ensure that the period will not be interrupted for adjustment or breakdown.

## Instructions and Training of Local Staff

The Contractor shall allow operator’s access to the Site during the erection and commissioning of the systems as part of their training program. There shall be in addition to this, a period of three weeks minimum of official instructions and training after the end of the commissioning period and prior to hand over of the complete systems,

The Contractor shall make available for the purpose of instruction, competent staff and all information necessary for the effective execution of the training program. The Contractor must instruct and train the trainees in such a way that the operation, maintenance and if necessary, repairs to the systems can be handled competently by the respective personnel.

## Works Executed by the Employer on by Other Contractors

The Employer reserves the right to execute, on the Site, works not included under this contract and to employ for this purpose either his employees or other contractors whose contracts may be either a subcontract under this contract, or an entirely separate contract. The Contractor shall ensure that neither his own operations nor trespass by his employees shall interfere with the operation of the Employer, or his contractors employed on such works and the same obligations shall be imposed on the Employer or other contractors in respect of work being executed under this contract.

## Sequence of Operations and Delays to Other Contractors

The Contractor shall be deemed to have included in his pricing of the Tender for costs associated with works carried out outside normal working hours where such works have been necessary to meet the requirements outlined in Section .28 above.

## Contractor's Site Offices, Workshops, Storage and Working Areas

The contractor shall have stated in his tender the additional areas that he requires for his workshops, storage and working areas. The Employer reserves to allocate the areas of the land smaller than the Contractor may require. In such cases the Contractor shall make his own arrangements for obtaining the use of the additional areas that he requires. The location of all offices, stores, and the like shall be to the approval of the Engineer.

## Use of Site

The lands and other places outside the site, which are under the control of the Employer, shall not be used except with the approval of the Engineer.

The Contractor shall at any time remove any vehicles, wagon, barge or vessel or any other obstruction under his control that may be required to be moved by the Engineer for any purpose. The Contractor shall move such obstruction promptly on instruction given.

The Contractor shall maintain access for the inspection, operation and maintenance of any of the Employer's plant or works, which lies within the site or elsewhere.

The Contractor shall maintain access for the inspection, operation and maintenance of any of the Employer's plant or works, which lies within the site or elsewhere.

The Contractor shall not use any portion of the site for any purpose not connected with the works unless the written permission of the Engineer has been obtained.

Except with written permission of the Engineer, to be given when necessary for the execution of the Works, the contractor’s employees will not be permitted to enter any of the Employer's buildings or lands or sites under the control of other contractors or the Engineer. The Contractor shall warn his employees that any person found within such buildings or sites without authority is liable to be removed from the works in accordance with the Conditions of Contract.

## Possession of Site

The Contractor shall restrict his activities to those areas of the Site adjacent to the work being executed and shall avoid any encroachment upon land outside the areas for which possession has been given. Any trespass or damage or any claim arising from such encroachment shall be the contractor's sole responsibility and he shall hold the Employer indemnified against all claims arising from such trespass or damage.

## Interference with the works

The contractors shall not interfere in any way with any existing works, whether under the control of the Employer or of a third party, whether or not the position of the works is indicated to the contractor by the Engineer, except where such interference is specifically described as part of the works, either in the Contract or in an instruction from the Engineer.

## Rejected Materials and Defective Work

Materials or work which, in the opinion of the Engineer, do not comply with the specification, shall be classified as rejected materials or defective work, and shall be remove from the works and replaced as directed by the Engineer.

## Existing Works and Services

The Contractor shall acquaint himself with the positions of all existing works and services including water mains, sewers, storm water drains, cables for electricity, telephone lines and telephone, electricity and lighting poles before any excavation is commenced.

The Contractor will be held responsible for any damage, however caused, in the course of the execution of the works, to the existing works and services.

Such existing works and services, where exposed by the execution of the works, shall be properly shored, hung-up and supported to the satisfaction of the Engineer and of the authority concerned. The Contractor shall exercise special care when refilling trenches or other excavations around such existing works or services and water meters. Stop cock boxes and the like shall not be covered up/

Poles supporting cables and the like adjacent to the works, shall be kept securely in place until the works are completed and shall then be made as safe and permanent as before.

Notwithstanding the foregoing requirements and without lessening the Contractor's responsibility, the Contractor shall inform the Engineer immediately any existing works have been exposed and shall comply with any requirements of the authority concerned.

Only when and as directed by the Engineer shall the position of existing works or services be changed by the contractor to meet the requirements of the proposed work.

The Contractor shall make adequate provision so that when carrying out his work, no interference, damage or pollution is caused to highways and footpaths, or to any mains, drains, sewers, and the like or other parts of the works. Wherever loads have to be carried over the ground in which pipes, valves, culverts, and the like are buried, the contractor shall take all precautions including where necessary the provision and use of sleepered road, light gauge railways or other means to prevent damage occurring to such underground works. The Contractor shall not store any plant or materials or spoil heaps over existing water services, or in such positions that interference with access to the services is created. Approval by the Engineer of the means of protection employed shall not relieve the contractor of any responsibility in respect of damage occasioned by his operations.

The laying of pipe work, ducts, drains, and the like shall be arranged so as to cause as little interference as possible with the smooth operation of existing works.

When breaking out and making good existing structures the contractor shall disturb the existing structures as little as possible. All structures shall be made good with the materials similar to those used in existing works, or such materials which are considered by the Engineer to be of similar appearance and suitable in all other respects.

## Overhead Power Lines

Where work is being carried out in the vicinity of overhead power lines, the Contractor is responsible for ensuring that all persons working in such areas are aware of the relatively large distance that high voltage electricity can "short" to earth when cranes or other large masses of steel are in the vicinity of power lines.

The Contractor's attention is drawn to BS 162, which gives safe clearances for the various voltages.

The Contractor shall take all necessary precautions to ensure the safety of his employees and all other persons where work is being carried out in the vicinity of overhead power lines.

## Existing Access

Existing access to lands, property and all other places, shall be maintained by the contractor during the continuance of the Works to the Engineer's satisfaction.

## Excavation Across Roads and Tracks

Before excavating across any public or private road or track, the contractor shall give the Engineer 10 days’ notice of his intention to excavate and shall include, in writing, the precautions he proposes to take for continuance of passage and traffic, and details of the warning signs and lights to be provided and operated. The excavation shall not commence until the written approval of the Engineer has been given.

## Liaison with Police and other officials

The Contractor shall keep in close contact with the police and other officials in the area concerned regarding their requirements for the control of workmen, movement of traffic, or other matters and shall provide all assistance and facilities which may be required by such officials in the execution of their duties.

## Preservation of Trees

No tree shall be removed without prior written permission of the Engineer who will limit the removal of trees to the minimum necessary to accommodate the permanent works. If trees are removed or damaged by the contractors or his employees, without approval then the contractor shall replace such trees.

## Protection From Water

The Contractor shall keep the whole of the works free from water and shall be deemed to have included for all pumping, sorting, temporary drains, sumps and other measures and provisions necessary for such purposes and clearing away and making good to the satisfaction to the Engineer any damage caused thereby.

## Protection Against Fires

The Contractor is advised that, at all times, it is necessary to guard against fires starting within the site or in the environs thereof, particularly as the result of the works or from the actions of his employees. The Contractor shall have available, at all times, a trained fire-fighting team provided with adequate fire-fighting equipment and shall deal with all fires on the Site howsoever caused.

## Watching, Fencing and lighting

The Contractor shall employ competent watchmen and guard the works both by day and night. Any excavations, material dumps, spoil dumps or other obstructions likely to cause injury to any person or thing shall be suitably fenced off and adequately marked and identified.

## Water and Power for Use on the Works

The Contractor shall be solely responsible for the location, procurement and maintenance of a water supply adequate in quality to meet his obligations under the contract. The Contractor may purchaser water for normal and reasonable use on the works from the Employer when and where available and at current rates.

The Contractor shall be solely responsible for the location and continuity of the supply adequate in quality to meet his obligations under the Contract. The contractor may purchase water for normal and reasonable use on the works from the Employer when and where available and at current rates.

The contractor shall be solely responsible for the location and continuity of the supply of water for use on the works. Supplies may be derived form boreholes, rivers and streams, but shall in all cases be to the Engineer's approval, and the abstraction of water from any sources shall not interfere with permanent water supply. The Contractor shall be solely responsible for the transporting of water from its sources to the point at which it is required for construction purposes, and in such quantities and quality as to enable the works to proceed without hindrance due to the shortage to adequate water supplies.

The Contractor shall take care to avoid unnecessary use of water and to prevent any water running to waste.

The Contractor shall make his own arrangements for power supplies and shall be solely responsible for the location, procurement and maintenance of a power supply, adequate to meet his obligations under the Contract, nor, in respect of any such failure, shall the contractor have any claim under the contract against the Employer.

## Fuel Supplies

The Contractor shall arrange for obtaining, storing and distributing all fuel oils required for the completion of the Works.

## Telephone and Communications

The Contractor shall be responsible for obtaining a suitable means of communication between all sites and compounds for the duration of the contract. This is particularly relevant during the testing, commissioning and fourteen-day continuous operation of the plant where communications between sites and compounds must be established before the commencement of the testing and commissioning program.

## Sanitation

The Contractor shall provide adequate sanitation and refuse collection and disposal facilities complying with the laws and local by-laws for all houses, offices, workshops, and the like erected on the site, all to the satisfaction of the Engineer.

The toiled facilities provided at the Site by the Civil Works contractor may be made available, to the employees of the contractor supplying and installing the mechanical and electrical plant. However, it is the responsibility of contractor to make his own arrangements.

The Contractor shall warn his employees and Subcontractors that any employee found fouling the Site shall be remove from the site immediately in accordance with the conditions of contract.

## First Aid and Medical Services

The contractor shall provide and maintain all equipment necessary to render first aid in case of accidents, snakebites or other emergencies. This equipment shall be kept in readiness at the Works, at camps and wherever the Contractor's staff may regularly live and work. The Contractor shall ensure that there are persons available at all such places with knowledge of simple first aid procedures and able to administer snakebite treatment.

## Inspection by Engineer During Defects Liability Period

The Engineer will give the Contractor due notice of his intention to carry out any inspection during the Defects Liability Period. The Contractor shall, upon receipt of such notice, arrange for a responsible representative to be present at the times and dates name by the Engineer. This representative shall render all necessary assistance and shall take note of all matters and things to which the Engineer directs attention.

## Sign Boards

The Contractor may provide a signboard at each site or compound. However, before the erection of any signboards or posters by the contractor, the contractor shall obtain the approval of the Engineer to the size, location and wording of such signboards and posters.

## Reference Documents

|  |  |  |
| --- | --- | --- |
| BS 10 | 1962 | Specification for flanges and bolting for pipes, valves, and fittings |
| BS 21 | 1985 | Specification for pipe threads for tubes and fittings where pressure-tight joints are made on thread (metric dimensions). |
| BS 88 |  | Cartridge fuses for voltages up to and including 1000 V a.c. and 1500 V d.c. |
|  | 1988 | Specification for General Requirements. |
| BS 89 |  | Direct-Action Indicating Electrical Measuring Instruments and their Accessories. |
|  | 1990 | Specifications for definitions and general requirements common to all parts. |
|  | 1990 | Specification for special requirements for ammeters and voltmeters |
|  | 1975 (1987) | Specification for direct acting electrical recording instruments and their accessories. |
| BS 143/1256 | 1986 | Specification for malleable cast iron and cast copper alloy threaded pipe fittings. |
| BS 171 |  | Power Transformers |
|  | 1978 | General |
| BS 183 | 1972 (1982) | Specification for general purpose galvanized steel wire strand. |
| BS 381 C | 1988 | Specification for colours for identification, coding and special purposes |
| BS 534 | 1990 | Specification for steel pipes, joints and specials for water and sewage. |
| BS 639 | 1986 | Specification for covered carbon and carbon manganese steel electrodes for manual metal arc welding. |
| BS 729 | 1971 (1986) | Specification for hot dip galvanized coatings on iron and steel articles. |
| BS 775 |  | Specification for Contractors. |
|  | 1974 (1984) | a.c. contractors for voltages above 1kv and up to and including 12 kv. |
| BS 848 | Fans for General Purposes |  |
|  | 1980 | Methods of testing performance |
| BS 970 |  | Specification for wrought steels for mechanical and allied Engineering purposes. |
|  | 1991 | General inspecting and testing procedures and specific requirements for carbon, carbon manganese, alloy, and stainless steels. |
| BS 1363 |  | 13 A plugs, socket-outlets and adapters. |
|  | 1989 | Specification for adapters |
| BS 1376 | 1974 (1985) | Specification for colour of light signals. |
| BS 1387 | 1985 (1990) | Specification for screw and socketed steel tubes and tubulars and for plain end steel suitable for welding or for screwing to BS 21 pipe threads. |
| BS 1440 | 1985 | Specification for copper alloy ingots and copper alloy and high conductivity copper castings. |
| BS 1449 | 1991 | Steel plate, sheet and strip |
| BS 1452 | 1990 | Specification for flake graphite cast iron. |
| BS 1486 |  | Lubricating nipples |
|  | 1959 (1982) | Lubricating nipples and adapters for use on machinery and tools |
| BS 1501 |  | Steel for pressure purpose: plates. |
|  | 1980 (1990) | Specification for carbon and carbon manganese steels. |
|  | 1988 | Specification for alloy steels. |
| BS 1564 | 1975 (1983) | Specification for pressed steel sectional rectangular tanks. |
| BS 1650 | 1971 | Specification for capacitors for connection to power frequency systems |
| BS 1789 | 1985 | Specification of bourdon tube pressure and vacuum gauges |
| BS 1794 | 1952 (1984) | Specification for chart ranges for temperature recording instruments. |
| BS 1853 |  | Tubular florescent lamps for general lighting service |
|  | 1990 | Specification for internationally specified lamps. |
| BS 2494 | 1990 | Specification for elastomeric seals for joints in pipe work and pipelines. |
| BS 2569 |  | Specification for sprayed metal coatings. |
|  | 1964 (1988) | Protection of iron and steel by aluminum and zinc against atmospheric corrosion. |
|  | 1965 (1988) | Protection of iron and steel against corrosion and oxidation at elevated temperatures. |
| BS 2633 | 1987 | Specification for Class 1 arc welding of ferritic steel pipe work for carrying fluids. |
| BS 2692 |  | Fuses for voltages exceeding 1000 V a.c. |
|  | 1986 | Specification for current limiting fuses. |
|  | 1956 | Expulsion Fuses |
| BS 2779 | 1986 | Specification for pipe threads for tubes and fittings where pressure-tight joints are not made on threads (metric dimensions). |
| BS 2789 | 1985 | Specification for spheroidal graphite or nodular graphite cast iron. |
| BS 2926 | 1984 | Specification for chromium and chromium-nickel steel electrodes for manual metal-arc welding. |
| BS 2971 | 1991 | Specification for Class II arc welding of carbon steel pipe work for carrying fluids. |
| BS 2898 | 1992 | Specification for continuously hot-dip zinc alloy coated steel flat products: tolerances on dimensions and shape. |
| BS 2914 | 1972 (1979) | Specification for surge diverters for alternating current power circuits |
| BS 3274 | 1960 | Specifications for tubular heat exchangers for general purposes |
| BS 3416 | 1991 | Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water. |
| BS 3496 | 1989 | Specification for E glass fiber chopped strand mat for the reinforcement of polyester and other liquid laminating systems. |
| BS 3505 | 1986 | Specification for unplasticised polyvinyl chloride (u-PVC) Pressure pipes for cold potable water. |
| BS 3506 | 1969 | Specification for unplasticised PVC pipe for industrial uses. |
| BS 3532 | 1990 | Method for specifying unsaturated polyester resin systems. |
| BS 3600 | 1976 (1988) | Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes. |
| BS 3506 | 1969 | Specification for unplasticised PVC pipe for industrial uses. |
| BS 3532 | 1990 | Method for specifying unsaturated polyester resin systems. |
| BS 3600 | 1976 (1988) | Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes. |
| BS 3601 | 1987 | Specification for carbon steel pipes and tubes with specified room temperature prepares for pressure purposes. Switches for household and similar fixed electrical installations. |
|  | 1889 | Specification for general requirements. |
| BS 3691 | 1990 | Specification for E glass fiber roving for the reinforcement of polyester and epoxy resin systems. |
| BS 3693 | 1992 | Recommendations for design of scales and indexes on analogue indicating instruments. |
| BS 3871 |  | Specification for miniature and molded case circuit breakers. |
|  | 1965 (1984) | Miniature air-break circuit breakers for a.c. circuits. |
| BS 3923 |  | Methods for ultrasonic examination of welds. |
|  | 1986 | Methods for manual examination of fusion welds in ferritic steels. |
| BS 3939 |  | Graphical symbols for electrical power, telecommunications and electronics diagrams. |
| BS 4099 | 1986 | Colours of indicator lights, push buttons, annunciators and digital readouts. |
|  | 1986 | Specification for colours of indicator lights and push buttons. |
| BS 4190 | 1967 | Specification for ISO metric black hexagon bolts, screws and nuts. |
|  |  | Guide on the reliability of electronic equipment's and parts used therein. |
|  | 1974 (1987) | Terminology. |
| BS 4211 | 1987 | Specification for ladders for permanent access to chimneys, other high structures, silos and bins |
| BS 4343 | 1968 | Specification for industrial plugs, socket-outlets and couplers for a.c. and d.c. supplies |
| BS 4346 |  | Joints and fittings for use with unplasticised PVC pressure pipes. |
|  | 1969 | Injection moulded unplasticised PVC fittings for solvent welding for use with pressure pies, including potable water supply. |
|  | 1970 | Mechanical joints and fittings, principally of unplasticised PVC. |
|  | 1982 | Specification for solvent cement. |
| BS 4360 | 1986 | Specification for weldable structural steels. |
| BS 4368 |  | Compression couplings for tubes |
|  |  | Specification for heavy series couplings (metric) |
| BS 4504 |  | Circular flanges for pipes, valves, and fittings (PN designated), |
|  |  | Steel, cast iron, and copper alloy flanges. |
|  | 1989 | Specification for steel flanges. |
|  | 1989 | Specification for cast iron flanges. |
| BS 4515 | 1984 | Specification for welding of steel pipelines on land and offshore. |
| BS 4533 |  | Luminaires |
| BS 4568 |  | Specification for steel conduit and fittings with metric threads of ISO form for electrical installations |
|  | 1970 | Steel conduit, bends and couplers. |
|  | 1970 (1988) | Fittings and components. |
| BS 4607 |  | Non-metallic conduits and fittings for electrical installations: Specification for switchgear and control gear for voltages up to and including 1000 V a.c. and 1200 V d.c. |
|  | 1977 (1990) | Circuit Breakers: |
| BS 4772 | 1988 | Specification for ductile iron pipe and fittings |
| BS 4800 | 1989 | Schedule for paint colours for building purposes |
| BS 4865 |  | Dimensions of gaskets for pipe flanges to BS 4504. |
|  | 1989 | Specification for non-metallic flat gaskets (including gaskets for flanges to BS 4772). |
| BS 4870 |  | Specification for approval testing of welding procedures. |
|  | 1981 | Fusion welding of steel |
|  | 1985 | Arc-welding of tube to plate joints in metallic materials |
| BS 4921 | 1988 | Specification for sheradised coatings on iron or steel. |
| BS 4941 |  | Motor starters for voltages up to and including 1000 V a.c. and 1200 V d.c. |
|  | 1979 (1990) | Direct-on-line (full voltage) a.c. starters |
| BS 4999 |  | General requirements for rotating electrical machines |
|  | 1987 | Specification introduction and information on other parts. |
|  | 1987 | Specification for rating and performance. |
|  | 1987 | Specification for build in thermal protection for electric motors rated at 660 V a.c. and below |
|  | 1987 | Specification for tests |
| BS 5000 |  | Rotating electrical machines of particular types or for particular applications. |
| BS 5135 | 1984 | Specification for the arc-welding of carbon-manganese steels |
| BS 5150 | 1990 | Specification for cast gate valves |
| BS 5153 | 1974 (1991) | Specification for cast iron check valves |
| BS 5155 | 1984 (1991) | Specification for butterfly valves |
| BS 5156 | 1985 (1991) | Specification for diaphragm valves |
| BS 5163 | 1986 (1991) | Specification for predominantly key operated cast iron gate valves for waterworks purposes |
| BS 5227 | 1984 | Specification for a.c. metal-enclosed switchgear and control gear rated voltages above 1 kV and up to and including 72.5 KV. |
| BS 5253 | 1990 | Specification for alternating current disconnectors and switches |
| BS 5292 | 1980 | Specification for jointing materials and compounds for installations using water low-pressure steam or 1st, 2nd and 3rd family gases. |
| BS 5308 |  | Instrumentation Cables. |
|  | 1986 | Specification for polyethylene insulated cables. |
|  | 1986 | Specification for PVC insulated cables. |
| BS 5311 | 1988 | Specification for high-voltage alternating current circuit breakes |
| BS 5316 |  | Specification for acceptance tests for centrifugal, mixed flow and axial pumps |
| BS 5391 |  | Specification for acrylonitrile-butadiene-styrene (ABS) fittings for use with ABS pressure pipes |
|  | 1976 | Fittings for use with pipe for industrial uses |
| BS 5419 | 1977 (1990) | Specification for air break switches, out break disconnection's, air break switch disconnection's, and fuse-combination units for voltage up to the including 1000 V a.c. and 1200 V d.c. |
| BS 5420 | 1977 (1988) | Specification for degrees of protection of enclosures of switchgear and control gear for voltages up to and including 1000 V a.c. and 1200 V d.c. |
| BS 5423 | (1987) | Specification for portable fire extinguishers |
| BS 5424 |  | Specification for control gear for voltages up to and including 1000 V a.c. and 1200 V d.c. |
| BS63 |  | Specification for high voltage switches |
|  | 1991 | High-voltage switches for rated voltage above 1 kV and less than 52 kV |
| BS 5467 | 1989 | Specification for cables with thermosetting insulation for electricity supply for rated voltages up to and including 600/1000 V and up to and including 1900/3300 V. |
| BS 5486 |  | Low-voltage switchgear and control gear assemblies. |
|  | 1990 | Requirements for type tested and partially type tested assemblies |
|  | 1988 | Particular requirements for busbar trunking systems. |
| BS 5490 | 1977 (1985) | Classification of degrees of protection provided by enclosures. |
| BS 5493 | 1977 | Code of practice for protective coating-of iron and steel structures against corrosion. |
| BS 5500 | 1991 | Specification for unfired fusion welded pressure vessels |
| BS 5514 |  | Reciprocating internal combustion engines: performance |
|  | 1987 | Specification for standard reference condition and declarations of power, fuel consumption, and lubricating oil consumption |
|  | 1979 (1984) | Speed governing |
|  | 1988 | Specification for codes for engine power |
| BS 5728 |  | Measurement of flow of cold potable water in closed conduits |
|  | 1979 (1987) | Specification for single meters |
|  | 1980 (1988) | Specification for installation requirements for single meters. |
| BS 5733 | 1979 | Specification for general requirements for electrical accessories. |
| BS 5792 | 1980 (1986) | Electromagnetic flowmeters. |
| BS 5856 |  | Specification for motor starters for voltages above 1 kV a.c. and 1.2 kV d.c. |
|  | 1980 (1985) | Direct-on-line (full voltage) a.c. starters. |
| BS 5953 |  | Guide on power transformers |
|  | 1980 | Application of power transformers |
| BS 6004 | 1991 | Specification for PVC insulated cables (non-armoured) for electric power and lighting. |
| BS 6007 | 1991 | Specification for Rubber insulated cables for electric power and lighting. |
| BS 6207 | 1991 | Mineral insulated copper sheathes cables with copper conductors. |
| BS 6231 | 1990 | Specification for PVC-insulated cables for switchgear and control gear wiring. |
| BS 6346 | 1989 | Specification for PVC-insulated cables for electricity supplies. |
| BS 6500 | 1990 | Specification for Insulated flexible cords and cables. |
| BS 7079 | 1990 | Preparation of steel substrates before application of paints and related products. |
|  | 1990 | Introduction |
|  | 1989 | Method for the grading of surface profile of abrasively blast cleaned steel using a comparator |
| BS 7365 | (1990) | Specification for hard drawn aluminum wire overhead line conductors |
| BS 7430 | 1992 | Code of practice earthing |
| PD 6499 | 1981 | Guide to insulation co-ordination within low voltage systems including clearances and creepage distances for equipment. |
| BS CP 1016 | 1980 | Code of Practice for the use of Semiconductor Devices. |
| PO D2155 C |  | Solderless Connections made by Wire-Wrapping Method (or equivalent Standard) |
| PO D2237 |  | Terminal Tags for Solderless Wrapped Connectors |

**B - MECHANICAL GENERAL SPECIFICATION**

## Introduction

This Section covers workmanship, materials of construction and other miscellaneous items applicable to all items of plant and equipment, together with general requirements for particular items of mechanical plant. All component parts of the Works shall, unless otherwise specified, comply with the provisions of this Section or be subject to the approval of the Engineer.

## Materials and Workmanship

All submerged moving parts of the plant, or the pins and spindles, etc., of the submerged moving parts or the faces, etc., in contact with them shall be of corrosion resistant metals. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall also maintain their properties without aging due to the passage of time, exposure to light or any other cause.

Where "stainless steel" is specified or used it shall have resistance to atmospheric corrosion not less than that provided by BS 970, Grade 410 S3. Particular attention shall be made to the prevention of seizure by fretting where tow corrosion resistant metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants. Where bronze is specified or used it shall be zinc free.

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, they shall be selected so that the bimetallic corrosion is as low as possible.

Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice.

All similar items of plant and their component parts shall be completely interchangeable, Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of plant. Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturers' drawings may be readily installed.

All equipment shall operate without excessive vibration and with the minimum of noise. All revolving parts shall be dynamically balanced so that when running at all operating speeds and any load up to the maximum there shall be no vibration due to lack of balance.

All parts, which can be worn or damaged by dust, shall be totally enclosed in dustproof housings.

## Design Life

Unless otherwise specified, all items of Plant shall be rated for continuous service at the specified duties under the prevailing atmospheric and operational conditions on site.

All materials and equipment shall de designed for long life with a minimum of maintenance and the Contractor may be called upon do demonstrate this for any component either by the service record of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall, as far as possible, not require the services of highly skilled personnel.

Except for consumable items such as gland packing, carbon brushes, etc., which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continuous normal operation and where major dismantling is required to replace a part, such life shall be not less than ten years.

## Welding

Welded parts consisting of steel to B.S.4360, B.S.1501-Grade 490A, RT, DIN 17100 or similar steel shall comply with requirements not less than B.S. 5135 or equivalent standard. B.S. 5135 gives the requirements for preheating the work before welding. Circumferential welds, etc. shall be fabricated and tested in accordance with B.S. 5500, B.S.2633 or equivalent standards where applicable. All joints shall have the plate edges accurately prepared tot he appropriate profile for welding. The parts shall then be assembled and accurately checked before welding proceeds. The welding and fabricating procedure shall be such that residual stresses are a minimum and distortion avoided. Special attention shall be given to ensure that distortion does not occur after machining to affect the alignment and operation of the part concerned.

Welding procedures shall be in accordance with B.S. 4870. Each unit shall be fabricated and welding completed before final machining or other fitting work is carried out. All fillet welds shall be continuous. Electrodes used shall be low hydrogen type and shall comply with requirements not less than B.S. 639 or equivalent standard for carbon steels, and B.S. 2926 or equivalent standard for stainless steels. Only stainless steel electrodes shall be used for welding stainless steel. Stainless steel to be welded shall be suitably stabilized. Heated storage and ovens shall be provided for the electrodes. Only skilled, qualified and tested welders shall be employed. The welders shall be tested in accordance with B.S. 4871 Part 1, or other equivalent standard. Detailed records of welding shall be kept; showing the name of each welder against each run in a weld and any welder found to be producing an unacceptable amount of defects should be removed until he has passed the test again.

Where valve bodies, sleeves, etc., are of welded construction all longitudinal butt welds in the shell plates shall be completely radiographically tested. All circumferential butt welds in pipes shall, where possible, have at least 100 mm in 1,000 mm of their lengths radiographically tested.

All welds shall be 10 per cent ultrasonically tested. Ultrasonic testing shall be carried out in accordance with B.S. 3923 and the Contractor shall propose a standard of acceptance. All fillet welds shall be tested by ultrasonic crack detection, or other approved means. For all other items of plant the Contractor shall allow for the cost of adequate radiograph examination of the welds. The positions to be examined will be indicated by the Engineer. The "International Institute of Welding Collection of Reference Radiographs of Welds" shall be used as a guide for the interpretation of radiographs and as a basis for comparison regarding the nature and extent of weld defects. The minimum grade for acceptance shall be blue.

## Castings

All cast iron shall be of standard grey close-grained quality to BS 1452: Grade 220 or better. The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surfaces of castings, which are not machined, shall be smooth and shall be carefully fettled to remove all foundry irregularities.

Minor defect not exceeding 12 ½ percent of total metal thickness and which will not ultimately affect the strength and serviceability of the casing may be repaired by approved welding techniques. The Engineer shall be notified or larger defects and no repair welding of such defects shall be carried out without prior approval. If the removal of metal for repair will reduce the stress-resisting cross-section of the casting by more than 25 per cent, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 per cent, then that casing may be rejected. Castings repaired by welding for major defects shall be stress-relived after such welding.

Non-destructive tests will be required for any casing containing defects whose extent cannot otherwise be judged, or to determine that repair welds have been properly made.

## Forgings

All major stress-bearing forgings shall be made to a standard specification, which shall be submitted to the Engineer for approval before work is commenced. They shall be subject to internal examination and non-destructive tests for the detection of flaws, and shall be heat-treated for the relief of residual stresses. The name of the maker and particulars of the heat treatment proposed for each such forging shall be submitted to the Engineer. The Engineer may arrange for such forgings to be inspected at the place of manufacture with a representative of the Contractor.

## Fixings

Nuts, bolts studs and washers for incorporation in the Plant shall conform to the requirements of the appropriate British or other approved standard. Nuts and bolts for pressure parts shall be of the best quality bright steel, machined on the shank and under the head and nut. Bolts shall be of sufficient length such that one thread shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of a diameter such that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at Site.

Washers, locking devices and anti-vibration arrangements shall be provided where necessary and shall be subject to the approval of the Engineer.

Where bolts pass through structural members taper washers shall e fitted where necessary to ensure that no bending stress is caused in the bolt.

Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt and nut does not exceed half the yield stress of the material under all conditions.

All bolts nuts and screws, which are submerged in water, shall be made of nickel-bearing stainless steel.

## Allowance for Wastage

The Contractor shall supply as specified and to the satisfaction of the Engineer reasonable excess quantities to cover wastage of those materials, which will normally be subject to waste during erection, commissioning and setting to work.

## Lubrication

### General

Provision shall be made for suitable lubrication to ensure smooth operation, heat removal and freedom from undue wear. Plant selected shall require minimum lubrication attendance and down time for lubricant change.

The Contractor shall furnish a complete schedule of recommended oils and other lubricants. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Engineer for approval before incorporation in the instruction manuals. In the case of grease lubricated roller type bearings for electric motors lithium base grease is preferred.

The Contractor shall supply the first fill of oil and grease from approved lubricant suppliers.

All grease nipples, oil cups and dipsticks shall be readily accessible, being piped to a point as near as practicable to the lubrication point.

### Grease Lubrication

Where lubrication is effected by means of grease, preference shall be given to a pressure system, which does not require frequent adjustment or recharging. Frequent, for this purpose means more than once weekly and grease systems having shorter periods between greasing should be avoided. Where necessary for accessibility grease nipples shall be placed at the end of the extension piping and, when a number of such points can be grouped conveniently, the nipples shall be brought to a battery plate mounted in a convenient position with spacing in accordance with the recommendation of BS 1486 Part 1. Button head type nipples shall be used for normal grease lubrication. (Anti friction bearings requiring infrequent charging shall be fitted with hydraulic type nipples). Where more than one special grease is required a grease gun for each special type shall be supplied and permanently labeled.

**Oil Lubrication**

Oil sumps shall be fitted with oil level indicators of the sight glass type, or where this is no practicable, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The normal, maximum and minimum levels at 300 C shall be clearly visible in the sight glass types as viewed from the normal access floor to the particular item of plant, and they shall be easily dismantled for cleaning.

All sight glasses shall be firmly held and enclosed in metal protection in such manner that they cannot be accidentally damaged.

All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricants and to avoid leaking lubricants coming into contact with any electrical equipment, heated surfaces or any other potential sources of fire.

Gearboxes and oil baths shall be provided with adequately sized filling and draining plugs and suitable means of oil level indication.

Roller chain drives shall have oil bath reservoir lubrication.

Drain Points shall be located or piped to a position such that an adequately size container can be placed beneath them. Where a large quantity of oil is involved or drainage to a container difficult, a drain valve and plug shall be provided at the point of discharge.

Bearings equipped with force fed oil lubrication shall be automatically charged prior to machinery staring up and pressure monitored during operation with automatic shutdown of machinery and alarm on low oil pressure.

Access, without the use of portable ladders, to lubrication systems shall be such as to permit maintenance, drainage and re-filling, without contamination of the charged lubricant.

The design of breather shall take into account the humidity and atmospheric contamination at the vent point and measure be incorporated to prevent contamination of the lubricant.

The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running and a sufficient quantity of the approved lubricants for settings to work and for the commercial operation of the plant for two year after the Taking-Over Certificate has been issued.

## Machinery, Lifting, Dismantling, Guards, Noise and Vibration

### Alignment

Machinery bedplate design, packing and fixing shall be such as to minimize distortion and vibration. Aligned machinery shall be mounted on either bed or sole plated permitting removal and reinstatement without a requirement to rigidity.

Bedplate shall incorporate fine adjustment of the vertical and horizontal alignment between driver and driven members.

### Lifting

All machinery shall be fitted with lifting facilities, large structures shall be provided with jacking points.

### Machinery Dismantling

Tapped holes or other provisions must be made in all main castings, for the insertion of jacking screws or the fixing of drawings fear to facilitate dismantling. On items of machinery subject to frequent dismantling, bolts or studs shall be employed in preference to setscrews.

### Guarding

Guards shall be provided to prevent access to electrical apparatus and moving parts of machinery. They shall be designed to be secure but removable without disturbing other parts of the Plant. The Contractor shall ensure that stationery points, requiring access, are located safely, outside the guards. Large guards shall be equipped with small removable panels for the inspection and checking of enclosed components.

### Noise and Vibration

The Contractor shall provide a quiet installation. All items of plant and equipment shown on the drawings shall be carefully chosen with a view to quiet operation.

All plant must be capable of being operated without excessive vibration and the minimum amount of noise. Should the overall sound level of any item of plant exceed 85dB (A) at 1 metro radius the Contractor shall include for suitable sound attenuation to achieve this level. This will apply in the audible frequency range 20 Hz-20 kHz. Above 20 kHz, the Contractor must state whether any fundamental frequencies are generated in the ultrasonic region. Where plant is operating in the vicinity of residential buildings then the sound level at 1 metre radius from the outside of the pump or plant house enclosure or building shall not exceed 65dB (A).

The Contractor shall provide and fix all material for the prevention of transmission of noise and vibration through the structure. All fans, motors, A/C package units, compressors, diesel engines and other motive plant shall be mounted on resilient mountings in such a manner that the plant foundations are isolated from the floor or structure. In addition, all rotating plant shall be statically and dynamically balanced. Mechanical vibration shall be isolated by the use of anti-vibration mountings and flexible connections to ensure an isolation efficiency of 95% from the building structure.

## Gear Boxes

Gearboxes shall have a life of 100,000 hours, be selected in accordance with A.G.M.A recommendations for horsepower calculation and service factor application and employ a standard reduction ratio. Gearboxes, which have to be angle mounted, shall have a rating, choice of bearings, seals and lubrication system, which are suitable for such mounting. Dependence on splash lubrication alone is not acceptable but it may be used in conjunction with a forced feed method to reach all bearings and gears. Calibration of the oil dipstick and its position together with that of the sump drain plug will require special consideration.

## Bearings

### Below Water Bearings

The Contractor shall select the most appropriate type of bearing for the Plant being supplied. Equipment with vertical shafts shall have thrust and guide bearings. All bearings shall be designed to exclude the ingress of water except where the bearings are water lubricated. Sealed for life units are acceptable subject to a minimum design life of 50,000 hours operation at maximum loading. Plant, which may be subject to vibration whilst stationary, shall be provided with bearings designed to withstand damage from such a cause. Below water bearings shall be of the journal type, of Ferro-asbestos, rubber gunmetal or equal and journal of stainless steel.

Single journal plain bearings shall have phosphor bronze or synthetic lubrication impregnated bushes and carbon or stainless steel journals respectively. Synthetic bearings shall only be used where bearing condition can readily be inspected. Plain type bearings shall be self-lubricating by either grease, forced oil or impregnation. Ball and Roller type bearings shall be adequately lubricated by oil or grease and sealed to prevent leakage of lubricant along the shaft. Attention shall be given to ensure that dismantling of bearings is simple and free from risk of damage.

Bearings fitted to gearboxes shall have a minimum design life of 100,000 hours at maximum loading.

## Pumps

### General

Each pump shall be designed and constructed to be suitable for the particular liquid to be pumped. Pumps shall be of the type specified and arranged as indicated in the Specification and Drawings. Pumps shall be designed to give the specified output against all losses including those relating to the pump station pipe work and valves. The Contractor shall match his pump characteristics to the pipe systems networks to achieve the highest pump efficiency and reliability. The pumps shall have a non-overloading characteristic over the complete range of head and quantity delivered and the drive shall be capable of operating the pumps against maximum run out conditions and still have a 10 per cent margin. Each set must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system characteristics given.

Centrifugal pumps shall have head/quantity characteristics, which fall continuously from the maximum pressure at closed valve conditions and which are steep in order that variation in head shall have a minimal effect on the quantity discharged.

The whole pumping unit shall be capable of withstanding, without detriment, reverse rotation to a speed that would occur if the pump were to stop when the differential head was at a maximum and the delivery and / or non-return valves failed to close.

## Pump Casings

The pump design shall ensure that alignment is maintained between the various assemblies by recesses, spigots and dowels and shall be such that all components liable to wear can be replaced. Components shall be permanently marked with the manufacturer's number and where dowels are not used, permanently marked for correct assembly. The pump casing shall have replaceable wear rings. The casings of the pumps shall be of a suitable grade of close-grained cast iron to BS 1452 Grade 220 or nickel iron and have flanges to match the specified pipe work. The waterways through the pumps shall be smooth in finish and free from recesses and obstructions.

Pumps shall be designed to facilitate maintenance and manholes or hand holes shall be provided to allow the interior of the casings and bearing seals to be examined without dismantling the pump. It shall be possible to remove pump impellers with the minimum disturbance to pipe work and by suitable joints to allow the pump to be removed without dismantling the main pipe work.

Al joints shall be machined and faced and bolt holes shall be drilled and arbored. Location pins shall be provided where necessary, also starting screw holes, the latter being provided with setscrews.

## Impellers

The impellers and guide vanes (if any) shall be of suitable material, accurately machined and smoothly finished to minimize hydraulic losses. The rotating elements shall be statically and dynamically balanced before final assembly. The impeller shall be readily withdrawable from the pump casing without the need to disconnect pipe work.

## Pump Shafts

The pump shaft shall be of high tensile or stainless steel adequately sized, with good fatigue, shock load and corrosion resistance. The duty speed range shall be well below the first critical speed of the shaft. Where a change in diameter of the shaft occurs the shoulder shall be radiused or undercut to the appropriate BS to reduce stress concentration. The shaft shall be complete with easily renewable stainless steel protecting sleeves at glands and bearings.

## Bearings

All bearings shall be liberally rated to ensure cool running and meet and the load factors specified.

For vertically mounted pumps, the bearing shall be a combined thrust and journal type; designed to prevent any thrust loads being imposed upon the drive motor. The pump bottom bearing shall be an enclosed water lubricated sleeve bearing suitable for potable water applications.

Where grease points are necessary they shall be fitted with removable screwed plugs, which shall be accessible without removing guards. All bearings having automatic lubrication shall also have provision for hand lubrication.

## Shaft Seals

The Contractor shall select a seal, compatible with his plant and best suited for the worst conditions likely to be met when the Plant is in operation. All seal materials shall be compatible with and/ or resistant to the fluid or gas being handled. For potable water, seal materials shall be those specifically approved for use in the Water Industry.

Stuffing boxes shall be provided with renewable gland packing. Glands subject to abrasive liquors or negative pressures shall embody suitably positioned lantern rings and a clean water continuous flushing system, operative whenever the Plant is in motion or a corrosive element is present. Gland adjustment nuts shall be readily accessible for routine maintenance. Gland drainpipe work shall be installed, incorporating drainage facilities and adequate inclines discharging to the nearest sump or drainage channel.

Mechanical seals which are on pumps subject to abrasive liquor or gas, or subject to negative pressures or corrosive elements, shall be provided with a clean water continuous gland flushing system, operative when the item of plant is in motion or a corrosive element present. A back-to-back sealing arrangement with a flush/cooling system shall be accepted as satisfying the requirements of this Clause.

Special care in the selection of materials shall be taken in order to avoid binding and electrolytic action between the shaft sleeve and the seal components, particularly where long periods of idleness are inherent in the duty cycle as in the case of standby pumps.

The gland water connections supplying water seals of the pumps shall be provided with suitable filters to prevent abrasive matter in suspension from entering the glad stuffing box. These filters shall be designed to facilitate easy cleaning.

## Pump sleeves

When the flow past submersible motors is less than the minimum required for cooling when the submersible pumps are installed at the recommended depth, cooling sleeves or shrouds shall be installed on the pumps so as to induce flow past the motors to the pump inlet strainer.

The cooling sleeves shall be of such dimensions as to provide a minimum velocity of water flow past the motor as recommended by the manufacturer of the pump.

The material of the sleeve can be of stainless or galvanized steel and shall be connected to the pump through a bolt & nut arrangement.

## Pumps Miscellaneous

Cooling and lubrication water pipe work shall be fitted with flow indicators where specified.

Horizontal pumps shall be mounted on common fabricated steel bedplate manufactured from substantial rolled steel section of welded construction with machined pad mounting both pumps and motors. Folded plate type bedplates shall not be acceptable. Pumps and motors shall be doweled in position to allow for easy relocation in the event of their being removed. The pump shall be connected to its driving motor by a flexible coupling of a type approved by the Engineer, which shall be adequately guarded.

On horizontal pump sets fitted with hydraulic balance devices the couplings shall permit free movements of pumps shafts under load.

On vertical pump sets where the shaft couplings are of the screwed type the couplings shall be positively locked.

The Contractor shall ensure that adequate N. P.S.H. is available to ensure the pumps operate without cavitation under the worst operating conditions.

Indicating pressure gauges each with an isolating cock and snubber shall be provided on the suction and delivery side of each pump except that a suction gauge is not required on submersible type pumps. All pressure gauges shall be provided with high and low level adjustable contacts which can be used to provide additional pump protection where specified.

## Performance

The guarantees given in respect of output, overall efficiency and N.P.S.H. shall be verified with Class C tests in accordance with BS 5316 at the manufacturer's works in the presence of the Engineer. No negative tolerance shall be applicable to the guaranteed values for Flow, Head or Efficiency. The tests shall be performed on pumps driven by their own motors.

The NPSH tests shall be carried out at the guaranteed duty point, at the maximum run out conditions and at three points in between.

clause 2.13 provides general specifications common to all types of pumps. For the specific case of borehole submersible pumps, clause 2.13 is amended as follows.

## Submersible Borehole Pumps

1. Submersible borehole pumps shall be of radial or mixed flow type, multi-stage units suspended from surface plates by vertical riser pipes and driven by submersible electric motors. The pump and the motor shall be delivered as a single pumping unit completely assembled.

The speed of these pumps shall usually be 2,900 rpm.

1. The materials and the pump construction will be suitable for the groundwater quality
2. The impellers shall be cast in high-grade zinc-free bronze or stainless steel.

The pump body shall be cast in zinc-free bronze, stainless steel or cast iron. The body shall be capable to withstand a hydraulic pressure, equal at least to one and a half (1.5) times the shut-off head.

In case of impellers of enclosed type, the bowls shall be equipped with wear rings of renewable type, made of zinc-free bronze and having larger bearing surface.

The pump shaft shall be of stainless steel with journals sleeved with renewable, hardened stainless steel sleeves.

All bolts, nuts, studs, washers, etc. shall be manufactured in stainless steel.

The pump body shall have separate sections for each stage, which shall have matching faces machined and spigotted, to allow accurate location and alignment of the sections during assembly. The fixing nuts, bolts, washers and studs or bolts shall be manufactured in stainless steel.

The pump shall be fitted with removable shaft bearing sleeves, bearing bushes, casing wear rings and impeller wear rings. Each impeller shall be located on the shaft by identifiable distance sleeves or similar, such that re-assembly of the rotating element can be carried out without the necessity of accurate measurement. The rotating assembly shall be statically and dynamically balanced after which each part of the assembly shall be identified and marked to ensure identical re-assembly after maintenance, etc.

Bearings shall be water lubricated and where rubber type bearings are used the bearing material shall be securely bonded to a metal housing. Rubber bearings shall only be used where there is sufficient pressure difference through the bearing to afford adequate lubrication and cooling of the bearing.

Bearings shall be positively retained within the pump body to prevent the possibility of the bearing rotating; a press fit alone shall not be acceptable.

The pump shall be fitted with a suction case of a material suitable for the liquid being pumped and shall be provided with long bearings to stabilize the shaft and motor shaft and to avoid radial thrust on the motor bearing. A screen shall be incorporated having a minimum open area of four (4) times the eye of the impeller.

The submersible motor shall be of the completely enclosed type for continuous duty under water operation on 380 V 50 Hz, 3 phase AC. The motor shall be equipped with an approved seal, located at the top of the motor, where its shaft extends through the motor housing, to isolate the well water from the liquid filled in the motor. The liquid shall be either water or a high dielectric strength mineral oil, and it shall be circulated throughout the motor for cooling the motor, stator windings and bearings. Motor performance shall be in accordance with the relevant section of BS 5000:Part 99.

Motor thrust bearing ratings must be ample to carry the thrust load imposed by the pump when operating under the maximum anticipated pumping head. Motor thrust bearings shall be capable of operating with rotation in either direction, and the thrust capacity when operating in reverse shall not be less than the rated capacity.

An expansion chamber or diaphragm shall be provided to relieve thermal expansion of internal motor fluid due to temperature, and shall provide motor internal and external pressure balance under all conditions of temperature and pressure.

The drive shaft shall be of a 13% chromium steel or equivalent corrosion resistant material. Outer shell shall not be less than 0.012 m thickness and shall be of material to resist corrosion.

1. The strainer shall be constructed entirely of stainless steel and shall have a net inlet area equal to at least four (4) times the impeller inlet area.
2. The bearings shall be water lubricated. The motor thrust bearing should be capable to carry the thrust load corresponding to maximum head, operating with rotation in either direction.
3. The pump cable will be also a part of the delivery. It will be a flat cable suitable to the type of the starter.
4. The borehole pump column (rising pipe) including discharge elbow shall be supplied and installed together with the pump. It will comprise a number of sections at the option of the Supplier so that the total length may be adjusted by plus or minus 2 m.

The column shall be manufactured from threaded or flanged steel pipes. The flanges shall be provided with suitable grooves to facilitate the installation of the power cable of the pump motor.

Flange diameters should agree with the internal diameter of the borehole casing.

The pipe sections shall be internally lined and externally coated with epoxy bituminous paint or other approved anti-corrosive protection. The bolts and nuts should be made of stainless steel.

1. The surface plate (pump base) shall be of a design, which will ensure a watertight, capping of the well and shall be rigid and strong enough to support the entire weight of the suspended parts when filled with water. The plate shall provide suitable openings for the power cable, well vent and water level indicator.

The plate shall also support the discharge connection (discharge elbow) and therefore the surface plate shall be provided with a welded connection piece consisting of a double flanged steel pipe section as a support for the discharge elbow.

The capping should be fitted directly on the upper portion of the inner casing.

1. The discharge connection (elbow) shall be flanged, at a diameter similar to the rising pipe, and with a pressure rating consistent with the surface pressure to be delivered by the pump.

The discharge elbow shall be equipped with a discharge pressure gauge.

## Flanges

* + 1. **General**

All flanged connections of pumps, pipe work, valves and other relevant equipment shall have flanges in accordance with BS 4504 Table 16, unless otherwise specified in the Particular Specification Sections.

* + 1. **Jointing**

All flanged joints shall be made with 3 mm thick full-face canvas reinforced rubber insertion gaskets to BS 4865 Part 1. During Installation all pipes shall be hung on their respective supports and lined up so that their joint faces are parallel before flanges are bolted together. In making joints, no springing of pipes into position shall be allowed.

Joints on flanges that exist or have been installed under other contracts shall be made with the same materials and suitable for the flange faces.

## Pipe work

* + 1. **Pipe work General**

All pipe systems shall be arranged, installed, supported and provided with all necessary means of venting, draining and expansion, all to the approval of the Engineer.

The pipe work layout shall be designed so that item of equipment and sections of pipe work can be removed from the pipeline without major disturbance to the adjacent pipe work. Particular care shall be taken to ensure that pipe work thrusts are not transmitted to machinery or associated apparatus. The Contractor shall indicate on his detailed drawings the thrust blocks required to anchor his pipe work.

The Contractor shall provide flexibility in the pipe work at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipe work where necessary to allow for some margin or error in the building work. Wherever possible flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust as a whole so that external anchorages may be kept to minimum. Flexible joints shall also be provided for ease of erection and future dismantling.

All necessary supports, saddles, slings, fixings bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valves, meters, strainers and other devices mounted in the pipe work shall be supported independently of the pipes to which they connect.

Dead legs shall be avoided but where this is not possible provision shall be made for flushing the pipe works. Changes in pipe bore size shall be by the use of proprietary fittings or fabricated section to avoid sudden changes.

Where relevant, formed bends and offsets shall be used and be cold formed in a standard pipe-bending machine. They shall have an inside radius of not less than 4 times the outside diameter of the pipe.

Flushing and drain connections on pipe work below 150 mm shall be made using proprietary welded fittings with G series internal parallel threads to BS 2779 which shall be immediately sealed with hexagon headed shouldered plugs and seals. Holes thus made in the pipe shall have burrs removed and be finally pulled through to removed loose particles.

Template or closure pipe shall be provided where necessary to facilitate erection. The design and construction of the template pipes shall be to the approval of the Engineer, and the Contractor will be responsible for establishing the dimensions of the template pipe such that there will be no strain placed on the connected items after installation.

All nuts, bolts, washers, flanges, gaskets, flanged tied adapters, drain valves, special connection materials shall be supplied under the Contract.

Viking-Johnson or approved equivalent flange adapters shall be fitted where necessary to facilitate the removal of valves, etc. Adequate provision shall be made for anchoring pipes at these joints.

Hydraulic pipe work shall be sized to maintain fluid velocities below those specified and provide a safety factor of 4:1 on the design pressure, which shall be taken as 120 per cent of the pump closed valve head.

Compressed air pipe work shall be sized such that the airflow velocity does not exceed 8m/s. To provide adequate condensate drainage, the pipe work system shall be run with a horizontal fall of not less than 1 in 50 in the direction of air flow and incorporated drainage points at distances of not less than 30m. Drainage points shall be formed by use of equal tees with a down-pointing leg fitted preferable where changes of direction of flow occur.

Pipe work materials, sizes, pressure ratings, fittings, coupling arrangements and medium carried shall be as detailed in the Particular Specification, pipe work being in metric sizes throughout.

* + 1. **Steel pipe work**

General-purpose steel pipe work with screwed fittings shall be of galvanized mild steel to BS 1387 heavy grade with fittings of galvanized malleable iron to BS 143/1256, having tapered internal and external threads to BS 21.

Steel pipe and fitting over 80 mm diameter, shall be carbon steel in accordance with BS 3601 with pipe sizes to BS 3600. Joints shall be flanged. Pipes shall be fabricated in accordance with BS 534 with welding in accordance with BS 2633 or BS 2971 and BS 4515.

After fabrication and machining of flanges all pipe work and fittings shall be tested to a test pressure equal to 1½ times the flange pressure rating.

Where pipes are to be joined with sleeves or couplings, a sufficient length of pipe shall be left bare of coating to accommodate the sleeve or coupling.

Plain-ended pipes shall be supplied rounded at both ends. An adequate number of pipes shall be supplied rounded throughout their length so that they may be cut and such pipes shall be clearly marked.

Couplings for use with steel pipes shall comply with BS 534 except where other types of couplings are shown on the contract Drawings or specified in other sections of this Specification. Components of flexible joints from different manufacturers shall not be used together.

Tests on pipes shall be made in accordance with the relevant British Standard in the manufacturer's works when required by the Engineer and in the presence of the Engineer. Two copies of the results of all such tests shall be submitted to the Engineer.

Flanges on steel pipes shall be welded in accordance with BS 2633 or BS 2971 and shall have raised or flat faces. Gaskets for use in flanged joints shall consist of rubber complying with BS 2494 for type 1 rings or rubber reinforced with cotton and complying with BS 5292 or as instructed by the Engineer. On flat face flanges the gaskets shall extend over the full flange area and on raised face flanges they shall cover the raised face only. No asbestos shall be used on any flanges of pipe work or fitting carrying potable water.

Steel pipes, which are to be welded, shall have the ends prepared by the manufacturer of suit the type of welded joints shown on the Contract Drawings. The pipes shall be free of external and internal coating for a distance of 75 mm from each weld line.

After fabrication all welding scale and beads as well as hardened fluxes shall be removed and joints shall be free of pores and as smooth as possible. Where specified all pipes and specials shall then be degreased and grit blasted prior to coating with an approved fusion bonded epoxy coating. The coating shall be tested to ensure the correct thickness and the absence of pores using spark-testing equipment. Bends branches and other fittings for use with steel pipe shall comply with British Standard or other approved standard. Calculations for the design of all special fittings shall be submitted to the Engineer before manufacture commences.

Pipes shall be stacked on a firm bases using two timber packers only under the barrel pipes.

Fittings and specials of any type shall be stored in a single layer only. Pipes and fittings shall at all times be adequately protected from damage during transport, storage and handling. Pipes shall be fitted in the factory with end caps and reinforcement adequate to prevent distortion during transport, storage and handing. Rubber rings and other pipe jointing material shall be stored under cover away from direct sunshine.

* + 1. **Accuracy of Work**

The fabrication, machining and finish of all pipe lengths shall be such that when assembled either in the shop or on the site, the appropriate tolerances are obtained. Clearance at joints shall be sufficiently small to avoid turbulence, etc. and thus avoid vibration and all moving parts shall operate freely without risk of undue wear or jamming. Finished faces shall be free of any wind or twist.

Pipe dimensions shall conform to the following tolerances:

* Roundness = 0.2% on a gauge length of D/4
* Ovality = 0.2 % D
* Step between adjacent strakes, 2.0 mm maximum.
* Straightness, = 20 minutes
* Line and level, each section shall be set within 2 mm of the true line and level.
  + 1. **Cutting Pipes**

The cuttings of pipes for making up lengths shall be carried out by a method, which leaves a clean square end. Steel pipes used for cutting shall have been rounded throughout their length and shall be clearly marked as such. Cutting shall be carried out by cutting disc or by oxy-acetylene and the cut end shall subsequently be ground to the correct profile for the method of jointing in use.

* + 1. **Welded Joints**

Line-up clamps shall be designed to prevent tears, scare, or indentations of the pipe walls and keep misalignment of pipes at a minimum. Interior line-up clamps are required for the mm diameter pipe.

All welding shall be carried out in accordance with specific procedures prepared by the contractor and approved by the Engineer. Adequate precautions shall be taken to protect welding operation from wind, rain, blowing sand, etc.

All welders employed on the Works shall be fully qualified and shall have successfully passed all tests required by BS 4871 or the relevant API code for the type of work each individual welder does. Welder qualification tests shall be carried out in the presence of the Engineer or his authorized representative. The Contractor shall provide all necessary labour, pipe welding materials, and equipment for performing welder qualification tests on site. Arrangements for laboratory tests of coupons, if required, will be made and paid for by the Contractor. The Contractor shall maintain a list of approved welders agreed upon with the Engineer and no other employees shall perform welding operations on the Permanent Works.

Before welding, the pipe ends shall be swabbed with a leather or canvas belt disc to remove dirt, loose mill scale, rust, oil, grease, and other matter, which may be injurious to the weld. Cleaning of pipe ends shall be done by power wire brushing and/or grinding. Pipe ends damaged such that they no longer meet joint specifications shall be rebevelled by a suitable machine. Pipe ends shall be aligned with line-up clamps such that the longitudinal weld seams of the adjacent pipes staggered by at least 20 degrees. Stringer bead shall be applied by at least two welders welding in opposite quadrants. The number of filler and finish beads shall be in accordance with approved procedures.

Completed weld shall have a substantially uniform cross-section around the entire circumference of pipe. At no point shall the crown surface be below the outside surface of the pipe nor be raised above the parent metal by more than 1.5 mm. All joints on which welding has started shall be completed before the end of each day's work. At night or when work is not in progress, pipe ends of the pipeline shall be securely capped with a suitable cover to prevent the entrance of dirt, small animals, water, and foreign matter into the pipeline. Tie-ins shall be carefully aligned to limit residual and/or reaction stresses after completion of the weld. Tie-ins shall be made within the temperature range of 10 0 to 30 0 C. All production welds shall be subject to visual inspection by the Engineer. Visual inspections may be carried out at any stage of the welding of a joint. Each weld shall be clearly marked adjacent to the weld indicating the identification of the welder. Steel die stamping will not be permitted.

Non-destructive testing shall be carried out on all welds, both in the shop and on the site. All longitudinal butt welds shall be radiographically tested. All circumferential butt welds carried out in the shop shall have 10 per cent of their length radiographically tested at positions indicated by the Engineer. Junctions between longitudinal and circumferential welds shall be included in this test. The remainder of the shop and site welds shall be ultrasonically tested throughout 100 per cent of their length. Ultrasonic testing shall be carried out in accordance with BS 3923 and the Engineer shall approve the standard of acceptance.

Where ultrasonic tests indicate a flaw or defect in the weld this shall be examined using radiographic means.

In the case of fillet welds the Engineer may require dye penetrant tests to be carried out on selected welds.

The Contractor will pay for the testing and he should include these costs and expenses during pricing of the Schedule of Prices.

The Engineer retains the right to have cut out and removed one weld only for each welder at no cost to the Employer.

Welds rejected by the Engineer shall be cut out and replaced by the Contractor. If the cut out weld is found on test not to meet the Specification, the cost of the cutting out and rejoining shall be borne by the Contractor. If the weld is found satisfactory, the cost shall be borne by the Employer.

Welds rejected by the Engineer may, at his discretion, be repaired subject to the following:

* Repair to the filler weld, which would penetrate the stringer bead, will not be permitted.
* Arc burns shall not be repaired by welding, but shall be removed by grinding provided that no reduction in wall thickness is made in excess of 12 ½ percent of the nominal wall thickness.

The Contractor shall maintain records of all repairs of whatever nature of pipe and pipeline describing and locating such repairs.

Welding pipes together which have been cut shall be done with one weld if it is practical to pull the line into position, otherwise, two welds shall be made by setting in a piece of pipe at least 2 m in length.

The testing of welds shall be in accordance with the requirements of the International Institute of Welding, Collection of Reference Radiographs. These shall be used as a guide to the interpretation of radiographs and as a basis for comparing the nature and extent of weld. The minimum grade for acceptance shall be blue.

* + 1. **Flexible Joints**

Any flexible joints in steel pipe work shall be of the type specified or as shown on the Drawings. Flexible joints between pipes having integral sockets shall be formed by a shaped rubber gasket fitted within the socket or by a rubber ring of circular cross section (O-ring) placed on the pipe spigot. The type of flexible joint to be used shall be subject to the approval of the Engineer. Before any joint is made all parts of joint shall be clean and free from mud, oil, grease or other deleterious matter. Fixed gaskets shall be lubricated strictly in accordance with the manufacturer's recommendations. O-ring gaskets shall not be lubricated. Component of flexible joints from different manufacturers shall not be used together. After jointing, the position of O-rings shall be tested with a feeler to ensure that they are correctly positioned. If any ring shows a significant departure from a line following a pipe circumference, the joint shall be broken and remade using a new ring. After completing the joint any damage to the protective coating shall be made good.

* + 1. **Flanged Joints**

Flanged joints shall be made with rubber gaskets and shall be fitted without twist or distortion. Pipes and fittings shall be fully supported so that the flange faces are parallel and concentric. The flanges shall be drawn together uniformly by tightening opposite pairs of bolts in succession and no bolts shall be omitted. The size and number of bolts in flanged joints shall be in accordance with BS4504 and BS4772 for the pressure rating of the pipeline given on the Drawings. Bolt threads shall be coated with an approved paste such as Loctite before use unless otherwise instructed by the Engineer.

* + 1. **Bonding**

All flexible, flanged and similar discontinuous joints shall be bonded across the joint to provide electrical continuity throughout each buried pipeline.

* + 1. **Deviations at Joints**

The maximum deflection at each joint shall not exceed the following:

* For any type of flexible joint, three quarters of the maximum permissible deflection stated by the manufacturer:
* For welded joints in steel pipe work, the deflection shown on the Contract Drawings. The ends of the pipes shall be cut to suit.
* No deviations shall be made as flanged or solvent welded joints.
  + 1. **Protection of Buried Pipes**

External and internal protection to pipes shall be made good after completion of joints as directed by the Engineer. Protective tape of a type acceptable to the Engineer shall be applied in two separate layers. Each layer shall be would with an overlap equal to half the tape width and shall extend at least 150 mm beyond the area requiring protection.

* + 1. **Gaps for Equipment**

Where gaps have to be left in pipe work for the later installation of equipment such as valves and other items, the ends of the pipes shall be accurately aligned one with the other across the gap paying strict attention to bolt positions if relevant. The length of the gap shall be accurately determined with the aid of dimensional sketches, which shall be submitted to the Engineer before the work is carried out.

All gaps left for valves or other equipment shall include space for dismantling joints.

* + 1. **Ductile Iron pipe work**

Unless shown otherwise on the Drawings, ductile iron pipes and fittings shall be in accordance with the followings:

ISO 2531: 1974 "Ductile iron pipes, fittings and accessories for pressure main lines"

BS 4772: 1971 " Specification for ductile iron pipes and fittings"

Flanged joints shall be drilled in accordance with BS 4504, and shall be supplied complete with galvanized steel nuts and bolts, and appropriate gaskets.

Self-anchored flexible joints shall be of the spigot and socket type, but the joint shall be tied together to prevent longitudinal movement. The joint shall permit an angular deviation of 20 relative to the pipe axis after assembly, and shall be subject to the approval of the Engineer.

All spun ductile iron pipes shall be of Class K9. All standard branched fitting shall be Class K14. All other standard fittings shall be Class K12.

All puddle flanges shall be of the thrust resisting type.

All ductile iron pipes and fittings shall receive a cement mortar lining in accordance with ISO 4179, and an external surface finish in accordance with ISO 8179 comprising a sprayed zinc coating to give a coverage of 130 g/m2 , followed by a bituminous varnish of 70 micron minimum dry film thickness.

* + 1. **uPVC pipe work**

Unplasticied PVC (uPVC) pipes shall comply with ISO 161/1 is stated on the drawings. Joints shall be either made with rubber sealing rings or shall be solvent welded as specified. Solvents shall comply with BS 4346 Part 3. Ferrules, straps and other metal fittings shall be gunmetal.

* + 1. **Small Bore pipe work**

Small bore pipe work up to 15 mm OD shall be manufactured from stainless steel tubing with suitable compression type fittings. All small bore pipe work and capillary tubes shall be adequately and securely clipped or clamped. Compression fittings & bends shall be kept to a minimum, as pulled bends of generous radii are preferred. Compression couplings shall be heavy series to BS 4368 Part 1.

Any gauges, transducers or switches, etc., fed via small bore pipe work shall have an individual isolating cock adjacent to each component with adequate space being allowed for component removal for servicing.

* + 1. **Puddle Flanges**

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the Contract Drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer's prior approval.

After the pipe work is installed, the contractor shall seal the ends of all ducts, pipes, or trenches leading into building. The seals shall be approved water, gas and fire sealing transit units with appropriate fillers Insert blocks shall be fitted to duct and trench entries. All steelwork on such transit assemblies and frames shall be hot dip galvanized. Where detailed in the specification or shown on the Contract Drawings, transit frames will be incorporated in the construction by the Civil works contractor.

* + 1. **Reference Marking**

Prior to dispatch from the manufacturer's works each pipe section shall be marked with an appropriate reference number for future identification.

* + 1. **Protection of pipe work**

Immediately after the completion of fabrication at the works or on site and during transport and storage, pipe ends shall be protected from external damage and sealed against ingress of dirt by suitable caps, plugs or other similar means. After cleaning and inspection, machined surfaces of all steel and ironwork shall be covered with preserving fluid of approved types or otherwise protected and all flanges shall be fitted with bland discs bolted to each face.

* + 1. **Branch Pipes and Bosses**

Whenever any small bore pipe work makes a connection into the pipeline system, a boss or branch pipe shall be provided which shall be at least twice the diameter in width and one diameter in thickness of the tapped hole which it contains.

Bosses shall be located at the main pipe horizontal centre line and those provided for water sample cocks shall be tapped 38 mm (1.5") BSP and have reasonable access for sampling. Bosses provided for instrumentation equipment shall be tapped 25mm (1") BSP with a reducer fitted to suit the small bore pipe work and isolating cock. Unused bosses shall be fitted with bland plugs having a central squared projection for tightening or removal.

Bosses shall be provided from pump performance monitoring. These shall be installed on all pump suction and delivery pipes at least 2 pipe diameters from the pump flange unless otherwise specified in the Particular Specification. Each tapping shall be provided with ½ inch isolating cock.

* + 1. **Testing pipe work**

Before testing commences the Contractor shall ensure that all anchor and thrust blocks are complete or that temporary supports have been installed. Thrust from temporary pipe ends or branch pipes shall be adequately strutted and the section under test closed off with stop ends, blank flanges or other closure fittings.

All pipes shall be cleaned before testing by flushing or as agreed by the Engineer.

All tests shall be carried out in the presence of the Engineer and for this purpose the Contractor shall give the Engineer 24 hours notice in writing of any pressure tests, which he intends to carry out.

Within 24 hours of the completion of any test the Contractor shall submit two copies of a full record of the test to the Engineer. The record shall be in a form acceptable to the Engineer.

The pipe work to be tested shall be filled with clean water, making sure that all air is expelled. Mortar lined pipe shall then be kept under nominal working pressure for 24 hours. The pressure shall then be raised to the specified test pressure using a hand-operated force pump, which is fed, from a calibrated tank. The test pressure will depend upon the particular circumstances and will be specified by the Engineer but for general guidance only will be about 1.5 times the maximum sustained operating pressure.

The test pressure shall be held for the period instructed by the Engineer, pumping in water as required from the calibrated tank, and the amount of water used per hours shall be noted. The pressure shall be held for 24 hours and there shall be no loss of water.

* + 1. **Commissioning pipe work**

Pipes for the conveyance of potable water shall be flushed with clean water and then sterilized in accordance with the recommendation contained in BSCP 2010, Part 2, and BS 8010 Part 1 as specified.

Commissioning shall not be commenced until the Engineer has approved the whole of the installation in writing.

## Valves and Penstocks

* + 1. **Valves and Penstocks-General**

Valves shall be provided as specified on the Drawings and in the Particular Specification, and shall be specifically designed for use in raw and treated water and in chemical solutions used in water treatment.

Valves shall unless otherwise specified be double flanged and flanges shall be as specified in Section 2.14.

All valves and penstocks shall be of the sizes shown on the Drawings or started in the Documents and shall be obtained from manufacturers approved by the Engineer.

Where specified valves shall be fitted with easing screws and a clean-out box in the base.

All valves bodies shall give the following information

* Manufacturer's name
* Hydraulic test pressure
* Size of valve
* Direction of flow 'Arrow'
  + 1. **Valve Access**

All valves, hand wheel, spindles and headstocks shall be positioned to give good access for operational personnel.

Extension spindles shall be supplied wherever necessary to achieve the specified operating requirements.

Valves buried or installed in underground chambers where access to a hand wheel would be impractical shall be key operated.

It shall be possible either to remove and replace or to recondition seats and gates. Gland packing shall be accessible without removal of the valve from the pipe work.

* + 1. **Operation**

The operating gear of all valves and penstocks shall be such that they can be opened and closed by one man against an unbalanced head 15 per cent in excess of the maximum service value and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required operating torque of 150 Nm.

All hand wheels shall be arranged to turn in a clockwise direction to close the valve or penstock and the direction of rotation for opening and closing shall be indicated on the hand wheels.

Unless otherwise stated the hand wheels shall be coated with black plastic and incorporate facilities for padlocking in either the open or closed position.

Headstocks and valves of 50 mm, or greater, nominal bore shall be fitted with mechanical position indicators to show the amount which the valves is open or closed in relation to its full travel, i.e. 0.25, 0.50, 0.75, 1.

* + 1. **Materials**

Valve bodies discs and wedges shall be of cast iron, with facing rings, seating rings, wedge nuts and other trim of corrosion resistant bronze, all as specified.

The valves stem, thrust washers, screws, nuts and other component exposed to the water shall be of a corrosion resistant grade of bronze or stainless steel.

Valve bodies and other components of plastic or other non-metallic materials shall be compatible with the medium and of robust industrial design.

* + 1. **Wedge Gate Valves**

All wedge gate valves, unless otherwise specified shall be of the non-rising spindle type and be in accordance with the relevant clauses of BS 5163.

Valves shall have good quality cast grey iron bodies, high tensile brass spindles, gun-metal nuts, wedge gates with gun-metal faces and seat, bronze gland bushes and bonnets fitted with soft packing glands. Valves greater that 400 mm diameter shall have detachable bolted covers for inspection, cleaning and flushing purposes.

Valves shall be proved with renewable seats and it shall be possible to remove the gates without removing the valve body from the pipe work.

The gate face rings shall be screwed into the gate or alternatively securely pegged over the full circumference.

Unless otherwise detailed on the Contract Drawings, gate valves in chambers, and other similar locations shall be provided with hand wheels. Valves, which are to be buried in the ground, shall be provided with extension spindles, protection tubes, spindle caps, spindle supports and surface boxes.

Valves larger than 400mm diameter and accessible for maintenance shall be fitted with a studded cast iron cover at the bottom of the valve body for inspection, cleaning and flushing purposes.

Where necessary to meet the requirements of Section 2.16.3, gate valves shall be provided with appropriate thrust bearing guides, and /or gearing and /or bypass valves. When reduction gearing is employed, the gear ratio shall not exceed 4:1. Valves of 450 mm diameter and above shall always be provided with reduction gearing for manual operation. Valves of 600 mm diameter and above shall always be provided with a bypass valve.

Each valve shall be tested in accordance with the requirements of BS 5150 open-ended in each direction.

Where specified, resilient seat type valves shall be provided. The wedge shall have a resilient Nitrile Rubber bonded to the cast iron wedge. The gates of all resilient seal valves of the same size and class shall be completely interchangeable, and be shaped so that the shoulders of the gate seal against the valve bonnet when the gate is fully open. Stem sealing shall be by O-rings, which shall be replaceable under pressure with the gate fully raised.

* + 1. **Butterfly Valves**

Rubber seated butterfly valves shall be airtight when shut-off. Valves shall be suitable for the application/pressures and for mounting in any position and shall comply with BS 5155, for double flanged valves, except where otherwise specified. All bolts, nuts and other fixings, which will be in contact with the contents of the pipelines or, in the case of buried valves within the ground, shall be stainless steel.

Butterfly valves shall be suitable for frequent operated as well as for operation after long periods of idleness in either the open or closed position.

Unless otherwise specified valves shall be hand operated with hand wheels driving through 900 gearboxes.

The valves body shall be cast grey iron, the flanges and hubs for the shaft bearing housing being integrally cast with the valve body.

The disc shall be ductile iron having edges machined with rounded corners and polished to a smooth finish. The valves disc shall rotate through an angle of 90 degrees from the valve opened to the fully closed position where the seating shall be at an angle normal to the axis of the pipe. Adjustable mechanical stops shall be provided to prevent over-travel of the valve disc in both the open and closed positions.

Particular attention shall be given to the pipe work both upstream and downstream of all butterfly valves to ensure that the disc cannot foul the adjacent pipe.

The shaft shall be fabricated of stainless steel. The shaft, disc and mechanical stops shall be capable of absorbing the full operating torque with a minimum design safety factor of five. Shaft seals, when used, shall be of the rubber 0-ring type. Packing shall be either rubber 0-ring or self-adjusting chevron type.

The valve seat shall be replaceable and formed of nitrile rubber 70/75 IRHD securely clamped into a machined groove in the valve body or to the edge of the disc by seat retention members, or equivalent so as to prevent leakage and to hold the seat securely during operation. The seat retention members shall be of stainless steel and securely clamped with stainless steel fasteners. All fastenings shall be set flush so as to offer the least resistance possible to the flow through the valve.

Valve seats which extend over the face of the flanges to secure the seat in place, or which require surface grinding and/or hand fittings of the disc, or designs which require the adjoining pipe flange to retain the seat in place and resist line pressure, are not acceptable.

Each valve shall be tested in accordance with the requirements of BS 5155 for body, seat and disc strength tests. Seat and disc strength tests shall be carried out in each direction and the valve shall be drop tight.

Metal-faced butterfly valves shall generally be as above except.

1. The valves shall have metal to metal seating
2. The valves shall be designed for operation in the partly closed, throttled position, for long periods.
3. The valves shall not be of tight shut-off type and the leakage rate shall not be greater than the following figures: 300 mm - 0.075 l/s; 1200 mm - 0.225 l/s.
   * 1. **Non-Return Valves**

Non-return valves shall be installed as shown on the Drawings, suitable for the operating condition and where applicable conform to BS 5153. Long pattern valves shall generally be used.

Check valves shall possess high speed closing characteristics by used of heavy flaps with external weights where specified but designed for minimum slam condition when closing.

Flaps shall be fitted with renewable bronze or gunmetal sealing faces, which shall mate accurately with renewable bronze on gunmetal seating rings in the valve body. All seating/seals shall be positively located.

Covers shall be provided to allow ample access for inspection, cleaning and servicing and shall be supplied complete with tapped boss fitted with an air release cock.

Valves greater than 500 mm diameter shall be provided with lifting eyes, feet and jacking screws.

Hinge pins/shafts and internal fixing devices shall be stainless steel. Hinge pins/shaft shall preferable by square in section to ensure positive location of flaps and provide for secure fixings.

For valves with external levers and adjustable balance weight the hinge pins/ shafts shall extend through a renewable sealing gland on the side of the body.

Valves installed on delivery lines at boreholes shall be of the single door swing type and fitted with heavy-duty external level suitable for back flushing.

Valve body design shall be such that there is adequate clearance around and at the back of the flap to minimize jamming by rags, solid matter, etc.

Check valves for potable water shall be free acting type single flap or multiflap with external by-pass and hand operated control valve as necessary. Flaps shall be of design and weight to suit the prevailing hydraulic conditions and shafts shall turn in close fitted low friction bearings.

Each valve shall be tested in accordance with BS 5153 or if outside the size of this standard to the form as set out in BS 5153 and to the nominal pressure designation/ test pressure relationship set out therein or 700 kPa for 30 minutes whichever is the greater.

For potable water application where space is at a premium wafer type double flap non-return vales with spring assisted closing may be specified. These valves shall have cast iron bodies and flaps with resilient seats and be fitted with stainless steel hinge pins and springs.

* + 1. **Air Release Valves**

Air valves shall normally be installed at high points in pipe work and as shown on the Drawings. The valves shall be capable of exhausting air from pipe work automatically when being filled, the air being released at a sufficiently high rate to prevent the restriction of the inflow rate.

The valves shall also automatically release air accumulating in pipe work during normal conditions. Air valves shall be designed to prevent premature closure prior to all air having been discharged from the line.

Similarly the valves shall be capable of ventilating pipe work automatically when being emptied, the air inflow rate being sufficiently high to prevent the development of a vacuum in the pipelines.

The material of the body and cover shall be cast grey iron.

Air valves shall be of the double orifice type with a large orifice for ventilation or exhaustion of the pipeline and a smaller orifice for automatic release of air under normal working pressure. The valves shall be suitable for the maximum working pressures in the system and tested for pressure tightness in steps of 200 kPa up to the maximum working pressures and then for mechanical strength at 1.5 times maximum working pressures. All air valves shall be provided with isolating valves and flanged end connections.

The orifice shall be positively sealed in the closed position but the float (ball) shall only be raised by the water and not by a mixture of air and water spray.

The seating shall be designed to prevent the float sticking after long periods in the closed position.

* + 1. **Pressure reducing Valves**

Pressure reducing valves shall be of automatic control type whereby fluctuating high inlet pressures are controlled by means of a pilot to lower preset outlet pressures regardless of changes in flow rates.

Downstream control pressures are set locally by simple adjustment to the pilot or relay device. An integrated manometer incorporated with the device allows for ease in setting the desired pressure. The control accuracy shall be ± 2.5% of set value.

The valves shall be designed with minimal maintenance and proven reliability with the relay/ pilot device removable without breaking supply for checking, maintenance or replacement of the component. This shall be by way of isolating cocks or similar arrangement.

Shut-Off is drop tight by full face sealing.

The valve body shall be of high-grade cast iron or ductile iron with all other components of appropriate non-corroding materials. The valve ends shall be flanged.

Cover on valves of 200mm and larger should have two blind tapped holes for lifting eyebolts or similar arrangement for ease in handling.

* + 1. **Pressure sustaining Valves**

Pressure sustaining valves shall be of the automatic control type whereby the upstream pressure is restricted at the calibration value and the downstream network is supplied if the upstream pressure stays over the calibration value.

Upstream control pressures are set locally by simple adjustment of the screw at the top of the device. An integrated manometer incorporated with the device allows for ease in setting the desired pressure. The control accuracy shall be ± 2.5% of set value.

The valves shall be designed with minimal maintenance and proven reliability. Shut-Off is drop tight by full face sealing.

The valve body shall be of high-grade cast iron or ductile iron with all other components of appropriate non-corroding materials. The valve ends shall be flanged.

Cover on valves of 200mm and larger should have two blind tapped holes for lifting eyebolts or similar arrangement for ease in handling.

* + 1. **Pressure Relief Valves**

Pressure relief valves shall be designed to prevent the pressure in the pipeline immediately upstream of the valve rising above a preset value. The valve shall remain closed at lower pressures.

Adjustment of the pressure at which the valve open to relieve pressure shall be made by screw on the relay valve or by changing weight as appropriate. A pressure gauge indicating upstream pressure shall be incorporated.

* + 1. **Diaphragm Valves**

Diaphragm valves shall be of the straight-through design with minimal flow resistance and glandless construction conforming to requirements of BS 5156.

The valves shall be made up to two durable body parts and the diaphragm, all interchangeable with replacement parts for easy maintenance.

The diaphragm shall be moulded in a reinforced, flexible material of a grade to suit the specified duty and liquid content of the system. In the open state the diaphragm shall lift clear and not obstruct the flow of liquid. The internal surfaces of the valve body shall also be lined with material compatible with diaphragm duty.

Diaphragm valves shall be completely leak-tight and suitable for pressures up to 10bars.

The valves shall be operated by hand wheel unless otherwise specified on the contract Drawings. Hand wheels shall have adequate leverage to give the closure effort required and a facility to lock in any position.

Where indicated on the Drawings diaphragm valves shall be supplied with extended spindles or extensions for pedestals.

* + 1. **Ball Float Valves**

Ball float valves shall be designed for installation on the inlet pipe to a storage tank and shall automatically shut off when the water reaches a predetermined level. They shall be of the single-beat type with balancing piston and direct float and level operation.

Valves shall be designed for a working pressure of 1000 kPa. Valves shall be drop-tight when they are held shut by the floating ball. Valves shall be tested for leakage at 1000 kPa when they shall be drop-tight, and shall be tested for body and valve element strength with the valve closed and a test pressure of 1500 kPa applied to the inlet end.

Valves shall be constructed of mechanite cast iron to BS 1452 Grade 220 with gunmetal trim to BS 1400 Grade LG2. The valves shall incorporate rubber faces. The ball float shall be made in tinned copper and the float lever shall be mild steel.

* + 1. **Isolating Cocks**

For isolation of small bore pipe work tapping for instrumentation equipment, etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valves with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or rear surface.

Where corporation cocks are specified, these shall be similar to the above isolating cocks but shall have a detachable key handle for fittings onto a squared operating shaft, the shaft end being marked to indicate the open and closed valve positions.

* + 1. **Penstocks**

All penstocks shall be of the rising type unless otherwise specified and the spindles shall be of adequate size to avoid bucking under load.

All spindle nuts shall be self-aligning and their length shall be not less than twice the spindle diameter.

The top part of the penstock frames shall be sufficiently robust and substantial to prevent the frames bowing and if necessary, additional holding down bolts shall be fitted.

On rectangular penstocks the inverts shall be flush with renewable synthetic rubber seals on the bottom of the door. The rubber shall be suitable for the application and of an approved type.

Penstocks shall be designed to ensure watertight closure at maximum head encountered in service

Materials of construction shall be as follows:-

Stems and Spindles -Stainless steel

Stem Nuts -Gun metal BS 1400 - LG2

Sealing Faces -Appropriate to the conditions to be encountered in service

Fixing bolts, nuts -Stainless steel

& Washers

Simple template shall be supplied as soon as possible after approval of drawings to enable the civil contractor to position the holes for holding down bolts for all penstocks over 1.0 m square.

* + 1. **Extension Spindles and Pedestals**

Extension spindles shall be adequately sized to prevent bucking and shall be attached to the valve/penstock stem by a suitable adapter incorporating two muff couplings, scarf lap jointed and pinned with at least tow coupling joints included. Universal joints and waterproof sleeves shall be provided where specified. Extension spindles shall be manufactured from 080M40 (EN 8) steel.

Intermediate bearing support or guide brackets of cast iron, with slotted holed for site adjustment, shall be fitted to long shafts where necessary. Bearings shall be of PTFE or similar approved type.

Penstock and valve pedestals shall be of cast iron or heavy duty, welded, mild steel construction, with a substantial bases and fixing provision. The base and top of the pedestals shall be machined normal to the axis of the drive shaft.

Where necessary, support guide bushes shall be fitted at the base of the pedestal.

The pedestal height shall be such that the hand wheel is approximately 1 meter above the operator's floor level.

Cover of an approved type shall be provided for all rising spindles to totally enclose them when in the fully raised position.

## Instruments and Ancillaries

* + 1. **General**

All instruments, gauges and control equipment, which perform similar duties, shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

Panel mounted instruments shall have damp-protecting and dust-protecting cases. Instrument mounted outside instrument panels shall have weatherproof and dustproof cases. Instrument cases shall be of corrosion-resistant material or finish. Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part, Moving parts and contacts shall be adequately protected

Unless otherwise specified shall be finished in the manufacturer's standard colour. Instrument dials shall be of such materials that no peeling or discoloration will take place with age.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which and operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 100 mm except where forming part of standard instruments and accessories such as air sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant materials.

Equipment mounted in enclosure shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that changes of component characteristics within the manufacturer's tolerances shall not affect the performance of plant. All equipment shall be designed to operate without artificial cooling. Instruments shall be easily withdrawable from cases without interrupting their circuits.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously.

Measuring instruments shall have zero and span adjustment.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steel work and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance. Instruments mounted in open areas, which could be vandalized, shall be mounted in lockable vandal proof boxes.

* + 1. **Domestic Type Water Meters**

Water meters from 15 mm to 25 mm nominal diameter shall be P.S.M Kent domestic type water meters or similar approved. The meters shall have a nominal pressure rating of 10 bar and comply with BS 5728/1 Class C measuring requirements.

* + 1. **Bulk Water Meters**

Unless otherwise directed bulk water meters shall be in-line helical vane water meters. All bulk water meters shall comply dimensionally with ISO 4064, and shall have flanges drilled to BS 4504.

The rotors shall be manufactured from polypropylene with stainless steel shafts. The counter covers shall be provided with a hinged polyacetal or brass cover to protect the counter face from dirt and damage. Water meters shall consist of self-contained integrating measuring instruments continuously determining and displaying the volume of water flowing through them, employing a direct mechanical process involving the action of velocity of the water on the rotation of moving part, and conform to the recommendations of ISO 4064.

Water meters for potable water services and public fountains shall be a single rotary vane type, capable of withstanding a working pressure of 1.0 Mpa (PN 10) with dry dial, completely waterproof encased gear train, flow indicator, register, magnetic coupling and conform to the following supplementary data:-

1. Nominal sizes shall be 12, 20, 25, 40 and 50mm with male threaded end connections complete with tailpiece couplings on each end to connect the meter to threaded fittings which are the same nominal size as the meter.

Threads shall be of a uniform standard throughout, compatible with threaded pipe, valve and fittings specified in these documents.

1. Materials used in the construction of the meters shall be of the best quality, mechanically and chemically suited for the intended service conditions without any detrimental effect on the quality of the water.
2. The flow indicator shall consist of a single pointer and circular scale which shall rotate whenever the flow through the meter is greater than the starting flow rate. One revolution of the pointer shall correspond to a fixed unit of flow.
3. The register shall consist of a row of direct reading, in-line consecutive digits visible in one or more apertures, indicating totalized volume of water in cubic meters as following:-

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Characteristics** | **Nominal Meter Size (mm)** | | | | |
| **12** | **20** | **25** | **40** | **50** |
| Nominal Flow Rate (m3/h) | 1.5 | 2.5 | 3.5 | 10 | 16 |
| Minimum Capacity of Register (m3) | 104 | 104 | 104 | 105 | 106 |
| Minimum Readable Quantity (m3) | 0.001 | 0.001 | 0.002 | 0.005 | 0.010 |

e. Meters shall conform to the minimum operating and performance standards as follows:-

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Characteristics** | **Nominal Meter Size (mm)** | | | | |
| **12** | **20** | **25** | **40** | **50** |
| Nominal Flow Rate (m3/h) | 1.5 | 2.5 | 3.5 | 10 | 16 |
| Starting Flow Rate (m3/h) | 0.010 | 0.020 | 0.030 | 0.035 | 0.070 |
| Limiting Flow Rate (m3/h) | 0.075 | 0.125 | 0.175 | 0.500 | 0.800 |
| Maximum Flow Rate (m3/h) | 3 | 5 | 7 | 20 | 32 |

Maximum head loss at the maximum flow rate shall not exceed 10m water column.

1. Tamper proof devices consisting of a wire and lead seal shall be provided for the register and the plug above the adjusting screw to protect against unauthorized opening and tampering with the meter.

Meters shall be designed for a lifetime of ten (10) years under normal operating conditions. The Supplier shall obtain and submit a separate written guarantee from the Manufacturer of the meters against defects due to five (5) years after the date of delivery. Meters that are found to be defective during this period shall be repaired or replaced by the Supplier at no additional cost to the Owner.

1. Flanged Water Meter

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Characteristic** | **Nominal meter size (mm)** | | | | | | | |
|  | **80** | **100** | **150** | **200** | **250** | **300** | **400** | **500** |
| Nominal flow rate m3/h  Maximum flow rate m3/h | 40  80 | 60  120 | 150  300 | 250  500 | 400  800 | 600  1200 | 1000  2000 | 1500  3000 |

* + 1. **Pressure Meters and Switches**

Pressure gauges shall comply with BS 1780. Pressure gauges, transmitters and switches shall have over range protection. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material. Pressure gauges shall have concentric scales.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitable adjusted and the amount of compensation shall be marked on the dial.

## Painting and Protective Coatings

* + 1. **Paint General**

All paints shall be obtained only from suppliers approved by the Engineer. Unless otherwise agreed by the Engineer, all pants forming part of any one painting system shall be obtained from the same sources. Paints shall be supplied in sealed containers of not more than 5 liters capacity, and shall be used in strict rotation.

All pigment and fillers used in manufacture of paints shall comply with the appropriate British Standards.

Painting specification for specific items are covered in the Particular Specification Clauses.

* + 1. **Painting General**

All items of structural steelwork, mechanical machinery, valves, and pipe work, supplied under the Contract shall be supplied having a metal protection system corresponding to one of the specifications tabulated at the end of this Section.

Preparation, application and conditions of work shall be in accordance with BS 5493.

* + 1. **Preparation of Surfaces of Receive Paint**

Before paint is applied to any surface the appropriate surface preparation, as described in the Contract, shall be carried out in accordance with me following: -

* 1. Bare Metal Surfaces
     1. Blast Cleaning

Blast cleaning shall be carried out to a minimum standard of BS 7079 second quality, unless stated elsewhere, using chilled iron grit or shot to grade G17, S17 or finer.

The abrasive used for blasting shall be free from contamination and any recovered materials shall be cleaned to the satisfaction of the Engineer. The maximum amplitude, (peak to trough), of the blast cleaned surface shall not exceed 100 microns. Surfaces shall be protected within four hours of having been blast cleaned.

* + 1. Pickling

Steel shall be pickled by the "Footner" process, as defined in BS 5493, the first priming coat of paint shall be applied as soon as the steel had dried and is still warm.

* + 1. Flame Cleaning

The flame clean surface shall be cleaned of all loosed material. The first priming coat shall be applied while the steel is still warm. The sequence of operation for flame cleaning steelwork shall be planned and controlled to avoid the risk of distortion and buckling.

* + 1. Mechanical Cleaning

Mechanical cleaning shall be carried out by power driven tools such as abrasive grinding discs, chipping hammers or needles guns, followed by steel wire brushing and dusting to remove all loosened material. Excessive burnishing of the metal through prolonged application of rotary wire brushes shall be avoided. Surfaces shall be protected within four hours of having been mechanically cleaned.

Note: Methods of surface preparation utilizing (b), (c), (d) will only be permitted with the written permission of the Engineer.

* 1. Welds and Weld Affected Areas

Unless otherwise described in the Specification, welds and surfaces, which have been affected by welding, shall be prepared for painting by the same process as described in the Contract for the adjoining metal.

* 1. Painted Surfaces

Painted surfaces shall be cleaned of all dust immediately prior to the application of further paint. Any loose paint and rust shall be removed. Areas contaminated by oil and grease shall be cleaned with white spirit. Where required by the Engineer, the whole surface shall then be cleaned by washing down with a solution of an approved liquid detergent, followed by rinsing with clean fresh water and allowed to dry thoroughly before paint is applied.

* + 1. **Galvanizing and Metal Coatings**

Surface preparation for the application of metal coatings shall be in accordance with the following British Standards:

* BS 729; Hot Dipped Galvanized Coatings
* BS 4921; Sheradized Coatings
* BS 2569; Part 1 Sprayed Metal Coatings

Sprayed metal coatings, which are subsequently to be painted, shall have a nominal thickness of 100 microns. The nominal local thickness of coatings shall comply with Clause 5 (a) and (b) of BS 2569; Part 1

All materials and fabricated parts to be galvanized shall be of the full dimensions shown or specified with all welding, punching, cutting, screw tapping, removal of burrs, etc., completed before the galvanizing process commences.

All galvanizing shall be done by the hot-dip process with smelter of which not less than 98% shall be pure zinc. The zinc coating shall be uniform, clean, smooth and as free from spangle as possible. The zinc coating shall weight not less than 400 g/m2 of area covered and be not less than 0.6 mm in thickness.

No parts likely to come in subsequent contact with oil shall be galvanized. Bolts shall be completely galvanized but the threads of all nuts shall be left un-coated.

All galvanized parts shall be protected from damage to the zinc coating due to poorly ventilated damps conditions and abrasion during the periods of transit, storage and erection. Damaged areas of the coating shall be cleaned back to bright metal leaving feathered edges of the surrounding galvanized coating and touched up with a zinc-dust paint or other flake metallic compound.

All galvanized parts must be finally protected on site by an approved paint system.

Sampling and testing shall be carried out in accordance with BS 729; or BS 2569; Part 1, whichever is appropriate. All metal-sprayed steelwork shall be protected within four hours of spraying with one coat of approved etching primer. Where a metal coating is required only on part of an assembled section, it shall be applied before the rest of the section receives its first priming coat.

* + 1. **Storage of Paint**

The paint shall be stored in sealed containers in a lock-up store where it is not exposed to extreme temperature. The temperature of the store shall be kept between 40 C and 270 C; and special storage conditions recommended by the manufacturer shall also be observed. Paint, which has not been used within the “shelf life” period, specified on the containers or within 12 months of the date of manufacture, whichever is the lesser shall be replaced. Paint from painter's kettles shall be returned to the store at the end of each working period where it shall be kept in a sealed container. This is not permissible for any two-pack paints such as Epoxy type. Before it is re-issued for use it shall be thoroughly mixed and no fresh paint or thinners shall be added.

* + 1. **Application of Paint**

Preparation, application and conditions of work shall be in accordance with BS 5493,

All primers, undercoats and finishes shall be applied by brush or airless spray, except where otherwise specified.

Consecutive coats shall be in distinct but appropriate shades.

All paint shall be supplied from the store to the painters, ready for application, and addition of thinners or any other material shall be prohibited. Any instructions given by the paint manufacturer shall be strictly followed. All painting shall be carried out by the painters under adequate supervision. Paint shall be applied to the dry surfaces, which have been prepared in accordance with Clause 2.18.3

Paint shall not be applied under the following conditions:

* When the ambient temperature falls below 40C or relative humidity rises above 90%
* During rain, snow, fog or mist.
* When condensation has occurred or is likely to occur on the steel.

Two-pack paints of epoxy resin type shall not be applied when the temperature falls below 50 C or as required by the paint manufacturers, nor shall it be applied when the temperature is likely to fall below the shall be applied by the method described in the Specification to produce a continuous firm of uniform and even thickness.

As soon as the first priming coat has dried, an extra stripe coat of paint shall be applied by brush, to the edges, corners, crevices, bolt heads, rivet heads and welds, using paints of a similar composition to the priming coat but of a contrasting shade. Successive cats shall have different shades for identification and each coat shall be thoroughly dry before the application of a further coat.

Particular care shall be taken to maintain the full paint thickness at all corners and edge and special attention shall be given to the application of protective coatings after welding.

The total dry paint film thickness of the paint system on the sealed surfaces shall not be less than 275 microns. The dry paint film thickness shall be measured by Elcometer or other instruments approved by the Engineer. In order to obtain the dry film thickness specified, the Contractor should ensure that the coverage rate given by the paint manufacturer would enable this thickness to be obtained. Wet film thickness gauges may be used for checking but shall not be used after the expiration of the 'pot life" stipulated by the manufacturer and the paint of limited "pot life" shall not be mixed with fresh paint or have thinners added to them.

Painted fabricated steelwork which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no pools of water or dirt can accumulate on the surface. Suitable packing shall be laid between the stacked materials. Where cover is provided, it shall be ventilated.

Where primer painted steelwork is to be stored out of doors before being overcoated shall not be exposed for periods longer than the following:-

Etch Primers nil

Etch primers on metal coatings two weeks

Chromate primer two weeks

Zinc chromate primers two weeks

Zinc rich primer 25/37 microns thick four weeks

* + 1. **Repairs to Damaged Surfaces**

Areas of paint, which have been damaged, shall be cleaned to bare metal or metal coating where this has been applied and the edges of the undamaged paint bevelled with sand paper. Where a metal coating has been damaged, the affected areas shall be rubbed down to remove excessive rust, cleaned and an additional coat of an approved primer applied. The full-specified painting system shall then be re-applied and new paint shall overlap the existing paid by at least 50 mm all round the affected part.

* + 1. **Painting of Existing and Previously Painted Surfaces**

In general all surfaces shall be suitable prepared by cleaning, abrading and degreasing, etc., and may be repainted with the finishing systems as detailed in Section 2.18.18. Decorative paints such as Deluxe Trade

Gloss Finish or similar type finishes may be applied to clean, dry and well-prepared surface direct without primer, etc.

Exposed surfaces should be primed and brought forward in the normal manner, i.e: prime where necessary followed by undercoat and gloss finish as detailed in Section 2.18.18, but sound surfaces may in general be recoated with the finishing paints only. Where two pack materials have been used and where adhesion of the new paint may be difficult, the weakness in adhesion may be overcome with the use of an etch primer. An etch primer such as Deluxe Primer S68 cab be used in most applications. Care should be taken to avoid over application of this primer since this can create additional problems.

* + 1. **Paint Specifications**

The Contractor shall give full details of the preparation, type of materials, methods and sequences he proposes to use to comply with the requirements for the protection of the Plant. In the case of materials he shall submit details of the basic raw materials sources, volatile matter content, nature of solvent number of constituents including the percentage of epoxy resin, type of application, coverage, time interval between coats, recommended number of coats, toxic properties, shelf life and details of 'patch' repairing.

For epoxy-based paints the total percentage of epoxy resin in the dry film shall not be less than 25 per cent.

No thinner shall be used unless approved by the Paint Manufacturer. To prevent loss of adhesion and solvent entrapment the Paint Manufacturer's instructions shall be rigidly following particularly with respect to the minimum and maximum periods between coats and the permissible temperature and humidity range for application.

The Contractor shall submit for review an overall colour scheme for the exposed surfaces of all Plant. All final coats shall be in the colours thus approved.

* + 1. **Protection During Transportation**

All Plant shall receive adequate protection in the workshop or factory to ensure that metals are not affected by corrosion during transportation, loading and off-loading, storage and site erection.

The Contractor shall supply full details of the extent to which blasting, metal spraying and painting will be carried out in his supplier's workshop, on the site of the work prior to erection or in-situ after erection. If it is decided to carry out the bulk of the painting on the site of the work, a properly equipped painting shop shall be set out using a specialist organization, experienced and skilled in the preparation of surfaces and the application of protective coatings under the prevailing conditions.

* + 1. **Parts Built into Concrete**

Cast iron or mild steel parts to be built into concrete over a depth of 75mm shall remain unpainted. Immediately before it is cast in situ it shall be made perfectly free from dirt, scale, loose rust, paint, oil, lime wash or any other coating.

* + 1. **Inspection and Tests**

The Plant shall be inspected and reviewed at the various stages of the coating application both at the Manufacturer's Works and at the site of the work. Samples may be taken from the paints as delivered and submitted to such tests as are deemed necessary. The completed paint systems shall be tested by instruments to ensure that the protection is of adequate thickness and is free from pinholes and the adhesion shall be checked by the removal of a small section of the coating. The Contractor shall supply all instruments and apparatus required for carrying out such tests.

* + 1. **Corrosion Resistant Materials**

No blast cleaning or painting shall be applied to corrosion resistant materials such as stainless steels, Ni-resistant cast iron, bronze and other metals used for seals, bearings, lighting fittings, etc.

* + 1. **Box and Tubular Sections**

Box and tubular section shall be permanently sealed. All such sections shall be thoroughly dried out using hot dry air before final sealing and painting is carried out. After sealing all sections shall be tested for air tightness.

* + 1. **Machined Surfaces.**

Machined surfaces such as gear-teeth shall be coated with a tick layer of grease. Other machined surfaces such as shaft ends, deep plates and other bright parts shall be coated with two coats of an anti-rust solution, which can be removed easily when required. Permanently bolted-machined interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly.

* + 1. **Manufacturer's Standards Finishes**

Where it is the usual practice of the manufacturer of items such as pumps, electric motors, switchgear, control panels and similar Plant, to apply a high standard of protective paintwork in the shop before dispatch this will normally be acceptable provided that such standard finisher are at least equal to the surface finish specified.

Full details of such manufacturer's standard finishes shall be given to the Engineer for his approval prior to manufacture. Special care shall be taken to ensure that standard finishes are suitable for the particular conditions applicable to the individual items of Plant.

* + 1. **Switchboards**

The interiors of control panels switchboards and switchgear, shall be finished white enamel paint (two coats) and shall comply with the appropriate BS for enamel finish and the and the exteriors of such panels shall be to BS 4800 colour 00 A 05 (mid grey) to give a minimum reflection value of 42%. Instruments shall be finished dull black and control handles, push buttons and similar fittings shall be chromium plated or otherwise durable finished to the approval of the Engineer.

* + 1. **Paint Systems**

The following paint system shall be used for the items of Plant listed.

The coatings are defined in accordance with BS 5493: 1977 "Code of practice for Protective coating of Iron and Steel Structures Against Corrosion "and systems shall be designed to give a maintenance free period of between ten and twenty year.

System P1

USES: Any immersed, wetted or buried steelwork.

PREPARATION: Abrasive blast clean to B.S. Second Quality

PAINTING

Painting shall correspond to BS 5493 SKB with an additional primer coat.

1. Apply two-pack zinc phosphate primer (KP 1A) single coat to 70 micron D.F.T.
2. Apply three coats of two-pack coal tar epoxy (KF 3A) to a total D.F.T. of 450 microns. Final colour black.

System P2

USES: Steelwork exposed to weather.

PREPARATION: Abrasive blast clean to B.S. Second Quality

PAINTING

Painting shall correspond to BS 5493 SL5

1. Apply two-pack zinc phosphate primer (KP 1A) single coat to 70 micron D.F.T.
2. Apply three coats of two-pack coal tar epoxy (KF 3A) to a total D.F.T. of 450 microns. Final colour black.

System P3

USES: Steelwork exposed to weather.

PREPARATION: Abrasive blast clean to B.S. Second Quality

PAINTING

Painting shall corresponds to BS 5493 SLS

1. Apply two coats of two-pack epoxy zinc phosphate primer (KP 1A) to total D.F.T of 140 microns.
2. Apply two coats of two-pack epoxy undercoat (KU 1B) to total D.F.T. of 200 microns.
3. Apply one coat of chlorinated rubber finishing coat (HF 1D) to 100 microns D.F.T.

Alternatively the finishing coat could be two-pack polyurethane (KF 2D) to 100 microns D.F.T. in accordance with BS 5493. SK4 painting system. Final coat shall be a colour in accordance with BS 4800 and approved by the Engineer.

Systems P4

USES: Internal plant and pipe work, cranes within pump houses and miscellaneous steelwork not exposed to weather.

PREPARATION: Abrasive blast clean to B.S. Second Quality

PAINTING

Painting shall correspond to BS 5493 SF5.

1. Apply two coats of two-pack epoxy zinc phosphate primer (KP 1A) to total D.F.T. of 140 micron.
2. Apply one coat Alkyd undercoat (FU 2A) to 35 micron D.F.T.
3. Apply two coats Alkyd finishing coat (FF 3B) 70 micron D.F.T
4. Apply two coats Alkyd topcoat (FF 3B) to 70 micron total D.F.T

Final coat shall be a colour in accordance with BS 4800 and approved by the Engineer.

System P5

USES: Buried steel pipe work prior to the application of pipe wrap.

PREPARATION: Abrasive blast clean to B.S. Second Quality

PAINTING

1. Apply single coat of two-pack epoxy zinc phosphate primer (KP 1A) to 70 micron D.F.T.
2. Apply single coat of two-pack coal tar epoxy (KF 3A) to 150 micron D.F.T.

Final colour black.

System P6

USES: Handrailing, steelwork, etc., which has been galvanized.

PREPARATIN: Degrease and wash surface

PAINTING

Painting shall correspond to BS 5493 SF8 after suitable pre-treatment.

1. Apply pre-treatment primer in accordance with Clause 11.3.2 of BS 5493.
2. Apply two coats Alkyd Primer (FP 3A) to 70 micron D.F.T
3. Apply two coats Alkyd undercoat (FU 2A) to 70 micron total D.F.T.
4. Apply two coats Alkyd topcoat (FF 3B) to 70 micron total D.F.T.

Final colour shall be in accordance with BS 4800 and approved by the Engineer.

Systems P7

USES: Internal surfaces of Pipes, valves and fittings,

PREPARATION: Abrasive blast clean to B.S. Second Quality

PAINTING

1. Apply single coat of two-pack epoxy zinc phosphate primer (KP 1A) to 70 micron D.F.T
2. Apply two coats of two-pack epoxy (KF 3A) to 300 micron D.F.T Epoxy to be approved for use with potable water.
   * 1. **Wrapping of Buried Pipe work**

All buried steel pipes and fittings shall be coated and wrapped with a cold applied self-adhesive pipe wrap. Comprised of an extruded, heavy, highly conformable thick PVC carrier combined with a layer of rubber rich tropical grade bituminous compound.

Minimum thickness of PVC shall not be less than 0.76 mm with total thickness of wrap not less than 1.65 mm.

Minimum physical characteristics of wrap to be:

Tensile strength 13.6 Mpa

Elongation 230%

Tear resistance 47 N force

Impact strength 7.2 Joules

Adhesion to ASTM D1000

(1800 Peel) 3.7 N/cm

Dielectric Strength 20,000 V min.

Operating temperature 200C-750C

Insulation resistance 1,000,000 megaohms

All pipes shall be prepared in accordance with system P4 (Clause 2.18.18).

The dry, primed pipe lengths shall be spirally wrapped with the specified tape wrap using 150 mm wide tape and 25mm minimum overlap during application. Sufficient tension shall be applied to ensure complete conformity of the tap to the pipe. The spigot end of the pipe shall be left unwrapped for a minimum distance of 150 mm to allow for engagement.

All field joints shall be wrapped after pipe laying and testing. Any exposed metal surfaces and the existing coating shall be cleaned and primed as stated previously. The tape wrap shall then be applied to the prepared joint area overlapping the pipe barrel wrapping a minimum distance of 75 mm using 100mm width of tape applied with a 50mm overlap. Sufficient tension shall be applied during application so as to ensure complete conformity of the wrap to the joint area.

End laps between adjoining rolls shall be a minimum of 150mm.

## Chemical Plant

* + 1. **General**

All chemical plant and equipment shall be non-corrodible for the conditions in which it is being used.

Glass reinforced chemical mixing tanks will be provided by the Contractor. Any necessary GRP protective lining to prevent chemical attack on concrete tanks shall be provided by the Contractor.

* + 1. **Chemical Dosing Pumps**

Chemical dosing shall be by means of electrically driven metering pumps, or gravity solution feeders unless otherwise stated in the Specification or on the Drawings.

The metering pumps shall be manually adjustable and shall be calibrated to allow setting at the required dosage. Dosing adjustment shall be possible while pumps are running. The metering pumps shall have an accurate dosing range down to 10% of their maximum output. Metering pumps shall be provided with dosage charts or tables in an approved durable material suitable for wall mounting.

Metering pumps shall be manually and automatically adjustable by a control signal 4/20mA. Variable speed motor will be preferred as actuator. Output shall be adjustable through a stepless variable stroke mechanism. Materials in contact with the liquid shall be polypropylene or appropriate stainless steel like Hastelloy C. Diaphragm materials shall be buty1 or PTFE. Bedplates shall be protected from gland drip. The pumps shall be driven by close-coupled motors with reduction gears and cam mechanisms housed in a totally enclosed oil bath.

Gravity solution feeders shall comprise a constant level tank with a float controlled inlet valve, and outlet regulation orifice discharging to atmosphere and into the inlet of the pipe delivering the solution to the dosing point. The regulating orifice shall be either of the fixed orifice type through which the output can be adjusted by varying its height relative to the liquid level in the constant level tank, or an orifice with discharge area varied by a tapered needle. In both cases the orifice shall always be drowned to avoid blockage through crystallization. Materials in contact with the liquid shall be stainless steel, rubber, PVC, polypropylene or PTFE.

* + 1. **Chemical Dosing Pipe work**

Chemical dosing pipe work and valves shall be of uPVC or polyethylene unless otherwise required in the Particular Specification. Where possible all pipe work shall be routed so that it can be fixed to walls. Rigid pipe work Specification. Where possible all pipe work shall be routed so that it can be fixed to walls. Rigid pipe work, including uPVC, shall be fixed to walls and in ducts using clamps or brackets spaced at such intervals so as not to cause noticeable sagging in the pipe work between supports. Flexible pipe work shall be laid on galvanized mild steel (GMS) cable tray securely fixed to walls. Pipe work spanning between walls shall also be supported by GMS cable tray. Adequate drainage and flushing points shall be provided on chemical dosing pipe work.

* + 1. **Mechanical Mixers**

Mixers for preparing chemical solutions or slurries shall be of the electrically driven propeller type suitable for permanent mounting in a vertical position. The mixers shall be sized to agitate the whole contents of the mixing tank to dissolve the chemical concerned within a reasonable time, or to prevent any settlement in tanks containing slurries. The mixers shall be driven by close-coupled motor with gears housed in a totally enclosed oil bath. Bearings shall be sealed against ingress of dust. The shafts and propellers shall be of stainless steel.

* + 1. **GRP Lining**

Glass-fibre reinforced polyester (GRP) lining to concrete tanks shall be applied using the wet lay-up process. The lining shall have a minimum thickness of 3 mm and have a glass content of chopped strand mat of not less than 30%. It shall be finished with a resin rich surface layer containing binding tissue.

The polyester resin shall be commercial grade inert to aluminum sulphate solution and shall comply with the minimum requirements of BS 3532. Fillers shall not be permitted.

Reinforcing materials shall be a suitable grade of glass-fibre having a glass finish compatible with the resin used and complying with the relevant requirements of BS 3532. Fillers shall not be permitted.

Reinforcing materials shall be a suitable grade of glass-fibre having a glass finish compatible with the resin used and complying with the relevant requirements of BS 3496 and BS 3691/

The concrete surface shall be thoroughly cleaned and dried before the GRP is applied. The reinforced material shall be overlapped by not less than 50mm. The final surface of the lining shall be finished smooth and free from crazing and cracks; and defects shall be ground and repaired by a method agreed by the Engineer's Representative.

## Floor Trench Covers, Chequer Plating and Egg Crate Flooring

Unless otherwise specified, pipes and cable are to be laid in ducts below the finished floor level. The ducts shall be covered with steel plates with diamond chequering or other approved non-slip pattern, or with egg crate flooring. The plates or flooring sections shall be of sufficient thickness not to bend or spring in ordinary usage and shall fit evenly and truly into steel angle frames or kerbing with suitable attachment for building into the concrete floor.

The Contractor shall supply complete drawings showing the arrangement of trenches, chequer plates and egg crate flooring section, fully dimensioned so that the trenches can be formed and the kerbs built into the floor by the civil works contractor. The plates and flooring sections shall be divided into suitable sizes and lengths for lifting, with two holes in each section. One set of lifting keys shall also be supplied at each location.

## Foundation Bolts and Fixing Arrangements

All foundation bolts and fixing bolts required to secure the items to be supplied and erected under this contract shall be provided.

The Contractor shall provide, within the time (s) specified, dimensioned foundation drawings showing the type of foundation or fixing required for each item of plant. The contractor shall state the mechanical strength of large fixing bolts, which shall be of an approved size and diameter. Galvanized where not embedded in concrete, with galvanized nuts and washers.

## Brackets, Fixings, Anchor Points and Pipe and Valve Supports

All bracket, hangers and fixings, anchor points and supports for the satisfactory installation of all pipe work, valves and other equipment shall be supplied and erected. The supports shall prevent excessive movement of the pipe work and eliminate extraneous stress on pump casings and other items of plant.

Where pipe and valve supports or anchors at attached to structures, the loadings imposed at the points of attachment shall be stated by the Contractor on submission of the relevant foundation drawings and approved by the Engineer.

All necessary nuts, bolts and washers for such fixings shall be included.

## Guarding and Protection of Moving Parts

Moving parts of machinery including all shafts, couplings, collars, projecting key heads, gear wheels, belt drives, chain drives and all other moving machinery shall be guarded where necessary to give complete protection to operating personnel. All setscrews on revolving shafts shall be countersunk or suitably protected. Guards shall be of an approved design, fitted where necessary with inspection doors. All guards shall be arranged so that they can be removed without disturbing the parts of the equipment they protect. Guards for shaft couplings shall at least be equal to BS 5304.

## Schedule of Test

* + 1. **General**

This Section is to be read in conjunction with the details contained within the Specification, in particular Section 1.26.

As many tests as possible shall be arranged together. Five copies of the Contractor's records of all tests shall be furnished to the Engineer.

All material, which is specified for tests at the manufacturer’s works, must satisfactorily pass such tests before being painted or otherwise coated.

All test instruments, fuels and consumables required for the tests, commissioning and setting to work the Plant should be supplied by the Contractor. Test instruments and shall be to approval and shall be calibrated by a competent authority as may be approved by the Engineer.

* + 1. **Tests at Manufacturer's Works**

The mechanical equipment supplied under this Contract will be tested to prove compliance with the requirement of this Specification and with the relevant British Standard specification where applicable.

* + 1. **Tests After Erection on Site**

All Plant shall pass such tests on site as are required by the Engineer to prove compliance with the Contract independently of any tests, which may already have been carried out at the Manufacturer's Works. In particular, all pump performance tests made at the Manufacturer's Works shall be repeated.

If, in the opinion of the Engineer, the Plant does not comply with this specification, the defect shall be rectified at no cost to the Employer.

## Standby Power Generating Plant

* + 1. **General**

The Out Door diesel generating sets shall consist of diesel engines and alternators mounted together on common base plates. They shall be suitable for continuous duty of twenty-four (24) hours per day, for operation under the climatic conditions and altitude as set out in the Particular Technical Specification, and shall be rated at 1,500 rpm.

The generating set shall be capable to deliver continuously 110% of its rated output for one hour in every twelve (12) hours, without any part impaired.

The Plant shall be designed to operate continuously in ambient temperature of up to 50°C (indoor conditions). They will be located Outdoor (canopy protection is required).

Whenever EEU power failure occurs, so as to satisfy part of the water demand, in the pump station an outdoor (canopy type) Standby diesel generator sets shall be erected in the Borehole-03 located at the respective site. The diesel generator sets shall include:

* + Diesel generating set together with exhaust pipe work
  + Fuel tanks and pipe work (for 12 hrs)
  + Switchgear
  + Cables
  + Earthing
  + All accessories and other necessary items
  + Weather proof

The goods and associated equipment shall be of the highest possible standard and requiring the minimum of maintenance. The contractor shall therefore ensure that the equipment offered meets all relevant British Standards and is of a type and manufacture such that spares are readily available for immediate and long term use.

The diesel generator sets, while providing a standby power sources, shall be continuously rated and of a type suitable for continuous operation: the diesel generating sets being brought into service only in the event of EEU mains supply failure or insufficient EEU power. Each set shall be rated for the pump and auxiliary duties specified together with all staring current, surges and the like, due allowance being made for the altitude and climate conditions specified.

It is intended that the diesel generating set is sized/rated to supply for the total electrical load at compound and sites specified. The details of the load capabilities of each set shall be clearly identified on the set and as part of the operating manual supplied by the contractor.

The total power required at the station is calculated by considering the starting current of the pump. Also de rating factor of 0.8 is taken. And the final size of the generators shall be determined by the equipment going to be supplied & installed.

Altitude masl: 2372

Diesel engine:

Ignition Compression

Starting medium Electric 12 or 24 volts heavy duty

Staring method manual push button

Cycle 4 stroke -diesel

Cooling Water-cooled with radiator

Lubrication Pressure

Shut down manual push button and

automatic shut down safety feature

Engine speed 1,500 revolution per minute

Alternator:

Coupling Direct

Generating voltage 400 volts

Phase Three (3)

Connection Star with neutral earth point

Power factor 0.8

Frequency 50Hz

Rating Continuous

Overload 10% for 1 hour in any 12 hour period

Excitation Self

The diesel generating equipment shall be designed and/or selected to operate under the specified conditions prevailing at the site in outdoor installation. In this respect the contractor shall allow for operation in an unheated, minimum ventilated building and dust-laden atmosphere.

The goods and mandatory spare parts shall be suitable for continuous operation and shall be rated to suit the prime power requirements of the complete installation including staring currents, surges and the like.

The ratings specified for the diesel generating sets are approximate only. It shall be the responsibility of the Contractor to liaise with the EEU and the Engineer to determine precisely what loadings should be used to size the diesel generating sets, all details being agreed before the commencement of supply.

All components shall be fully tropicalised and protected against mould growth.

* + 1. **Engines**

Engines shall be industrial four stroke, water or air cooled, direct injection machines and shall operate at not more than 1,500 rpm. Standardization of types is required such that all machines of the same output shall be from the same manufacturer. Where the requirement is for machines of different sizes, every attempt shall be made to supply machines from the same manufacturer, which share many components in common.

The site rating of the engine shall be calculated in accordance with BS 5514 and shall have an inherent overload capacity of 10% for 1 hour in any 12 hours. The engine shall be capable of operating at full load for 500 hours without attention to filters or injectors, and for 10,000 hours between major overhauls.

An automatic speed governor complying with class A2 of BS 5514 Al (ISO 3046) shall be fitted. Facilities shall be provided to manually trim the engine speed by ± 5%. An independently acting, shaft driven over-speed device shall be fitted to trip the set at 120% of the rated speed. The device shall require resetting by hand before the engine can be re-started.

Engines driving generators of 2 MVA or less shall be started and controlled using 12/24 V (as applicable) supply from heavy-duty lead acid batteries. The engine starter motor shall be of the reselect type and the batteries sized to give six 30 second consecutive starts of the engine at an ambient temperature of 0°C. For small generators (up to 250 kW) the batteries may be set–mounted. For larger sets the batteries shall be separately mounted. A charging dynamo with automatic cut out, voltage regulator, ammeter, and all necessary cables shall be provided. The engine shall be provided with a contact (starting) key.

The engine lubrication system shall be of the closed circuit wet-sump forced feed type supplied by an engine-driven pump. The pump shall be fitted with pressure regulating and relief valves, sump suction filter and renewable micro-felt flow line filter.

In the case of water-cooled engines, the engines cooling system shall be by means of a heavy-duty air blast radiator, mounted on the generator base plate, together with an engine driven fan and water circulating pump(s). A thermostatically operated bypass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. The radiator cooling air shall be exhausted to the atmosphere via a louvered opening and a bellows connection to the radiator. A further louvered opening shall be provided to supply cooling and charge air.

A charge air intake filter (or filters) shall be fitted. This shall be of the heavy-duty type to BS 1701 and shall be suitable for operation in a dust-laden atmosphere. Where the engine is turbo-charged, the filter shall be of the oil-wetted type.

The engine shall be capable of operating with fuels complying with clause A, B1 and B2 of BS 2869. The fuel feed shall be via a fuel filter of the fine steel wire mesh type.

Cyclic irregularity of the engine/alternator combination shall not exceed that specified in BS 5514 Al (ISO 3046).

* + 1. **Alternators**

The alternator shall provide 3 phase, 380 V, 50 Hz output and shall be suitable for operating under load conditions with a power factor of 0.8 lagging.

The alternator shall be of the salient pole, revolving field, brushless, self-regulating type and shall be three phase. The unit shall be manufactured in accordance with BS 4999 and shall be continuously rated and capable of withstanding a 10% overload for 1 hour in any 12-hour period. The unit shall additionally withstand a short circuit for not less than 3 seconds.

The alternator shall conform with Bs 5000 part 99, shall be tropically finished and insulated with class F insulating materials, complying with Bs 2757.

The alternator shall be capable of supplying an unbalanced load where the current of the highest loaded phase exceeds that of the lowest loaded by 40%.

The winding insulation shall be to class F, but the machine shall be designed to limit conductor temperatures to class B. The machine shall be designed to operate continuously in ambient temperatures up to 50°C.

The exciter shall be of the revolving armature type with the armature overhung on a shaft extension at the non-driving end. The output of the exciter shall be rectified by a rotating silicon diode rectifier bridge to supply the main generator field windings. The exciter field shall be controlled through automatic voltage regulation (AVR).

The machine shall be protected to IP22 with open circuit air-cooling. The air ducts shall be designed to reject falling drops of water, and they shall be fitted with grills to keep out vermin.

An anti-condensation heater shall be provided and this shall be energized automatically when the generator is out of service

The alternator shall be equipped with a static voltage regulator and brushless excitation, holding voltage within a maximum deviation of ± 2.5% from nominal value, between no-load and full load conditions.

The maximum instantaneous voltage drop during maximum load conditions, when starting the largest motor, shall not exceed 20% of the nominal voltage. This requirement must be strictly observed and the successful starting warranted.

The alternators shall be effectively cooled by open forced air ventilation. The ventilation openings shall be screened against ingress of small insects and rodents.

All rotating components shall be properly, statically and dynamically, balanced.

Alternator bearings shall preferably be of the cartridge type, preventing contamination by dirt or moisture when the alternator is dismantled. The bearings shall be grease lubricated. Easily accessible nipples for re-greasing shall be provided.

All bearings shall be liberally rated to ensure average life rating of not less than five (5) years of continuous operation.

The alternator shaft shall be directly coupled to the diesel engine via a flexible coupling.

* + 1. **Control Panel**

The control panel shall be constructed to BS 5486 with a rating of not less than IP 54. In the case of small generators (up to approximately 250 kW), the control panel may be mounted on the set itself, but for larger sets the control panel shall be separately mounted. Where the panel is separately mounted it may be necessary for some direct reading gauges to remain set-mounted. In this case, the instruments shall be mounted together on a panel fixed to the set, but where they generate alarms or other electrical signals these shall be transmitted to the separately mounted control panel.

The control panel shall contain the following items:

On/off switch for control circuitry

Engine stop/start push buttons

Emergency stop push button with twist reset

Combined frequency /RPM meter

Oil pressure gauge

Water (or oil) temperature gauge

Ammeter for each phase

Voltmeter and phase selection switch

DC ammeter (battery starting/charging current)

DC voltmeter (battery volts)

Indicator lamps for:

Low oil pressure

High water (or oil) temperature

Over speed

Hours run meter

Off/auto anti-condensation heater switch

In the case of a generator with electric starting, consideration shall be given, when selecting the relays and other electromagnetic devices in the control system, to the voltage drop, which occurs during operation of the starter motor.

All control panels shall be complete with a mains powered battery charger and battery. In the case of an electric starting generator the battery shall be the starting battery and shall be rated accordingly.

* + 1. **Exhaust Systems for Diesel Engines**

The exhaust system shall incorporate silencers suitable for use in an industrial area and shall include all necessary supports and other items to make a complete installation. Exhaust tubing shall be heavy gauge mild steel to BS 3600, and shall include a stainless steel bellows close to the engine to reduce vibration and permit engine movement.

The system shall be suspended from the walls and roof by suitable brackets and angle ties, which shall include mountings to prevent the transmission of vibration and noise to the building.

The system shall be adequately lagged and fixed with in the building. Where the roof is of combustible material and the walls of the building are of incombustible material, the exhaust shall be routed to atmosphere through the wall rather than the roof. Where both the walls and roof are of combustible material, special care shall be taken to protect the building from the exhaust piping and the hot gases discharged from it.

The exhaust system outlet section shall be horizontal and where possible it shall point in the direction of the prevailing wind.

* + 1. **Daily Service Tank**

A daily service fuel tank holding sufficient fuel for twelve (12) hours operation at full load shall be provided for each generator. In the case of a small generator (up to 250 kW) the tank may be set mounted, but for larger machines the tank shall be mounted on a frame. Fuel supply to the generator shall be by gravity.

The tank shall be constructed in mild steel and the fittings in materials other than:

Yellow brass, including low-grade alloys of copper and zinc

* Lead and zinc
* Galvanized metals
* Natural rubber

The tank shall be complete with the following fittings:

* Local indication of fuel level, to be provided at a position where it can be easily read during fuel delivery.
* Drainpipe situated at the lowest point in the tank, complete with isolating valve.
* Outlet pipe complete with water trap and isolating valve.
* Filling point at the top of the tank with removable gauze filter.
* Vent pipe. This shall be routed to atmosphere with a continuous rise from the tank and shall be terminated with an inverted ‘U’ bend and vermin screen.

The tank shall have unused volume above the normal maximum contents level of the tank of not less than 5% of the maximum volume of the tank.

The vent pipe shall be located not less than 50 mm above the highest possible fuel level.

* + 1. **Protections**

The generating set shall be shut down in case of:

- Low oil pressure.

- High water or oil temperature.

- Over-speed.

**2.25.8 Finishes**

All ferrous metalwork shall be either painted or processed to give a rustproof coating. Ferrous metalwork to be painted shall first be either shot blaster or thoroughly wire brushed to remove all scale and oxide and immediately given one brushed coat or two sprayed coats of primer. After not less than four hours, one brushed or two sprayed undercoats followed by one brushed or two sprayed finishing coats of hear and oil resisting quality paint shall be applied.

Successive coats of paint shall be slightly differing shades. The interior surface of electrical equipment enclosures shall be finished white and all external surfaces shall be finished to the BS 4800 to suit the manufacturer's standard colour. The engine crankcase shall not be painted internally unless the plant is resistant to the lubricating oil.

**2.25.9 Drawings**

The contractor shall provide to the Engineer specific sets of the following drawings:

* Building drawings showing details of cable entries, pipe entries and ducts required.
* General arrangement drawings showing the principal dimensions and set weights.
* General arrangement of the diesel engines.
* Details, supports and general requirements associated with the exhaust system.
* General arrangement of the alternator and exciter showing terminal markings, polarity and phase rotation.
* General arrangement of the electrical control panel.
* Schematic and wiring diagram of the electrical control panel.

**2.25.10 Works Tests**

The set shall be tested as a unit at the manufacturer's works (or elsewhere by agreement) for output and performance generally in accordance with the requirements of BS 649 and BS 5000 Part 99. The Engineer shall be given adequate notice in writing of the date and the time of the works test and he, or his representative, shall, if he so desires, be present at such test and be given all reasonable facilities for his own inspections during the course of the tests.

**2.25.11 Commissioning**

The Contractor shall include for fully commissioning the set and its control equipment and for the purpose of the required tests, shall provide all necessary instruments, tools, fuel and lubricating oil. The following tests and checks, as applicable, shall be carried out by the contractor in the presence of the Engineer or his representative.

* Check that the main frame is level in all directions, engine and generator shafts are in proper alignment and the vibration absorbing devices are properly installed and located.
* Check water and sump oil levels and that the water jacket and radiator heater (if fitted) are in working order.
* Check the battery electrolyte levels and the specific gravity.
* Examine the containers in which the fuel and lubricating oils are delivered and check that the type and grades of oil are as recommended for the unit.
* Ensure that sufficient fuel oil is in the fuel tank for a six-hours test run.
* Check that all radiator and engine block water drain points are free from sludge and other blockage.
* Check engine bolts, main drive coupling, valve clearances, fuel pump settings, governor set-rings, pipeline connection, water hose, exhaust couplings, flexible pipe work and the like.
* Check all outgoing connections on the generator and at the control panel. All lugs for principal connections shall have clean and bright contact surfaces. A suitable abrasive material shall be used where necessary.
* Check access panels and doors for proper opening and closing and for the functioning of any interlocks fitted.
* With the set isolated from the system, start the engine by means of the "start" push button and allow it to run up to normal speed. Check that the battery charging dynamo is in operation with the engine running.
* Check instruments and gauges for normal operation and response and that the generator voltage is being maintained within the prescribed limits.
* Compare the reading of the frequency meter with that of the engine tachometer, where both are fitted.
* Stop the engine and verify that the generator contactor opens at between 95% and 85% of normal voltage. Re-check water and oil levels.
* Run the set a various load for periods totaling at least 30 minutes. Check the voltage and current in each phase in turn and check that the voltage and frequency are being maintained within the required limits with large alternations of loads. Note the rate of charge on the dynamo ammeter with the engine running and the rate of charge on the battery-charging ammeter with the engine stopped. Check against the manufacture's recommendations and adjust charging rates if necessary.
* Check that the various engine safeguards operate satisfactorily.
* Check vibration absorbing devices for proper operation and that the performance of all flexible connections, both mechanical and electrical, is satisfactory.

When all tests are satisfactory and agreed with the Engineer or his representative, the lubricating oil and water levels shall be finally checked, the fuel tank replenished and the set left in normal operating order.

* An initial supply of all lubricating oils and grease shall e provided by the Contractor.

*Running of the engine for any length of time under- non-load conditions is undesirable and tests calling for such operation should be carried out in as short a time as possible consistent with thoroughness.*

**C - ELECTRICAL GENERAL SPECIFICATIONS**

## Introduction

This Section covers the supply and installation of all electrical plant and equipment including all necessary calculations, technical details, catalogues, drawings, etc., for the plant, machinery apparatus, equipment, systems, articles, and associated accessories as outlined on the Drawings and described in the Sections of the Specification.

The final rating of switchgear, electrical protection devices, cable ratings, etc., shall, in general, be dependent upon the ratings and characteristics of the pumping sets and mechanical plant being supplied and the adopted method of starting. In this respect it shall be deemed that Contractor has taken this into consideration and has offered compatible electrical and mechanical plant and equipment.

The final arrangement of switchboards, switchgear and motor control panels is dependent upon the equipment offered and therefore subject to approval.

## Voltage and Supply System

The supply to the Site is provided by the national electricity supplier and will, in general, be 15,000 V, 3 phase, 3 wire 50 Hz, stepped down through suitable rated transformers to 380 V/220 V for distribution and service connections to the various pumping stations and compounds.

It shall be the responsibility of the Contractor to ascertain the voltage supply systems at the various sites and compounds. As shown on the Employer's Drawings, loads may be such that a 380 V supply can be extended directly to the compound without the need for a step down power transformer.

The Contractor shall also be responsible for liasing fully with the national electricity supplier with respect to:

* Providing a detailed assessment of the load demands at each site
* Agreeing methods of staring for the proposed motors
* Finalizing details of metering requirements, terminations, glands, lugs and the like to suit the national electricity supplier’s meters and cables
* Advising the national electricity supplier of the approved programme of Works so that the national electricity supplier can plant their installation

## Cables

* + 1. **General**

This Section of the Specification deals with the materials and types of cables, which may be used along with termination and identification requirements for the cables. Full details, catalogues, etc., shall be submitted with the Tender.

All cable supplied for use under the Contract shall be British Approval service for Electric Cables (BASES) approved and shall be manufactured to the following British Standards, as appropriate, BS 5308 (Parts 1 and 2), BS 5467, BS 6004, BS 6007, BS 6207, BS 6346, BS 6480, BS 6500 and BS 7430.

The Tenderer shall submit, at no extra charge, full descriptive pamphlets and technical literature of the type of cables and cable manufacturer's offered.

Manufacturer’s test certificates for multi core cables shall be submitted to the Engineer for approval before any cables are installed. All cables shall be accompanied by the manufacturer's original guarantee, and shall be delivered to Site in the original wrapping.

Cable ratings and sizes have been indicated on the drawings and included within the Schedule of Prices. These rating have been based upon the assessed load details, ambient conditions and de-rating factors associated with each compound or pump station. The Contractor shall be responsible for finally checking the sizes/ratings of all cables and overhead line conductors to suit the loads. The sizes of the cables and conductors shall take into account voltage drops, fault levels, de-rating factors and ambient conditions. Details shall be made available by the Contractor for discussion and approval.

* + 1. **Materials and Minimum Size**

Cables shall have standard copper conductors, with minimum cross sectional areas as follows:

* Motor supply cables 4 mm2
* Cabling to control devices external to switchboards 2.5 mm2
* Telemetry control/digital signal cables 0.75 mm2
* Domestic lighting 1.5 mm2
* Domestic general power 2.5 mm2

The neutral core of a cable or the neutral cable of a circuit shall be of the same cross sectional area as the associated phase.

* + 1. **XLPE Single Wire Armoured Cable**

XLPE/SWA/PVC - cross linked low density polyethylene insulated, stranded copper conductors, extruded PVC bedding, galvanized steel wire armoured, flame retardant black PVC sheathed overall, suitable for use on an earthed system at a rated voltage of 0.6/1 kV as specified. Conductor temperature shall not exceed 900 C for continuous operation and 2500 C for short circuit. Cables shall comply with BS 5467.

Installation shall be direct in the ground, in underground service ducts or inside buildings clipped direct to a surface or cable tray.

Non-magnetic armour of hard drawn aluminum shall be used on single core cables.

* + 1. **PVC Insulated Single Wire Armoured Cable**

PVC/SWA/PVC-PVC insulated, extruded PVC bedding, galvanized steel wire armoured, flame retardant black PVC sheathed overall, stranded copper conductors suitable for operation on a system at a rated voltage of 0.6/1 kV. Conductor temperature shall not exceed 700 C for continuous operation. Cables shall comply with BS 6346 and BS 6746 19990/

Installation shall be direct in the ground, in underground service ducts or inside buildings clipped direct to a surface or cable tray.

Non-magnetic armour of hard drawn aluminum shall be used on single core cables.

The cables shall be used on the low voltage (380 V) systems for cable ratings up to and including 10 mm2, or control system as appropriate shall be

* Multi-core, PVC insulated, extruded PVC bedded, single steel wire armoured, PVC over sheathed, or
* Single core, PVC insulated and sheathed, unarmored, or
* Single core, PVC insulated, aluminium wire armoured with overall black PVC sheath.
  + 1. **Polyethylene Insulated Armoured Instrument Cable**

Cables for use as instrument cable shall be to BS 6622 and shall be multi-pair, polyethylene insulated and bedded, single wire armoured PVC over sheath.

* + 1. **Sheathed and Insulated Flexible Cords**

These cords shall be to BS 6500 and shall be 850 rubber insulated, H.O.F.R sheathed.

Flexible cords shall only be used for the following;

* Final connection between fused connection units, having flex outlets, junction boxes, and their associated appliance
* Lighting pendants

The minimum cross sectional area of conductors in flexible cords shall be 0.75 mm2 (24/0.2 mm) and the length not exceeding 400m

* + 1. **Flexible Cables - Power**

Flexible cables where required and used to supply submersible motors shall be 600/1000 Volt grade EP rubber insulated with Niplas outer sheath having flexible, annealed and tinned copper conductors. Alternative, special, standard manufacturer cables may be considered. Details to be provided.

* + 1. **PVC Insulated Cable**

This cable type shall be PVC insulated 600/1000 volt grade copper cable to BS 6004 and shall only be used when enclosed within a conduit or trunking.

* + 1. **PVC Insulated and Sheathed Cable**

This cable type shall be PVC insulated PVC oversheathed 600/1000 volt grade copper cable to BS 6004 and BS 6346 and shall be used as meter tails or transformer tails to switchgear provided that it is protected from mechanical damage. This type of cable shall also be used for direct surface run domestic wiring.

* + 1. **Screened Cable**

These cables shall be PVC insulated, lapped with a non-hygroscopic tape, tinned copper wire braided. Signaling cable shall conform to BT Specification CW 1128 with armouring to CW 1198.

* + 1. **Mineral Insulated Cable**

These cables shall be to BS 6207 and shall have copper conductors with copper outersheath and PVC oversheath, 600/1000 volt grade.

This type of cable may only be used in specific environments or for specific services such as fire alarm systems, or similar type requirements.

* + 1. **Telephone Cables**

Telephone cables shall be thermoplastic insulated multipair telephone type cables having twisted pairs of copper conductors.

* + 1. **Bare Copper Earth Wire (BCEW)**

An earth wire shall be run with any selected cable, and be buried in the trench with it. The minimum size of earth wire shall be as shown on the Employer's Drawings or half the cross sectional area of the cable with which it is laid, whichever is the larger, and fixed to the power cable with nylon tie clips at regular intervals not exceeding 2,000 mm. The earth wire shall consist of annealed bar stranded copper conductor.

* + 1. **Earth Bonding Cables**

Earth bonding cables shall be PVC/PVC type and have stranded copper conductors PVC insulated and sheathed.

## Cable Installation

* + 1. **General**

The Contractor shall plan and position all cable runs so that they do not foul other services, maximum accessibility is maintained and unsightly crossovers are avoided. The cable routes shall be planned along with other services so that agreed service reserves are followed. Details shown on the Employer's Drawings are indicative only.

All cables shall be neatly run, dressed and supported to the approval of the Engineer.

All cable supports and racks together with fixing bolts, clamps, nuts and screws for indoor situations and in cable trenches shall be included, and shall be made from galvanized steel or cast silicon aluminum. Cable supports and racks shall be made by a recognized manufacturer and to the approval of the Engineer. All supports and racks shall be arranged for the easy removal of any single cable is a multi-cable run without threading cables through supports and racks.

The Contractor shall produce a cable schedule so that all information relating to the cables is maintained. This information includes dates of manufactured, dispatch, delivery to Site, installation, initial tests, connecting up and final testing and commissioning. In addition, the Contractor shall maintain a daily/weekly record of the cables as installation proceeds. These records shall be witnessed as necessary and shall form the basis of the Record Drawings.

Where cables are run together in the same tray, trench or conduit they shall be suitably derated or spaced to maintain current rating. Crossovers shall be avoided where possible. Power and signal cables shall be run separately to minimize interference.

Where a number of cables are terminated in equipment, they should finally approach the equipment from a common direction.

The Contractor shall supply all cable tray, cable trunking, saddles, cleats, hangers, brackets, trays, ladders, ties, nuts, bolts, screws, washers, packing and marker tape as may be necessary to complete the installation.

Marker tape shall be 150 mm wide, yellow with black printing "DANGER-ELECTRIC CABLES."

Where cables cross other services or other cables the required separation shall be maintained. In addition, concrete cable tiles shall be provided between the services to maintain the separation and protection, the tiles extending for a distance of 1000 mm either side of the existing services.

Power cables shall be installed without tees or joints unless approved by the Engineer. Cables shall not be installed in areas of direct sunlight. Where this is unavoidable, approved sunshields shall be supplied and installed.

All cable shall be suitably protected. Those running on the external surfaces of structures shall be protected against the effects of ultra-violet light. Where cables are sleeved through conduit or ducts, all ends shall be bushed to prevent damage to cable sheathing. The Contractor shall be deemed to have allowed for cable protection in his rates.

The as-installed drawings provided by the Contractor shall clearly show all services and cables detail dimensions.

* + 1. **Installation Direct in the Ground**

The Contractor shall carry out all excavation, supply and install pipes or ducts where required, prepare the trench bottom, lay cables, provide and install markers and warning tape, backfill, consolidate, compact and make good, including the removal and disposal of all surplus material.

Power cables of rated voltage up to 1,000 V shall be buried at a minimum depth of 600 mm to the cable, Power cables of rated voltage above 1,000 V up to and including 15 kV shall be buried at a minimum depth of 1,000 mm to the cable center. This may only be varied due to the presence of other cables or services.

The bottom of excavated trenches shall be free of sharp stones and other obstacles and shall be covered with sand or fine sifted soil compacted to a depth of 75 mm.

Cable shall be unrolled from the drums in such a manner as to avoid loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp obstacles or stones. A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

Cable shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered with a minimum depth of 100 mm of sand or fine sifted soil. The cables shall be overlaid with marker tape, before backfilling the trench with soil.

Where cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to separate the cables.

Controls and communication cable shall be laid not closer than 1,000 mm to high voltage cables.

When cables are in position in the trenches, an inspection will normally be required by the Engineer before backfilling commences. The first stage of backfilling is to be sifted soil or sand (as specified for the trench bottom) with cover being provided to a minimum of 70mm over the cable. Soft excavated materials free of stones is then backfilled with the backfill rammed every 150mm.

Small stones extracted from the excavated material may be mixed in with the backfill in the final stages, but large stones are to be removed from site. surface material and any hard-core removed prior to excavation is to be backfilled last and well rammed to restore the undersurface to original conditions. Excess backfill is to be removed from the site.

The contractor is responsible for reinstating any damage to gates, hedges, kerb stones, concrete paving, etc, and normally for the surface of any privately owned made up roads. For public roads reinstatement of made up road surfaces will be carried out by the roads. For public roads reinstatement of made up road surfaces will be carried out by the road authority and the trench backfill must be left in a suitable condition as required by the road authority.

Approved surface route markers shall be situated at all joints, bends at minimum intervals of 30 metres on straight runs, as specified. Whenever the cables change direction markers shall be so placed that the change in direction is readily seen.

No cables shall be buried direct in the ground within buildings or concrete covered areas.

* + 1. **Installation in Underground Ducts**

Where cables are laid under roads and paved area more than 1,000 mm wide, they shall be installed in continuous runs of approved underground ducting, generally supplied and installed by others unless otherwise specified or shown on the Employer's Drawings. The Contractor shall be responsible for advising the civil works contractor of all required cable duct locations, these locations being agreed with the Engineer and shown on the Contractor's reticulation Working Drawings.

Underground ducts shall be constructed of impact resistance uPVC and laid at a minimum depth of 600 mm (to the duct center), surrounded by at least 75 mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100 mm shall be laid at a minimum depth of 1,000 mm (to the duct center). The duct shall be encased by 150 mm concrete on all sides.

When installing cables in ducts the following measures shall be observed.

* Cables shall be pulled in a straight line
* Rollers shall be positioned at the edges of draw pits both at the drawing in and drawing out points over which the cables shall be drawn
* uPVC pipes and cables sheaths shall be coated with an approved lubricant
* Sufficient draw-in points shall be provided and adequate room allowed for installation of cables
* The pulling rope shall be guided by rollers

In general, only one power cable shall be drawn into one duct. Where multiple cable systems are used, smaller cables (16mm2 and below) may occupy the same duct. However details must be agreed with the Engineer, and included on the Contractor's Working Drawings.

When a duct is laid in the ground, a draw wire shall be pulled through with at least 1000 mm excess at each end and the draw wire left if the duct is not to be used immediately.

* + 1. **Sealing Cable Entries into Buildings**

Where cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with "petroleum tap" and mastic or silicon foam.

Where cables pass in or out of any duct entries into or within buildings, such entries together with any spare ducts, shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes.

* + 1. **Marking of Underground Cables**

The location of all direct buried underground cables shall be identified by:

* brass plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass though the wall;
* marker posts on road verges, etc., at intervals of not more than 100m and at all junctions and changes of direction along the route;
* Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 150 mm high above ground level with an inscribed brass or enamel metal plat. The inscription shall indicate the presence of a cable below, the depth and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer.

* + 1. **Installation in Cable Trunking**

Cabling trunking shall be manufactured from heavy-duty mild steel of thickness not less than 1.25 mm and hot dipped galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50 per cent spare capacity. Trunking shall have minimum dimensions of 50mm x 50mm.

Segregation of cable shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.

The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick fix type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

Earth continuity straps shall be provided at all connection and jointing points along the route of the trunking to ensure complete earth continuity.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous each wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals as detailed in the IEE Wiring Regulations. Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking or a trunking fitted the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Engineer before any work is started. The run shall be at least 150 mm clear of plumbing and mechanical services.

Trunking systems erected outside a building shall be weatherproof.

* + 1. **Installation in Troughs and Trenches**

Where the building structure incorporates purpose built covered trench systems, to accommodate the cables, power distribution cables may be laid on the floor of the trench providing all cables are readily accessible without the need to disturb other cables. Where the Engineer considers too many cables are present, or where the trenches are not suitable for laying cables on the floor of the trench, supports shall be provided. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.

Where the building structure incorporates general service trenches containing pipe work, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls, Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipe work.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1 mm for trays up to 100 mm width, not less than 1.25 mm for trays from 100 mm to 150 mm width and not less than 1.5 mm width for trays from 150 mm to 300 mm width.

Cable tray and supports shall be to BS 6946 and hot dipped galvanized to BS 729.

Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc rich cold galvanizing paint. Similarly for PVC coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Engineer, together with proprietary cable cleats.

* + 1. **Installation in Buildings**

Cables required to be run on walls, ceiling, or other structures shall be carried on substantial cleats, either in-groups or singly at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

No cables shall be buried directly in the ground within buildings or concrete covered areas.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

Allowance shall be made for expansion and contraction of the cables.

Where cables cross a building expansion joint, due allowance shall be made for cable movement.

The spacing of clips, saddles and clear shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips, etc. shall be by means of non-corrodible screws inserted into approved wall fixings.

Cables hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to the recommendations in the IEE Wiring Regulations.

Ladder racking shall be constructed from heavy galvanized steel secured to walls or ceilings, or by performed galvanized interlocking channel, cast into the structure.

Cables shall be located between 5 mm pegs spaced at 40 mm centers across a rung so that a 40mm or 80 mm space is maintained between cable centers. Cleats shall be used where the ladder racking is vertical.

Wherever ladder sections are cut and shaped on site, cut edges shall be dressed and immediately painted with a coat of cold galvanizing compound.

Cable shall be run at least 150 mm clear of plumbing and below heating and hot water pipe work.

* + 1. **Cable Installation in Conduit**

Conduits shall, in general, be galvanized heavy-duty gauge steel screwed type for outdoor applications. Accessories shall either be malleable cast iron or pressed steel. PVC conduit will be considered for certain installations as specified. Conduits and fittings shall comply with BS 4568, 4607 and 6099 as appropriate and shall not be less than 20 mm diameter.

A space factor of 40% shall not be exceeded, and conduit of less than 20 mm diameter will not be permitted. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed with all sharp edges removed before erection.

Where conduits converge, adapter boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type.

Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All junction boxes, draw-in boxes, and inspection fittings shall be placed so that the cable can be inspected, withdrawn and re0wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory, Fish wires shall to be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.

Ends of conduits which are liable to be left open for any length of time during building operation shall be plugged to prevent the ingress or dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanized flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

Surface conduits shall be secured and fixed by means of distance spacing saddles or clips, which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. Runs shall be properly ventilated and allow for drainage of condensation. All surface conduit runs shall be marked out for approval by the Engineer before the installation is carried out. Where large multiple parallel conduit runs occur, galvanized trunking may be used instead.

Conduits installed on structural steelwork shall be secured by girder clips, drilled and tapped to the steelwork. Power driven fixings shall be used only with the approval of the Engineer. Any drilling or access which is required through any structural member of the building shall be clearly shown on the Contractor's Drawings submitted to the Engineer for approval. The Engineer may either restrict the size and locations of approved drilling or access, or may instruct the Contractor where such drilling or access shall not be allowed.

Exposed threads and plates where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

Concealed conduits shall be securely fixed to prevent movement before laying of screed, floating of plaster, casting of columns or other building operations necessary after the conduit installation.

Crampers or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.

At least 15 mm shall be allowed for finished over the conduit. Where this cover cannot be maintained them expanded metal shall be fitted over the conduit. Conduit cast into reinforced concrete shall be fixed to shuttering to give a flush finish, and the conduit boxes shall be of a type approved by the Engineer for use in such locations.

Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for surface conduits. Draw-in wires shall not be pulled into the conduits during erection. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floor shall be sealed against ingress of moisture.

The Engineer shall inspect the conduit installation before the building operation conceals the work.

Flexible conduits shall be of the waterproof galvanized type of PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough type box. The flexible conduit shall extend from this box to the equipment; the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws, etc. will not be permitted.

Adapter shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

In locations where galvanized conduit would be liable to corrosion, PVC conduit shall be considered.

PVC conduit shall be of the oval or round high impact non-flame propagating type as specified and self-extinguishing. To BS 6099 part 2. Surface and concealed installations shall be generally as described for steel conduit.

PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

Jointing shall be carried out using a PVC solvent and socketed accssessories. Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose made bends may be used providing that the cable-bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperature of between 100 C and 600 C and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16 mm or less shall be 1.5 mm. For deeper boxes the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaries or other heat sources shall have either external fixing lugs riveted to the metal fixing inserts or utilize steel insert clips.

## Cable Terminations, Joints and Identification

* + 1. **General**

Cable terminations shall be provide to suit the requirement specified and shall be either crimp type lugs; crimp type insulated wiring pins or soldered connections.

Where crimp type terminations are used lugs shall only be applied using a crimping tools having a ratchet, which only releases after the correct pressure has been applied.

Excessive solder and "Dry" solder connectors will not be accepted. Care shall be taken to eliminate "dry" solder joints and in removal of excess solder.

Cables lugs shall be of such a size that only the minimum amount of solder is required in order to sweat the lugs solidly onto the tail ends.

The foregoing termination methods are not essential in "domestic" lighting and power installations beyond the final distribution board.

At termination the cores of the cables shall be left of sufficient length beyond the termination to form cable tails for connecting to the equipment. Tails shall be adequately insulated and each cable core shall have its phase identification clearly marked.

Terminations shall be long enough to allow one additional termination.

The installation requirements associated with both the low voltage and control cables are such that, in general, no joints are necessary, the cable distances being such that one complete cable length is required between the various items of Plant. The Tender shall be submitted on this basis, joints only being permitted where authorized by the Engineer. Where joints are permitted they shall be made as set out below.

* Joints in cables shall be made in accordance with the cable manufacturer's recommendations to suit the particular cable type
* All cables shall be joined colour to colour and shall be tested for insulation resistance and continuity before jointing commences
* The seals of the cables shall not be removed until preparations for jointing are complete
* Joints shall be finished on the same day they are begun, and protection from weather shall be provided by the Contractor
* Cast resin moulded type joints shall be used for PVC multicore cables
* The jointing cores shall be insulated by means of several wrappings of PVC tape and then coated with PVC past
* The cable armouring shall be made continuous within the joint and be filled with copper bonding tape and clamps
* A split mould, preferably of PVC, shall encase the joint and be filled with a proprietary brand of polyester resin
  + 1. **Termination of screened signal cables**

Where the termination of a screened signal cable is required the cable shall be bonded to earth at one end only and the termination carried out as follows:

* screen to earth connection - A suitable length of overall sheath shall be removed, the conductors separated from the screen and the screen insulated using a PVC sheath self- coloured green/ yellow. A 30 mm long silicone rubber over sleeve shall be installed over the point of separation of the conductors, screen and overall sheath.
* Isolated screen -Suitable length of the overall sheath and the screen shall be removed and a 30 mm long silicone rubber over sleeve installed over the point of separation of conductor and overall sheath.
  + 1. **Cable glands-general**

Glands shall comply with BS6121. they shall the inner and outer cable sheaths against ingress of dirt and moisture and provide mechanical support. Where cable glands are exposed to the weather these shall be protected by heat shrink plastic tape or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.

Where the apparatus enclosure classification required sealed cable gland entries, sealing shall be achieved by using threaded cable gland holes and polyfluorethylene (PTFE) tape.

Where terminations are to be effected for XLPE or PVC insulated cable, a compression type gland shall be used with means of securing armour wires with the body of the gland, and shall be of a size suitable for the cable used. The gland shall provide both armour moisture seal and outer sheath seal.

PVC gland shrouds shall be provided for all terminations.

Cable glands shall be both electrically and mechanically sound and shall be complete with backnuts and bonded earth tags.

BW type indoor glands shall have a minimum of exposed armoring between sheath and gland. Self adhesive PVC tape shall be applied to exposed armouring and glands before the shrouds and fitted

* + 1. **Identification of Cores and Wires**

Terminal shall be identified by using purpose made indelible markers.

Each core shall be identified, at points of termination, using colour coded slip-on ring type markers.

The wire and associated terminal number shall be identical

Where source and destination terminal blocks have different numbers, cores shall be double ferruled with both numbers.

Unless otherwise specified it shall not be necessary to identify termination in domestic installation beyond the final distribution board.

* + 1. **Power Cable Terminations and Joints**

Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors. Each cable entry into a terminal box shall be made through a suitable gland.

Boxes shall be of adequate proportions to accommodate all cable fittings including stress cones or other means of insulation grading. Boxes shall be openable for inspection without disturbing the gland plate, cable or termination.

Where air insulated terminations are used, the cable crutch shall be protected by a heat-shrink sleeve.

Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

Glands for armoured cables shall provide a positive armour clamp to the box or switchgear coating. This clamp shall completely support the cable weight so that no tension is applied to the termination. The clamp shall also provide earth continuity and be of adequate size to withstand the full fault current of the system for one second.

Where single core glands are required, these shall be non-magnetic. The gland plate shall also be of a non-magnetic material. Removable connections for bonding across the gland insulation shall be provided. The gland insulation shall withstand a test of 2 kV AC for one minute.

Aluminium cores of power cables shall be terminated using approved bimetallic connectors. All glands shall be provided with an earthing tag. For cables of 4 mm2 or less, a serrated washer may be used instead for earth continuity.

* + 1. **Multicore and Control Cable Terminations**

A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

Terminal blocks for terminating cables up to and including 35 mm2 shall securely clamp the conductor, without damage, between two plates by means of a captive screw; pinch screw type terminal blocks shall not be used.

For cables above 35mm2 stud or bolts terminal shall be used, each cable being fitted with a suitable lug.

Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose made solid links shall be incorporated in the design of the terminal blocks.

Terminals which remain energized when the main equipment is isolated shall be suitable screened and labeled.

Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labelled.

Plant which has to be dismantled for maintenance shall have muticore cable terminations made off through glands onto an adaptable box. The box shall have terminal blocks, and connections shall be made to the equipment by single core wires and flexible waterproof plastic conduit. A separate earth core shall link the box to the equipment.

The Contractor shall supply and install complete approved marshaling boxes for both indoor and outdoor use, as required for terminating and marshaling all power and control cables at each item of Plant or en-route as required. Spare pairs shall be included to facilitate cross patching in the even of a fault developing on the operational pairs. All marshaling boxes and terminal within panels and mimic panels shall accommodate all control cable requirements. Details of which shall be agreed and approved by the Engineer.

## Switchgear and Control Equipment

* + 1. **Introduction**

This Section of the Specification covers all switchgear and control equipment up to 1,000 VAC, including distribution switch and fuseboards, multimotor control centers, control panels and desks, as well as individual units, This Section shall be read in conjunction with Sections 3.7.3.8,3.9 and all other related Section of the Specification.

LV switchboards and panels shall comply fully with BS 5486, and be rated and ASTA certified for operation on a 380/220 V 3 phase 4 wire 50 Hz supply. They shall have and a minimum prospective short circuit fault rating of 5 kA or as may be shown on the Employer's Drawings. The fault ratings shall be commensurate with the fault levels of the nerwork to which the components connected. The Contractor shall be responsible for establishing the fault level at each site or compound and designing the panels accordingly.

The Contractor shall be responsible for checking the panel and switchgear manufacturer's drawings, together with all necessary interfacing requirements with EEU and other. He shall signify his approval in writing to the Engineer, and submit copies of all manufacturers’ drawings for the Engineer's approval. The Contractor shall be responsible for carrying out measurements of prospective short circuit current and earth fault loop impedance at each LV switchboard/distribution board upon completion of the works and shall incorporate the actual values onto the 'as-installed' drawings.

* + 1. **Construction-General**

Switchboards and control panels shall be flush fronted and accessed, manufactured from 2.0 mm minimum thickness mild steel, multi-cubicle type. They shall be of folder and welder construction forming rigid units. Floor mounted panels shall be equipped with a mild steel channel bed frame at least 100mm high to ensure rigidity and shall be impervious to corrosion by rust. Small units may be of the wardrobe type.

The switchboards and control panel shall generally be of the industrial/enclosed modular cubicle type the switchboards and panels being of the cubicle pattern suitable for floor or wall mounting, comprising a sheet steel cubicle with front access as required and specified complete with bus bars, circuit-breakers, fuse switches and MCCB's. They shall be of uniform height, rigid construction and neat appearance.

Where rear access is possible removable covers shall be provided for cabling etc. Separate cable compartments shall be provided.

All switches and breakers shall be individually labelled, showing the circuits controlled, by means of laminated plastic labels showing black letters on a white background.

Busbars shall be copper on insulated supports and capable of withstanding the fault level on the system at that point.

Switchgear shall be heavy-duty, cast metal enclosed type, dustproof, and capable of operating on load at the rated current. Contacts shall be heavy-duty silver surface type.

Cubicles shall be rigidly constructed. Those accommodating heavy-duty switchgear shall be provided with an angle iron or heavy gauge folder steel framework, paneled in zinc-anneal or galv-anneal.

All mounting brackets and additional items shall be supplied and installed to suitably support the switchboard in the position in which it is to be erected.

Ventilation shall be provided where required, with fine bronze mesh and suitable trim fitted to prevent entry of insects.

Dust tight enclosures shall have ample volume to dissipate heat, which may be generated in service, and doors shall be provided with a neoprene seal fitted with a channel and closing against a suitable folder edge or ridge. Moulded sealing strips may be submitted for approval as alternative.

Switchboards and control panel shall consist of incoming fused switches, circuit-breakers or isolators, and outgoing circuits controlled by fused switches, switch fuses, MCB's and MCCB's required and as shown on the Employer's Drawings.

No live metal shall be exposed by the removal of normally closed or fixed door or panels. Shrouds or insulated barrier pieces shall be provided.

The use of either circuit-breakers or fused units is subject to final approval by the Engineer. Alternatives to the use of the circuit breakers indicated will be considered, but only as an alternative.

Entry of cables, ducts, and conduits shall be neatly made and head boxes shall be provided as required. All entries and opening shall be vermin-proof.

The maximum height of panels shall be 2,200 mm above finished floor level.

Where switchboards are split for delivery each section shall have a maximum width of 2,000 mm and a maximum mass of 1,000 kg with removable eyebolts provided for lifting.

The switchgear, distribution boards and terminal cabinets shall fit in the spaces provided as indicated on the drawings. If there is any reason why a board will not fit into the space indicated on the drawings, the attention of the Engineer shall be drawn in good time to enable alternative arrangement to be made, either to the board or to its fixing position. It shall be the responsibility of the Contractor to verify the suitability of the space provided before trays of boards are fixed.

Unless otherwise specified, all contactors and relay control circuits shall be connected to an AC supply of a maximum of 240 volts.

Isolation of a control circuit supply to one or a group of starters shall not interrupt supplies to other starters.

All fuses shall be of the HRC type to BS88. Fuses rated 30A and below shall be mounted in approved withdrawable fuse Carriers. Carriers containing links shall be coloured white, whilst carriers containing fuses shall be coloured black.

Timer delay relays shall have a good repeat accuracy and the direction of adjustment for increasing and decreasing the timing period shall be clearly marked.

The circuit breaker associated with each starter shall be a triple pole unit rated for stalled motor duty and shall comply fully with the relevant British Standard. A padlocking facility shall be provided for locking in the OFF position.

The circuit breaker shall generally be houses within the same compartment as the starter with which it is associated and shall be mechanically interlocked with the compartment door.

The control supply shall be broken by auxiliary contact on the circuit breaker in the open position.

The switchboards and panels shall be designed so that they can be extended in the future with the addition of further busbar/cubicle sections.

* + 1. **Mounting**

Fixings for floor mounted switchboards and panels shall be by not less than four holding-down bolts at the front and rear of the equipment. They shall not be visible from outside the panel, but be readily accessible from within.

At least four lugs shall be provided for bolting wall mounted switchboards and panels to the wall. Fixings holes shall not be provided inside the panel, which shall stand at least 10mm off the wall surface.

Fixings for post/column switchboards and panels shall be provided outside the enclosure. The back of the enclosure shall be drilled to accept fixings.

All mounting brackets, supports and additional items shall e supplied and installed to securely support the switchboards, panels and cubicles in position.

* + 1. **Cubicles**

Separate cubicles shall be provided for each of the following:

* Incomer
* Bus-section
* Motor starter
* Common controls
* Telemetry
* Distribution board
* Feeder
* Outgoing terminations
* Other specified equipment

Each cubicles having its own door shall be totally separate from any other so that work can be safely carried out in one cubicles while other are still live.

* + 1. **Doors and Covers**

Doors shall be adequately sizes to readily and neatly accommodate all equipment to be mounted on them. They shall open at least 120 degrees, be rigidly constructed, suitably braced and provided with at least tow substantial hinges, which shall be captive when the door is closed.

Lockable catches shall be used each being provided with 3 keys on individual ring having a nameplate showing its identity details. Locking combination requiring different keys shall be approved before manufacture.

Where padlocking facilities are specified, the padlocks will be supplied.

No equipment shall be mounted on covers, Large covers equivalent to half full height and above, shall be provided with handles to facilitate removal and replacement.

Each door and cover shall be provided with an internal welded earthing stud, and shall be bonded to the switchboard main earth bar.

Doors and covers giving access to potentially live conductors shall be proved with prominent warning labels,

Suitable shrouds or covers shall be provided for all live terminal and termination, such that accidental contact cannot be made by the operators or maintenance staff.

Where required, provision shall be made for inter-locking the incoming EEU supply and standby diesel supply such that paralleling cannot take place under any circumstance. The inter-locking shall be by an approved means, castelle keys being provided such that the front covers for any unit cannot be opened when the switch is in the "ON" position and the switch cannot be operated when the cover is in the open condition. Flexible earth continuity bonds shall be provided for all hinged and swing panels.

* + 1. **Component Mounting**

Each cubicle shall be provided with a removable rustproofed steel backplate bolted to studs welded onto the rear of the cubicle. All components, other than door mounted, shall be located on the back plate by bolting into tapped holes or using self-tapping screws. Nuts used to fix components shall be captive on the back plate. DIN rail type fixing may be used where appropriate.

Components shall be so mounted to prevent shock being transmitted from large components and thereby adversely affecting their proper function. The components shall be arranged to give adequate accessibility for maintenance and for removal of any one component with the minimum disturbance to the wiring. Plug in connectors shall be used where possible.

* + 1. **Cabling Arrangement**

Cabling shall enter panels through removable gland plates of not less than 3 mm thick steel or brass (for single core cables) fitted at least 350 mm above floor level, the final height being dependent on the cable sizes and bending radii. They shall be rustproofed and provided with a welded and bonded earthing stud and adequately sized to accommodate present and known future cabling requirements. Access to both sides of each gland plate when it is position shall be possible from within the equipment. Cabling shall enter at the top and/or bottom of panels as appropriate, and have a suitable means of fixing.

Gland plates are not necessary on small individual starters where access shall be by "knock outs" Gland plates shall be removable for drilling.

* + 1. **Bolts, Nuts, Washers and Screws**

All bolts, nuts, screws and washers used for the construction of the switchboard shall be nickel or cadmium plated, except fixings on the face of the switchboard, which shall be stainless steel.

* + 1. **Protection and Finish**

The internal colour shall be white and the protection of externally mounted components shall be no less than that of the panel on which they are mounted. External colours shall be grey unless otherwise specified or approved. Full colour details to be submitted with the Tender.

Cases shall be rubbed down, undercoated with suitable primer and finished in not less than 2 coats of hard enamel, oven baked where practicable,

Externally mounted panels shall be protected to IP65 (weatherproof), with a rear sloping weather canopy projecting over the front by at least 150 mm. Door-mounted components shall be protected by a vandal resistant secondary glazed door so that all controls and indicators are clearly visible. Doors shall be locked and provided with stays.

Protection classification for all internal boards and panels shall be IP54 unless there is a specific requirement and the manufacturer considers that a particular compartment requires louvered ventilator. In such a case the classification shall be not less than IP31. Louvres shall be provided with fine mesh screens, as specified in Clause 3.6.2.

Externally mounted panels shall also be protected from the sun, a sun canopy being provided. The canopy shall overhang the panel by a minimum of 500 mm on all sides and shall provide an air gap above the panel of at least 200 mm. Proposals shall be submitted with the Tender.

* + 1. **Auxiliary Supplies and Anti-condensation Heaters**

Control supplies shall be 110 V or 220 VAC, derived from a transformer within the panel or a 4 wire 3 phase supply fused on its primary and secondary winding, each cubicle being separately sub fused so that a fault in one cubicle does not affect others.

Supplies to equipment mounted on the panel such as instruments shall be 110 V or 220 V AC derived from the control supply. Major items of equipment shall be separately fused. Other items within the same cubicle may be collectively fused, but separately from the control supplies.

Anti-condensation heaters shall be proved in all control panels, switchboard and motors to prevent internal condensation due to atmospheric or load variations.

Anti-condensation heaters within switchboards and panels shall be provided at the bottom of each cubicle to maintain an internal temperature of 50 C above ambient. An adjustable thermostat with clear scale shall be installed at the top of each cubicle to limit the maximum temperature. Each heater shall be individually fused and provided with an isolation switch.

All heaters shall be rated for 110 V or 220 V AC and shall derive their supply from the control supply circuit.

Motor heaters shall be switched by normally closed contacts on the main contactor (s) such that the heater is energized when the motor is de-energized and vice versa. The heater circuit shall include an isolating switch and indicator lamp to show 'Heater Circuit On'. The heater shall be energized from a 110 V or 220 V 50 Hz supply.

When maintaining plant fitted with heater it will be necessary to switch off both the main isolating switch and the switch for the heater. A warning notice of this danger shall be fitted near the terminal box of every remote heater and at every panel or switchboard with heaters.

All such plant, whether fitted with a heater device or not, is to be provided with suitable drainage and to be free from pockets in which moisture can collect.

All indication lamps shall be separately fused and protected.

All panels, switchboards and three phase motor starter shall be fitted with line indication lamps so that the operators and maintenance staff can readily identify the operation of all phases.

All protection components, under/ over voltage relays, phase failure relays, etc., shall be provided with a visual identification to show when operation has occurred. Details shall be provided.

In addition to the individual lock-off emergency stops specified for each motor and rotating plant the composite motor control panels and/or switchboards supply separately mounted starters shall be provided with an emergency "main" button such that all rotating plant can be immediately shut down. Auxiliary contacts shall be provided to enable this shut down circuit to be extended to remotely sited main buttons should this be a future requirement.

All switchboards and motor control panels shall be fitted with a separately fused 13 ampere switched socket for maintenance.

In addition, larger panel shall be fitted with their own-switched internal lighting system to facilitate maintenance. The fused circuit shall be extended from the live side of the incoming switch, suitable warning notices shall be provided to advise operators that the isolation of the main incoming switch/breaker does not render these circuit in operative.

* + 1. **Busbars and Main Connections**

Each switchboard or control panel as may be required shall be equipped with a set of 3 phase and neutral air insulated busbars rated for a current of not less than the future connected load.

Busbars, risers and droppers shall be ASTA certified and manufactured from solid copper fully complying with BS 5486, Part 2, enclosed in a separate chamber and shall be continuous over each section of panel as assembled prior to shipping, with the facility for future extensions at both ends of the panel. Busbars shall not be drilled for outgoing connections, which shall be made with clamps.

The riser and dropper bars shall be of an approved a minimum prospective short circuit fault corresponding to the let through energy of a protective MCCB of equal rating to the busbar rating and connected to a prospective symmetrical fault level of 5 kA r.m.s.

The busbars shall be housed in their own compartment running the length of the switchboard or panel and shall not be exposed when any of the access doors or plates (other than those provided for busbars access) of the panel are moved for maintenance or other work.

Auxiliary bus wiring between units shall be protected and accommodated in areas other than the main busbar chamber.

All busbars shall be air-insulated, with tinned and bolted connections, clearly painted in correct colour of red, yellow, blue of the phase and black for the neutral.

It shall be possible, by removing covers, to readily gain access to all busbar, riser, and dropper joints in order to check tightness of nuts and bolts.

The framework and cable armouring clamps shall be efficiently bonded (with continuous copper strip) mechanically and electrically to the building and switchboard main earthing system. A high conductivity copper earth bar shall be bolted and efficiently bonded to the main frame to run the full length of each panel. This shall be color coded yellow/green. Flexible earth continuity conductors/bonds shall be provided for all hinged doors and swing panels

* + 1. **Balance**

The entire installation shall be balanced to the satisfaction of the Engineer and the Contractor shall carry out such alterations to switchboard connections as may be required to balance the installation.

* + 1. **Circuit Lists**

The switchboards and distribution boards shall be fitted with a typed circuit list in the form of a card within a transparent envelop fixed to the inside door or each panel and distribution board. The form of the chart shall be to the approval of the Engineer and shall contain the following details:

* 1. Incoming cable type and size including any circuit protective conductor
  2. Size and type of incoming protective device
  3. Measured values of earth fault loop impedance and prospective short circuit current at the board
  4. Size and type of protective device on all outgoing circuits
  5. Size and type of cables on all outgoing circuits including circuit protective conductors.
  6. Block layout of switchboard components to assist maintenance staff in the identification, operation and function of each component.

## Motor Starters

* + 1. **General**

All starters and controllers shall comply in all respects to BS 587 and/or BS 775; Part 2, and BS 5424: Part 1, and shall form complete individual package units or complete units within the switchboards.

The control and protection arrangement shall be suitable for the type, size, voltage and duty capability of the relevant motor and the supplier shall state in detail the control and protection equipment which he proposes to used for each type and size of motor.

The starters shall be of the triple pole air breaker type. Unless otherwise stated, for motors up to and including 7.5 kW the starters shall be of the "Direct-on-Line" type capable of operating the relevant motor 15 times per hour, suitable for remote automatic and local push button manual operation.

Unless otherwise stated, for motors over 7.5 kW the starters shall be of a current limiting type suitable for remote, automatic and local manual operation. The type of starter shall be selected with due regard to the nature of the load being driven to ensure that the starting current does not exceed 2.5 times the full load current. Current limiting starters shall be of the Korndoffer autotransformer or star delta type. The number of starts per hours for each motor rating shall be stated, this generally being a minimum of 5. Details are to be included in the Data Schedules.

In general each motor starter shall be equipped with the following basic equipment:

* Door interlocked, fault make/load break, on load, incoming main circuit breaker.
* Contactors which shall be of the air break type fitted with arc chutes, magnetic blow outs and heavy hard drawn copper main contact. Interlocks shall be provided to prevent simultaneous closure of the star and run contactors.
* Timing relay, where required, shall be electomagnetically-operated controlled timing of contactor sequence; a fully adjustable eddy current retarding mechanism shall be provided where necessary to suit the nature and conditions of the motor.
* Continuously rated operating coil (voltage to suit control conditions of 230 V).
* Auxiliary contacts for remote automatic control
* Adjustable over voltage relay unit
* Adjustable under voltage relay unit
* Overload relay device suitable for adjustment with calibration plates scaled in amperes. A door mounted reset facility shall be provided
* Control circuit fuses and links
* Relay to protect against single phasing.
* Ammeter of the moving iron type mounted on the starter and operated by a current transformer, where justified by rating, and complete with phase selector switch.
* Provision for remote emergency stop button, float controls, etc..
* Hours run counter
* Anti-condensation heater with thermostatic control
* Supply on, Running and Tripped indicator light
* Phase identification lights
* Test facility
* Hand/off/manual selector switches as required.
* Motor winding over-temperature release shall be provided in conjunction with the specified thermistor protection
* Duty selection switch as appropriate
* Manual Stop/Start push-buttons
* Relays to operate in conjunction with anti-vibration protection on larger motors shall be provided where specified.
* Relays to operate in conjunction with bearing temperature thermocouples on larger vertical spindle motors are to be provided where specified.

\* These facilities shall be door mounted.

Each starter shall be provided with a test facility enabling the control circuits to be energized only when the starter isolator and cubicle door are open. It shall not be possible to close the cubicle door with the test facility still switched on.

General layouts of the switchboards, control panels, etc. shall be submitted for approval before commencing manufacture. The final layout of all switchboards, panels, etc. shall be to suit the motor loads, standby diesel sets and mode of operation.

Suitable relays and timers shall be provided to prevent the simultaneous starting of the pump sets unless the operating and protection systems are designed to accommodate the resulting starting surges.

* + 1. **Instruments, Indications and Alarm**

The operating push buttons, switches or handles of all circuit-breakers, motor starters, isolators, etc. shall be located on the front of cubicles, or for cubicles of the desk type, on the face of the desk. There shall be visual indication of the "ON" and "OFF" positions. The stop push-buttons (and remote emergency stop buttons) shall be operable at all times and for all modes of operation.

All operations of fault and alarm circuits shall be clearly and individually indicated by lamps on the fascia of the switchboard. Fault and alarm lights shall remain on until the associated fault or alarm condition has been cleared and the system reset. An audible alarm shall also be provided to indicate operation of any major fault or alarm function. Acknowledgement of the major fault or alarm condition shall also cancel the audible alarm.

Indicating lamps shall incorporate a lamp test feature with either individual push to test or a common lamp test button.

Lamps on outdoor equipment shall be shaded from sunlight so that their operation can be clearly seen at all times of the day.

Push buttons fitted on the panel shall be of the shrouded type, unless otherwise specified, and shall have a label indicating their function.

Indicating lamps on panels shall be rated to withstand not less than 20% continuous over voltage and shall be so designed that the heat from the bulb does not discolor the panel.

Indicating lamps fitted into the fascias of switch and instrument cubicles or panels shall be adequately ventilated.

Lamps shall be easily replaceable from the front of the panel by manual means preferably without the use of extractors.

The bezel of metal or other approved material holding the lamp glass shall be of an approved finish and easily removable from the body of the fitting so as to permit access to the lamp and lamp glass.

The lamps shall be clear and fit into a standard form of lamp holder. The rated lamp voltage should be 10 per cent in excess of the auxiliary supply voltage, whether AC or DC. For AC circuits lamp units shall be connected to the 110 V supply and shall have an integral transformer providing a 6 V supply to the lamp.

The lamp glasses shall comply with BS 1376 and BS 4099 and are to be in standard colours, red, green, blue, white and amber. The colour is to be in the glass and not an applied coating and the different coloured glasses are not to be interchangeable. Transparent synthetic materials may be used instead of glass, provided such materials have fast colours and are completely suitable for use in tropical climates and remain unaffected by the lamp temperature.

To comply with BS 4099, as a general principle, the following colours shall be adopted:

Green - Supply available but switch, starter, etc., in the open position

White-Switch or starter, etc., closed and plant running correctly

Red- Overload trips operated or major fault on plant

Amber - Warning signal, i.e, overloading of machine, high temperature, etc.

Blue- As necessary for other indication

Indicating lamps and push buttons shall be clouted in accordance with IEC 73 and in particular as follows:

Indicating Lamps Colours

On White

Off Green

Fault Red

Alarms Yellow/Amber

Heaters Blue

Push Buttons Colour

Start Green

Stop Red

Alarm Accept Acknowledgment Black

Emergency Stop Red

A separate indicator light or other means of indication shall be provided for each separate motor protection device to indicate activated.

Live line indication shall be provided at all panels so that the supply status in all compounds, pumps stations or facilities is readily available to operators and maintenance staff.

Indicating light bezels manufactured from plastic will not be acceptable.

All electrical indicating instruments shall comply with BS 89,BS 3693 and IEC 51, be of the moving iron spring controlled type self contained instruments to Class 1.5 or better. Instrument size shall be 96 mm square with quadrant scale.

All instruments shall be back-connected mechanisms well protected by strong cases which shall be earthed and fully insulated. They shall be clearly readable with black markings on a white background. A red pointed shall be provided, adjustable (with a tool) from the front of the instrument, to indicate the normal or maximum reading.

Instruments shall be of the industrial grade and shall have a means of zero adjustment from the front without the need for dismantling. They shall be capable of sustaining the normal full load current, voltage, (via current transformer of other transducer as necessary) and shall not be damaged by the effects of faults in the system being monitored. Scales shall be of the 2700 type.

All wiring, space and connections and other items shall be provided for tariff meters, ammeters, voltmeters, selector switches and the like as applicable.

Instruments shall be flush mounted on the cubicles and effectively sealed against ingress of moisture, dust and insect. Instrument mounting height shall not exceed 1.80 meters above floor level. Unless otherwise specified instrument full scale deflection shall be at least 120% of the normal operating point (i.e. nominal voltage or full load current).

All relay cases shall be lack glass finish.

All voltage circuits of instruments shall be protected by a fuse in each unearthed phase, situated as close as practicable to the point of connection.

Voltage selector switches shall give phase to phase, phase to neutral readings. The class of accuracy of all metes, voltage transformers and current transformers shall be provided with the Tender.

Voltmeters shall be suitable for operating from the secondary side of the 110 V voltage transformer.

Ammeters in motor circuits shall be capable of withstanding the staring current of the motors and shall have a compressed overload scale for this purpose. The full load current shall be defined with red line. Voltmeter scale shall have a red line indicating normal voltage.

Current transformers shall have short circuit ratings not less than those of the circuits with which they are concerned, and shall fully comply with BS 3939/

Separate current transformer shall be provided or protection and instrumentation duties. The rated burden of all current transformers shall be a minimum of 150% of the sum of the burden to be imposed.

All protective relays, where provided, shall be fitted with indicating flags.

Instruments and relays shall be removed from the switchboards for transport and delivery and shall be packed in case and transported and delivered with the associated switchboard.

Where specified, capacitors for correcting power factor shall be incorporated in the panel. Such capacitors shall comply fully with BS 1650.

All motors shall be provided with emergency stop push buttons mounted on or adjacent to the motors, which shall lock out the control circuit and shall require a key to reset the circuit.

* + 1. **Control Panel Cabling**

Control wiring for motor control panels, switchgear, etc., shall be 600 volt grade PVC or XLPE insulated multi-stranded copper wire to BS 6004 or BS 6007. The minimum size shall be 1.5 mm2 stranded conductor.

All terminals shall be referenced and detailed on the schematic diagrams to be submitted to the Engineer.

It shall be possible to gain access to any terminal of any component so as to be able to remove and replace the wire from that terminal without recourse to special tools, and without the need to disturb other components.

All wiring shall be neatly run bunched in neat forms. All wiring accessories of plastic materials, such as cleats, conduits, strapping, etc., shall be non-corrodible and resistant to flame propagation.

Crimped pin extensions shall be fitted to all control circuit cables to prevent wandering strands before being inserted into Klippon type terminal blocks.

Cabling shall enter the panel from above or below as applicable and as specified elsewhere in the Specification. Cables shall be terminated using external boxes or internal gland plates.

Where necessary cable tray work shall be provided for supporting and fixing cables, and full glanding and terminating equipment and facilities shall be provided. Gland plates shall be mounted not less than 150 mm above the cubicle bottom. It shall be possible to terminate all cables without requiring access to live interiors.

Primary cabling shall be completely isolated from all control wiring, etc., and auxiliary terminals shall be likewise isolated from primary terminals.

All terminal boards and terminal blocks shall be of a type providing a positive mechanical clamp on connection. Terminals for the connection of all external cabling shall be situated near their respective gland plate and at a minimum distance of 200 mm from it.

Separate terminals shall be provided for incoming and outgoing connections and not more than two wires shall be connected to any one terminal.

Supplies for the motor heaters shall be controlled automatically by the main contactor such that the heater is on when the motor is de-energised. Motor heaters shall be separately fused and provided with termination facilities. Details shall be provided for approval.

## Switchboard and Control Panel Components

* + 1. **General**

Switchboard and motor control panels shall include all components specified together with the following, fully detailed drawings and manufacturers specifications and component details and catalogues shall be provided for approval.

* + 1. **Air Circuit-breakers**

Air circuit-breakers shall be 3-pole and neutral or 4-pole where used in conjunction with a standby generation scheme, spring-operated, withdraw able type having the following minimum features:

* Mechanical and electrical interlocking.
* Mechanical open, closed, spring-charged, and tripped indication.
* Trip-free mechanism
* Manually or motor wound spring closing mechanism
* Facilities for padlocking
* At least one unused volt-free changeover auxiliary contact, wired down to outgoing terminals.
* Magnetic and thermal adjustable overload, short circuit and earth fault protection with facilities to prevent unauthorized adjustment.
* Mechanical trip push-buttons

Additionally and where necessary

* Closing solenoid
* Shut trip coil
* Under voltage trip coil

These features shall be provided to suit the specified operational requirements at the various compounds, the details of which shall be agreed.

If circuit-breaker carriages cannot be comfortably handled by one man, a suitable trolley shall be provided.

* + 1. **Contactors**

Contactors shall be block type, equipped with auxiliary contacts for all necessary indication, local and remote control requirement together with a means of mechanical indication to show when it is energized. They shall generally be of the triple pole air break type, electromagnetic ally operated with inherent no volt feature. Each contactor shall have a minimum of three spare auxiliary contacts.

Rating of contractors shall be strictly according to manufacturer's instructions

Contractors shall be suitable for continuous heavy duty and normally fitted with 220 volt coils. They shall be of the robust construction to BS 775, BS 4941, Part 1 and BS 5424 Part 1, 1997 where applicable, and rated at not less than the current carrying capacity of the outgoing circuit.

Contractors shall comply with IEC 158, Part 1 and those for motor circuits shall have made and break capacity of the motor starting current and mechanical duty of double the frequency of starts under the most extreme operating conditions with an absolute minimum of three consecutive starts from cold and five starts in any one hour when hot.

* + 1. **Current Transformers**

Current Transformers shall be of an appropriate class and accuracy for the application, with outputs such that the combined relay. Instrument and internal burden is not greater than 60% of the rated output of the current transformer. They shall be securely fixed but have provision for easy removal and replacement. Details shall be submitted for all current transformer types being supplied.

* + 1. **Fused Switches and Isolators**

Fused switches and isolators shall comply fully with BS 5419 and shall be air-break, door interlocked and pad lockable in the off position, preventing the cubicle door from opening. They shall be mounted on cubicle back plates, with a spindle connecting each switch or isolator to a door-mounted actuator. Spindles shall be kept short or be provided with an intermediate support, so that they readily engage the actuators when the door is closed.

Fused-switch units, where installed, shall be of the flush type, totally enclosed in sheet steel cases and door. Units shall be dustproof and capable of operating on load at the rated current. Contacts shall be heavy duty silver surfaced type, and in open position the fuse elements shall be disconnected from both line and load terminals. HRC fuse elements shall be fitted to each unit, of correct rating for the outgoing conductors, which they protect.

Where operating handles of the units protrude in front of the board, they shall be of either the removable or telescopic type.

Fuse switches not forming part of composite panel shall be as specified above nut suitable for wall mounting in an enclosed sheet steel case.

Fused switches shall be fitted with appropriately rate HRC fuse links in each phase and a solid like in the neutral.

Sufficient auxiliary contracts shall be provided to isolate all incoming power supplies to the cubicle. The fuse switch main contacts shall be open in the test position.

Moving contacts of fused switches shall, for maintenance purposes, be safety and readily removable as a complete assembly when the remainder of the switchboard in energized.

The fuse switch associated with each starter shall be a fully shrouded triple pole unit rated for installed motor duty and shall be housed within the same compartment as the starter with which it is associated and shall be mechanically interlocked with the compartment door.

A padlocking facility shall be provided for locking in the OFF position and minimum of four spare auxiliary contact shall be provided in each unit.

Switch fuse units shall be generally as specified for the fused-switch units and shall be of a similar pattern and form the same manufacturer.

* + 1. **Fuses and Links**

Fuses shall be of the high rupturing capacity cartridge type complying with BS 88 and rated according to their function in accordance with the manufacturer's recommendations. They shall be fixed inside panels behind a 3mm polished bakelite escutcheon panel which shall be readily removed, and to face the doors, at sufficient spacing to facilitate easy fuse/link withdrawal.

Fuse holders and carriers shall be coloured black, and link holders and carriers white.

Both fuse holder and fuse element where provided shall be correctly rated for the duty required. Fuses and links shall be grouped where appropriate according to their functions and shall be clearly marked both on the panel and the associated wiring diagrams.

Spare fuses shall be provided and fitted into clips within the switchboards, three fuses to be provided for each of the ratings installed. Details to be agreed to suit each switchboard/panel.

* + 1. **Hours Run Counters**

Hours run counter shall be of the cyclometer type, suitable for flush mounting and non-resetable, having 6 digits (minimum) plus tenths, and with a readily visible indicator to show that they are operating.

* + 1. **Moulded Case Circuit-breakers**

Moulded case circuit breakers shall be manufactured in accordance with the requirement of BS 3871 Part 1, BS 4752 Part 1, or IEC 157.

Unless otherwise specified circuit breakers shall be category P2 in accordance with IEC 157 requirements of the fixed pattern, triple pole and neutral, and four pole where used in conjunction with a standby generator unit.

Moulded case circuit breakers shall employ a trip free mechanism capable of simultaneous operation of all poles and providing contract clearance and contract position indication sufficient to allow the circuit breaker to be employed as an isolator. Contact clearance shall conform to the minimum figures specified in draft BS PD 6499 and/or the equivalent IEC standard. Circuit-breaker closing mechanisms shall be manually operated unless otherwise specified.

Unless otherwise specified moulded case circuit-breakers shall be fitted with a thermal overload device to provide an inverse time characteristic and magnetic trip device adjustable for all ratings of MCCB in excess of 100 A. The following, minimum, features shall be included:

* Mechanical and electrical interlocking
* Mechanical open, closed and tripped indication
* Trip-free mechanism
* Facility for padlocking without the use of loose components
* At least one unused volt free changeover auxiliary contract, wired down to outgoing terminals, for remote indication.
* Shunt trip coil and under voltage trip where required.

Full details of the units being offered shall be submitted with the Tender.

* + 1. **Miniature Circuit-breakers**

Miniature circuit breakers shall be manufactured in accordance with the requirements of BS 3871, Part 1. Unless otherwise specified miniature circuit breakers shall be category M5 and Type 1, 2, 3 or 4 as specified.

Miniature circuit breakers shall be single pole or triple pole as specified and shall be suitable for the type of load that they feed. They shall be fault rated so that back-fuse protection is not required and shall include clearly marked ratings.

Miniature circuit breakers shall be suitable for bolted or clip fastening to busbar assemblies and may be assembled together to form a distribution board.

Unless otherwise specified miniature circuit breakers shall be provided with manual trip free mechanism and thermal and magnetic trip elements to provide inverse time overload and instantaneous over current operation to the characteristic required.

For special application, as required by the IEE Regulations or as specified herein or shown on the Drawings or in the Schedules, miniature circuit-breakers employing residual current detection and tripping operation shall be employed.

Such units shall be rated to detect and operate at an earth leakage current of 30 mA, unless specified otherwise.

RCD's shall be used in conjunction with, and not in place, of miniature circuit breakers, the MCB's providing the overload and short circuit protection requirements of the circuit.

* + 1. **Overload Relays**

Overload relays shall be of the thermal type with inherent ambient temperature compensation and single phasing protection. They shall be of the manual reset type, having mechanical indication of the tripped conditions, respectable without opening the compartment door.

Calibration shall be adjustable between 80 and 150% of motor full load current.

On motor drives, of 100 kW and above, over current relays shall be of the definite minimum and inverse time limit pattern.

* + 1. **Voltage Protection Relays**

Regulation at certain towns has proven to be a source of plant failure and damage. Adjustable protection relays suitable for providing both under voltage and over voltage protection shall be included within the starter units. Full details shall be submitted with the Tender. The relay units shall suitable for voltages of + 10% and - 15% of the nominal voltage.

* + 1. **Phase Failure Relays**

Phase failure relays shall be connected to all phases and neutral and shall de-energise at or below 90% of rated voltage on any one or more phase. The relays shall be separately fused with contacts wired down to outgoing terminals.

* + 1. **Push Buttons**

Push buttons shall be at lease 25 mm in diameter with chromium plated or similar Bezels. Plastic Bezels will not be acceptable.

They shall generally match indicating lamps in style, start push button being recessed to prevent accidental operation. Stop push buttons shall be recessed.

Emergency stop push buttons shall be of the "stay put" mushroom-headed type. Composite motor control panels shall include a door mounted emergency stop button that will automatically shut down all pumping

* + 1. **Relay Units**

Relay shall be either of the plug in or block type.

Plug-in relays shall be fitted with transparent plastic dustproof covers, retaining clips a bases into which the relay plugs and external connection, made using easily accessible screw clamp terminals. Bases and relays shall be keyed to prevent relays being plugged into incorrect bases.

Block type relays shall be totally encapsulated.

Relays shall have changeover contacts and a means of visually indicating that they are energized.

The pin configuration of each relay shall be printed on the casing and on the schematic diagrams.

Time delay relays shall be of the multi-pin plug-in type and adjustment for increasing and decreasing the timing period shall be clearly marked.

* + 1. **Residual Current Devices (RCD's)**

Residual current devices shall be back connected (behind the door), current operated, with a sensitivity of 30mA, door mounting so that the test push-button and operating lever is readily accessible.

Operation of RCD's shall not be impaired by any DC component in the current.

* + 1. **Selector Switches**

Selector switches shall be of the rotary type spring loaded to ensure clean controlled operation having bezels at least 50mm square with all switch positions fully and clearly identified.

They shall be equipped with sufficient contact of the correct rating and type, if necessary by means of auxiliary relays, to enable all control/indication/alarm requirements to be fulfilled.

Operating handles shall be interchangeable and securely fixed to the switch mechanism by a keyed shaft and recessed retaining screws.

Where lockable switches are provided it shall be possible to operate them without the key, but also possible to luck them in any positions and withdraw the key.

* + 1. **Terminals**

Removable DIN rail terminals shall be provided for all wiring, mounted at an angle to provide ease of access, with center-disconnecting like type terminals for analogue signal circuits, isolation or test purposes, sufficient, suitable sized earth terminals, and end and earthing end stops

All terminal boards and terminal blocks shall be of a type providing a positive mechanical clamp on connection. Terminals for the connection of all external cabling shall be situated near their respective gland plate and at a minimum distance of 150 mm from it.

All main phase terminals shall be suitable marked to ensure that the correct phase rotation is obtained when the plant is connected to the supply.

Separate terminals shall be provided for incoming and out-going connections and not more than two wires shall be connected to any one terminal.

Barriers shall be provided on all banks to group terminals into logical divisions and between power terminals of different phases.

Control terminals shall be separated from power terminals.

Outgoing terminals shall be grouped on a common rail in the termination section. Each group shall comprise terminals common to a motor starter reference or alternatively, for control circuit wiring, grouped or barriered with regard to the voltage levels.

In all cases care shall be taken to ensure that terminals are easily accessible after all wiring has been installed and terminated. All connections shall be made on the front of terminal blocks.

No more than two conductors shall be connected to one side of a terminal. Outgoing cables shall be wired so that all panel wiring is connected to one side only.

The terminal numbers, voltage grouping, and terminal block layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring cab be made.

All terminals shall show the circuit wire number reference.

* + 1. **Thermostats**

Thermostats shall be of the tamperproof adjustable type, with a range centred on the temperature at which they will normally be set and not close to one end. They shall not be mounted close to heat-generating equipment.

* + 1. **Timers**

Timers shall be of the electronic, synchronous or cam type only depending upon the application. They shall have linearly calibrated scales, in units of time, each scale division being a maximum of 5% of full scale. Repeat accuracy shall be within 0.5% of full scale.

Electronic and synchronous timers shall be of the plug-in or block type, provided with "energized" and "timed out" indicators. They shall be surface mounted when within cubicles but where front mounted to give operator access, they shall be flush mounting and provided with a lockable cover to prevent unauthorized interference.

Plug-in units with retaining clips shall plug into bases to which external connections are made using screw clamp type terminals that are easily accessible. Timers and bases shall be keyed to prevent mismatching.

The pin configuration of each timer shall be printed on the casing.

* + 1. **Transformers**

Small transformers for auxiliary supplies shall be double wound, screened, and suitably rated, with all windings of copper and terminals fully shrouded. Each transformer shall be provided with an indelibly marked and permanently fixed label to indicate ratio, rating, voltage, currents, and connections.

Primary and secondary circuits shall be fused (or MCB protected) and neutral linked with one side of the secondary earthed.

Where 110 V socket outlet supplies are required transformers shall have a center-tapped earthed secondary winding, both ends of the winding being fused.

* + 1. **Spare Ways**

The drawings generally indicate the number of spare circuits that are to be provided and equipped under this Contract as part of the manufacture of the switchboards, motor control panels and distribution boards. Where spare ways have not been indicated, the following shall apply.

For switchboards, a minimum of two spare, equipped, ways shall be provided, the rating of the protection devices being commensurate with those shown for active circuits.

For motor control panels, a minimum of two spare equipped ways shall be provided, the spares relating to the provision of the protection, MCCB or similar but not starters. However, space shall be provided for the inclusion of future starter units. The ratings of the protection devices shall be commensurate with those shown on the drawings.

A minimum of two TP/N spare, equipped ways shall be provided in distribution boards, the ratings being commensurate with those shown on the Employer's Drawings. In addition, a minimum of two blanking plates shall be provided for the future inclusion of additional circuit breakers.

Details shall be submitted for final agreement and approval.

## Switchboard and Panel Wiring

Ample wiring space shall be provided within the switchboards and panels and all wiring shall be carried out in a neat and systematic manner with cable supported clear of the panels and other surfaces at all points to obtain free circulation of air.

In all cases, the sequence of the wiring terminal is to be such that the junction between multi-core cables and the terminals is effected without crossover. Insulated bushes are to be provided where necessary to prevent the chafing of wiring.

All panel wiring is to comply with the requirements of BS 6231 Type A or B, as appropriate. Conductors are to be copper and have a minimum cross section equivalent to 7/0.67 mm (2.5 mm2) or 1/1.78 mm (2.5 mm2 ). but single stranded conductors should only be employed for rigid connections, which are not subject to movement or vibration during shipment, operation or maintenance. Flexible conductors equivalent to 30/0.25 mm (1.5mm2) or smaller sizes generally shall only be employed with the written approval of the Engineer.

No wired may be teed or jointed between points.

Electrical wiring and instrument are to be located so that leakage of oil or water cannot affect them.

Bus wiring between control panels, etc., is to be fully insulated and to be completely segregated from the main panel wiring.

All metallic cases of instruments, control switches, relays, etc., mounted on control panels or in cubicles, steel or otherwise, are to be connected by means of copper conductors of not less than 2.5 mm2 section to the nearest earth bar. These conductors may be bare or have insulation coloured greed or green/ yellow striped.

Colour coding of the separate phases, neutral and earth, shall be provided and maintained throughout the installation. Where necessary, further identification of wiring shall be provided to the extent necessary to permit any conductor to be located and traced. Also colour coding of remote control and local control wiring shall be provided. Voltage of control systems shall be clearly stated.

Colour coding shall be:

Red - Red phase

Yellow - Yellow phase

Blue - Blue phase

Black - Neutral

Green/Yellow - Earth

Grey - 110 V AV

White - D.C

Cable for specialist applications such as co-axial shall be of an approved type.

All wiring shall have crimped terminations, only one wire being held by any one crimp. Crimped lugs shall be of the insulated type without conductor exposure between the crimps and wire insulations.

The type of crimp used shall be appropriate for the type of terminals to which it connects.

Terminations shall be neatly arranged leaving adequate length for one additional termination.

Wiring shall be neatly laid in limit compression insulated cleats, insulated straps or, where more than ten wires follow the same route, in plastic slotted-sided trunking with clip-on cover. Where trunking is used, the ratio of effective overall cross-sectional area of cables shall not be greater than 40% of the trunking cross sectional area.

Hoes in steelwork, etc., through which cables pass shall be protected using nylon grommets, or edging strip suitable for the size of hole.

Cables used for control, extra low voltage and instrument signal transmission likely to be affected by interference shall be screened and or spaced from each other and from heavy current power cables, at a distance to ensure that resultant electrical "noise" is insufficient to cause any form of malfunction of associated equipment.

All wiring shall be identified at each end by means of glossy plastic ferrules showing the wire number as on the schematic diagrams. Ferrules shall be colour codes, 'Z' type and indelibly marked.

## Electric Motors

* + 1. **General**

All motors shall be of a make approved by the Engineer and shall be suitable for operating from the specified power supply. Motors shall comply in all respects with the relevant parts of BS 4999 and BS 5000, and shall be designed to run at high power factor and efficiency at the prescribed plant duty.

Motors shall be three phase, squirrel cage, induction type, continuously rated for the heaviest specified duty, totally enclosed and suitable for operation on the electricity supply and determined by the Contractor in relation to the power requirements, ambient temperature, altitude and normal working conditions of the mechanical plant offered.

The starting (locked rotor) current of any motor shall not exceed 6 times the full load operating current, Motor starting torque shall be at least 120% of the pump torque requirements throughout the starting sequence. Motors shall be capable of running backwards at rated speeds under backflow conditions without damage to the motor.

In addition to the requirements of BS 5000, the motors shall be capable of satisfactory operation with a frequency variation of = 5% above or below the normal frequency of 50 Hz.

The design of the motor shall be adequate in all respects for the number of starts per hour required when the pumping plant is in normal operation.

Where an insulation Class is specified the requirements of BS 4999 shall be met. The limit of temperature rise shall be for the appropriate Class of insulation quoted. Class F insulation shall be provided, but with Class B temperature rise limitations.

Motors shall be fitted with locating type bearings and/or heavy type thrust bearings at the non-drive end and roller type bearings at the drive and according to the type of motor offered, but all bearings shall be of adequate proportions and design suitable for the particular application, and shall have ample capacity all allow the pump to operate for short periods with the discharge valve closed.

Details of the bearing types being proposed, grease, oil, shall be submitted for all vertical motors together with details of the grease lubricated bearings for horizontal split case motors.

The motors shall be built of high-grade components and materials in accordance with the best practice for the type of plant offered.

Motors 5 kW and above shall be fitted with temperature sensitive thermistors embedded in the motor to control a winding over-temperature relay mounted in the control cubicle. Each motor shall have at least 3 thermistors. The thermistors shall be suitable for connection to a monitoring unit in the motor control circuit to provided protection against winding failing due to overheating. The motor starters shall trip in the event of high winding temperature being experienced.

The motors shall be capable of delivering 10% in excess of the maximum power absorbed by the equipment being driven. The motors, where practicable, are to be selected to provide an element of commonality, thus flexibility in use at each site, particularly dosing pump motors.

Only ISO standard roller and/or ball grease lubricated bearings shall be fitted.

The grease lubrication shall be applied using hydraulic type nipples, which are freely accessible, without, and dismantling, or otherwise piped out to a readily accessible location.

" Sealed for life" bearings shall not be used.

Continuously rated anti-condensation heaters shall be installed in all motors above 5 kW that are to be installed or in damp or cold environments. They shall be sized by the supplier to suit the motor frame size.

Heaters shall be located within the motor so that the heat dissipated does not damage the insulation of any of the windings or associated cables.

Terminals boxes shall be separated from the frame and shall be reversible to allow cable entry at the top, bottom or either side, suitable for cable glands required. Terminal mountings shall be arranged such that the motor supply wiring can be disconnected without disturbing its internal connections.

The end of each winding shall be brought out to a separate terminal, connecting links being provided to facilitate interconnection of individual terminals.

A diagram of connections shall be fixed inside the terminal box cover, which shall be provided with watertight, oil resisting gaskets.

Where motor anti-condensation heaters are fitted additional terminals and a separate cable gland entry shall be provided. A warning label on the terminal box cover shall be provided stating" WARNING, LIVE HEATER TERMINALS, ISOLATE BEFORE REMOVING COVER".

Plates shall be fixed on each motor, giving the following information:

BS No \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ No. of Phases \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Manufacturer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Motor kW \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Serial No \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Votage \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Insulation Class\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Current at FL \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Frequency \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Speed \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

All motors rated in excess of 160 kW shall be fitted with suitable vibration control devices to automatically shut down the motor in the event of excessive vibration. The Contractor shall stipulate the vibration tolerances associated with each motor rating above 160 kW and shall recommend appropriate control devices, details of which shall be submitted for approval.

For motors larger than 160kW, kilowatt hour meters, with maximum demand indicators shall be provided.

Vertical spindle motor units rated in excess of 5 kW shall be fitted with a thermocouple at the upper thrust bearing to shut down the motor in the event of the bearing temperature exceeding a recommended value. Details shall be provided for approval.

Motor that are water-cooled shall include suitable protection to safeguards against the lack of water flow.

Where required by the specified operation system, motor circuits shall include suitable rated rotary off, manual or automatic switches.

The Contractor shall submit details of the painting specification ad colour range being proposed. The Employer will finally decide on the colour, this being accordance with the manufacturers standard colour charts.

All motors shall be provided with two earthing terminals.

The motors shall be commercially silent in operation and shall run free from vibration. They shall be of robust design with frames and covers constructed in cast iron. Fan covers and cowls shall be of a strong and durable material (plastic, PVC or GRP will not be acceptable). The rotors shall be fully keyed to the shafts and shall be balanced both statically and dynamically.

Motors shall be labeled to correspond to their respective starters. These shall be at least 40mm x 75 mm x 2mm in stainless steel on non-ferrous metal. Details shall be agreed.

Air vents and other opening where provided would be screen protected.

* + 1. **Submersible Motors**

A submersible motor shall be capable of continuous operation under water at the conditions specified. Heater requirements do not apply to these units.

The motor shall be installed vertically and rigidly coupled to the multistage submersible pump such that both the pump and motor are completely flooded. The windings of the motor shall be insulated with an approved waterproof plastic or other approved material as recommended by the manufacturer. The motor shall be squirrel cage rotor motor with the rotor suitably supported in lubricated plain bearings.

The cable from the motor shall be sealed at its exit by a watertight cable gland. Sufficient cable shall be provided to meet the installation requirements.

* + 1. **Surface Motors**

Surface mounted motors shall be weather proofed fully tropicalised, and suitable in all respects for external operational duties in the climatic conditions prevailing. The connections of the motors shall be brought out to terminals at the side of the frame and properly clamped and terminated within a cable box complete with correct gland to accept the size and type of cable specified. In general the glands shall be downward pointing at an angle to pass the cables clear of the based frame and plinth.

* + 1. **Cable for Submersible Motors**

Cables for submersible motors shall be a 600/1000 volt grade multicore cable and consist of conductors of high conductivity tinned copper wire, EPR insulated and with super tough rubber sheath. The cable shall be suitable for suspension within a borehole approximately 60 meters deep and shall include all necessary internal support (i.e. steel core or similar) to prevent undue strain being imposed on the cable conductors. Two clips shall be supplied for each length of riser.

Details of the cable proposed shall be provided with the Tender.

* + 1. **Emergency Stop/Lock-Off Push Buttons**

Emergency stop/lock-off push buttons shall be provided adjacent to the pumping units specified. Each shall be of the surface mounted weatherproof push to break and mushroom type with latching device to resist the push button return movement so that contacts remain normally open unit the latch is released by a counter clockwise direction.

The buttons shall be robust and watertight suitable for the environment at the various location, with IP enclosure. Certain stop buttons will be wall mounted, others will be mounted on frames 1,000 mm above the floor level, as started in the Particular Specifications. The frames, boxes, terminations, screws and fixings shall be supplied.

* + 1. **Power Factor**

The overall power factor of the plant under any load or operating condition shall not be lower than 0.9 lagging. Power factor correction capacitors shall be provided for each motor of above 5 kW rated output. In addition capacitors shall be fitted to smaller motors and necessary to maintain the minimum power factor specified above.

* + 1. **Safety Devices and Controls**

The control requirements for the pumping plant have generally been specified elsewhere. The Contractor shall include for all requirements to meet both the manual and automatic control of the plant and pump sets. In addition to the safety devices already specified, the Contractor shall provide for other protection devices and equipment that are necessary to protect against any operating conditions which would be liable cause damage to the plant, for example, lack of water at the pump suction.

## General Services

* + 1. **Labels and Notices**

Labels shall be provided to describe the duty of or otherwise identify all items of equipment, mounted internally and externally, with clear, concise and unambiguous wording. Each label shall be permanently secured to the panel surface adjacent to the item to which it refers but not to trunking covers or other readily removable items, using plated screws.

All component labels shall have circuit designations, which can be easily correlated with the drawings. Labels shall be provided on or adjacent to fuse carrier bases, where provided, to indicate the rating of the fuse to be employed. Labels shall be manufactured from laminated plastic or similar white/red/white for danger and warning labels. Otherwise white/black/white. Edges shall be beveled and lettering at least 5 mm high. In addition to component labels, each cubicle door shall bear a large identification label (minimum lettering size 8 mm), whilst each panel shall bear a large overall identification label (minimum lettering size 12mm). In addition to individual terminal number each group of terminals shall be provided with a "Function Description" label.

Warning notices, in red lettering on white background, shall be provided on all automatic start-up equipment.

Component "stick on" block diagram identification labels shall be fixed to the inside of each cubicle and starter panel.

The diagrams shall match the component layouts so that easy identification of all components is possible.

* + 1. **Shrouding**

Shrouding shall be provided such that it is not possible to touch a live conductor, with or without a tool, unless a positive step has been taken (using a tool) to remove a cover, shroud, etc.. All such covers and shrouds shall bear adequate labels identifying the potential danger.

* + 1. **Control Circuits**

All circuits shall be designed as far as possible to fail to safety. Generally, control relays shall de-energise for the safe condition.

Safety interlocks, designed to prevent injury to personnel or damage to equipment, shall be direct in operation.

Circuits shall be as simple as possible subject to necessary operational and safety constraints, involving a minimum number of components.

Where automatic control of several items of equipment is provided by a PLC, then a simple back-up automatic control system, independent of the PLC, shall be provided to give rudimentary unmanned control in the event of PLC failure. Such a system need not to be efficient or even provide 100% plant availability, but it shall come into operation automatically in the event of normal control system failure.

* + 1. **Steel Conduit and Fittings**

Steel conduits and fittings shall comply with BS 4568, 4607 and 6099 as appropriate. Distance type saddles shall be use for all surface-exposed steel conduit.

Conduits shall be installed in such a manner that all cables can be drawn in after erection by means of a draw-in tape. Conduit joints shall be painted with approve metallic paint. Elbows and tees shall be avoided where practicable, and normal bends or sets used. Exposed outlet boxes shall be cast metal type, and flush boxes shall be cast or sheet metal. No knockouts shall be removed unless used. Where conduits enter sheet metal boxes they shall be lock-nutted back and front. Burrs and obstructions shall be removed before installation of boxes and conduits.

No conduit shall be smaller than 20 millimetres in diameter.

Boxes shall generally be galvanized steel, small, circular 60mm type with steel covers.

Adaptable boxes shall be galvanized steel with overlapping lids but without "knockouts".

Box covers shall be fixed by brass round or cheese head screws.

* + 1. **Plastic Conduit and Fittings**

Plastic conduit, where approved for use by the Engineer, shall be heavy gauge, high impact, Fittings, fixing and accessories shall be of the same manufacture and colour as the conduit.

All accessories shall be fitted with earthing terminals.

* + 1. **Trunking**

Trunking shall be heavy duty, galvanized, minimum coating designation being grade G275, manufactured from grade Z2 steel.

* + 1. **Cable Tray and Accessories**

Galvanised cable tray shall be perforated, heavy-duty return flange type, hot dipped galvanized after manufacture.

Plastic coated cable tray shall be diamond pattern, heavy duty, black PVC covered.

Rigid PVC cable tray where approved for use by the Engineer, shall be manufactured from rigid unplasticized PVC having a thickness of not less than 3.0 mm. It shall be perforated and have provision for a cover. The material of manufacture shall be self-extinguishing or non flammable and suitable for use in ambient temperature of -20 to -800C.

Fixings shall be carried out using manufacturer's recommended brackets and supports.

* + 1. **Low Water Level Sensor**

Low water level electrode sensor units, shall be provided within all boreholes and within certain storage tanks and water inlet chambers. The sensor shall be supplied complete with all required cabling, fixings and terminations. The units required for installation within the boreholes shall be complete with two clips for each length of riser.

* + 1. **Sump Pump Controls**

Submersible drainage pump units shall be supplied complete with suitable float operated on-off controls. The pump units shall be supplied with control panels/starter units as specified, cables, supports, fixings as required.

* + 1. **Coordination**

The Contractor shall be fully responsible for the necessary liaison and coordination of all works on site.

Cross site cable runs shall be basically as indicated in the drawings. However, the final routes and layouts shall be to suit pipe work, drainage, cables, foundations and the like. The Contractor shall produce drawings for approval indicating the proposed routes of his cable. These shall in general follow an agreed service reserve.

* + 1. **Locks**

Sufficient padlock with individual keys of a type approved by the Engineer shall be provided for locking the following items.

* Lockable, lock-off, isolating fuse switches and feeder pillars and the like, and
* Inter-locks, lock-off, ACB's (and/or Castelle interlocks)

Each shall be provided with four keys and be individually identified.

* + 1. **Continuity**

All conduits, trunking, duct, trunking, cable tray etc shall be mechanically and electrically continuous thought. Where steel conduits cross expansion joints, flexible steel conduit sections, PVC served, shall be inserted, or other approved means used to provide the necessary continuity and flexibility.

* + 1. **Radiated Interference**

The Contractor shall ensure that radiated interference from all items of Plant is suppressed to the limits specified in BS 800 and BS 833.

## Earthing

* + 1. **General**

The system of earth on the LV reticulation will generally be TN-S as defined in the IEE Wiring Regulations (16th Edition). Earthing systems shall comply BSCP 1013 and BS 7430 and the current edition of the IEE Wiring Regulations. Separate earth protective conductors shall be employed throughout on mains, sub-mains and all final circuits.

As a minimum the metalwork of all items of electrical plant, electrical system neutral points, power and control cable armouring and screens, and extraneous metalwork including structural steelwork and pipe work, shall be connected to the earthing installation.

Earthing continuity in non-electrical plant shall normally be achieved via metal to metal faces, metal hinges, and metal fixings. Earth straps shall only be supplied where earth resistance is high or there is risk of corrosion or similar which could in the future increase resistance and affect earth continuity.

All structural steelwork within the site shall be bonded to the earth system.

All pumping plant shall include and earth continuity conductor or tap which shall extend from the pump/motor frame/bed plate to the main station/switchboard earthing system.

The final arrangement of the earth electrode system shall be to the requirement of the supply authority and to the satisfaction of the Engineer.

The earth resistivity at the sites may vary and the Contractor shall include for taking earth resistance reading both before and at least once during construction, and one final reading, at every earth point to ensure the specification values are obtained.

Each system shall be varied according to the immediate location. Each local earth system shall be installed progressively until the value of earth resistance is obtained to the satisfaction of the Engineer.

At the various compounds an earth busbar system shall be supplied, connected to earth electrodes, to which the following shall be connected.

* Star points of all transformers on the medium voltage side.
* Sheathing of cables.
* Metalwork at the compounds, other than carrying cables.
* Earth wires from equipment, external to main pump stations that is fed only from that pump station.
* Main incoming water pipes.
* The building metallic structure.
* The lightning protection system where provided.
* Fencing as finally agreed.

The earthing continuity of each metal sheathed cable shall be maintained by efficient bonding between the cable sheath, the gland, and the metal case of the switchgear or other metal clad accessory or appliance at which the cable terminate. In addition, ICEW's or BCEW's shall be run with all cables as specified or as shown on the drawings.

3 Core cables may be used to single phase items of equipment, the third conductor being used as the insulated copper earthwire.

The size of all earth wires bonding equipment to a main earthing system shall be such that a current of three times the fuse rating of the circuit or one and one half times the overload setting of the circuit breaker can flow without adverse effects.

All joints between wires and other earthing metalwork shall be mechanically sound and soldered.

The earth leads shall be insulated until the connection is made to the electrode system. A bolted test link shall be installed to facilitate regular testing of the earth electrode system resistance.

The insulation of the earth lead shall be insect and rodent resistant.

All materials used in any earthing installation shall be adequately protected against corrosion and earth lead shall be protected against any mechanical damage.

* + 1. **Installation**

The earthing installation shall comprise an earth terminal, earth busbars, circuit, earthing conductors, equipotential bonding conductors, main earthing conductor and earth electrodes. The circuit earthing and equipotential bonding conductors shall be of the radial, grid or ring form as dictated by the plant layout.

The earthing installation shall be protected from mechanical damage and corrosion.

Joints in tape conductors shall be riveted and soldered, brazed, clamped, bolted or exothermically welded. Non-corrosive flux shall be used for soldered joints. Clamped and bolted type joints shall be tinned and shall only be used above ground.

The interconnection of conductors below ground shall be by means of exothermic welding or brazing. Compression type lugs shall be provided for the termination of cables.

Earthing conductors shall be buried directly in the ground or secured to building structures, cable racks and trays using proprietary fixings.

Where the soil is aggressive to copper, buried earthing conductors shall be protected by an approved sleeving.

An equipotential bond shall be provided to all buried metal pipe work at the point of entry into a building or chamber where electrical apparatus is installed. Electrical continuity across all pipe joints within the structure shall be ensured. Where pipe work incorporates a compression coupling (e.g. Viking-Johnson coupling), a bond shall be provided to any isolated section.

Cable armouring and screens shall be bonded to earth at both ends unless otherwise specified. Cable armour shall not be used as the sole earth protective conductor.

* + 1. **Conductors**

Circuit and main earthing and equipment bonding conductors shall be high conductivity copper tape or 1000 V grade PVC insulated multi-stranded cable. PVC cable insulation shall be striped green/ yellow. Cable lengths shall be continuous and intermediate jointing is not permitted.

The main bonding conductor shall be not less than 16 mm2 and supplementary bonding of non-electrical plant not less than 10mm2. All connections shall be made using compression type cable lugs, taped on completion to completely seal the lug and any bare copper from the atmosphere. The surface to which earthing bonds are fixed shall be cleaned free from paint and other non-conducting material and coated with petroleum jelly.

The Contractor shall provide the following supplementary bonding conductors, which shall be made in 2.5 mm2 cable if mechanically protected;

1. All sink and shower units to pipe work
2. All small power outlets and sink units within a 2.5 meter radius of each other
3. All metallic tanks
   * 1. **Earth Electrodes**

Earth electrodes where used shall be copper or copper clad high tensile steel rods having minimum copper thickness of 0.25 mm and outer diameter not less than 16mm. The rod shall penetrate a minimum of 2,400 mm below ground level. Where multi-rods are used they shall be separated by a distance of not less than the driven length.

Earth rods shall have hardened tips and caps and be extendable. Bare copper tape buried at a minimum depth of 600 mm shall be used for interconnection of rods.

Where soil conditions make the use of rods type electrodes impracticable a grid configuration may be used comprising horizontally buried bare high conductivity copper tape of dimensions 15mm x 4 mm minimum. Tape shall be buried at a minimum depth of 600mm.

All earth electrodes shall be buried in a mixture of well grinded charcoal and common salt in a ratio of 2:1.

Earth rods shall be proved with a non-ferrous clamp for the connection of the earthing conductor. Each connection between conductor and earth electrode shall be suitably protected against corroding elements in the soil with bituminous tape.

The connection shall be made in a concrete inspection chamber set flush with the finished ground level. The inspection chamber shall be permanently marked ELECTRICAL EARTH'.

Marker posts and plates shall be provided to make the position of the electrodes and buried connections. The markers shall be similar to those provided for cable routes.

* + 1. **Main Earthing Terminal**

Where specified, a main earth terminal shall be installed in a convenient location. This shall comprise a high conductivity copper bar of sectional area at least that of the main earthing conductor. The terminal shall be supported on porcelain barrel type insulators and wall-mounted.

The terminal shall be of sufficient length to accommodate, with 25% spare capacity, bolted copper tape connection to:

* 1. the earthing conductor (s) between the earth terminal and earth electrodes
  2. circuit protective conductors between the earthing terminal and exposed conductive parts
  3. the main equipotential bonding conductors between exposed and extraneous conductive parts
  4. the system neutral earthing conductor (where specified)

Facilities (i) and (iv) shall be removable with a tool to permit measurement and testing.

Earth studs shall have a minimum size of M8.

* + 1. **Tests on Site**

On completion of the earthing installation the Contractor shall measure the resistance of each electrode installation and of each complete earthing system to the general body of the ground. All other tests stipulated in the Reference Standards shall also be carried out.

The contractor shall carry out tests to verify that exposed metalwork within the buildings is effectively bonded and install supplementary bonding connections as necessary to ensure proper continuity. In particular supplementary bonding shall be provided to individual suspended systems throughout the buildings.

The resistance to each of each complete network shall not exceed five.

* + 1. **Lightning Protection**

Where buildings structures or sections of the plant are to be protected against lightning or static charges, an earthing system shall be provided. The installation shall be carried out in accordance with BS 6651.

The down run conductor shall be of hard drown high conductivity copper of 25 mm \*3 mm section . the tape shall be fixed to the outside of the structure by means of stand off saddles. where indicated. connection shall be made to the concrete reinforcing. the route of the tapes and the fixings shall be discussed with the Engineer before installation.

Where specified the conductors shall be PVC insulated to prevent corrosion and to blend with the building fabric.

A test link shall be installed in each down conductor adjacent to the earth rod at a height of 1,200mm above ground level. the overall resistance of the earth termination system to earth shall not exceed 10 Ω. If this requirement is not met the number of earth electrodes shall be increased or they shall be interconnected until a value of 10 Ωis attained.

Earth rods shall be not less than 16 mm diameter copper or copper-clad steel, provided with hardened tips and driving caps. Each rod shall be provided with a non-ferrous clamp for connections of the copper strip. Each connection shall be housed in an inspection chamber set at ground level.

Where feasible, the lightning, protection grounding system may be inter-connected with the system earth to ensure equipotential under all conditions.

A provisional sum has presently been included for supply and installation of the lightning protection system, the details of which will be agreed as may be required to suit the operation and protection of the compound.

## Small Power and Lighting Distribution System

* + 1. **General**

The complete internal an external lighting and small power requirements shall be provided for all buildings, pumping stations, booster stations and compounds.

Each installation shall include the distribution board, wiring, lighting fittings, socket outlets, earthing and lightning protection and external floodlighting as required together with all conduits, trays and accessories as necessary to complete the whole of the installations as specified and as shown on the drawings.

In general, fluorescent fittings shall be used for internal lighting with watherproof fittings for exterior fittings mounted on building structures above and adjacent to the door openings.

External wall mounted luminaries shall be installed using a back entry conduit system terminating behind the respective fittings with an end box mounted on the building fabric. Appropriate neoprene seals shall be used to prevent ingress of moisture. The final connections of each fitting shall be sleeved with silicon glass over sleeving.

The final circuit arrangement and phasing shall be agreed for all compounds and buildings to suit the requirements of the IEE Regulations and the Contractor's working drawings.

* + 1. **Wiring**

The installation shall in general be surface within pump houses, etc, but concealed in offices, dwellings and similar structures. The circuit wiring being continuous on a loop-in, loop-out system. The final connection to the fittings shall be by lid and cord grip, the circuit wiring terminating within the conduit box at a suitably rated terminal block. The final connection from the block (via the cord grip) to the fitting shall be carried out in heat resisting 3 core PVC/PVC (or similar) cable, white in colour.

* + 1. **Internal Lighting**

Luminaries shall be complete with all supports, suspensions, flexible cables, pendants and plugs. They shall be connected to the main circuit wiring heat resisting flexible cables of a minimum core size of 24/0.20 mm.

Protective classification shall be IP42.

The earthing of all luminaries shall be by a separate core in the connecting flex cable or cable system, securely bonding the earth terminal on the fitting to that of the interconnecting cables.

Where adjacent luminaries are connected to different phases of the supply, a label shall be fitted internally warming of the presence of the phase-to-phase voltage.

Luminaries shall not transmit load to suspended ceilings unless the ceiling and lighting is of integrated design with the appropriate supports.

Lampholders for flexible pendants shall be of the all-insulated skirted pattern with cord grips.

The fixings, connection boxes and other parts of the luminaries shall be erected at times to suit the building programme. The glassware, diffusers, shades, lamps and tubes shall not be fitted until all building works are complete. Fittings shall be left clean inside and outside are ready for use.

* + 1. **Incandescent Fittings**

Incandescent fittings shall be of the types shown on the drawings and included in the Schedule prices, and shall be supplied complete with their lamps. Lampholders in totally enclosed fittings shall be of a heat resistant type and shall be connected with heat resistant cable. Generally, Bayonet Cap lampholders and lamps shall be used.

* + 1. **Fluorescent Fittings**

Fluorescent fittings shall be of the shown on the drawings and as indicated in the schedule of prices, shall be supplied complete with their lamps. They shall be complete with tubes, auxiliaries and all other items required for their complete installation. The fittings shall have completely enclosed wiring channel for accommodating wiring and auxiliaries, and supporting the lamp holders, reflector and diffuser as applicable.

In general fluorescent fittings complete with reflectors shall be used for lighting within the buildings and weatherproof fluorescent fittings with IP65 enclosure shall be used for exterior fittings mounted on building structures above or adjacent to the door openings.

Diffusers where specified shall be of flame retardant extruded acrylic or GRP material. They shall be either opal or prismatic pattern as specified.

A gasket shall be fitted between the diffuser and the body to form an effective seal.

The luminaries shall comply with BS 4533 for Class 1 ordinary, indoor normal atmospheres and Class 11A for chemically corrosive atmospheres, where appropriate.

Fluorescent luminaries shall have two suspension or fixing points and shall be complete with lamps.

Fluorescent lamps shall comply with BS 1853.

Unless otherwise specified, lamps shall be colored 'white' for industrial use and 'warm white' for commercial and domestic lighting. Lamp caps shall be of the bi-pin type.

The light fittings shall be manufactured by Thorn or similar in all respects.

* + 1. **Lighting Switches**

All lighting switches shall generally be metal clad surface mounted in pump houses and similar area and flush in domestic and office buildings. They shall be fitted into approved surface or flush conduit boxes. Lighting switches shall be minimum 6 Amp rating of the type specially designed for AC circuits. Exterior switches shall be of IP65 enclosure pattern. All switch boxes shall be provided with earthing terminals. Mounting height shall generally be centred at 1.375 m above FFL subject to site and building details. Metal clad switches shall be to BS 3676.

Internal lighting switches shall have white moulded plates and shall comply with BS 3676. They shall be supplied complete with box, cover plate and fixing screws. External lighting switches shall be of the metal clad, galvanized and weatherproof pattern with rotary action. They shall be surface mounted. Alternatively, the sealed splash proof pattern with enclosures IP54 to BS 5420 will be considered.

At multi-switch positions, the switches shall be contained in multi-gang boxes.

Where operation of a lamp or group of lamps is required from two separate locations, two-way switches shall be fitted with intermediate switching where shown.

* + 1. **Socket Outlets and Spur Outlets**

The socket outlets in pumps houses and similar shall be generally metal clad and positioned as indicated on the drawings. The socket outlets shall be surface mounted, fitted into approved surface conduit boxes. All boxes shall be supplied with adjustable steel grids and earthing terminals. They shall be 3 pin shuttered and switched where specified. Earthing pins and shutters shall be provided throughout, the outlets being manufactured by Legrand, MK, or similar.

Domestic pattern socket outlets shall be flush mounted, or ratings indicated on the Employer's Drawings, 3 pin (with earth) and shuttered complying with BS 1363. Industrial pattern socket outlets shall comply with BS 4343. Spur outlets shall comply with BS 5733 and shall include a switch and neon light.

Plugs tops shall be provided with all outlets complete with fuses and 100% spare fuses.

Industrial sockets shall be to IP44 protection for surface mounted switch socket outlets used internally and IP67 where used externally. A corresponding plug top shall be issued with each socket.

The light switches and socket outlets shall be of the same rang and pattern where located in one room, structure or building. The units shall be as manufactured by Legrand, MK, or similar approved. Details shall be provided.

The mounting height to the bottom line of the outlet shall be:

* 250 mm above the worktop surface
* 450 mm above the finished floor level in office areas
* 1,200 mm above the finished floor level in workshop and storage area (excepting over workbenches)
* 1,200 mm above the finished floor level in pump stations.

The above requirements are intended as a general guide. Final details shall be agreed with the Engineer on site to suit the particular facility, plant layout etc.

* + 1. **Three Phase Power outlets**

Three phase power outlets shall be provided where indicated on the drawings. These shall be surface mounted, switched, complete with plug top and as manufactured by Legrand, MK, or similar approved,

* + 1. **Distribution Boards and Consumer Units**

The distribution boards shall be a moulded case and miniature circuit-breaker type and shall be of the totally enclosed metal clad, cubicle type of surface pattern as indicated. They shall be complete with hinged lid and so constructed that the circuit-breaker toggles are concealed when the lid is closed. The distribution board shall be controlled by an isolating switch integral with the board.

Distribution boards shall be equipped with RCD's, HRC fuses or miniature circuit-breakers, arranged for triple pole and neutral or single pole and neutral outgoing circuits from a three or single phase and neutral incoming supply.

The circuit breakers shall be provided with thermal overloaded and magnetic short circuit tripping and a quick trip-free mechanism. The Contractor shall ensure that the necessary discrimination between each main panel and final sub-circuit is provided. Circuit breaker distribution boards used throughout the installation shall be of the same pattern, range and manufacture. All MCBs shall have a short circuit capacity not less than 5kA.

Doors shall be lockable, hinged and gasketted to give a damp and dustproof enclosure. The degree of protection shall be IP43 (indoors) and IP55 (outdoors). The boards shall conform to BS 5486 and shall be provided with conduit and cable gland entry plate.

The busbars shall be mounted on non-hygroscopic insulators, completely shrouded or PVC insulated, coloured to denote the appropriate phase. The current rating of the busbars shall not be less than the current rating of the incoming circuit. A neutral bar shall be provided with a separate terminal for each circuit.

Fuse carriers used in distributions boards shall be of the fully shrouded pattern and shall employ HRC fuses only. They shall be mounted on the back plates using spacers so that outgoing wiring can pass behind the carriers.

Distribution boards employing miniature circuit breakers shall be capable of accepting breakers of mixed ratings of standard or residual current detection type.

Distribution boards shall be provided with an earth bar to allow connection of circuit protective conductors. The number of connection shall be equal to the number of single ways. A main earth terminal shall be provided to allow bonding of the enclosure in accordance with the requirements of the IEE Regulations. All earth, neutral and phase connections within distribution boards shall be numbered correspondingly by tagging the wires.

A fully detailed and comprehensive circuit list approved by the Engineer shall be fixed inside each distribution board, enclosed in a transparent incombustible envelope.

Consumer units shall be of the flush or surface mounted metal enclosure type complete with all MCBs and isolating switches, basically as specified for the distribution boards. Details shall be submitted for approval.

* + 1. **Fused Connection Units**

The Contractor shall supply and install all fused connection units feeding electrical appliances mounted adjacent to the electrical appliance. For floor-mounted appliances the mounting height to the bottom line of the outlet shall be 450 mm above finished floor level except where otherwise stated on the drawings.

Fused connection units shall be installed such that, where applicable, the connecting flexible cable is no longer than 300 mm.

Fused connection unit shall be to BS 5733 or similar and shall be mounted in enclosures with white moulded cover plates in offices etc and metal clad type in plant rooms, pump stations or similar locations, and shall be of the MK Crabtree or Legrand type as shown on the drawings. Isolators shall be to BS 3676: Pt.1 and shall be mounted in enclosures with white plastic or metal cover plates as shown on the drawings.

* + 1. **Emergency Battery Lighting Unit**

Portable emergency lighting units shall be supplied and installed and positioned

Emergency self-constrained light fittings will be positioned ad indicated on the drawings to provide lighting in the event of a power failure. The lighting units will have between 1 to 3 hour autonomy.

The units shall be double spot light or multi-spot type complete with mounting bracket and charging facilities operated from a 220 V AC supply. The battery light shall be arranged to switch on in event of failure of the AC supply to the fittings and shall operate for minimum of three (3) hours from the battery without re-charging.

Recharging shall be automatic on the restoration of the main supply and the period of the recharging shall be approximately 12 hrs. The fitting shall generally be provided with an earthed metal case housing the battery and switching equipment.

The lamps shall be 12W tungsten halogen operated by a sealed type lead acid battery. A solid-state constant voltage charger shall be provided together with low voltage cutout protection to protect the battery against over-discharge. The units shall be suitable for the environments in which they are to operate.

* + 1. **Portable Hand Held Fire Extinguishers**

Portable hand held fire extinguishers shall be provided as indicated on the drawings, as specified and as included within the schedule of prices. They shall be in accordance with BS 5306; Part 3, BS 5423 and local CFO requirements.

Each extinguisher shall be complete with a suitable wall-fixing bracket. The final mounting /fixing shall be agreed on site.

The 5 kg portable carbon dioxide fire extinguishers shall comply with BS3326; 1960 and BS 5423. The bodies of the extinguishers shall be seamless steel cylinders manufactured to BS 491, BS 1287 or BS 1288.

The 12 kg portable dry powder fire extinguishers shall comply with BS 3465 : 1962 and BS 5423. The bodies shall be constructed of steel not less than the requirements of BS 1449 or aluminum to BS 1470: 1972 and shall be suitable protected against corrosion.

* + 1. **Floodlights**

Floodlighting units shall be of a type designed and constructed for the application. They shall be complete with 500 W tungsten halogen lamp, enclosure, reflectors, etc, and all items necessary for their installation.

They shall be of corrosion resistant light alloy with clear toughened glass front, the whole assembled to provide a weatherproof unit with IP65 enclosure.

Galvanized steel poles, complete with horizontal mounting brackets, shall be provided as shown on the drawings. The poles shall be complete with a service door, which shall provide access to the backboard, fused cutout, gland plate. Sufficient space shall be provided to permit a maximum of three cable terminations.

Wiring between the MCB, fittings and lamp, via the control gear, shall be 20A rating butyl 1 rubber insulated, PVC sheathed cables or equal approved.

A separate earth wire shall be run between each lighting fitting and the earth termination situated at the supply point.

Foundation details shall be provided for approval. All cable glands, fixings and terminations shall be provided.

The mounting of the floodlights and associated brackets shall be such that both horizontal and vertical alignment can be carried out at site after installation.

The floodlights shall be manufactured by Thorn or similar in all respects

The holes for the planted root columns shall be excavated to a depth as recommended by the column manufacturer and the hole diameter shall not be more than twice the diameter of the column base, and shall be to the satisfaction of the Engineer.

The column with bracket affixed shall be placed centrally in the hole in a vertical position on a pad of concrete and the hole filled with concrete in 150 mm layers of 200 mm radial thickness around the column up to a depth of 150 mm below ground level. The excavation shall be backfilled and evenly rammed. A flexible PVC duct not less than 50 mm diameter shall be installed through the concrete surround into the column via the cable entry slot to provide a clear route for the electricity supply cable complete with draw cord.

## Road Lighting

Road lighting shall be provided at the compounds as indicated on the drawings and as generally specified. The lighting shall utilize galvanized steel poles as specified for the area floodlighting, the top mounting spigot being modified to accommodate an outreach support bracket capable of supporting a 70 W high pressure sodium 50N-T corrosion resistant fittings with IP65 enclosure, strong durable canopy, integral control gear with hinged tray. Details of the poles, outreach bracket and fitting supporting arrangements shall be provided for approval.

The outreach brackets shall be fixed to the pole spigot by at least three allen screws or similar type fixings, the poles and outreach brackets shall be galvanized steel, the service door, fuse cut-out, wiring and earthing shall be generally as specified for the floodlighting poles.

Road lighting and floodlighting requirements are, in general, photocell controlled from the switchgear. The Contractor shall located the photoelectric cell units externally on structures at location to be agreed on site. All conduit, wiring, cabling and connections required for the photocells shall be supplied and installed under this contract. Override test/control switches shall be provided on the face of the switchgear panels to permit the manual operation of all lighting circuits should this be required.

The Contractor shall label all columns with their respective designated numbers, the details of which shall be agreed. This shall be done by means of stenciling the number in black characters onto the column, bollard or mast. Size of characters and locations shall be advised on site and shall be to the approval of the Engineer.

All road lighting columns shall have their access doors orientated in a common manner with respect to the roadway throughout the site and shall have their lanterns orientated as shown on the drawings. Columns shall be positioned at least 1000 mm back from the road edge, the final distance being agreed to suit overhangs, curbing etc.

## Control and Monitoring Systems

* + 1. **General**

The Contractor shall design, supply and install all equipment for the automatic control and monitoring of the plant being supplied under this contract and to achieve the operating sequences specified. The equipment shall be complete in all respects and shall be suitable for use with the plant offered.

In general the plant will be controlled from water level probes and switches located in the wet welt, flow channels, storage tanks and pumping stations unless otherwise specified, and will operate the motor starters located in the motor control panels. Manual means of controlling the plant shall also be provided at the motor control panels.

The pumping and protection system shall include:

* High level alarms
* Low level alarm/cut- out
* Pressure switches to detect a change in pressure (high/low) to include alarm
* Cut-outs to protect against closed valve, broken pipe, etc., and
* Start and stop for pump sets

All protection and safety devices shall initiate an alarm siren on the monitoring/control panel section of the main motor control center, and will also initiate a warning light, dedicated warning lamps being provided for each protection/safety device. The siren shall be muted, the warning light remaining energised until the fault or protection device has been cleared and reset. A complete monitoring/warning/control system shall be provided for all plant and equipment, details to be submitted with the Tender.

In addition to the control of the pump sets, means of identifying high water level and low water level in the wet wells, tanks, etc. shall also be provided. The activation of either the high or low water probes shall, in addition to stopping or starting the pump set, also initiate a visual alarm. This shall take the form of a suitably labelled red indicator light mounted integral with the relay/changeover switch cabinet positioned within the control room or similar type operators areas to suit each compound.

The operation of the pressure switches, high level and low level probes and other safety/warning devices shall automatically energise a warning lamp on the control panels and switchboard the operators are fully aware of the nature of the plant shut down/ operation.

The final method of wiring to the above switches, probes and safety devices, the actual locations of the switches and their settings shall be agreed to suit the layout of the pipe work and ht operating parameters of the system. It shall be deemed that the contractor's prices included for all requirements.

* + 1. **Marshaling Cabinets**

Marshaling control cable cabinets shall be provided at the sites to suit the requirements of the control system. The cabinet shall be either independent units protected to suit the environment or may form an integral part of the motor control center or switchboard. The final locations shall be to suit the overall control systems.

The cabinets shall be complete with access doors and all terminating blocks and units as manufactured by Klippon or similar approved. Sufficient spare units shall be provided to facilitate cross patching from a faulty section of the cable to a healthy section.

* + 1. **General Facilities**

The Contractor shall ensure that all starters, cabinets and the like have sufficient auxiliary spares to meet future requirements.

The pressure switches and control probes shall be of approved manufacture and type, suitable for use with potable water. The Contractor shall include, in addition to the supply and installation of the switches and probes, etc., for all wiring, cables trunking, connections and the like to complete the entire control system as specified, including all wiring to and from switches, floats, probes, switchboards and alarms, etc. Details of the pressure switches, floats and probes shall be submitted with the Tender.

Alarm circuits shall consist of indicator lights which shall re-set automatically only upon cessation of the alarm condition.

The system of level and alarm condition sensing and signal transmission shall be to the approval of the Engineer, with emphasis placed on simplicity of operation and durability of construction.

## Civil Works Associated With Installation Of Services

The Contractor shall carry out all works and supply and install all materials as necessary to provide the following civil works associated with the mechanical and electrical installation being carried out under this contract:

* Foundations for flood lighting, road lighting columns and cabinets
* All foundations, cable trenches and supports for externally mounted motor control cubicles and switchgear.
* All trenching, tilling, sanding, backfilling, compaction and removal of surplus soil for all cables and associated services
* Cable ducts, pipe work and exhaust sleeves, etc. unless otherwise specified or indicated
* Sun canopies over all externally located cubicles and switchgear, including foundations
* All builders works associated with the installation of the plant
* Any other civil works, as specified or shown on the Employer's Drawings

## Schedule of Test

* + 1. **General**

This section is to be read in conjunction with the details contained within the specification, in particular Section 1.26.

As many tests as possible shall be arranged together. Five copies of the contractor's records of all tests shall be furnished to the Engineer.

All material which is specified for tests at the manufacturer's works must satisfactorily pass such tests before being painted or otherwise coated.

All test instruments, fuels and consumables required for the tests, commissioning and putting the plant into full operation shall be supplied by the Contractor. Test instruments shall be to approval and shall be calibrated by a competent authority as may be approved by the Engineer.

* + 1. **Tests at Manufacturer's Works**

Details of tests to be carried out on particular items of electrical plant shall be as follows. Other items of plant and equipment will be tested as required. Similarly, further tests as necessary will be carried out on the plant as instructed by the Engineer or required by the relevant BS or code of practice.

The electrical equipment supplied under this contract will be tested to prove compliance with the requirements of this specification and with the relevant British Standard specification where applicable.

High voltage and insulation resistance test shall be made when the apparatus is hot.

Test shall include, but not be limited to, the following as may be applicable.

* H.V. pressure tests and insulation resistance check
* L.V. pressure tests and insulation resistance check
* Injection test
* Shunt trip test
* Closing test
* Operation of all inter-locks and protection devices.
  + 1. **Test After Erection on Site**

All Plant shall pass such tests on site as are required by the Engineer to prove compliance with the contract independently of any tests which may already have been carried out at the Manufacturer's works. In particular, all electrical pressure tests made at the Manufacturer's works shall be repeated at voltages to be approved by the Engineer.

The entire installation shall be tested and commissioned in accordance with the Regulation for Electrical Installation published by the institute/of Electrical Engineers (London) - 16th Edition, including the latest amendments and with the details contained within the General Specification. In addition, particular attention shall be paid to the specified testing requirements of specialist equipment described in this Specification. Prospective Fault Currents (Ipsc) and Earth Fault Loop Impedance (EELI) shall be measured and recorded at different locations on each installation including at each LV switchboard, distribution board and at the furthest socket outlet from the source on each socket outlet circuit, and at each item of fixed equipment.

Testing and commissioning procedures shall be such as to effectively prove the correct operation of all components and their integration into the systems. The testing shall also prove that the systems function in accordance with the appropriate design criteria.

All systems shall be fully tested and commissioned prior to the Engineer being invited to witness a full demonstration of the system and verification of its functioning and correct commissioning, except where specifically indicated otherwise within this specification.

No equipment other than 380/220-volt lighting supplies shall be energized without the permission of the Engineer. The contractor shall be responsible for the safety of both plant and personnel from the initial energization of all plant and until handover.

The results of all tests shall be recorded and inserted into the operating and Maintenance manuals.

If, in the opinion of the Engineer, the plant does not comply with this specification, the defect shall be rectified at no cost to the Employer.

**PARTICULAR TECHNICAL SPECIFICATIONS**

**A – SCOPE OF WORK**

# TECHNICAL SPECIFICATIONS

* 1. **Introduction**

**General**

Guradhamole CR- Multi-village water supply Projects involves supply and installation of Transmission Main and Distribution pipes, Electro – mechanical equipment’s, construction of River Intake, Treatment Plant, service reservoirs, Booster Reservoir, water points, cattle troughs, construction of auxiliary building, etc.

The scheme has been divided into three contracts: -

* A contract for the supply of pipes, fittings, valves, and jointing materials.
* A contract for constructing of all pipelines, civil and building Structures,
* A contract for the supply of Electro - mechanical equipment’s and electrical Power

**General Rolls and Responsibilities of Each Party**

The roles and responsibilities of each partner (Civil, Pipework, and EM contractors) during the testing and commissioning phase. Below is the proposed breakdown:

1. **Volume I Contractor (Supply of Pipes, Fittings, Valves, and Jointing Materials)**
   * **Responsibility:** Ensure timely delivery of all required materials, meeting project specifications.
   * **Role during Testing & Commissioning:**
     + Provide technical support to verify the integrity of the supplied materials, such as pressure testing of pipes and fittings.
     + Assist in resolving any defects or material-related issues identified during commissioning.
2. **Volume II Contractor (Civil and Pipe Works)**
   * **Responsibility:** Construct pipelines, civil, and building structures as per design specifications.
   * **Role during Testing & Commissioning:**
     + Perform pre-commissioning activities such as hydrostatic pressure tests for pipelines and structural inspections for reservoirs and pump houses.
     + Collaborate with the EM contractor to ensure that pipelines and civil structures are ready for integration with the EM systems.
     + Address any construction-related deficiencies identified during testing.
3. **Volume III Contractor (Electromechanical Equipment and Electrical Power)**
   * **Responsibility:** Supply, install, and ensure the operational readiness of all EM equipment and electrical power systems.
   * **Role during Testing & Commissioning:**
     + Conduct functionality tests of EM equipment, including pumps, motors, and electrical control systems.
     + Integrate EM systems with pipelines and civil structures to create a fully operational water supply system.
     + Collaborate with Volume I and II contractors to troubleshoot and resolve any system-level issues.

**Integrated Testing & Commissioning Plan**

To ensure the project operates cohesively as a single system, a **joint testing and commissioning plan** will be developed, involving all three contractors. Key elements include:

* **Joint Pre-Commissioning Inspections:**
  + - Review readiness of materials, structures, and equipment.
    - Identify and rectify issues collaboratively before formal testing.
* **System-Wide Functional Tests:**
  + - Pressure tests for pipelines, operational tests for EM equipment, and verification of electrical systems.
* **Operational Testing and System Integration:**
  + - Simulate real-world conditions to verify seamless interaction between all components.
    - Ensure water supply operates as per design parameters.

**The Roll of the consultant**

The consultant's role in the **“Design Review, Supply & Installation of Electro-Mechanical Equipment for Guradhamole Multi-Village Water Supply Project”** spans across all aspects of the project to ensure that the work meets design specifications, quality standards, and overall project objectives. Since there is only one consultant overseeing the entire project, their role will be integrative, providing a unifying oversight across **Volumes I, II, and III**. Below is a detailed breakdown of the consultant's responsibilities:

By consolidating the following responsibilities under one consultant, the project ensures consistency, accountability, and efficiency in oversight, leading to a well-coordinated and successfully executed project.

* + 1. **Design Review and Approval**
* **Role:**
  + - Review and validate the designs submitted by contractors under all volumes.
    - Ensure that the designs are consistent with project specifications and standards.
    - Provide design feedback and approve finalized designs for execution.
    1. **Coordination Between Contractors**
* **Role:**
  + - Act as the central authority to coordinate the activities of the contractors under Volume I (pipe supply), Volume II (civil and pipe works), and Volume III (electromechanical equipment).
    - Resolve conflicts or overlaps in scope between the contractors.
    - Ensure smooth communication and collaboration between all parties to achieve seamless system integration.
    1. Quality Assurance and Control
* **Role:**
  + - Monitor the quality of materials, construction works, and equipment supplied by the contractors.
    - Conduct periodic inspections during procurement, installation, and construction phases to ensure compliance with project standards.
    - Review test results from contractors (e.g., hydrostatic tests, equipment tests) and provide certification for milestones.
    1. Progress Monitoring and Reporting
* **Role:**
  + - Track progress across all project activities to ensure adherence to the project timeline.
    - Regularly report to the project owner (client) on the status of design review, material supply, construction, and equipment installation.
    - Highlight potential delays or risks and propose mitigation strategies.
    1. Testing and Commissioning Oversight
* **Role:**
  + - Lead and oversee the joint testing and commissioning activities, ensuring that all systems (civil works, pipelines, and electromechanical equipment) function as a single, integrated system.
    - Verify and approve the performance of materials, structures, and equipment during commissioning.
    - Ensure all required documentation (test reports, certificates) is completed and submitted by the contractors.

**Client’s role (Ministry of Water and Energy)** Contractual Oversight

* **Role:**
  + - Oversee the overall contractual framework for the project, including managing contracts with the consultant and contractors (Volume I, II, and III).
    - Ensure that all parties adhere to the terms and conditions of their contracts.
    - Resolve contractual disputes or escalate them for arbitration if necessary.

The client's role is pivotal in maintaining project alignment, ensuring resource availability, and providing a framework for effective coordination and accountability among all parties. By actively engaging in these responsibilities, the client ensures the successful delivery and sustainability of the water supply project.

This approach ensures a clear definition of roles and responsibilities, facilitating smooth project execution and a successful commissioning process.

**Scope of the works to be conducted by Civil Contractor**

The scope of the Works to be executed is as indicated on the Drawings and Specification, as itemized in the Bill of Quantities. The scope of the Works can be summarized as follows: -

* Construction of River intake at Dumal River consisting of retaining wall, Sump well, Generator house and Pipe and Fittings.
* Constructions of Treatment Plant of the following component:

| **No.** | **Description** | **Unit** | **Quantity** |
| --- | --- | --- | --- |
|  | **Treatment Components** |  |  |
| 1 | Plain Sedimentation tank | No | 1 |
| 2 | Coagulation-Flocculation Tank | No | 1 |
| 3 | Chemical mixing, store | No | 1 |
| 4 | Sedimentation tank (Clarifier) | No | 1 |
| 5 | Slow Sand Filter (SSF) | No | 1 |
| 6 | Post Chlorination EM part | No | 1 |
| 7 | Clear water tank (500 m3) | No | 1 |
| 8 | Laboratory Equipment | No | 1 |

* Constructions of Civil Works Structures of the following component:

| **SNo** | **Description of Item** | **Quantity** |
| --- | --- | --- |
| 1 | Construction of 300m3 booster Reservoir at Barde Kebele | 1 |
| 2 | Construction of Elev 50m3 Reservoirs @ Barde & Ara-as Kebeles | 2 |
| 3 | Construction of 500m3 Service Reservoirs @ Haro-Dibe Town | 1 |
| 4 | Construction of Artificial Wet Wells At Boosting Stations and CWT | 2 |
| 5 | Construction of Generator House For Booster Station | 1 |
| 6 | Construction of Guard House for Intake, Treatment, 300m3 BS & 500m3 SR | 4 |
| 7 | Construction of Toilet and Septic Tank for Intake, Treatment, 300m3 BS & 500m3 SR | 4 |
| 8 | Construction of Water Point (4F) | 17 |
| 9 | Construction of Cattle Trougth | 5 |

* Supply and installation of pipes and Fittings for Transmission Main with total length of 24.293km
* Supply and installation of pipes and fittings for Distribution Network with a total length of 11.43km.
  1. **Scope of Work to Be Conducted by Electromechancal Contractor**
     1. **General**

The mechanical and electrical works for the Guradamole Multi-Village Water Supply Project in the Somali Regional State, which include design review, supply, installation, commissioning, and testing of electromechanical components including the pipes, and fittings.

* + 1. **Scope of the Works**

Under this contract the raw, clear water, booster pumping stations and treatment plant will be equipped with two vertical turbine pumps at Raw water pumping station and six submersible centrifugal types at clear water and booster pumping stations, associated suction and discharge pipes, valves and fittings, manually operated overhead travelling cranes, surge tank, chemical plant, and necessary electrical works.

The pump stations will also be equipped with standby diesel generator sets and associated and ancillary works required for the completion of the above works.

In Generally, the scope of works for the Guradamole Multi-Village Water Supply Project shall be carried out as follows:

* Design review, Supply, installation, commissioning, and testing of electromechanical components including the pipes, and fittings at Raw, Clear and Booster pumping stations
* Design review, Supply, installation, commissioning, and testing of two vertical turbine pumps of design discharge 24.5 l/s at 83 m head @ raw water intake pumping station,
* Design review, Supply, installation, commissioning, and testing of three submersible pumps of design discharge 13 l/s at 257m head at clear water pump station,
* Design review, Supply, installation, commissioning, and testing of three submersible pumps of design discharge 8 l/s at 255m head at Booster Pumping Station (BPS).
* Design review, Supply, installation, commissioning, and testing of one prime power generator of 150KVA at intake pump station.
* Design review, Supply, installation, commissioning, and testing of one prime power generator of 350KVA at clear water pump station.
* Design review, Supply, installation, commissioning, and testing of one prime power generator of 250KVA at booster pump station to 500m3 SR at Haro-dibe Town.
* Design review, Supply, installation, commissioning, and testing of Pipes and fittings related to EM (Treatment plant: Plain Sedimentation tank, Coagulation-Flocculation Tank, Chemical mixing, store and laboratory Building, Sedimentation tank (Clarifier), Slow Sand Filter (SSF), Clear water tank (500 m3),post chlorination and Laboratory Equipment’s).
* Design review, Supply, installation, commissioning, and testing of Treatment plant EM Equipment’s
* Design review, Supply, installation, commissioning, and testing of Chemical plant
  1. **Ambient Conditions**
     1. **Altitude**

The altitude of the works is 890 masl at the raw water pump station site, 962.72 masl at treatment plant, 958.72 masl at clear water pump station, and 1150 at booster pump station.

* + 1. **Derating**

Items of plant at the works shall be de-rated for an altitude of 1150masl at all pumping stations and treatment plant site and a maximum ambient temperature of 400C.

* 1. **Tools and Workshop Equipment**
     1. **General**

Comprehensive tools kits to permit routine repairs and maintenance of equipment shall be provided. The tools shall be supplied in lockable steel boxes and cabinets. These tools shall be supplied in addition to the specified special tools.

* + 1. **General Tool Kit**

Sets of the following items shall be supplied in lockable steel toolboxes:

ONE Set of ten open-ended spanners, 6-27 mm

ONE Set of open-ended spanners, 5-10mm

ONE Set of nineteen ring/open end combination spanners, 10-32 mm

ONE Set of Allen keys, 1.5 - 13mm

ONE 7" locking grip wrench

ONE 8" adjustable wrench, capacity 25 mm

ONE 18" adjustable wrench, capacity 50mm

ONE 18" Stillson wrench

ONE 30" Stillson wrench

ONE 1 ½ " chubby flat tip screwdriver

ONE 1 ½ " chubby No 2 crosshead screwdriver

ONE 4" flat tip screwdriver

ONE 6" flat tip screwdriver

ONE 8" flat tip screwdriver

ONE 10" flat tip screwdriver

ONE No 1 crosshead screwdriver

ONE No 2-crosshead screwdriver

TWO Pairs 8" Engineers' pliers

ONE Pair 6" long nose pliers

ONE Pair 10" multi position groove joint pliers

ONE Pair 10" straight cut tin snips

TWO Pairs circlip pliers

TWO Adjustable frame 12" hacksaws, each supplied with 50 18 tip blades, 50 24 tip blades and 50 32 tip blades

SIX Engineers' files, flat/half round with handles

ONE Ball pein hammer

ONE Claw hammer

ONE 3m steel tape

* + 1. **Power Tools, Accessories and Measuring Equipment**

The following items shall be boxed in clearly marked steel or wooden boxes and supplied in a lockable steel cabinet:

ONE Two speed electric drill with 15mm chuck

ONE Electric angle grinder, complete with 50 6" disks

ONE 50m extension lead with plug and socket

ONE Set of 25 straight twist drill bits, 1-13mm

ONE Set stud extractors

TWO Sets metric feeler gauges

ONE 300mm steel rule

ONE 900mm steel rule

ONE 900 mm spirit level

ONE Engineers square

* + 1. **Welding Equipment**

The following welding equipment shall be supplied:

ONE Diesel driven arc welding unit, 150A

ONE Mains driven arc welding unit, 75A

FOUR Sets welding tackle and clamps

FOUR Boxes of electrodes for carbon and carbon manganese steel

* + 1. **Electrical Test Equipment**

The following shall be supplied complete with test lead and leather carrying cases, locked in a steel cabinet;

ONE Multi-meter tester, AC current 100 mA- 10A full scale deflection in four ranges, DC current 50mA-10A full scale deflection in seven ranges, AC voltage 2.5 KV full scale deflection in five ranges, DC voltage 2.5 V - 1000 V fsd in five ranges.

ONE battery powered clamp meter, AC current to 300 A, AC voltage to 600V, resistance to 10kΩ

ONE Insulation tester, hand crank type, capable of testing at 500 V and 1000 V.

SIX Panel keys

* + 1. **Work Bench**

One wooden mechanic's workbench shall be supplied, complete with soft faced vice.

**Laboratory Equipment**

The following laboratory equipment shall be supplied.

ONE Hand held, battery powered pH meter

ONE Hand held, battery powered colorimeter

ONE Turbidity meter

TWO Sets of jar test apparatus

ONE Set laboratory glassware, comprising beakers, flasks, pipettes, burettes, reagent bottles culture dishes, etc

ONE Water bath with thermostat

ONE Drying oven

ONE Refrigerator

ONE Autoclave

ONE Incubator

TWO Membrane filtration kits

* 1. **Spare parts**

A Sum has been allowed in the Schedule of Prices for the supply of spare parts. Two years supply of spare parts essential for regular servicing of equipment as recommended by the manufacturer or indicated in the service manuals is required. The spare parts shall at least include the following items for each pump;

* Service kit, Bearing, Mechanical seal, Packing gland etc. for the Electric Submersible pump, Vertical inline shaft pumps & motors.
* Recommended service parts and spares for generator sets and control panels
* Any other spares recommended by the manufacturer

**MANDATORY SPARE PARTS**

* Complete set of spare fuses or MCB's as required
* Spare coils and contactors for starters
* Spare overload relays and contacts for starters
* Recommended spares for control systems
* The service kit and spare parts required for the maintenance and repair of electric submersible pumps, vertical inline shaft pumps, and motors include critical components to ensure optimal performance. For electric submersible pumps, key items include impellers, wear rings, diffuser plates, O-rings, gaskets, mechanical seals, and shaft sleeves. Bearings, such as thrust and radial bearings, are essential for smooth operation. Sealing components like mechanical seals, seal housings, and cable glands, along with, and sensors (e.g., temperature,), are also vital. Additional accessories like check valves, and sand screens may be required for specific applications.
* For vertical inline shaft pumps, service kits typically consist of impellers, wear plates, casing rings, O-rings, and shaft sleeves. Bearings, including line shaft and thrust bearings, are necessary for reliable functionality. Sealing components such as mechanical seals, packing glands, and lantern rings play a key role in ensuring leak-free operation. Other essential parts include flexible couplings, coupling guards, and alignment shims, as well as strainers and mounting bolts for structural support.
* The motors used with these pumps also require regular maintenance. Key components include thrust and radial bearings, stator winding insulation materials, rotor balancing parts, and fan guards, and, while lubrication systems require grease, oil, seals, and sight glasses. Other parts like vibration dampers, shaft keys, and motor housings may be necessary based on the repair requirements. To support maintenance activities, tools and consumables like alignment tools, pullers, torque wrenches, lubricants, and cleaning solvents are essential. This comprehensive list ensures the continued efficiency and longevity of the pumps and motors in various applications.

All spare parts shall be new, unused and strictly interchangeable with the parts for which they are intended to be replacements. The parts shall be treated and packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose.

When more than one spare is packed in a single case or other container, general description of its containers and other packages shall be marked and numbered in an approved manner for purposes of identification.

* 1. **Special tools**

A Sum has been allowed in the Schedule of Prices for the supply of special tools. One complete set of any special tools and appliances necessary for the operation, testing, maintenance and dismantling of equipment, whether of a mechanical or electrical nature shall be supplied for each type of equipment. Special tools indicated as essential in-service manuals or recommended by the manufacturer shall be supplied with the equipment. Items like bearing extractors, uniquely shaped spanners and wrenches manufactured for specific maintenance duties on the equipment should be included in the supply.

* 1. **Record Drawings**

Record drawings shall be prepared and compiled by the Contractor after the Works have been completed and handed over and shall constitute a permanent record of the whole of the works as finally built and installed. They shall be produced in the form of black lines on a durable translucent film from which paper prints can be taken by others as required.

A print of the appropriate wiring connection diagram shall be fixed to the inside of the hinged front of each control cabinet, switchboard panel or distribution switchboard. The print shall be protected by non-flammable transparent material. Where insufficient space is available, the print shall be reduced in size. A copy of the print shall also be provided with the Record Drawings and inserted in the Operating and Maintenance Instructions. In addition, block diagrams of the panel components shall also be fixed to the inside front covers so that operators and maintenance personnel are made aware of the function of each component.

* 1. **Installation, Operating and Maintenance Manuals**

The Contractor shall supply to the Engineer illustrated operating and maintenance manuals. The manuals shall be in one or more volumes in order to separate literature from drawings, etc., as necessary.

The manuals shall have tests in English. They shall include the following information for the operating personnel:

1. Description of all systems installed, including electric lighting and power installation, electronic installations, mechanical installation, air systems, automatic controls systems, etc. An identification system should be established and shown on drawings and in the manuals.
2. Description of all Plant supplied including manufacturers' leaflets, which are to be scheduled for easy reference.
3. Schedule of all Plant supplied, giving duties, electrical loads, etc.,
4. Schedule of all equipment suppliers (and their local agents) including names, addresses, telephone, telex and Fax numbers.
5. Fully detailed instructions for the installation testing and commissioning of all plant, which will be undertaken by the contractor including detailed schedules of checks to be carried out prior to putting the equipment into operation.
6. The Start-Up Operation and shut down instructions for all equipment and systems,
7. Full maintenance instructions for all equipment including planned maintenance schedules or charts giving daily, weekly, monthly, quarterly, half yearly and annual maintenance instruction, together with recommended lubricants and spares. This should also include details of routine maintenance work that will be within the competence of the normal maintenance staff, and notification of maintenance work that will have to be done the manufacturer, his agent or other specialist operator.
8. Spare parts list.
9. Fault finding charts.
10. Record drawings of all systems installed including general arrangements, conduit and wiring trunking systems, Plant rooms details, air and water systems flow sheets, wiring diagrams, control schematics and valve charts, etc., to a reduced scale.
11. Certified supplier's drawings of all equipment supplied, which are to be scheduled for easy reference.
12. Copies of performance curves.

A copy of each manual at least in draft form shall be submitted four weeks before shipping the equipment to which it refers. The draft manual submitted shall include details of all items of plant and equipment unless the Engineer approves separate submission of details of particular items. The final version, modified as necessary to accommodate any changes on site and all test results and certificates as specified, shall be presented as soon as possible thereafter. Six copies of each set of manuals and two CDs shall be issued to the Engineer before the Plant is shipped.

Each manual shall be durable and permanently bound within a stiff binder. The cover of each binder shall be finished with a black waterproof and greaseproof material and the title printed in gold block lettering on the front and on the spine.

* 1. **Tests After erection on Site**

All Plant shall pass such tests on site as are required by the Engineer to prove compliance with the contract independently of any tests which may already have been carried out at the Manufacturer's works. In particular, all electrical pressure tests made at the Manufacturer's works shall be repeated at voltages to be approved by the Engineer, and all pump performance tests shall be repeated on Site.

The Contractor shall prepare all on site test results and certificates for all items as required by the IEE Regulations and relevant British Standards. These certificates and test results shall be provided in triplicate with copies included within the operation and maintenance manuals. The Contractor shall maintain on Site marked up copies of all changes to the installations as they proceed. These changes shall be agreed with the Engineer on a weekly basis and shall be included on the Record Drawings produced by the Contractor for all installed equipment as specified elsewhere.

All skilled labour, supervision, apparatus, electricity, water, fuel and the like for tests, and instruments required for carrying out the tests efficiently will be the responsibility of and at the expense of the Contractor. The accuracy of the instruments shall be demonstrated if required. Tests on completion shall be carried out to ensure that the Plant is complete, has been correctly installed, is reliable in operation under the conditions at site and is able to operate over its whole working range. In addition, the efficiency and performance of the Plant shall be checked as far as possible over the whole works

Range and the values obtained will be compared with those obtained during the tests at the Contractor's premises. The Contractor shall include for all tests that may be require by any statutory Authority. On completion, all plant and pipe work systems shall be properly balanced, left in working order and instructions given on the efficient operation and maintenance of the plant to the Engineer satisfaction. If, in the opinion of the Engineer, the Plant does not comply with this Specification, the defect shall be remedied at no cost to the Employer.

* + 1. **Continuous Test Period**

The Plant shall be tested, under normal operating conditions over a continuous period of 14 days. The Plant shall, at the discretion of the Engineer, be divided into sections for the purpose of these tests but each and every section shall be tested for the full period of 14 days continuous operation. Where sections of Plant form an integral operation the section of the Plant shall be tested together to ensure the correct and proper functioning of the water pumping, storage and flow systems,

The Contractor shall arrange to run all Plant before submission for final testing to ensure that the period will not be interrupted for adjustment or breakdown.

* 1. **Instructions and Training of Local Staff**

The Contractor shall allow operator’s access to the Site during the erection and commissioning of the systems as part of their training programme. There shall be in addition to this, a period of three weeks minimum of official instructions and training after the end of the commissioning period and prior to hand over of the complete systems,

The Contractor shall make available for the purpose of instruction, competent staff and all information necessary for the effective execution of the training programme. The Contractor must instruct and train the trainees in such a way that the operation, maintenance and if necessary, repairs to the systems can be handled competently by the respective personnel.

* 1. **Employer’s & Engineer’s in Attending Factory Inspections**

The following factory tests shall be witnessed by both representatives of the Employer and Engineer.

* Vertical in line shaft Pump Performance Tests
* Submersible pump Performance Tests, if any
* LV Electrical Switchgear Function tests for both surface and submersible pumps
* Standby Generator Performance Tests

In addition to the performance test, which will be guaranteed by a third party, the witness test and physical test will also be conducted by the Purchaser at the manufacturer's facility. The Ministry of Water and Energy will carry out inspections at the manufacturer's warehouse before shipment (if required) and at the final destination.

The Ministry will assign five experts with varied qualifications and expertise to oversee the inspection process. All necessary facilities and assistance, including access to drawings and production data, must be provided to the inspectors at no additional cost to the Purchaser. However, the Ministry of Water and Energy will bear the travel and accommodation expenses for the inspectors.

This arrangement ensures thorough testing and verification of the pumps' compliance with the contract specifications.

**B - MECHANICAL PARTICULAR SPECIFICATIONS**

1. **MECHANICAL PARTICULAR SPECIFICATIONS**
   1. **Treatment Plant, Mechanical Particular** 
      1. **Treatment Plant Process**

The raw water will be pumped from raw water wet well to Plain Sedimentation tank from where it flows by gravity to Coagulation-Flocculation Tank.

The treatment process incorporates the following stages:

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Description** | **Unit** | **Quantity** |
|  | **Treatment Components** |  |  |
| 1 | Raw water Intak and Raw water Pumping Sation | No | 1 |
| 2 | Plain Sedimentation tank | No | 1 |
| 3 | Coagulation-Flocculation Tank | No | 1 |
| 4 | Chemical mixing, store | No | 1 |
| 5 | Sedimentation tank (Clarifier) | No | 1 |
| 6 | Slow Sand Filter (SSF) | No | 1 |
| 7 | Post Chlorination EM part | No | 1 |
| 8 | Clear water tank (500 m3) | No | 1 |
| 9 | Laboratory Equipment | No | 1 |

River Intake

­­Slow Sand Filter

CWR

Sedimentation

Coagulation

Plain Sedimentation

Ca (OCl)2

Alum Line

Figure - Proposed Treatment Process for Guradamole Water Supply Project

The treated water will be delivered to a Clear Water Tank. From the clear water tank the water will be supplied to the clear water pump station (CWPS) from where it is pumped by three clear water pumps in a 2+1 arrangement, to BPS and this BPS will be pumping to service reservoir in the town.

* + 1. **Treatment Plant Performance**

The Contractor shall be responsible for checking of the hydraulic and process design for the treatment plant. The plant has been designed to treat raw water from River to potable standard complying with the Ethiopian Drinking Water Standard/WHO guidelines for drinking water quality.

The Bidder shall satisfy himself that the designed plant layout shown on the Employer's Drawings complies with the following design criteria and capable of producing water of potable standard. The leading dimensions of individual structures have been designed to fit the electromechanical requirements.

* + 1. **Design Flow**

The treatment plant is designed to produce clean water of 2,328 m3/day.

The treatment plants will be designed to meet the maximum day demands at the end of the design period. This is about 24.94 l/s or 2,155 m3/day and also an additional 172.39 m3/day water to be used for the treatment plant (for wash of Slow sand filter, chemical preparation and internal use within the treatment plant site). The net amount of water required to be produced by the plant will be 2,328 m3/day.

* + 1. **Design Dosing Rates**

The chemical preparation and dosing plant have been designed to supply aluminum sulphate at a maximum rate of 20mg/l to the incoming raw water. The lime dosage shall be sufficient to react with the aluminum sulphate dose and to ensure the product water is not aggressive and is about 6mg/l. The calcium hypochlorite dosing plant shall be designed to dose filtered water to achieve a minimum chlorine residual of 0.5 mg/l.

* + 1. **Inlet Control**

The raw water to the treatment plant will be conveyed by pipe from the Raw water Pumping Sation to Plain Sedimentation tank and enters Coagulation-Flocculation Tank. The inflow to the TP will be regulated by a butterfly valve in a valve chamber at the inlet to the rapid mixing chamber.

* + 1. **Rapid Mixer**

From the Raw Water Balancing reservoir water flows to the rapid mixer chamber through a pipe. Aluminium Sulphate will be gravitated from a gravity fed dosing system and is added at this point.

* + 1. **Flocculator**

Adjustable baffles will be installed at specified intervals along each flocculator. The baffles and their holding & adjusting frames should be able to be adjusted, assembled and disassembled easily, to clean the flocculation channel, to adjust distances between baffles and the baffle width.

* + 1. **Sedimentation Tank**

Two sedimentation tanks in parallel have been designed. Under this contract supply and installation of the necessary electromechanical equipment shall be done.

* + 1. **Inlet Pipe work**

The raw water from the flocculators is supplied to sedimentation basin through a perforated inlet distribution channel and diffusion wall.

* + 1. **Sludge Drains**

The sludge draw-off piping consists of a drain pipe and connected to a butterfly gate valve.

* + 1. **Clarified Water Outlet**

DN250 stainless steel perforated pipes, four to each tank, with a length of 5.4m and 45, DN40 holes on each pipe will collect the clarified water and supply the clarified water outlet channel of each tank.

* + 1. **Filters**

The designed general arrangement of the filters is shown on the Employer's Drawings. Two sets of three filters arranged in two parallel rows are to be equipped under this contract.

* + 1. **Filter Controls**

The filters shall be of the simple, rising head type, without complex control on the inlets or outlets. All filter control valves will be operated either from the filter walkway or directly at their installation position based on the arrangement of valves as shown on the drawings.

* + 1. **Inlet Pipe work**

butterfly valve will regulate flow into the inlet channel of each filter from the filter clarified water outlet pipe.

* + 1. **Filter Floor and Under-drains**

The under drain arrangement is indicated in the tender drawing. The necessary pipes, fittings and valves shall be supplied and installed under this contract.

* + 1. **Filter Overflow & Drains**

overflow pipe will be provided to each filter to drain excess water to the filter overflow and drain collection pipe which deliver overflow and drain water to the compound drainage system.

pipe system will drain the clarified water inlet channel to the filter overflow and drain collection pipe which deliver overflow and drain water to the compound drainage system.

* 1. **Pumping Stations, Mechanical Particular**

**General**

This section of the Specification sets out the particular requirements for the mechanical part of the pumping station Works. The Contractor shall supply, manufacture, test at manufacturer’s works, transport to site, store, protect and paint, unload, install, test on completion and carry out performance tests as detailed herein and as required to demonstrate the satisfactory operation of this part of the Works.

The Contractor shall prepare and submit for approval ‘as built’ documentation, including, operation and maintenance manuals, provide selected spare parts and perform training in the operation of the works.

The Contractor shall provide all labour, material, plant and equipment for a complete working installation to the satisfaction of the Engineer. To remove doubt references to the Contractor providing an item of plant shall include all of the above tasks unless otherwise stated.

* + 1. **Design Pump Duty**

The required capacities of the surface pumps are shown below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Description** | **Head, [m]** | **Discharge [l/s]** | **Pumps Arrangement** |
| 1 | Raw water pumping station | 83 | 24.5 | 1+1 |
| 2 | Clear water pumping station | 257 | 13 | 2+1 |
| 3 | Booster Pumping Station | 255 | 8 | 2+1 |

* 1. **Multi-stage vertical inline shaft pumps (turbine pumps) and Electric submersible Centrifugal Pumps and Associated Pipe Work**
     1. **Vertical Turbine Pumps**

**General**

The submersible vertical turbine pumps shall be multi stage units suspended from surface plates by vertical discharge pipes and driven by electrical motors. The impellers of the open, semi-open, or enclosed type shall be statically balanced and shall be fabricated from material which can withstand the pumped raw water high corrosive and abrasive characteristic condition which may change periodical in time. They shall be machined and polished to close tolerances. They shall be hand- finished to template.

The pump bowels shall be fabricated from materials which can withstand the conditions as the impellers as mentioned above, and working faces shall be accurately machined and where necessary, provided with registers of adequate depth to ensure accurate and true alignment. The bowels shall be capable of withstanding a hydraulic pressure equal, at least, to one and half times of the shut-off head.

In case of impellers of enclosed type, they shall be equipped with wear rings of renewable type. The shaft shall be of stainless steel with journals sleeved with renewable hardened stainless-steel sleeves. All bolt holes are to be drilled to template for easy interchangeability and tapped bosses shall be provided in appropriate places for primary drain and gauge connections.

All bolts, nuts, plates, guards, etc. necessary for installation of the pump and all external auxiliary piping and fittings necessary to render the complete shall be provided. The strainer shall be constructed entirely from stainless steel and shall have a net inlet area equal at least three times the impeller inlet area. The maximum unit opening shall not be more than 75% of the minimum opening of the water passage through the bowl or impeller.

The pump motor coupling, in case of separate pump, and motor shafts, shall be of non-corrosive material shall be capable of transmitting the total torque and total thrust of the unit in either direction.

The surface plate (pump base) shall of a design which will ensure a water tight capping of the well, and shall be rigid enough to support the entire weight of the suspended parts when filled with water. The plate shall provide suitable openings for the power cable, well vent and water level indicator as required. The plate shall also support the discharge connection (discharge elbow) and therefore the surface plate shall be provided with a welded connection piece consisting of a double flanged steel pipe section of a diameter equal to the discharge pipe diameter.

The capping must be fitted directly on to the upper portion of the inner casing and the contractor shall propose a method for connection of the surface plate to the bore hole’s inner protective casing, which according to the borehole design, will reach 12 inches above the normal ground level and will be temporarily closed by a screwed steel cap till the erection of the pumping equipment. The discharge connection (elbow) shall be flanged and furnished in a size adequate for the required flow rate and in a pressure series consistent with the surface pressure to be delivered by the pump.

The discharge elbow shall be equipped with discharge gauges of the Bourdon Tube type with dials of at least four inches in diameter. Each gauge shall be fitted with a stop cock.

The pumps shall be protected against low water level in the wet well/reservoir using an electrode probe and a protection relay (installed in the starter box of the switchgear in pump starter compartments).

* + 1. **Electrical Submersible Pump / as Clean & Booster Pumping**

**General**

The required pump type is a multi-stage, mixed flow type, electric motor driven, deep well submersible pump. The submersible pumps shall comply with the relevant clause of the general specification.

The pump sets shall comply with the requirements of the general specification on Electric Submersible Borehole Pumps ets except where the requirements of this part of the specification are more stringent or different.

The Contractor shall determine the need for a shroud if a shroud is required, the shroud shall be made from grade 304 stainless steel and the annulus separation between the motor and shroud shall be chosen to ensure that the manufacturer’s specified water velocity over the motor surface shall be sufficient to provide the necessary cooling at each duty flowrate and associated power loading. The water temperature shall be taken into account when establishing the cooling water flowrates.

Materials of construction shall be selected with due regard to the water being pumped and the risk of corrosion, cavitation, and metal-to-metal galling that can occur within a pump in all its modes of operation.

The following table outlines the general material construction of the pump. However, it is the Contractor’s responsibility to select the exact grade of materials that will provide an adequate service life. (Contractor to specify in detail materials offered in the Data Schedules of Technical Information).

* + 1. **Pump Motor Sizing and De-rating**

The motor sizing shall take account of maximum possible run out operation, de-rating due to both the high ambient temperatures in the pumping station and the high altitude of the pumping stations. The maximum ‘specified run out’ absorbed power shall be the absorbed power when only one pump is running under the system curve condition of minimum static head.

The sizing shall be calculated as follows:

Maximum ‘specified run out’ absorbed power P kW

Add a 10% margin (P+10%) kW

Factor up by 12% for altitude de-rating (P+10%) x 1.12 kW

Factor up by 4% for temperature de-rating (P+10%) x 1.04 kW

Hence the selected motor size must equal or be greater than 1.276P kW

* + 1. **Pump Materials**

Materials of construction shall be selected with due regard to the water being pumped and the risk of corrosion, cavitations, and metal-to-metal galling that can occur within a pump in all its modes of operation. The following table outlines the general material construction of the pump. However it is the Contractor’s responsibility to select the exact grade of materials that will provide an adequate service life(During the design review). (Contractor to specify in detail materials offered in the Data Schedules of Technical Information).

* + 1. **Pump Performance Requirements**
       1. **Raw Water Pumping Station (RWPS)**

Three singles/multi stage vertical turbine type pump sets shall be provided to transfer 24.5 l/s to the Plain Sedimentation tank/ reservoir located at treatment plant site. This shall be achieved with one duty and one standby pump sets.

the pumps running in parallel shall deliver 24.5 l/s at a head of 83m. The required guaranteed duty point is therefore 24.5l/s at a head of 83m. The pumps must be capable of operating over the operating range without cavitations, undue vibration or any detrimental effect.

The pumps shall have a minimum hydraulic efficiency of 70% at the duty point.

Materials of construction of Raw water Pumping Sation shall be as follows

| **Multistage Centrifugal Ring Section Type** | |
| --- | --- |
| **Pump Parts** | **Material** |
| Suction Casing | Cast iron |
| Inter-stage casing | Cast iron |
| Discharge casing | Cast iron |
| Diffuser | Cast iron |
| Bearing Housing | Cast iron |
| Stuffing box Housing | Cast iron |
| Shaft | Stainless steel |
| Impeller | Cast bronze/ stainless steel |
| Casing and diffuser wear rings | Bronze |
| Shaft sleeve | Chrome nickel steel |
| Shaft protecting sleeve | Chrome nickel steel |
| Gland packing | Teflon + graphite |

General

This specification outlines the requirements for vertical line shaft pumps intended for use in raw water pumping stations. These pumps are critical for water supply applications. including municipal, agricultural, and industrial uses.

Scope

* Application: Designed to transport raw water from surface water sources (like rivers, lakes) or groundwater wells.2
* Components: Includes pump assembly, motor, bearings, shaft, and necessary fittings.

Materials

* Pump Casing: Material: ASTM A48 Class 30 cast iron or equivalent corrosion-resistant material.
* Impellers: Material: Bronze (C93200) or stainless steel (AISI 316):
* Shaft: Material: High-strength stainless steel (AISI 304 or 316).
* Bearings: Material: Bronze or composite materials.
* Seals: Mechanical seals rated for raw water service.
  + - 1. **Clear Water and Booster Pumping Station**
         1. **Clear Water Pumps**

General

For the clean water and booster pumping station, as shown in the drawing, the electric submersible pump is installed vertically within a casing with a total length of 6 meters Casing. Of this, 3 meters are submerged below the Original Ground Level (OGL), while the remaining length extends above the surface. The above-surface portion must be equal to or greater than the wet well overflow level. The casing's inlet is located at the bottom. Accordingly, the drawing includes the following details: the OGL elevation, the minimum and maximum water levels in the booster reservoir, and the pump's position.

the final casing length will be determined during the design review by the contractor, taking into account the pump length and the minimum submerged depth required for the pump.

The Contractor shall determine the Diameter for a Casing, the Casing shall be made from grade steel. the motor and Casing shall be chosen to ensure that the manufacturer’s specified water velocity over the motor surface shall be sufficient to provide the necessary cooling at each duty flowrate and associated power loading. The water temperature shall be taken into account when establishing the cooling water flowrates.

* Each pump shall be run and tests will be carried out in accordance with BS 5316 part or other equivalent standards and each pump set shall be tested for efficiency at head/discharge/ duty speed and the tolerance of the curve is according to ISO 9906.
* Head/discharge, efficiency/discharge and power/discharge curve shall be drawn and the pump set shall be free from cavitation’s and vibration over the whole working range
* HEAD SHOULD BE AS REQUESTED IN THE BOQ and according to grade 2 2B +/-5%.
* DISCHARGE according t grade 2 2B +/-8% with reference to the requested discharge.
* THE MODEL AND CAPACITY (DISCHARGE AND HEAD OF THE PUMP) SHOULD BE WRITTEN ON THE BODY OF THE PUMP WITH LIGHT RAY /RADIATION, IF THE PLATE IS WELDED /ATTACHED ON THE BODY OF THE PUMP IT LEADS TO REJECTION DURING INSPECTION.
* Pump casings shall be subject to a pressure test of 1.5 times of the maximum pressure obtained with delivery valve closed.

## Submersible Pump Technical specification

* **Type**: Multistage centrifugal radial or mixed flow impellers and direct coupled to submersible motor.
* **Shaft**: shaft in stainless steel, protected by replaceable stain less steel bushes supported at the ends by bearings protected against sand infiltration.
* **Impellers**: In stainless steel, zinc free casted bronze keyed to the shaft by splines or Spilt cons or other means, other pump parts made of stainless and water lubricated bearings. Discharge chamber should internal threaded for pipe connection or flanged vertical directly coupled to the motor.
* **Balance**: Statically and dynamically balanced
* **Non-return valve**: built in with treaded port at the out let.
* Stainless steel strainer at pump suction
* Screwed connection for riser pipes conforming to ISO 65 and threaded to ISO 7 or equivalent.
* Motor cable protection /cable guard on the pump body.
* Painting approved for drinking water
* The pumps shall have a minimum hydraulic efficiency of 70% at the duty point.

**Material & technical specification for submersible pump**

Materials of construction shall be selected with due regard to the water being pumped and the risk of corrosion, cavitation, and metal-to-metal galling that can occur within a pump in all its modes of operation.

The following table outlines the general material construction of the pump. However, it is the Contractor’s responsibility to select the exact grade of materials (During the design review) that will provide an adequate service life. (Contractor to specify in detail materials offered in the Data Schedules of Technical Information).

| **Component** | **Material** | **Standard** |
| --- | --- | --- |
|  |  | Din W.-Nr. Or equivalent |
| Shaft | Stain less steel | Stain less steel |
| Impeller | Stain less steel/ Zinc free bronze DIN 1705/ Casted bronze |  |
| Bearing | NBR/stain less steel |  |
| Stop ring | Stain less steel | Stain less steel |
| Cable guard | Stain less steel | Stain less steel |
| Coupling | Stain less steel | Stain less steel |
| Washer | Stain less steel | Stain less steel |
| Wear ring | Stain less steel | Stain less steel |
| Spacing washer for stop ring | Carbon/graphite |  |
| Valve guide | Stain less steel | Stain less steel |
| Spring for valve cup | Stain less steel | Stain less steel |
| Shaft key/cone/spine or others | Stain less steel | Stain less steel |
| Chambers | Stain less steel | Stain less steel |
| Upper valve seat | Stain less steel | Stain less steel |
| Nut for stop ring | Stain less steel | Stain less steel |
| Neck ring | NBR |  |

## Pump Casing

The pump casing shall have replaceable wear rings. The casings of the pumps shall be of a suitable grade of close-grained cast iron to BS 1452 (or equivalent) Grade 250, DI to BS 2789 Grade 420/12, Stainless steel to BS 970 grade316c15 and have flanges or threaded to match the specified pipe work. The water ways through the pump shall be smooth in finish and free form recesses and obstructions. Pumps shall be designed to facilitate maintenance and manholes shall be provided to allow the interior of the casings and bearing seals to be examined without dismantling the pump. It shall be possible to remove pump impeller with the minimum disturbance to pipe work and by suitable joints to allow the pump to be removed without dismantling the main pipe work.

## Impellers

The impellers and guide vane shall be of suitable material preferably **cast in high-grade zinc free bronze or stainless steel,** accurately machine and smoothly finished to minimize hydraulic losses. The pump shall be equipped with wear rings of renewable/replaceable type, made of zinc free bronze, stainless steel, metal reinforced rubber and having larger bearing surface. The rotating element shall be statically and dynamically balanced before final assembly.

**Bearing: -**

All bearings shall be liberally rated to ensure cool running and meet the load factors specified.

For vertically mounted pumps the bearings, shall be a combined thrust and journal type, designed to prevent any thrust loads being imposed upon the drive motor. The pump bottom bearings shall be lubricated by an enclosed water lubricated sleeve bearing suitable for potable water applications.

**Shaft seals: -**

All seal materials shall be compatible with and/or resistant to the fluid or gas being handled. For potable water, seal materials shall be those specifically approved for use in the water industry.

**Flanges:** -

All flanged connections of pumps, pipe work, valves and other relevant equipment shall have flanges in accordance with BS 4504 or equivalent, unless otherwise specified.

**Pumps Shafts: -**

The pump shaft shall be of high tensile or stain less steel adequately sized, with good fatigue, shock local and corrosion resistance. The duty speed range shall be well below the first critical speed of the shaft. Where a change in diameter of the shaft occurs, the shoulder shall be reduced or under cut to the appropriate BS or equivalent to reduce stress concentration. The shaft shall be complete with easily renewable/replaceable stainless steel or bronze protecting sleeves at glands and bearings.

Manufacturer Technical data of the Submersible pump should be supported by hard copy of technical brochure.

| **NO.** | **Component** | **TO BE FILLED BY BIDDERS** |
| --- | --- | --- |
| 1 | Manufacturer |  |
| 2 | Country of origin |  |
| 3 | Model designation |  |
| 4 | Pump Serial No. |  |
| 5 | Required pump head, HR (m), (not to be altered) |  |
| 6 | Offered pump flow (m3/h) for the required pump head |  |
| 7 | Rated flow (m3/hr) |  |
| 8 | Rated head (m) |  |
| 9 | Efficiency at rated flow (%) |  |
| 10 | Power absorbed at rated flow (KW) |  |
| 11 | Power absorbed at duty point (KW) |  |
| 12 | Efficiency at duty point (%) |  |
| 13 | Power absorbed at duty point (KW) |  |
| 14 | Pump out let size (mm) |  |
| 15 | Pump outlet connection Type (Threaded or Flanged) |  |
| 16 | Material of shaft |  |
| 17 | Material of casing |  |
| 18 | Material of impeller |  |
| 19 | Material of non-return valve |  |
| 20 | Pump diameter over the cable (mm) |  |
| 21 | Allowable maximum sand particles content in water |  |
| 22 | Recommended borehole casing diameter (mm) |  |
| 23 | Pipe clamp thickness (mm) |  |
| 24 | Construction standard |  |
| 25 | Shaft |  |
| 26 | Impeller |  |
| 27 | Bearing |  |
| 28 | Stop ring |  |
| 29 | Cable guard |  |
| 30 | Coupling |  |
| 31 | Washer |  |
| 32 | Wear ring |  |
| 33 | Spacing washer for stop ring |  |
| 34 | Valve and Valve guide |  |
| 35 | Spring for valve cup |  |
| 36 | Shaft key/cone/spine or others |  |
| 37 | Chambers |  |
| 38 | Upper valve seat |  |
| 39 | Nut for stop ring |  |
| 40 | Neck ring |  |
| 41 | Head max/Min [meters] |  |
| 42 | Head at maximum efficiency [m] |  |
| 43 | Discharge max/Min [ l/s] |  |
| 44 | Head at maximum efficiency |  |
| 45 | Maximum Power {kW} [ P2/Q curve] |  |
| 46 | Power at duty point [KW] [ P2/Q curve |  |
| 47 | Revolution per minute |  |
| 48 | NPSH at maximum discharge |  |
| 49 | NPSH at duty point |  |
| 50 | Pump diameter over the cable [mm] |  |
| 51 | Discharge out let diameter [mm] |  |
| 52 | Suction |  |
| 53 | Cable guard |  |
| 54 | Pump casing |  |
| 55 | Diffuser |  |
| 56 | Bolt and nut |  |
| 57 | Pressure gauge size and capacity [mm/bar] |  |

## Submersible Motor Specification

Motor: - Motor shall be three phase, squirrel cage, induction type, continuously rated heaviest specified duty, the two-pole submersible motor easily rewind able and the winding of the stator are made of special water proof wire of pure electrolytic copper sheathed with special non hydroscopic thermoplastic material. Motors shall comply in all respects with the relevant parts of BS 4999 (general requirements for rotating electrical machines) and BS 5000 (Rotating electrical machines of particular types) or equivalent, designed to run at high power factor and efficiency. In addition to the requirements, it shall be capable of satisfactory operation with frequency of + 5% above or below the nominal.

* MOTOR EFF= for motor capacity less than 15kw the efficiency should be greater or equals to 71% and for motor capacity of greater than 18.5kw 78%. It leads to Automatic rejection if it not fulfills the above requirement.

## Technical Specification for submersible motors:

* Submersible wet type motor of adequate power NEMA flange with stud
* Protection: IP 68
* Start per hour: 15
* Installation possibility: vertical and horizontal
* Motor tail cable: Pump-motor length plus 1meter
* Standard voltage; plus 4% of 400 Volt and minus of 5% of 400 volts.
* Protection: thermal over load relays with appropriate current rating range.
* Motors shall have class Y insulation winding the insulation class greater than class Y advantageous point. .
* HIGH VOLTAGE TEST: - The high voltage test shall be applied between the windings and the frame only to a new and completed motor with all of its parts in place filled with water.
* INSULATION RESITANCE TEST: -The insulation resistance when the high voltage test is applied shall be not less than 5 m Ω. The insulation resistance shall be measured with a dc voltage of 500 V applied for a sufficient time for the reading of the indicator to become practically steady, such voltage being taken from an independent source or generated in the measuring instrument.
* Voltage three phase 50 HZ
* Designed as to facilitate rewinding in field.
* Overload margin over rated HP by about 1.15% time
* RPM ≈ 2900
* PT100 motor winding temperature sensor with its cable for motors with capacity of 37KW and above.
* Starting type as specified on BOQ leading parameter.
* Rewind able motor for motors greater than 7.5 kW. REWINDABLE MOTOR FOR GREATER THAN 7.5KW ONE TAIL CABLE (ONE METER ABOVE THE PUMP OUTLET) OTHERWISE IT IS REJECTION DURING INSPECTION.
* Painting approved for drinking water

Material and technical specification for submersible motor

|  |  |  |
| --- | --- | --- |
| **Component** | **Material** | **Standard** |
|  |  | Din W.-Nr. Or equivalent |
| Bearing housing upper | Stain less steel/cast iron | Stain less steel/cast iron |
| Radial bearing | Graphite/stain less steel |  |
|  | Ceramic/tungsten carbide |  |
| Shaft | Stain less steel | Stain less steel/cast iron |
| Motor cable | EPDM/pvc |  |
| Motor sleeve | Stainless steel |  |
| Bearing housing lower | Stain less steel/cast iron | Stain less steel/cast iron |
| Intermediate housing | Stain less steel/cast iron | Stain less steel/cast iron |
| Diaphragm | Especial rubber |  |
| Shaft seal | Rubber lip type |  |
| Trust bearing |  |  |
| Insulation class | Class Y Winding |  |

Manufacturer Technical data of the Submersible motor should be supported by hard copy of technical brochure.

Power rating and technical data for submersible motor

| **NO.** | **Component** | **TO BE FILLED BY BIDDERS** |
| --- | --- | --- |
| 1 | Manufacturer |  |
| 2 | Country of origin |  |
| 3 | Model designation |  |
| 4 | Motor serial No. |  |
| 5 | Submersible motor type (whether rewind able or replaceable type) |  |
| 6 | Construction standard |  |
| 7 | Bearing housing upper |  |
| 8 | Radial bearing |  |
| 9 | Shaft |  |
| 10 | Motor cable |  |
| 11 | Stator |  |
| 12 | Winding type [double or single] |  |
| 13 | Motor sleeve |  |
| 14 | Bearing housing lower |  |
| 15 | Intermediate housing |  |
| 16 | Diaphragm |  |
| 17 | Shaft seal |  |
| 18 | Trust bearing |  |
| 19 | Insulation class |  |
| 20 | Working temperature of winding |  |
| 21 | Power derating factor due to temperature |  |
| 22 | Cooling flow min. [ m/s] |  |
| 23 | Voltage tolerance [ +%] |  |
| 24 | Protection: IP |  |
| 25 | Start per hour |  |
| 26 | Power: KW [in put power p1 >p2 ,  p1 =p2 ]  p1 stands for motor & p2 Stands for pump |  |
| 27 | Power factor [ cos ô] |  |
| 28 | Motor Diameter [ mm] |  |
| 29 | Out let diameter [ mm] |  |
| 30 | Cable led length[meter] |  |
| 31 | Over load capacity [ %] |  |
| 32 | Weight [ kg] |  |
| 33 | Starting type |  |
| 34 | Joint kit size and type |  |
| 35 | No load current (A) |  |
| 36 | Full load current (A) |  |
| 37 | Starting current (A) |  |
| 38 | Efficiency at full load (%) |  |
| 39 | Efficiency at duty point (%) |  |
| 40 | Efficiency at 3/4 load (%) |  |
| 41 | Efficiency at 1/2 load (%) |  |
| 42 | Material of motor body |  |
| 43 | Cooling water flow across the motor surface ( m/s ) |  |

* + 1. **Supply of Technical Information**

The Contractor shall submit the following technical information with the Tender and complete all Schedules of Technical Information.

The Contractor shall submit the following:-

(i) Motor De-rating curve & Calculations

(ii) The system curve, showing the pump H/Q curve with duty point.

(iii) A set of combined pumpset performance curves which shall include:

The standard head versus flow over the complete working range for the duty impeller diameter and both the maximum and minimum impeller diameters in each stage. (Impeller diameters shall be specified)

The pump efficiency

The NPSH required

The pump absorbed power

The motor efficiency

The motor input power

The guaranteed duty point and all other specified duty points shall be shown on these curves.

* + 1. **Pump Set Factory Testing**

All pumps shall be tested individually in accordance with standard spec BS EN ISO 9906 Grade 1 using clean water. The pump performance guarantee duty point shall relate to the flow rate, the total head and the efficiency of the pump.

The tests shall be conducted as follows:

(a). One pump set of each type shall be subject to a full test as follows:

* Pump sets shall be tested at their guaranteed duty point, closed valve, the specified run out point, pump maximum run out point, maximum permissible head and five other points on the performance curve to be determined by the Engineer.
* Temperature sensors shall be connected to motor windings and the temperatures recorded throughout the test
* Vibration of the pump sets shall be tested in accordance with the American Hydraulic Institute Standards (in range of 10 – 1000 Hz).
* The pump sets shall be subjected to a noise test and the maximum ‘A’ noise level shall be not more than 90dBA at 1 meter from the surface of the pump set.
* A full NPSH test

All the above pump tests shall be carried out with their electric motors and assembled on their base plate (for surface pumps) .

Tests shall provide information for performance curves to be drawn for: head/quantity, efficiency/quantity, power absorbed/quantity and net positive suction head/quantity. All the specified duty points in the Technical Schedules shall be shown on the performance curves.

All pump sets shall operate at their guaranteed design points within the ‘acceptance’ tolerances for flow rate and total head laid down in BS EN ISO 9906 level 1. The pump sets will not be accepted if they are outside the accepted tolerances. Vibration of the pump sets or any point outside the bearings shall be no more than 0.71 mm/s and the vibration amplitude (crest value) shall be no more than 0.05mm when the pump sets run normally.

Pump casings shall be subject to a pressure test at 1.5 times the pressure obtained with the delivery valve closed. The positive suction head shall be taken into account in determining this pressure. Electric Motor tests shall be carried out in accordance with the requirements set out in the standard specification.

The Contractor shall submit test results to the Engineer.

* 1. **Pipe work and Valves**

The Contractor shall supply and install all the required pipe work within the pumping stations in accordance with the specification and drawings. The pipe work shall be galvanized steel and flanged with EPDM gaskets approved for use with potable water. All pipe work shall be fully supported, including the installation of all necessary thrust blocks, and no loads shall be transferred to the pumps or valves.

The suction pipe work shall be sized for a maximum flow velocity of 1m/s. The pump suction pipe work incorporates a strainer, isolation gate valve and dismantling joint. The delivery pipe work shall be sized for a maximum flow velocity of 2.5m/s. The delivery branch from each pump shall incorporate a non-return valve, isolating gate valve, fittings and shall connect to the discharge manifold.

The valves shall comply in all respects, including class, testing, marking etc. to the relevant standards. The working pressure of the valves shall be suitable to the pump shut-off pressure. The pipe work shall be adequately supported & anchored to minimize bending stresses and to withstand hydraulic forces.

* 1. **Overhead travelling crane**

The raw and clear water pump houses will be equipped with manually operated overhead travelling crane for installation and maintenance of pumps and associated electromechanical equipment. The crane shall be rail mounted travelling single girder top running gantry crane comprising manual hoist with integral trolley, crane girder, chain, rail and support I-beam.

The cranes shall have manually operated hoist and manually operated longitudinal and transverse travel and shall be of sufficient height to lift the main pumps above any obstacles in the pump house

The Contractor should refer to the Tender Drawings for the following information at the pumping station.

* Crane span, centre to centre distance of rails
* The clearance distance of the centre of the gantry rails to nearest side obstruction
* Vertical distance of top of gantry rail from lowest overhead obstruction
* Distance from floor to top of gantry rail
* Hook travel above pumping station floor level
  1. **Chemical plant**
  2. 1. **General**

The chemical dosing unit is one story, with most of the ground floor reserved for the storage of chemicals. The first floor is used for the preparation of solutions for dosing and includes a total of six tanks. 2 tank each with a capacity of 2000 liters, one for the preparation and one for solution of aluminum-sulphate. 2 tank each with a capacity of 2000 liters one for the preparation and one for lime solutions. 2 tank each with a capacity of 1000 liters, one for the preparation and one for hypochlorite solutions.

* + 1. **Chemical Preparation and Dosing**

The tanks designated for the preparation of aluminum sulphate, hydrated lime and calcium hypochlorite shall be equipped with a mixer complete with electric motor, gearbox, shaft and propeller driven at a speed not exceeding 400rpm, and a mixing basket to dissolve chemicals. The material used for the tanks and ancillary equipment shall be chemically resistant to the chemical solutions of the strength proposed by the Contractor. The motor of each mixer shall be of the TEFC squirrel cage type with IP54 enclosure and be rated for 380 V, 3 phase 50 Hz supply.

A gravity solution feeder shall be provided from each solution tank, each comprising a constant level tank with float controlled inlet valve and outlet regulation orifice.

Aluminum sulphate and hydrated lime solutions shall be delivered to the rapid mixer and calcium hypochlorite solution to the outlet from the filters, through uPVC dosing pipe work. Within the chemical building, the dosing pipe work shall be fixed to the walls. Outside the building, the dosing pipe work shall be laid in trenches. Water supply pipes will be laid from the tanks to the nearest pipeline serving the compound.

* 1. **Surge Suppression Plant**
     1. **General**

The Contractor shall verify the requirement of surge protection, manufacture, supply, install and commission all surge protection equipment required for the pumping transmission main in accordance with the specification. In addition to the surge vessel and air compressor system all necessary valves, tee, pipe work and fittings required to connect the surge tank to the transmission line shall be supplied with the surge vessel.

The Contractor shall construct the concrete base and valve chamber for the surge vessel. The details of the base and valve chamber, including the RC details, shall be built to suit the size, shape and weight of the selected surge vessel determined by the Contractor’s surge analysis.

The surge protection equipment shall maintain pressures in the pipelines within the specified limits under all operation conditions, including simultaneous failure of all pumps.

Surge protection systems shall not utilize the operation of air valves or air valve attachments.

* + 1. **Surge Protection System**

The surge protection system shall take into consideration the maximum flows arising from the final pump selection. The nominal design flows are as follows:

The maximum transient pressure in the system shall not exceed a value of 1bar less than the system test pressure at any location.

Minimum transient pressure shall be maintained above atmospheric pressure at all locations along the pipe line by a margin of more than 5meters except for the pipe line approaching the delivery tanks where the transient pressure shall be maintained at 1m above atmospheric pressure.

* + 1. **Surge Analysis**

The surge protection system shall be checked and ascertained independently by an internationally experienced and approved specialist surge analyst firm.

The surge analyst shall:

1. Construct a mathematical model of the systems using network transient fluid flow simulation computer software;
2. List the steady state conditions under which the system will operate and list the adverse surge conditions under which the system will operate;
3. Determine maximum and minimum surge pressures along the system that can occur due to system operations;
4. Describe possible surgé suppression options,
5. Recommend the preferred option giving details of the maximum and minimum pressures to which the system will be subjected with the surge suppression equipment installed. Full details of the surge suppression equipment and ancillary equipment such as non-return valves, and their method of installation shall be given;
6. Prepare a Surge Analysis Report providing full details of tasks carried out including sufficient data sheets, figures and analysis output, etc. from the network fluid flow simulation software to allow the Engineer to undertake a detailed review of the Surge Analysis Report.

The surge analysis shall address the following issues:

1. Surge protection being provided under this Contract.
2. Nr/capacity of surge vessels to be provided under the contract with connection details and any constraints on their detailed design and location.
3. Type of check valves to be used in the pumping stations.
4. Special protection measures to air valves and chambers at locations where the air valve may experience low pressures during system operations.
   * 1. **Surge Protection**

It is envisaged that the following surge protection (in terms of air vessels) vessel will be provided at the pumping station. The final sizing of the vessels to meet the criteria indicated above shall be carried out by the Contractor (Surge Analyst).

1. **RAW WATER AND CLEAR WATER PUMP STATIONS AND TREATMENT PLANT PARTICULAR ELECTRICAL REQUIREMENTS**
   1. **Electrical General**

The electrical works for raw, clear and booster pump stations and treatment plant shall include the following items:

* Main LV switchboard (incorporating the control & instrumentation)
* Essential services LV switchboards
* 1 No. standby diesel generator at each station
* Cabling (main LV, auxiliary, control & instrumentation)
  + 1. **EEU Work**

All HV work including supply and installation of the station transformer will be carried out by EEU. One pole/pad mounted transformer of 15/0.4 with 200 KVA, 500KVA and 50KVA capacity will be installed at the raw, clear (treatment plant) and booster pumping stations respectively.

The following transformer protection devices may be incorporated by EEU:

* Buchholz relay (on conservator type transformers)
* Overpressure device (on hermetically sealed transformers)
* Coolant over-temperature alarm and trip.

EEU will connect them to their HV circuit breaker. EEU will provide an inter-trip signal to the corresponding downstream LV ACBs.. .

The Contractor shall provide the following:

* Main LV cabling from EEU metering to the MFS (mains failure switch)
* From Standby generator to MFS (mains failure switch)
* From MFS (mains failure switch) to main LV Switchboard
* From main switch board to respective loads.
* Auxiliary supply cables from the Essential Services Switchboard to applicable distribution boards and loads.
* Termination of the main LV cables shall be carried out to the satisfaction of EEU and if required, under their direct supervision.

Sizing of the main LV cables shall be in accordance with the design carried out to meet the requirements of the section of this specification relating to cable sizing and voltage drop.

The expected vector group for the transformers is DYn11, but even if this is not the case it can be expected that the secondary winding will be “star” connected with the star point brought out at the system neutral.

Earthing of transformer secondary winding star point shall be made solid by connection of the neutral conductor to earth. Each connection shall be via a bolted link.

* + 1. **Manual Changeover Switch (MCS)**

The MCS unit shall be fixed and supported to suit the final cabling requirements to the unit and switchgear.

The MCS units shall include the following basic requirements

* Incoming mains and standby circuit breakers
* Main bypass switch suitably interlocked
* Mains and alternator Changeover contractors electrically and mechanically interlocked

There is no requirement to parallel the standby diesel plant with the EEU incoming mains supply. All required electrical and, where possible mechanical interlocks shall be provided to prevent any form of inadvertent simultaneous closing of the supply source circuit breakers.

* + 1. **Motor and Equipment Voltages**

The drives of auxiliary pumps, fans etc shall operate on a 380 V 3 phase supply. Single phase power sockets provided as part of the building services system shall operate at 220 V.

Note:- The expected ratio of the EEU transformer will provide a nominal secondary open circuit voltage of approximately 400 V. Thus the fully loaded voltage will be 380 V phase to phase, and 220 V phase to neutral. The Contractor shall be responsible for ascertaining the actual supply voltage from EEU.

* + 1. **Local Control Facilities**

For each of the motors powered from a starter or drive in one of the LV switchboards, provision shall be made to start and stop the motor locally from the front panel of the switchboard.

Each local control station shall be equipped with pushbuttons for the following functions:

* Start
* Stop
* Emergency stop

Use of the start and stop pushbuttons shall be possible when the control selector at the starter is set to “Remote”, but the emergency stop button shall be effective in all modes of operation.

* + 1. **Starter Control Supplies**

Each motor starter shall be complete with its own integral control transformer to provide 110 V AC auxiliary voltages for the operation of the contactor(s) and other control circuits. Control transformers shall be supplied from two phases of the incoming 380 V supply and shall be connected on the downstream side of the incoming isolation device.

A test switch shall be fitted which will bypass the incoming isolation device and supply to the control transformer only. The test switch shall be arranged such that it can only be engaged when the compartment door is open, and its operation is automatically cancelled when the compartment door is closed.

Each control transformer shall have one end of its secondary winding connected to earth, and shall be complete with upstream fuse protection (in both poles) and downstream fuse protection (live pole only).

* + 1. **Auto-Resetting Function**

All starters and drives shall be fitted with an auto-resetting function which operates once each time the starter is powered up to reset any alarm or lockout condition arising from a cleared source. As a result, failsafe alarm circuits shall be set to the “healthy” condition thus allowing the drive to become available and ready for service.

Where the source of the alarm or lockout condition has not cleared the attempt to reset shall fail and the starter or drive will power-up into the failed or locked out condition.

* 1. **Electrical System – LV**
     1. **General**

The LV electrical system shall incorporate the following switchboards:

* Main LV Switchboard
* Essential Services Switchboards
* Chemical Plant Switchboard
* Blower Switchboard

Each of the switchboards shall be of the Form 4 type with a separate compartment for each main circuit breaker, starter, fuse-switch feeder, or distribution board.

* + 1. **Main LV Switchboard**

The main LV Switchboard shall be installed in the raw water, clear water and booster pumping stations and it shall incorporate incoming compartment, bus bar section, motor starter compartment, common controls & instrumentation, feeders etc. All loads within the station shall be supplied, directly or indirectly, from the Main LV Switchboard.

The incoming compartment comprises as a minimum the following:-

* General isolating switch with fuses and external handle.
* Protective relay against under/over voltage, phase reversal and loss of phase.
* Voltmeter and ammeter with phase selector switches.
* Over current relay
* Earth leakage relay
* Power on light
* Lightening surge arrestor etc.
  + 1. **Control & Instrumentation section**

A control & instrumentation section shall be provided as part of the Main LV Switchboard to house the station instrumentation converters and relays. The section shall incorporate a metal fronted panel complete with key lockable handle. The section shall match the appearance of the LV switchboard.

The control & instrumentation section shall be complete with the following items:

* 220 V single phase and switched neutral incoming switch-disconnector rated 16 A and incorporating protective shrouding on the circuit side (not door interlocked)
* 220 V single phase MCB distribution board with outgoing circuits for:
* 220/110 V control transformer
* internal lighting
* anti-condensation heaters
* Other 220 V loads
* 1 No. 220/110 V control transformer complete with primary and secondary fuse or MCB protection.
* Fluorescent type lighting to give illumination of the whole of the section interior. Each fitting shall be complete with safety cage or mechanically robust diffuser
* Door switch to automatically switch on the internal lighting
* Compartment anti-condensation heaters complete with thermostat
* Instrumentation earth bar
* Auxiliary relays, terminal blocks and sundry items as necessary

Transformer and power supply unit ratings to be determined by the Contractor.

* + 1. **Essential Services Switchboard**

The Essential Services Switchboard shall incorporate a single section of bus bar with provision for supply from incoming circuit fed from the Main LV Switchboard. The Essential Services Switchboard intern feeds power to pumping station auxiliary loads (overhead crane, sludge pump, compressor motor, internal lighting etc.), treatment plant building switch board, blower switch board, operator’s dwelling DB, generator house DB, Guard house DB, external lighting A 50 kA fault current design will be adequate for the Essential Services Switchboard.

* + 1. **Treatment plant Building switchboard**

A floor mounted metal clad LV switchboard shall be provided for the Chlorination Building. The switchboard shall be fed from the Essential Services switchboard and shall provide power supplies to all loads within the treatment Building.

The treatment building switchboard shall provide for all chlorination power supplies and motor starting and control.

* + 1. **Blower Building Plant switchboard**

A floor/wall mounted metal clad LV switchboard shall be fed from the Essential Services switchboard and shall provide power supplies to all loads within the blower Building.

* + 1. **Main Pump Motor Starters**

Six No. starter sections for (4 main pump motors and 2 backwash water pump motors) at clear water pump station, five No. starter sections for (4 main pump motors and 1 sludge pump motor) at raw water pump station and two No. starter sections for (2 main pump motors) at booster pump station shall be provided for the pumping stations main pumps. Each starter shall be complete with the following features:

* Incoming door interlocked switch disconnector
* Control circuit bypass “test” switch
* Set of three contactors for star/delta starting
* Star/delta changeover timer relay
* Motor protection relay incorporating instantaneous overcurrent, earth-fault, thermal overload, phase reversal, delayed start, current unbalance, loss of phase and over/under voltage protection
* Integral 380/110 V transformer for AC control supply
* Power factor correction device to 0.96 when the load is at rated value
* 110 V AC operated “external trip” relay (de-energise to trip/energise to permit running)
* 110 V AC operated “start/stop” command relay (energise to start)
* Thermistor relay
* Front of panel mounted start, stop and reset pushbuttons
* Front of panel mounted hand/off/auto selector switch (auto selects control from the C&I section)
* Front of panel mounted indicator lamps for running, stopped, motor protection relay fault, motor winding over temperature alarm, motor winding over temperature trip, and “external trip operated”
* Anti-condensation heater complete with fuse protection and thermostat
* Cable termination features for multiple outgoing multi core power cables
* Auxiliary terminals and contacts as necessary

The external trip relay shall be powered from circuitry in the Control & Instrumentation section and will be energized when external hydraulic conditions permit operation of the pump set. If the external trip relay is de-energized it shall latch out and power to the pump shall immediately be cut-off. The pump shall remain unavailable for service until the trip condition has been cancelled and the relay has been manually reset, or reset by a power-up auto reset function following power failure.

The “available” signal shall be generated when no internally detected trip conditions exist and the “external trip” relay is energized.

* + 1. **Chemical mixer Motor Starters**

Three mixer motors mounted on the solution preparation tanks will be controlled from the

Control panel installed. The panel can be free standing or wall mounted with front access and cable entries from below. The starting method is expected to be DOL type.

Cables, both power and control, from the motor control panel to the pump sets shall exit from the bottom of the panel and shall run to the upsets on suitably sized galvanized cable tray to the floor trenches. The cables shall continue to run on cable tray or cable supports to the mixers, controls and emergency stop buttons.

The MCC shall indicate the chemical tank levels and the mixing motors operation status. This panel will show:

* Starting and stopping of the stirrer motors.
* Stirrer motors operation status and total operated hours for each motor
* The solution tank levels

3 No. starter sections shall be provided for the chemical plant stirrer motors. Each starter shall be complete with the following features:

* Incoming door interlocked switch disconnector
* Control circuit bypass “test” switch
* Line contactor for DOL starting
* Motor thermal protection device incorporating thermal overload and single phasing protection
* Integral 380/110 V transformer for AC control supply
* Power factor correction to 0.96 when the load is at rated value
* 110 V AC operated “start/stop” command relay
* Front of panel mounted start, stop and reset pushbuttons
* Front of panel mounted hand/off/remote selector switch (remote selects control from the local control station in the Chlorination Building)
* Front of panel mounted indicator lamps for running, stopped and motor overload
* Anti-condensation heater complete with fuse protection and thermostat
* Cable termination features for outgoing multicore power cables
* Auxiliary terminals and contacts as necessary
  + 1. **Air scour blower motor starters**

2 No. starter sections shall be provided for air blower motors. Each starter shall be complete with the following features:

* Incoming door interlocked switch disconnector
* Control circuit bypass “test” switch
* Set of three contactors for star/delta starting
* Star/delta changeover timer relay
* Motor protection relay incorporating instantaneous over current, earth-fault, thermal overload, delayed start, current unbalance, loss of phase and under voltage
* Integral 380/110 V transformer for AC control supply
* Power factor correction device to 0.96 when the load is at rated value
* Front of panel mounted start, stop and reset pushbuttons
* Front of panel mounted hand/off/auto selector switch
* Front of panel mounted indicator lamps for running, stopped, and motor overload
* Anti-condensation heater complete with fuse protection and thermostat
* Cable termination features for outgoing multi core power cable
* Auxiliary terminals and contacts as necessary
* Power Factor Correction

Power factor correction capacitors shall be provided within each starter rated to achieve a target power factor of 0.96 when the drive is operating at rated load. Light fittings are specified in the document relating to building services to incorporate power factor correction.

Consideration shall be given to the fact that motor drives are de-rated due to altitude and will thus require additional capacitor correction to achieve the desired running power factor. No attempt shall be made to correct the power factor of any motor during its starting period.

As a result, the provision of automatic switched banks of power factor correction capacitors shall not be required.

* + 1. **Earthing**

1. **General**

A complete earthing system shall be supplied and installed, and shall be in accordance with the requirements of the General Specification, BS 7430:1991 (Code of Practice for Earthing), the 17th Edition of the IEE Regulations (BS7671), and any particular requirements stipulated by EEU.

The earthing system shall include:

* Two separate earth fields each comprising sufficient rods to ensure a resistance to earth of 1 ohms or less
* Main earth bar, wall mounted in the pumping stations building in the zone underneath the switchboards mezzanine floor
* Secondary earth bar wall-mounted in the Chemical Building
* Cross-bonding to the EEU transformer station
* Cross-bonding to pumping station earthing system
* Radial system of circuit protective conductors connecting to each electrical device
* Main equipotential bonding system connecting to all conductive pipes entering or leaving the station
* Equipotential bonding system connecting to all non-electrical items of plant; cable trays; metallic floors, stairs and handrails; metal doors and frames
* Instrumentation earth

The configuration of the earthing system shall be radial with an independent circuit protective conductor being provided for each plant item. Such a protective conductor shall either be the cable armour wires, or a separate green/yellow PVC insulated conductor, or shall be an unused core in the power cable to the plant item (e.g. a 4 core cable can be used for a circuit with no neutral, and the blue core can be used as earth provided that it is marked with green/yellow sleeving at every termination).

A cable number shall be allocated to each earthing conductor and this shall be shown on a cable sheath number fixed to each end of the cable. Earthing conductor numbers shall be shown on the drawings.

The main earth bar shall include three separate sections, two for the connection of the two groups of earth rods, and the third section for the connection of earth bonding conductors and earths to other earth bars. Bolted links shall be fitted to link the three sections together.

Bonding connections shall be made to any lightning protection system earth rods which are installed.

1. **Bonding**

All extraneous metalwork within the works shall be bonded to earth. A ring earth network (with radial connections as necessary) shall be supplied and installed to connect to all extraneous metalwork including but not limited to:

* Metallic cable trays and ladders
* Hand railings and metal barriers
* Pipes and cables entering the works
* Structural steelwork
* Concrete re-enforcement

1. **Station Earth**

A main station earth shall be provided comprising a sufficient number of earth rods arranged in two groups each one constructed to achieve a resistance to the general mass of earth not exceeding 5ohms. The actual resistance to earth of each individual group shall be determined by the Contractor to meet all of the following requirements:

* Enable fault current at any point within the installation to be returned to the supply source, ie. the transformer or generator neutral(s), without thermal or mechanical damage to connected apparatus and to enable protective equipment to operative correctly
* Limit the Earth Potential Rise (EPR) on all metalwork and the surface of the ground to which persons have normal access, to a safe vale under normal and abnormal circuit conditions
* Ensure compliance with the requirements of this specification and to ensure the site is classified “Cold” as defined by the International Telecommunication Union (ITU)

Each earth rod shall be provided with a pre-cast concrete connection box. The boxes shall be of a design which is flush with the ground and shall be installed away from areas required for vehicle access, or areas designated for future works.

1. **Instrumentation Earth System**

A separate earthing system shall be provided for instrumentation. A main instrumentation earth bar shall be provided in the pumping station adjacent to the main earth bar. Secondary instrumentation earth bars shall be provided in the control & instrumentation sections of the Main LV Switchboard and the Chlorination System signals marshalling box. Each instrumentation earth bar shall be clearly labeled to indicate its function for instrumentation purposes only.

The main instrumentation earth bar shall be bonded to the power earth at one point only. After the single connection to main earth, all instrumentation screen earths shall be insulated from main power earth.

The screens of all instrumentation cables running to/from a control or communications panel shall be connected to the instrumentation earth bar of that panel. Instrumentation earths shall be run in a radial arrangement to avoid loops. Particular attention shall be paid to the earthing of cable screens to ensure the integrity of the radial arrangement. In most cases, the screens shall only be connected to earth at the end terminated to the control or communications panel

All instruments having the facility for connection of a dedicated instrument earth shall be connected to the instrumentation earthing system. Where instruments do not have the facility for such a connection, they shall be connected to main earth only.

1. **Cable Armours**

All cable armours, metallic sheaths and screens shall be connected to earth. Earthing shall be at both ends except in the case single core cables and in this case the armours shall be earthed at one end only. At the non-earthed ends of single core cables, insulation shall be applied to the armour wires to prevent accidental contact with earth.

Where practicable the cable armour wires shall be used as the sole circuit protective conductor. Where this is not practicable or where there is risk of corrosion, either the power cable shall include an additional core or a separate earth cable shall be run alongside the power cable.

* + 1. **Lightning Protection System**

A study in accordance with BS 6651 shall be made to determine whether a lightning protection system is required for the pumping station buildings.

If a system is required this shall comprise:

* Colour co-ordinated PVC sheathed copper tape laid along the apex of the roof of the pumping station
* Down-conductors at each end and at intermediate positions every 20 metres
* Single earth rod in underground disconnecting chamber for each down-conductor to achieve a resistance to earth not less than 10 ohms

All earth rods provided as part of a lightning protection system shall be bonded to the staton’s main earthing system.

* + 1. **Cabling**

1. **General**

The Contractor shall supply, install, and terminate a complete cabling system including power, control, instrumentation, communications, and building services cables. Cables shall be as detailed on the cable schedule subject to confirmation of ratings.

All cables run within a building shall be mechanically protected either by being of armoured construction, being enclosed in galvanised steel conduit or trunking, or by being run on cable trays or ladders with galvanised steel protection covers fitted. In locations particularly vulnerable to damage, galvanised steel protection covers shall be fitted to cable trays and ladders even if all the cables on that route are of armoured construction. Cable armouring shall be of the steel wire type except for single-core AC cables which shall use aluminium wire or strip armouring.

1. **Cable Types and Uses**

Power cables shall incorporate XLPE thermosetting insulation and armouring (except where they are building services single insulated wires contained in conduit or trunking). Multi-core control cables (carrying digital signals for switching and signalling) shall be armoured type and shall be rated for the voltage at which they are required to operate subject to a minimum of 110 V.

Multi-pair cables (carrying analogue signals) shall be armoured and screened and constructed in accordance with BS 5308. These cables shall be used primarily for analogue signals based on power sources not exceeding 24 V DC. Additionally, the use of these cables to carry low level digital signals (voltage not exceeding 24 V DC and “on state” current not exceeding 5 mA) is permitted.

Data cables carrying RS232, Ethernet or similar shall be to designs and performance levels which are suitable for their intended duty. Where these cables run outside panels (including underground sections) they shall either be of an armour protected design, or they shall be run with a suitable form of mechanical protection (eg. run inside rigid metal conduit or wire protected flexible conduit). Cables run entirely within panels need not incorporate any form of armouring.

1. **Cable Routes**

Underground cables between buildings shall run using one of the following systems:

* Surface accessible concrete trenches with inlaid cover slabs
* Underground ducts and drawpits

The use of direct burial shall not be permitted.

Where surface accessible concrete trenches cross roadways the trenches and cover slabs shall be strong enough to support the axle weight of the largest truck, tanker, or crane likely to be used at the pumping station.

Unless unavoidable, drawpits shall not be positioned in roadways. If drawpits have to be located in roadways their covers shall be strong enough to support the axle weight of the largest truck, tanker, or crane likely to be used at the pumping station.

The following routes shall be provided:

* EEU substation to the pumping station building
* Generator House to the pumping station building
* Pumping station to the Chemical Building
* Pumping station to the contact tank (level sensor location)
* Pumping station to the valve house

Each duct route shall be provided with 20% spare unused ducts, with a minimum of 1 No. spare duct. Every spare duct shall be provided with a pull-cord. Cables entering buildings and structures, or running within buildings between fire zones, shall pass via cable transits guaranteed to form a fire barrier and gas seal. Cables other than building services circuits within the pumping station, the chlorination building or the valve house, shall run on cable routes constructed using cable tray and/or ladder.

Building services circuits shall run using one of the following methods:

* SWA cables shall run on cable tray/ladder as per plant cables
* Single insulated wires shall run inside conduit or trunking

Where a conduit and/or trunking system is used for building services, the conduit shall be of the galvanized steel type and shall be complete with compatible galvanized accessories and connection boxes. Trunking shall be galvanized steel.

1. **Voltage Drop**

Cable systems shall achieve voltage drops as detailed in the 17th edition of the IEE wiring regulations (BS 7671). For an installation fed from a dedicated transformer (ie. with no publicly owned LV distribution system) these permit the following voltage drops:

|  |  |  |
| --- | --- | --- |
| **Installation** | **Lighting** | **Other Uses** |
| Overall voltage drop | 2% | 3% |
| Voltage drop in the final circuit | 3% | 3% |

The overall voltage drop shall include the following components:

* Voltage drop from the transformer (or generator) to the Main LV Switchboard
* Voltage drop from the Main LV Switchboard to the next switchboard or distribution board (and for the section to a subsequent switchboard or distribution board for some circuits)
* Voltage drop from the final switchboard or distribution board to the connected device

Where a motor starter is located close to the source of supply it can be assumed that it will continue to receive an adequate level of voltage during motor starting, and no separate consideration need be given to voltage drop during motor starting.

Where a circuit feeds to a remotely located switchboard containing starters it might be necessary to separately consider the voltage drop experienced at the motor starters during the motor starting period.

Where part of the load on a remotely located switchboard is for lighting purposes, the overall voltage drop permitted up to the point where lighting circuits split from circuits used for other purposes shall be the allowance for lighting. After this point both the overall and final circuit voltage drops, the allowance for non-lighting loads shall be as per “other uses”.

Where control cables carry substantial amounts of current (eg. emergency stop circuits carrying contactor current) consideration shall be given to the voltage drop resulting from long circuit lengths. The maximum permitted voltage drop in a control circuit, from the transformer or PSU which produces the control voltage, shall be 5% as per non-lighting final circuits. Where possible, control circuits shall carry only signaling currents so that large currents are avoided (eg. operation shall be via relays rather than direct connections).

1. **Cable Rating Requirements**

Cables connecting to or from major transformers or generators shall be rated, both in terms of current and voltage drop, for the full load which could be supplied by that transformer or generator. A reduced size relating to the actual connected load shall not be permitted.

Cables connecting from one switchboard to another can be rated for the actual connected load (including allowance for future loads fed from “spare” circuits), provided they are able to withstand the prospective fault current let through by the upstream protective device.

Where cables are de-rated due to the proximity of other cables the following factors can be considered:

* Where a single trench or duct contains cables (or groups of cables) from two or more transformers or generators which normally share the load, the worst case will apply when one circuit is operating alone. In this case it can be assumed that the other circuit is generating no heat.
* For de-rating purposes earthing cables can be disregarded since under normal circumstances they carry no current
* The heat generation from control and communications cables is usually negligible and provided this is true in a particular circumstance, the presence of these cables can be disregarded

All cables using air as their cooling medium shall be de-rated according to the altitude at the installation.

1. **Oversized and De-Rated Cables**

Where cables have to be increased in size due to voltage drop or de-rating reasons, the equipment to which they connect shall be constructed to accept the oversized cables. Where this is not possible, a junction box shall be provided at the end of the oversized cable to allow a conversion to a smaller cable. The junction box shall be equipped with suitably sized terminals to accept the oversized cables and the smaller cable. Where the oversized cable is in fact multiple cables, the junction box shall accept all the cables installed as part of this circuit.

The smaller cable provided for the final connection into the equipment shall be sized according to the current rating of the circuit and shall be of negligible length so that additional voltage drop considerations will not apply.

The assumption is made that all equipment will be able to accept the full-sized incoming cables so the design does not include any junction boxes which might be necessary for size reduction. Where the limitations of the equipment provided by the Contractor makes such junction boxes necessary, the Contractor shall identify each location and shall supply and install each junction box, including termination of the incoming and outgoing cables. This shall be a no extra cost to the Employer.

The change from one cable to another, where this is solely for size change reasons, shall not require a change of cable number.

Size-change junction boxes shall not be installed underground or in locations where they could be subjected to flooding.

1. **Cable Termination Schedules**

The Contractor shall prepare a cable termination schedule for both ends of each control, instrumentation and communication cable.

1. **Cable Loop Diagrams**

The Contractor shall prepare a cable loop diagram for each signal carried by each control, instrumentation or communication cable. Each cable shall be shown from source to destination, and detailing all terminations and interconnections.

1. **Unused Cable Entries**

Any unused cable entries in motors, instruments, actuators, etc. not used after cabling is completed shall be plugged with threaded brass blanks and the threaded joints made watertight by using suitable tape or jointing compound.

* 1. **Instrumentation**
     1. **General**

Site instrumentation to be supplied and installed at the pumping stations comprises:

|  |  |  |
| --- | --- | --- |
|  | Flow metering of the incoming flow from the treatment plant |  |
|  | Flow metering of the stations discharge flow |  |
|  | Station discharge pressure |  |
|  | Direct reading discharge pressure gauges (per pump set) |  |
|  | Reservoir level monitoring (analogue) |  |
|  | Level control and monitoring of wet well |  |
|  | Level control and monitoring of backwash tank |  |
|  | Level control and monitoring of the drainage sump |  |

All instrumentation shall be suitable for operation from either a directly connected supply or a UPS unit at 110 V AC.

* 1. **Building Electrical Installations**

Electrical installation will be performed in various buildings in the pumping stations, treatment plant and within the TP compound.

1. **Electrical Installation within Clear Water Pump Station**

Electrical installation in the clear water pump house will include all lighting, power outlets, controls, cables, cable tray etc.

The main LV switchgear shall be installed within clear water pump house.

1. **Electrical Installation within Treatment Building**

Electrical installation in the buildings will include all lighting, power outlets, controls, cables, cable tray etc. all material will be suitable for operation in the area.

1. **Electrical Installation within Diesel Generator House**

Electrical installation in the diesel generator house will include all lighting, power outlets, controls, cables, cable tray, and accessories within diesel house and fuel tank area.

1. **Electrical Installation within Transformer House**

Electrical installation in the transformer house will include all lighting, power outlets, controls, cables, cable tray, and accessories within diesel house and fuel tank area.

1. **Electrical Installation within Guard House and operator’s dwelling**

Externally mounted floodlights will be controlled from the guardhouse. Electrical installation within Guard House and operator’s dwelling will include all lighting, power outlets, controls, cables, cable tray etc.

The control board shall be wall mounted to an approved height and positioned over the incoming cable duct such that the cables enter directly from below.

* 1. **Flood Lights Cables, Wiring and Accessories**

Armored power and control cables, together with bare copper earth wire conductors shall be extended underground from the compound switchgear to the various structures. Electrical installation in the compound will include Services and facilities within the compound, including road lighting and floodlighting columns.

Weatherproof termination cabinets shall be supplied and installed at the head of each tank structure, to suit the layout of the tank related pipe work, plant and equipment.

Tough rubber sheathed power and control cables shall be extended from the weatherproof cabinets to the controls within the tanks and wet well, the cables being suitably supported on cable trays.

Cables to the compound road lighting columns and the area floodlighting columns shall be terminated within the base of each column at separate miniature circuit breakers.

* 1. **Standby Diesel Generating Plant** 
     1. **General**

Whenever EEU power failure occurs, so as to satisfy part of the water demand, Standby generating plant shall be erected in the generator building at all pumping stations. The requirements shall include for the design, manufacture, supply, installation, test and commissioning of all materials, equipment, plant and components necessary for the provision of fully operational and functioning standby diesel plant, associated switchgear and services, as specified and shown on the drawings.

The diesel plant and equipment shall include:

* Diesel generating set exhaust pipe work
* Fuel tanks and pipe work
* Manual Changeover panel
* Switchgear
* Cables
* Earthing
* All accessories and other necessary items

The plant and associated equipment should be to the highest possible standard and requiring the minimum of maintenance. The contractor shall therefore ensure that the equipment offered meets all relevant Standards and is of a type and manufacture such that spares are readily available for immediate and long-term use.

The diesel plant, while providing a standby power sources, shall be continuously rated and of a type suitable for continuous operation: the plant being brought into service only in the event of EEU mains supply failure. The set shall be rated for the duties specified together with all starting current, surges and the like, due allowance being made for the altitude and climate conditions specified.

It is intended that the plant is sized/rated to cater for 50% of the total electrical load at the site. The details of the load capabilities of the set shall be clearly identified on the set and as part of the operating manual supplied by the contractor.

* + 1. **Starting Surges and Sequence Starting**

The Contractor shall/rate the diesel plant to suit the finally agreed starting method for the pumping sets. The effects of light load running must be taken into account, the contractor including for the provision of any dummy loads necessary. Full details of how the sets have been rated shall be provided.

* + 1. **Type of Plant**

The contractor shall supply and install the generating plant complete with all switchgear and controls, auxiliary equipment, and all other items as specified and required for the erection and setting to work of the plant in accordance with the specification.

The generating plant shall be suitable for manual start-up and changeover from mains to standby, this unit being located within the diesel generator house. All required interlocks should be provided to prevent inadvertent paralleling.

|  |  |  |
| --- | --- | --- |
| **Pump Station Description** | **Power in KVA** | **Type of Diesel Generator** |
| Raw Water Pumping Station | 150 KVA | Prime Power |
| Clear Water Pumping Station | 350 KVA | Prime Power |
| Booster Pumping Station | 250 KVA | Prime Power |

* + 1. **General Description**

The generating set shall be as set out below:

Number required 1 for each pumping stations

**Diesel engine:**

Minimum power at site To suit the alternator

Ignition Compression

Starting medium Electric 24 volts heavy duty

Starting method To suit the individual pumps

manual push button

Cycle 4 strokes

Cooling Water cooled with radiator

Lubrication pressure

Shut down Manual push button and automatic

shutdown safety features

Engine speed 1500 revolution per minute

**Alternator:**

Number required One for one engine

Coupling Direct

Generating voltage 400 ACV

Phase Three(3), 4-wire system

Connection Star with neutral earth point

Pole No. 4

Frequency 50 Hz

Rating Power 150, 500 and 50KVA

Duty Continuous

Overload 10% for 1 hour in any 12hr period

Excitation Self

The plant shall be designed and/or selected to operate under the specified conditions prevailing at the site. In this respect the contractor shall allow for operation in an unheated, minimum ventilated building and dust-laden atmosphere. The contractor shall be fully responsible for sizing the diesel plant to suit the rating of the alternator which in turn shall be sized and rated to suit the pumping plant, starting surges, equipment loads and auxiliaries at each of the compounds. Full details are to be submitted with the tender.

The plant and equipment shall be suitable for continuous operation and shall be rated to suit the prime power requirements of the complete installation including staring currents, surges and the like. The ratings specified for the diesel plant are approximate only. It shall be the responsibility of the Contractor to liaise with the EEU and the Engineer to determine precisely what loadings should be used to size the diesel plant, all details being agreed before the commencement of supply.

All components shall be fully tropicalised and protected against mould growth.

* + 1. **Alternator Power output**

The alternator power output for the diesel set shall be of sufficient rating to provide power for the items of plant finally identified by the contractor, particularly the pumping plant. The final rating of the diesel plant shall therefore be determined by the contractor to suit the pumping plant and auxiliaries, together with derating factors for temperature and altitude and an allowance for starting surges and transient voltage dip associated with starting.

It shall be the responsibility of the contractor to ensure that the plant offered and supplied is properly and adequately ventilated and suitable for the site operating conditions. In addition, the contractor shall size and rate the plant to suit the load demand, altitude and temperature, the necessary derating factors being taken into account to suit the plant characteristics.

The load details and set rating shown on the drawings are intended for guidance only. The Contractor shall be fully responsible for determining the final loads associated with the pumping plant supplied and shall consider staring characteristics, plant load requirements and auxiliaries so that the final size and rating of the diesel plant meets the load requirements associated with the compound. Staring details shown on the drawings are for information only and have been used to merely establish an indicative diesel plant rating. Details of the diesel plant shall be submitted with the tender.

The Contractor shall consider the details specified and shown on the drawings, taking into account the pumping plant identified together with the station auxiliaries, floodlighting, road lighting etc.

The contractor shall clearly identify, on the diesel control panel, the maximum load capability of the plant such the operators can add loads to the set and be fully aware of the set loadings. The contractor shall clearly identify the minimum load at which the set can operate for prolonged periods without causing damage to the set through "light load running". In addition to being indicated on the control panel, these limits shall also be clearly described within the operation/maintenance manual.

* + 1. **Operation**

Upon mains failure, the standby sets shall be manually started and within 20 seconds reach full operating voltage.

* + 1. **Performance**

With the operating conditions specified, the set equipped with its standard air intake filters, shall be capable to delivering its rated output continuously at rated voltage and 0.8 lagging power factor and of delivering 10% in excess of the continuous maximum rating for a period of one hour in any 12 hour period.

The deviation of the waveform of the voltage output from a pure sine wave shall not exceed the limits specified in BS 5000 Part 99.

Radiated interference shall be suppressed to the limits specified in BS 800 and BS 833.

* + 1. **Diesel Engine**

The diesel engine shall be designed and build to the appropriate British Standard Specification or to an alternative widely accepted specification, which maintains an equal standard of quality. The engine shall be a water cooled, direct injection, compression ignition type, suitable for operating on diesel commercially available in Ethiopia. The engine shall be totally enclosed, with forced lubrication from an integral pump having suitable coarse strainer and fine filter elements fitted to the suction and delivery sides respectively. The filters shall be conveniently located for servicing and shall be equipped with a spring loaded bypass valve to ensure oil circulation if the filters become clogged. The capacity of the lubricating oil system shall be sufficient to enable the engine to run continuously at any load without replenishment until normal routine maintenance is required.

A suitable filter shall be fitted in the fuel line immediately before the pumps. Air filters complying with BS 1701, Grade A or Grade B suitable for use in a medium atmosphere shall be fitted to the engine air intakes.

Cooling water system shall be of the fan cooled radiator type, thermostatically controlled, with means of discharging waste heat from the engine room. A circulating water pump of ample capacity shall be fitted and suitable provision made for waster expansion and make-up. Adequate drains shall be provided at low points in the water and lubricating oil systems.

A statically and dynamically balanced flywheel shall be provided of such mass to ensure smooth engine operating during staring and running. Bearings shall be suitable for operation over long periods without the need for replacement of the lubricant. Suitable means shall be provided for turning the engine main shaft by hand and the associated generator to facilitate inspection and overhaul. The engine governor shall ensure control within= 2.5% of nominal speed for all conditions of load, and shall be capable of fine adjustment with the engine running. Governor details shall be submitted with the tender. Injectors shall be suitable for the grade of fuel selected, and fuel pumps shall be capable of individual adjustment to maintain even load distribution between cylinders.

Starting shall be by means of electricity supplied from a starter battery. The engines shall be equipped with a 12 volt electric starting system of sufficient capacity to crank the engine at a speed, which will allow for diesel staring of the engine. The staring battery shall be capable of withstanding the loads imposed upon it. Auxiliary circuits connected to the battery shall be protected by fuses.

The battery shall be used to supply the staring and control equipment and relay operation shall not be impaired when the battery is supplying current to the starter motor. Lead-acid batteries shall be furnished having sufficient capacity for at least 30 seconds at firing speed in the ambient temperatures specified and with capacity for staring the diesel engine a minimum of ten times each day.

A suitable battery-charging generator shall be provided with sufficient capacity to recharge the batteries back to normal staring requirements quickly.

The engine mounted instrument panel and engine control shall include all items necessary for manual staring, governor speed control, shut down, and also visual alarms indicating, low fuel, low oil pressure, engine temperature, vibration alarm, oil temperature, high cooling water temperature and over-spread. In the case of all the above items, automatic shutdown shall occur. Additional safety measures shall be provided in accordance with the requirements of the particular plant offered.

The engine shall be complete with all pipe work, valves, heaters and ancillary equipment necessary for its correct operation, including inlet air filters, silencer, exhaust piping, all supports and anti-vibration mountings, hot air discharge louvres, canvas ducting, etc. Fuel level, oil pressure and temperature, water temperature and engine speed, shall be indicated by means of approved dial gauges and integrating house-run meter and fuel flow meter shall be provided in each case. Gauges shall be graduated in metric units.

The engines shall be capable of being started from crank position. Details relating to the lubrication, fuelling and cooling system of the diesel plant shall be finally determined by the contractor to suit the diesel plant offered. Details of systems, particularly the fuelling systems, shall be submitted with the tender such that sufficient information is readily available for an assessment to be carried out.

All auxiliary equipment for starting the set shall be provided. Critical speeds occurring during start up or shut down shall be countered by satisfactory means, and no critical speed within close proximity to the operation conditions will be acceptable.

After all tests, the contractor shall ensure that the fuel tanks are left full.The Contractor shall include for a series of suitable sized drip trays for installation below the diesel plant, tanks etc. These trays shall be sized such that they are easy to handle, remove and replace and shall be located to minimize the effects of oil spillage onto the power station floor. Details shall be provided for approval.

* + 1. **Exhaust System**

The exhaust system indicated on the drawings is for information only. The Contractor shall provide exact details of his proposals. The contractor shall supply silencers to meet the requirements of the installation and to reduce the exhaust noise to a level comparable to a domestic installation. The Contractor shall ensure that the system proposed does not create unacceptable backpressures.

The exhaust system shall be fully lagged within the building and shall be provided with sleeving where they pass through the building structures. The exhausts shall be suitable fixed and supported such that no undue strain is imposed upon the exhaust system and/or the building structure. Full details of the contractor's proposals for running, supporting and installation of the exhaust system shall be submitted for approval.

The exhaust shall exit the room via a mild steel sleeve with asbestos rope packing to ensure no heat transfer takes place to the structure. The final size, type and fixing arrangements for the domestic silencer shall be agreed. Details shall be submitted for approval.

The contractor shall be fully responsible for the supply and complete installation of the ventilation louvers required within the external wall of the power station for the discharge of the hot air. These louvers, forming part of the ducting and exhaust system, shall be designed to permit maximum discharge during the operation of the plant, but shall restrict entry of rain/dust during the stationary period of plant.

The gravity flap louvers shall be of the industrial, non-return design to permit air flow in one direction. The frames/apertures shall be sized by the contractor to suit the requirements of the plant offered. The frames shall be manufactured from prime galvanised steel. The blades shall be a minimum of 20 swg lightweight aluminum fixed to spindles, which shall rotate in self-lubricating nylon bushes. Canvas ducting from the radiator to the louvers shall be flame retardant. Details shall be provided for approval.

* + 1. **Auxiliary Equipment**

Any auxiliary equipment not specifically mentioned, but needed to start and operate the set, shall be provided and fitted. Normal starting sequence of circulating oil, fuel supply and the like shall be adhered to.

Critical speeds occurring during start up or shut down shall be encountered by satisfactory means, and no critical speed within the close proximity to the operating conditions will be accepted.

The engine shall be capable of, and adjusted to permit operation on a suitable diesel fuel such as gas-oil economically and readily available in Ethiopia. After test, the contractor shall ensure that the daily service tank is left full and that a change of lubricating oil is available for the engine as part of this contract. The filling of the main bulk storage tank will be at the Employer's expense, but the contractor shall make all necessary arrangement on his behalf, as part of this contract.

* + 1. **Alternator**

The contractor shall supply and install an alternator and associated equipment to operate in conjunction with the diesel engine described previously. The alternators shall be direct coupled by means of a flexible coupling and spigotted flanged ring to ensure permanent alignment and shall be capable of delivering their rated output continuously at 380 volts and 0.8 lagging power factor. The alternators shall be provided with direct self-excitation.

Alternators shall be constructed to BS 2613 and BS 5000 part 99 or other approved equal specification, and rated for operation under the conditions of climate, elevation and load previously specified. Insulation shall be Class F throughout. Heater windings shall be provided in the alternator so that the temperature of the machine can be maintained electrically at approximately 300 C above the ambient temperature. When the set is standing, as in the case of the standby set, the heater winding shall be supplied from 220 volt single phase circuit through a small double wound transformer having a secondary voltage of 50 volts. The mid-point of the secondary shall be earthed and the connections shall be such that when the set is running. the heater is disconnected. Thermostatic control or protection will be required. Details of this requirement are to be agreed to suit the site conditions.

The alternators shall also be of a screen protected, drip proof construction, and shall be radio suppressed to BS 800 and BS 833. The alternators shall be provided with automatic voltage regulation of an approved type, such that generated voltage shall be held within 2% over the full range of load. Maximum divergence of voltage waveform shall be to BS 5000 Part 99. The alternators shall be capable of sustaining a 10% overload for one hour without damage, and the degree of out of balance load which may be carried shall be stated in the tenders.

Three-phase machines shall be star connected, and a diagram showing terminal markings and phase rotation shall be provided in the terminal box. Cable connecting the machine windings and machine terminal shall not have a higher de-rating factor for r-temperature than the winding. Connection to the control cubicle shall be made through approved cable and boxes.

A non-ferrous metal rating plant shall be fixed on the front of the alternator giving the following information.

Continuous output kVA at 0.8 pf

Voltage V

Frequency Hz speed rev/min

Control supply V DC Marker's name

Serial number Year of supply

Any other relevant, standard information

Each alternator shall be fitted with embedded temperature sensitive thermistors to control a winding over temperature relay mounted in the alternator control cubicle. Each shall have at least three thermistors. Additional alternator protection shall be recommended by the contractor for consideration.

* + 1. **Control Panel**

A control cubicle shall be provided for each alternator and shall accommodate the following equipment, in addition to all other items necessary to the installation and operation of the plant. The control panels shall comprise totally enclosed steel cubicles, the numbers and layout of compartment being dictated by the additional switchgear requirements and manual mains failure chageover units. A hinged door (s) on the panel shall be provided for access to all components. The panel shall be free standing on a 100mm raised base. The final external colour of the panel shall be subject to an agreement. The inside shall be white and all instruments black on a white background.

The control panel shall include:

* a manually/automatically operated air or moulded case circuit breaker with overload and under voltage protection to control the generator load.
* tripped indication
* engine off, start, stop controls
* audible fault/stop alarm with mute and reset provision
* earth bar and neutral link
* mains and control cable terminal boxes for incoming and outgoing supplies
* a single phase switch fuse which shall be wired to a pair of incoming terminations and associated distribution fuses for supplying any required mains operated equipment on the set (i.e. heaters, battery, charger and the like)
* an automatic voltage regulator of the type which will maintain its adjustment for long periods without attention.
* where required, a hand field regulator complete with a "Hand/Auto" switch. The hand field regulator shall give stable control of the voltage under the specified operating conditions. If the hand field regulator is to be left in a precise position when the set is under the control of the automatic voltage regulator, this position shall be clearly marked.
* a hand-auto-test switch shall be provided to facilitate operation and maintenance checks. The Contractor shall recommend the frequency with which the sets shall be test operated on load/no load
* control equipment as necessary to fulfil the functional requirement associated with the engine start, stop, governor control and the like as necessary for each station.
* voltmeter
* voltmeter selector switch
* three ammeters, reading current in each leg
* polyphase maximum demand indicator meter
* hours run meter
* frequency meter of the vibrating reed type
* power factor meter
* kilo watt hour meter with maximum demand pointer
* battery trickle charge ammeter
* low oil pressure indicator
* high oil temperature indicator
* high water temperature indicator
* overspeed indicator
* overload indicator
* starter failed indicator
* set failed indicator

The panel shall also include other lamps as required for the correct operation of the generating set together with alarms and switches. Automatic shutdown shall occur with the operation of any of the first five alarm, protection and indicating circuits together with overload after reaching an agreed predetermined load value, and the operation of the thermistor protection relay.

* + 1. **Enclosures for Electrical and Control Equipment**

Enclosures for electrical and control equipment shall be drip proof and dust protecting with adequate front access as necessary for maintenance and repair and to IP51 classification. Special attention shall be given to the method of construction and to the mounting of the components to minimize the effect of vibration. Diagrams of connection in durable form shall be mounted inside the enclosures.

Full consideration shall be given to the fixing/supports and the running/connection of all cables. Full details shall be submitted for approval, the contractor taking into consideration all details including cable terminations, access to these terminations, cable-bending radii etc.

* + 1. **Finishes**

All ferrous metalwork shall be either painted or processed to give a rustproof coating. Ferrous metalwork to be painted shall first be either shot blaster or thoroughly wire brushed to remove all scale and oxide and immediately given one brushed coat or two sprayed coats of primer. After not less than four hours, one brushed or two sprayed undercoats followed by one brushed or two sprayed finishing coats of hear and oil resisting quality paint shall be applied.

Successive coats of paint shall be slightly differing shades. The interior surface of electrical equipment enclosures shall be finished white and all external surfaces shall be finished to the BS 4800 to suit the manufacturer's standard colour. The engine crankcase shall not be painted internally unless the plant is resistant to the lubricating oil.

* + 1. **Drawings**

The contractor shall provide to the Engineer specific sets of the following drawings:

* Building drawings showing details of cable entries, pipe entries and ducts required.
* General arrangement drawings showing the principal dimensions and set weights.
* General arrangement of the diesel engines.
* Details, supports and general requirements associated with the exhaust system.
* General arrangement of the alternator and exciter showing terminal markings, polarity and phase rotation.
* General arrangement of the electrical control panel.
* Schematic and wiring diagram of the electrical control panel.
  + 1. **Works Tests**

The set shall be tested as a unit at the manufacturer's works (or elsewhere by agreement) for output and performance generally in accordance with the requirements of BS 649 and BS 5000 Part 99. The Engineer shall be given adequate notice in writing of the date and the time of the works test and he, or his representative, shall, if he so desires, be present at such test and be given all reasonable facilities for his own inspections during the course of the tests.

* + 1. **Commissioning**

The Contractor shall include for fully commissioning the set and its control equipment and for the purpose of the required tests, shall provide all necessary instruments, tools, fuel and lubricating oil. The following tests and checks, as applicable, shall be carried out by the contractor in the presence of the Engineer or his representative.

* Check that the main frame is level in all directions, engine and generator shafts are in proper alignment and the vibration absorbing devices are properly installed and located.
* Check water and sump oil levels and that the water jacket and radiator heater (if fitted) are in working order.
* Check the battery electrolyte levels and the specific gravity.
* Examine the containers in which the fuel and lubricating oils are delivered and check that the type and grades of oil are as recommended for the unit.
* Ensure that sufficient fuel oil is in the fuel tank for a six-hour test run.
* Check that all radiator and engine block water drain points are free from sludge and other blockage.
* Check engine bolts, main drive coupling, valve clearances, fuel pump settings, governor set-rings, pipeline connection, water hose, exhaust couplings, flexible pipe work and the like.
* Check all outgoing connections on the generator and at the control panel. All lugs for principal connections shall have clean and bright contact surfaces. A suitable abrasive material shall be used where necessary.
* Check access panels and doors for proper opening and closing and for the functioning of any interlocks fitted.
* With the set isolated from the system, start the engine by means of the "start" push button and allow it to run up to normal speed. Check that the battery charging dynamo is in operation with the engine running.
* Check instruments and gauges for normal operation and response and that the generator voltage is being maintained within the prescribed limits.
* Compare the reading of the frequency meter with that of the engine tachometer, where both are fitted.
* Stop the engine and verify that the generator contactor opens at between 95% and 85% of normal voltage. Re-check water and oil levels.
* Run the set a various load for periods totaling at least 30 minutes. Check the voltage and current in each phase in turn and check that the voltage and frequency are being maintained within the required limits with large alternations of loads. Note the rate of charge on the dynamo ammeter with the engine running and the rate of charge on the battery-charging ammeter with the engine stopped. Check against the manufacture's recommendations and adjust charging rates if necessary.
* Check that the various engine safeguards operate satisfactorily.
* Check vibration absorbing devices for proper operation and that the performance of all flexible connections, both mechanical and electrical, is satisfactory.
* When all tests are satisfactory and agreed with the Engineer or his representative, the lubricating oil and water levels shall be finally checked, the fuel tank replenished and the set left in normal operating order.
* An initial supply of all lubricating oils and grease shall e provided by the Contractor.

Running of the engine for any length of time under- non-load conditions is undesirable and tests calling for such operation should be carried out in as short time as possible consistent with thoroughness.

* + 1. **Starting and Changeover**

The generating sets shall be designed for manual starting upon mains power failure depending on the requirement of power. Changeover from the EEU mains supply to generator supply will be carried out manually.

Interlocks shall be fitted to the switchgear to prevent operation of the generating set in parallel with the EEU mains supply.

On restoration of mains power the quality of the mains supply shall be monitored for an adjustable time period to ensure that it is healthy prior to stopping the borehole pump. The mains supply shall be manually reinstated and the borehole pump restarted if it is still required to run. The generator shall continue to run on for an adjustable time period prior to stopping.

* + 1. **Generator Set Ratings**

Detail of the required rating is shown in the bill of quantities. The generator set selected for the site shall be sized to start and run the associated pump plus any associated auxiliaries. The voltage drop on starting of the pump shall be limited so as not to affect the performance of equipment connected at the pump station site.

The combination of the alternator design and rating, the reduction in shaft speed resulting from the application of a step-load, the AVR and the generator cables shall ensure that the short-term voltage drop during starting, as measured at the associated generator incoming circuit breaker in the Main LV Switchboard, shall not exceed 20% or that voltage determined by the Contractor as the minimum allowable voltage for his plant, whichever is the lesser.

* + 1. **Recommended spare parts for three years Engine:**
* Air filter element
* Fuel filter element
* Lubricant Oil filter element
* Belts
* Injector Nozzles for each cylinder
* Overhaul gasket
* Piston ring set
* Connecting rod bearing
* Main bearing
* Trust bearing
* Fuel lift pump, Injector pump

**Alternator:**

* AVR (Automatic Voltage Regulator)
* Positive and negative rectifier plates
* Bearing
* Circuit breaker
  + 1. **Manufacturer Technical data**

Manufacturer technical data of the Engine (the bidder should fill the following table for each engine of the generating sets without changing the format Otherwise rejection point).

Output rating and technical data

|  |  |  |
| --- | --- | --- |
| **Item No.** | **Description** | **To be filled by the bidder** |
| 1 | Generating set model | \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | prime Power at 380-400-415V, 50 HZ | \_\_\_\_\_\_\_\_KVA |
| 3 | Engine Model | \_\_\_\_\_\_\_\_\_ |
| 4 | Number of cylinders and arrangement |  |
| 5 | Cubic capacity | \_\_\_\_\_\_\_\_\_cc |
| 6 | Bore/stroke | \_\_\_\_\_\_/\_\_\_\_\_\_mm |
| 7 | Compression ratio |  |
| 8 | Pressure [Compression] | \_\_\_\_\_\_\_\_\_KPA |
| 9 | Piston speed | \_\_\_\_\_\_\_\_\_m/s |
| 10 | Fuel consumption (at full load) | \_\_\_\_\_\_\_\_l/hour |
| 11 | Fuel tank capacity | \_\_\_\_\_\_\_\_liters |
| 12 | Heat rejection to exhaust system | \_\_\_\_\_\_\_\_KW |
| 13 | Heat rejection to cooling system | \_\_\_\_\_KW |
| 14 | Total radiated heat | \_\_\_\_\_\_KW |
| 15 | Exhaust Temperature | \_\_\_\_\_\_0C |
| 16 | Cooling air flow | \_\_\_\_\_\_\_m3/min |
| 17 | Exhaust gas flow | \_\_\_\_\_\_\_m3/min |
| 18 | Continuous power out put | \_\_\_\_\_\_\_\_\_KW |
| 19 | Prime power out put | \_\_\_\_\_\_\_\_\_KW |
| 20 | Stand by power out put | \_\_\_\_\_\_\_\_\_KW |
| 21 | Power deration factor due to altitude at 3000 m.a.s.l | \_\_\_\_\_\_\_\_\_% |
| 22 | Power derations factor due to temperature at 50oC | \_\_\_\_\_\_\_\_\_% |
| 23 | Over load capacity | \_\_\_\_\_\_\_% |
| 24 | Fuel governor type | \_\_\_\_\_\_\_\_ |
| 25 | Battery capacity and voltage | \_\_\_\_\_Ah and volt |
| 26 | Starter motor power | \_\_\_\_\_\_\_\_\_\_\_\_\_\_KW |
| 27 | Automatic battery charger Capacity and voltage | \_\_\_\_\_\_\_\_\_\_A/V |

## Manufacturer Technical data of the alternator

Manufacturer technical data of the Alternator (the bidder should fill the following table for each Alternator of the generating sets without changing the format Otherwise rejection point).

Output rating and technical data/but not limited to

|  |  |  |
| --- | --- | --- |
| Item | Description | To be filled by the bidder |
| 1 | Generating set model | \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | Prime Power at 380-415V, 50 HZ | \_\_\_\_\_\_\_\_KVA |
| 3 | Continuous power | \_\_\_\_\_\_\_\_\_KVA |
| 4 | Stand by Power | \_\_\_\_\_\_\_\_\_KVA |
| 5 | Alternator Model |  |
| 6 | Voltage | V |
| 7 | No. of Phase |  |
| 8 | Excitation system |  |
| 9 | Drip proof paint |  |
| 10 | Power factor |  |
| 11 | Number of poles |  |
| 12 | Winding pitch |  |
| 13 | Current capacity | A |
| 14 | Breaker Interrupting capacity [IC] | \_\_\_\_\_\_\_\_\_\_\_A |
| 15 | Terminals [No.] |  |
| 16 | Excitation voltage | V |
| 17 | Excitation current | A |
| 18 | Short-circuit ratio [ PU] |  |
| 19 | Saturated reactance [ PU] |  |
| 20 | Xd |  |
| 21 | X'd |  |
| 22 | X''d |  |
| 23 | Stator line-line resistance | Ohms |
| 24 | Main field resistance | Ohms |
| 25 | Exciter resistance at 20 degrees centigrade | Ohms |
| 26 | Voltage recovery time | Ms |
| 27 | Time constant, | Ms |
| 28 | Altitude ranges up to | M |
| 29 | Air flow at 50 HZ | M3/s |
| 30 | Voltage regulation [steady state] | % |
| 31 | Total harmonic content LL/LN | % |
| 32 | A.V.R model |  |
| 33 | Heat rejection | Watt |

**Technical information**

Include for each generator sets.

Generator type, model, made, KVA, AVR type and others

Details of operation, service and spare parts manuals for generator set which include wiring diagram of stator, rotor, exciters and AVR rectifier circuits including DC wiring

Full details of engine ratings (Continuous, Prime and Stand by) and fuel consumption etc

Engine spare parts, service and operation manuals

**Documentation**

As a part of the equipment supply, the following documents shall be supplied for owners’ approval/records.

1. General arrangement drawing of the diesel generating set, engine Outline dimensions and list of Accessories.
2. Layout of the diesel generating Sets along with recommended Size and type of D.G enclosure
3. Schematic & wiring diagram
4. Routine test certificate on engine
5. Routine test certificate on alternator
6. Operating instruction chart
7. Instruction Manual

Format for the Un-priced Bill of quantities (mandatory and should be filled and attached)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| It.  No. | Description | Genset Model | Engine Model | Alternator Model | Continuous power (KVA) | Prime Power (KVA) | Stand by Power (KVA) | Qty | Unit | Country of Origin (including full official factory address) | Brand |
| 1 |  |  |  |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |  |  |  |

Note: Description Means-Water cooled/air cooled, open type/sound proof, diesel driven /other type Generating set

Description of each generator set should coincide with manufacturer brochure, wrong description or different from manufacturer brochure is automatic rejection.

**MUST MEET TECHNICAL EVALUATION CRITERIA FOR GENERATING SETS (Only for evaluator)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item No.** | **CLIENT REQUIREMENT** | **Bidder Offer** | **Compliance to the specification** | **Evaluation Result** |
| 1 |  |  |  |  |
| 1.1 |  |  |  |  |
| 1.2 |  |  |  |  |
| 2 |  |  |  |  |
| 2.1 |  |  |  |  |
| 2.2 |  |  |  |  |
| 3 |  |  |  |  |
| 3.1 |  |  |  |  |
| 3.2 |  |  |  |  |
| 3.3 |  |  |  |  |
|  | **TOTAL TECHNICAL RESULT** |  |  |  |

NB: - the evaluation criteria stated by evaluator from the specification above this table.

1. **DATA SCHEDULES/DATA SHEETS**

**PREAMBLE**

a. The sheets of the schedule as hereto appended are not intended to be filled in by the Bidder but shall serve only as sample forms according to which the Bidder shall himself prepare and submit the schedule of supplementary information. In so doing the Bidder must strictly adhere to the order and numbering of the main items and the arrangement of the sub-items in each of the main items. The Bidder offering a proposal in compliance with the Basic Design shall use exactly the same words in describing the item of equipment and particulars to be supplied, as used in the schedule.

The bidder offering modifications to the Basic Design shall describe the item of equipment and particulars to be supplied at least as detailed in every respect as the description given in the schedule.

b. The bidder may, if he deems it necessary, provide information in addition to that called for in the schedule, but shall not omit any of the particulars called for.

c. All particulars called for in the schedule must be stated explicitly. Reference, in lieu thereof, to standard specifications of the bidder, or catalogues, leaflets, etc. of the maker or supplier shall not be acceptable.

d. Where the Bidder proposes more than one unit of the same description but differing in characteristics, such characteristics shall be arranged in the form of a table having a column for each unit.

e. The Bidder shall fill in Data Schedule C (Specification Deviations) in accordance with the plant and equipment that he proposes to use in the performance of the Work.

f. The complete schedules duly signed shall be provided with the Bid Documents and submitted with Bid.

g. The declaration of the last page of the schedule of supplementary information must be signed by the Bidder and submitted with the Bid.

h. The tenderer shall prepare as many sheets of the schedules as he may require for the project town depending on the requirements of the schedule.

**Mechanical & Electrical Equipment**

**1. Pumps and Associated Equipment**

**1.1 Pumps**

Manufacturer

Model designation

Standard to which manufactured

Actual speed (rpm)

Guaranteed flow per pump (m³/hr)

Guaranteed head at design flow, including station losses (m)

Guaranteed efficiency at design flow (%)

Guaranteed power absorbed at design flow (kW)

Minimum flow over operating range (m³//hr)

Maximum flow over operating range (m³/hr)

Minimum efficiency over operating range (%)

Maximum efficiency over operating range (%)

Maximum power absorbed (kW)

Maximum NPSH required (m)

Closed valve head (m)

Diameter of suction branch (mm)

Diameter of delivery branch (mm)

Maximum impeller diameter (mm)

Impeller diameter to obtain design flow and head (mm)

Moment of inertia of rotating assembly (kgm²)

Method of balancing impeller

Type of bearings

Method of lubrication

Suction lift (m)

Material of volute casing

Type of shaft seal

Material of impeller

Material of bearing pedestal

Material of shaft

Material of shaft sleeve

Mass of complete pump (kg)

Mass of bearing pedestal and rotating assembly (kg)

**1.2 Pump Motor**

Manufacturer

Type

Enclosure protective class (IP)

Frame Size

Class of Insulation

Number of Poles

Rated output for Site altitude and ambient temperature (kW)

Actual speed at full load (rpm)

Supply voltage (V)

Full load current (A)

Starting current (A)

Efficiency at full load (%)

Efficiency at ¾ full load (%)

Efficiency at ½ full load (%)

Power factor at full load (cos φ)

Power factor at ¾ load (cos φ)

Power factor at ½ load (cos φ)

Dull load torque (Nm)

Method of cooling

Method of thermal protection

Full load noise level (dB)

Mass (kg)

**1.3 Combined Pump and Motor**

Type of coupling

Type of coupling guard

Overall length of pump and motor (mm)

**2 Pipe work, Valves & Fittings**

**2.1** **Pipe material and specification**

Pressure rating (bar)

Diameter (s)

Internal lining

External coating

**2.2** **Gate valve**

manufacturer

Diameter (mm)

Figure number

Standard to which manufactured

Pressure rating (bar)

Method of sealing between gate and body

Maximum operating torque (Nm)

Material of body

Material of gate

Material spindle

Face to face length (mm)

Mass (kg)

**2.3 Non-return valve**

Manufacturer

Diameter (mm)

Figure number

Standard to which manufactured

Pressure rating body

Material of body

Material of flap

Material of hinge pin

Face to face length (mm)

Mass (kg)

**2.4**  **Air relief valve**

Manufacturer

Standard to which manufactured

Type

Rate of air released (m³/hr)

Pressure rating (mm)

Diameter (mm)

Material of body

Mass (kg

**2.5**  **Pressure Relief Valve**

Manufacturer

Standard to which manufactured

Pressure rating (bar)

Diameter (mm)

Material of Body

Mass (kg)

Other particulars

**2.6 Pressure Gauge**

Manufacturer

Standard to which manufactured

Type

Pressure rating

Diameter (mm)

Material of body

Mass (kg)

**2.7** **Water Meter**

Manufacturer

Standard to which manufactured

Nominal flow rate (m³/hr)

Pressure rating (bar)

Diameter (mm)

Material of body

Mass (kg)

Actual ±5% minimum flow rate (m³/hr)

Actual ±2% transitional flow rate (m³/hr)

Permissible 24 hr/d continuous load (m³/hr)

**3 Motor Control Center**

Manufacturer

Bus bar rated current (A)

Main circuit breaker rating (A)

Enclosure (IP)

Fault level (kA)

Starter

Type

Manufacturer

Rating at Site altitude and ambient temperature (kW)

Rated number of starts per hour

**3.1 Cables**

Between main LV switchboard/meter and motor control center

Type of cable

Size (mm²)

Length (m)

Between motor control center and pumps

Type of cable

Size (mm²)

Length (m)

**3.2 Circuit Breakers**

Maker's Name

Type

Rated Current

Rated fault breaking capacity

Insulation

Other characteristics

**3.3 Water Level Sensor**

Maker's Name

Type

Max. working pressure (kg/cm² or m)

Range of set pressure (kg/cm² or m)

Range of differential pressure (kg/cm² or m)

**3.4 Pressure Switch**

Maker's Name

Type

Maximum working pressure (kg/cm² or m)

Range of set pressure (kg/cm² or m)

Range of Differential (kg/cm² or m)

**4 Lifting Devices**

Maker's Name

Type

Max. load (kg)

Height from floor to hook (m)