

**EMPLOYER'S REQUIREMENT FOR  
MECHANICAL & ELECTRICAL WORKS**

**CHAPTER 04  
MATERIALS & WORKMANSHIP  
MECHANICAL WORKS**

## CHAPTER 4

### MATERIALS & WORKMANSHIP

### MECHANICAL WORKS

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## CHAPTER 04 MECHANICAL WORKS

### 4.01. Introduction

This Chapter of the Specification sets out the minimum standards of materials, workmanship and design to be used by the Contractor for mechanical works. Reference to any specific material or equipment does not necessarily imply that such material or equipment is included in the Work.

All components/parts of the Work shall, unless otherwise specified, comply with the provisions of this Chapter unless overridden by the Employer's Requirements or be subject to the approval of the Employer.

### 4.02. Reference of Standards

All goods, materials and workmanship shall comply with the requirements of the latest issue (with up to date amendments) of the appropriate standard or standards of the British Standards Institution (BSI) or, if none is applicable, with the standards of best practice.

Where standards other than British Standards are proposed by the Contractor in his tender, the acceptance of the tender based on such standards shall only signify the approval to the use of such standards, but shall not make the Employer liable to accept any standard subsequently found inferior to the corresponding British Standard. The Employer shall be empowered to reject any material components and workmanship found to be inferior to the appropriate British Standard and the Contractor shall make good the deficiency at his own expense.

The Contractor may propose at no extra cost to the Employer the use of any alternative relevantly authoritative and internationally recognized reference of standard which shall be no less exacting than the corresponding standard quoted in the Specification. The Contractor shall demonstrate to the Employer that the alternative standard is suitable and equivalent to the specified standard as well as provide proof of previous successful use.

### 4.03. Abbreviations for references of standard

The following abbreviations where used in the specification refer to standard; codes of practice and other publications published by the organizations listed below:

ACI	American Concrete Institute
ANSI	American National Standard Institute
API	American Petroleum Institute
ASA	American Standard Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
BS	British Standard Institute
CP	British Standard Institution (Code of Practice)
DIN	German Industrial Standard
HMSO	Her Majesty's Stationary Office
IEE	The Institute of Electrical Engineers
IEC	International Electro-technical Commission
IME	The Institute of Mechanical Engineers
ISO	International Organization for Standardization
JIS	Japanese Industrial Standard
NEMA	National Electrical Manufacturers Association
SI	International System of Units
SIS	Swedish Standard Commission

#### **4.4. Plant design and life**

The plant as a whole shall be new, of sound workmanship, robustly designed for a long reliable operating life and shall be capable of 24 hours per day continuous operation for prolonged periods and with minimum maintenance required. Particular attention shall be given to temperature changes, the stability of paint finish for high temperatures, the rating, electrical machinery, thermal overload services, cooling systems and the choice of lubricants for possible high and prolonged operation at high ambient temperature.

The plant shall be designed to provide easy and safe access and replacement of component parts which are subject to wear, without the need to replace whole units except for consumable items. No part subject to wear shall have a life of less than five years from new to replacement or repair. Where major dismantling is unavoidable to replace a part, the life of such part shall not be less than ten years.

Component parts shall be designed to be manufactured to strict limits of accuracy and to be interchangeable with parts of similar plant.

Design features shall include the protection of Plant against damage caused by vermin, dirt, dust and dampness and to reduce risk of fire. Plant shall operate without undue vibration and parts shall be designed to withstand the maximum stresses under the most severe conditions of normal service. Materials shall have a high resistance to change in their properties due to the passage of time, exposure to light, temperature and any other cause which may have a detrimental effect upon the performance

or life of the Work. All materials in contact with water shall be impervious to it and

not impart taste, odor and toxicity or otherwise be harmful to health or adversely affect the quality of water conveyed.

Manually operated plant located outside a building or structure shall be vandal-proof in addition to any other requirement in the Specification in respect of security.

Outdoor equipment shall be weatherproof and designed to exclude dust and to prevent the collection of water at any point. Metal-to-metal joints will not be permitted and all external bolts or screw shall be provided with blind tapped holes where a through hole would permit the ingress of moisture.

Mechanisms shall be constructed of materials which will not corrode due to rust, corrosion, brine or dust. Bearings of exposed operating shafts shall be designed to prevent moisture seeping along the shaft into the interior of the equipment.

Equipment and instruments shall not be located in positions where they are vulnerable to falling objects or water drips. Weather shields shall be provided where necessary to protect equipment and instruments from the sun.

#### **4.5. Workmanship**

Workmanship and the general finish of Plant installations shall be of first class commercial quality and in accordance with the best workshop practice and shall be performed by persons skilled in their respective trades.

Pipe work, fittings, cables, cable trays, etc., shall be fitted in a neat, straight and symmetrical manner so as to present a pleasing appearance.

Indicating gauges fitted to machine assemblies or to control panels shall generally be of similar style and grouped in a neat manner.

External welds and flame cuts shall have a smooth finish by means of careful grinding. Floor plate covering shall be fixed squarely in their frames and with their patterns lined-up. Hand railings shall be free from burrs.

#### **4.6. Welding**

All welding electrodes, wire and fluxes shall be stored in a clean dry place and protected from all forms of deterioration. All welding consumables shall be properly identified and shall retain their identification up to the time of use. Each batch of electrodes and wire shall be identifiable with the respective manufacturer's test certificate and advice note and shall be used in strict delivery rotation.

Gas cylinders shall be supplied to the site marked in accordance with the requirements of ISO 8448. They shall be stored under a suitable sunshade.

All welding equipment shall be of sufficient capacity and be maintained in such a condition as to ensure welds of acceptable quality throughout the range of electrode sizes to be used on the work.

Welding machine earth or ground leads shall be firmly fixed to the workplace.

Welding cables shall be maintained in good condition and shall be free from kinks and loose connections.

Welders and welding shall be protected by suitable equipment from wind, airborne sand and moisture. Work shall not be performed when weather conditions do not permit satisfactory workmanship or adequate inspection.

Weld preparation profiles may be prepared by machine, shear, flame or plasma cutting followed by grinding and shall be performed carefully and accurately. Whenever possible, a mechanically guided tool shall be used for flame or plasma cutting. All edges shall be left free of slag, burs, fins, oxides and foreign matter and the finished profile shall conform to the design tolerances for the weld preparation.

Tack welding of weld preparations may be permitted but all tacks must be ground to a feather edge prior to completing the next pass.

Where spacer strip or bridging pieces are used, due care shall be taken when tack welds are removed.

All scars and blemishes shall be grounded prior to submitting the weld for inspection.

Where preheating is required, preheat and inter-pass temperatures shall be checked by temperature recorders on indicating crayons at a distance of not less than 75 mm from the weld groove. The use of hand held torches for heating will not be permitted.

Work which is subjected to heat treatment by use of electrically heated elements shall be monitored by suitable thermocouples connected to a chart recorder. A minimum of two thermocouples shall be used.

All slag, excess filler metal and surface irregularities shall be removed between weld inter-pass runs. Flame gouging is prohibited.

Welding on attachments such as lugs, cleats, supports etc shall be positioned well clear of all pressure retaining welds carrying principal stresses. If it is found essential to bridge or span a principal weld, then the attachments shall be designed so as to ensure that no further weld is positioned within 40 mm of the principal weld.

All tube butt welds shall have full penetration with a maximum of 3 mm excess penetration in the root run. The surface of the finished weld shall not be concave.

Unless otherwise specified, welds subject to radiographic, ultrasonic or other forms of non-destructive test shall be dressed to a smooth contour. Care shall be taken to blend weld and parent metal without under flushing.

All weld dressings shall be carried except where otherwise specified or ordered by the Employer.

Mechanical and other non-radiographic test, if required, shall be carried out in the presence of the Employer. Welder shall be qualified in accordance with the requirements of the appropriate section of BS 4872 or BS 4871 whichever is applicable.

#### 4.7. Castings

The structure of castings shall be homogeneous and free from non-metallic inclusions and other defects. Surfaces of casting which are not machined shall be carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 10 mm in depth or 10% of total metal thickness whichever is less and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques.

If the removal of metal from repair reduces the stress-resisting cross-section of the casting by more than 25% or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25% then the casting shall be rejected.

Castings repaired by welding for major defects shall be stress-relieved.

Non-destructive tests may be required for any casting containing defects whose effect can otherwise be established, or to determine that repair welds have been properly made.

Unless otherwise specified, casting shall be produced to the following standards or equal:

Grey-Iron	BS 1452	Grade 220
Carbon Steel	BS 3100	Steel alloy
Stainless Steel	BS3100	Steel 316 C16

#### 4.8. Forgings

Major stress-bearing forgings shall be made to a standard specification. They shall be subjected to internal examination and non-destructive tests for the detection of flaws and shall be heat-treated for the relief of residual stress.

#### 4.9. Nuts, bolts, studs and washers

Nuts and bolts for pressure fittings as a minimum shall be of zinc plated high quality steel machined on the shank and under the head and the nut. Bolts shall be of such a length that only one to three-threads shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a tight driving fit in the reamed holes they occupy, they shall have the screwed portion of such a diameter 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 fittings shall be provided where necessary to ensure that no bending stress is caused in the bolt.

When there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material under all conditions. All bolts, nuts and screws which are subject to frequent



adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel or brass.

The Contractor shall supply all holding down, aligning and leveling bolts complete with anchorages, nuts, washers and packing required to attach the plant to foundations.

Unless otherwise necessary to meet special requirement all threads shall be have preferred metric sizes with standard coarse thread.

ISO metric black hexagon bolts, nuts and screws shall comply with S11 0585-81, or ISO 885, ISO 888, ISO 898-1 and ISO 898-2 and BS 4190 strength Grade 4.6.

ISO metric precision hexagon bolts, nuts and screw shall comply with ISO 272. ISO 4759-1, ISO 885, ISO888 898-1 and 2 or ASTM F-593, ASTM F-468M, strength Grade 8.8 and BS 3692 strength Grade 8.8.

The dimensions of metric countersunk head bolts, screws and hexagon nuts shall comply with ISO 225 or ISO 888 or ISO 898-1.

Plain steel washer for use with ISO metric bolts shall comply with ISO 887 or ASTM F-884.

Taper steel washer shall comply with ASTM F-844 and ASTM F-436.

#### **4.10. Non-metallic materials**

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated with an approved fungicide. Sleeves and fabrics treated with linseed oil varnish shall not be used.

The use of organic materials shall be avoided as far as possible, but where these have to be used, they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be seasoned teak or similar hardwood which is resistant to fungal decay and free from distortion and faults.

Woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insect, bacteria or chemical attack, unless it is naturally resistant to all these. Joints in woodwork shall be dovetailed or tongued and pinned. Metal fitting on wood shall be of nonferrous material. Adhesives shall be impervious to moisture and fungus growth. Synthetic resin cement only shall be used for joining wood. The use of casein cement will not be permitted.

#### **4.11. Guards for moving parts**

All moving parts shall be protected by safety guards. Guards shall be rigid, securely fixed and designed to allow normal operation, running, maintenance and routine inspection to be carried out on equipment without the need to remove the guard. Where this is impractical, guards shall be designed for easy fixing,

dismantling and re-assembly.

#### **4.12. Safeguarding of Plant**

The Contractor shall ensure that the whole of the Work as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise suppression devices, written notices, safety colours and the like shall be provided where necessary during erection and as a permanent feature.

Plant layout shall be designed to provide easy and safe access to valves hand wheels, electrical equipment, instruments and any other operating devices, free from hazardous obstructions.

Nothing in the Specification shall remove the Contractor's obligation from drawing the attention of the Employer to any feature of the Work which is not consistent with safety or prevents him from making proposals for incorporating equipments of design which would increase the safety of the Plant.

#### **4.13. Rating plates, name plates and labels**

The Contractor shall supply a Plant identification system showing the name and number of each item of the Plant and its respective arrangement drawing number and add any additional items necessary to fully identify it.

The Contractor shall supply all labels, nameplates, instruction and warning plates necessary for the identification and safe operation of the Plant.

All such labeling shall be securely fixed to items of plant and equipment with stainless steel rivets, plated self-tapping screws or other approved means. The use of adhesives will not be permitted.

Nameplates for plant, and equipment identification and record purposes shall be manufactured from stainless steel with a matt or satin finish and engraved with black lettering of a size which is legible from the working position.

Warning plates/labels shall be manufactured from stainless steel engraved with white lettering on a red background and sited in the position where they afford maximum safety of personnel.

All equipment within panels and desk shall be individually identified by satin or matt finish stainless steel labels or laminated plastic labels where approved.

Pipe work systems shall be color coded in accordance with the requirements of BS 1710.

Each valve shall be fitted with a stainless steel nameplate indicating the valve service and reference where nameplates shall be circular and fitted under the hand wheels captive nut. They have to be of such a diameter that there is no danger for persons operating the valve or that they do not prevent lock-off of the valve. For check valves and small valves, the Contractor may provide rectangular nameplates fitted to brackets on the valves or attached to a wall or steel work in convenient positions adjacent to the valves.

#### **4.14. Lubrication:**

##### **4.14.1. General**

Items of Plant shall be lubricated as necessary to ensure operation, heat removal and freedom from undue wear. Lubricated items shall be designed so that they do not require more than monthly lubrication attendance, unless otherwise required.

All grease nipples, oil cups and dip sticks shall be readily accessible, being piped where necessary to convenient positions.

The Contractor shall supply first fill of oil and grease for both Plant and maintenance equipment. In addition, the Contractor shall provide adequate supplies of lubricants for all equipment sufficient for 12 months of normal operation from the date of the Taking Over.

A complete schedule of recommended oils and other lubricants shall be provided by the Contractor as part of the Operating and Maintenance Manuals. The number of different types of lubricants shall be kept to a minimum. In the case of grease lubricated ball and roller bearing, a lithium based grease is preferred.

##### **4.14.2. Oil lubrication**

Oil reservoirs shall be fitted with oil-level indicators of the sight glass type, or where this is not practicable, with dipsticks. The normal, maximum and minimum levels shall be clearly visible to an operator standing on the normal access floor to the particular item of plant. The sight glasses shall be made from toughened glass, easily dismantled for cleaning and in exposed situations, fitted with the guards.

Drain points shall be located or piped to such a position that an adequately sized container can be placed beneath them.

For forced oil lubrication systems, the pressure shall be monitored during operation with automatic shutdown of the machine and alarm on low oil pressure.

All oil lubricated machinery shall utilize a common grade of oil which is readily available in Pakistan. High temperature high performance lubricates shall be avoided as far as possible.

##### **4.14.3. Grease Lubrication**

Grease lubrication shall be for steel lubrication nipples manufactured in accordance with BS 1486.

A separate nipple shall be provided to secure each lubrication point. Where a number of nipples supply remote lubricating points, they shall be grouped together on a conveniently placed batter plate, with spacing in accordance with BS 1486.

The Contractor shall provide a grease gun for each size and type of nipple

installed. Where different types of greases are involved, separate grease guns shall be provided for each type. They shall be suitably labeled and if possible of different style to prevent incorrect greasing.

#### **4.15. Joint Rings & Gaskets**

Joint rings shall be manufactured to conform to BS 2194 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80° C or greater to suit the application.

Joints shall be made in accordance with manufacturer's instructions or as specified herein. Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any constituents soluble in water. They shall be suitable for the climatic conditions at site and shall contain an approved bactericide.

Graphite grease or similar shall be applied to the threads of bolts before joints are made.

#### **4.16. Electroplating, galvanizing and sherardizing**

Parts to be galvanized, other than nuts, bolts and fasteners, shall be hot dip galvanized to BS 729 to give a minimum average coating of 610 g/m<sup>2</sup> area covered and a zinc thickness of not less than 85 microns.

Where specified, nuts, bolts and fasteners to be galvanized shall be hot dip galvanized to BS 729 to give a minimum average coating of 305 g/m<sup>2</sup> and a zinc thickness of not less than 43 microns. Where hot dip galvanizing is not practicable, nuts, bolts and fasteners shall be sherardized. Sherardizing shall be in accordance with BS 4291, the thickness of zinc coating being not less than 30 microns.

Where chromium plating is used, it shall comply with the requirements of BS 1224 including the provision that no blistering of any surfaces will be accepted. For all base metals, the service condition number 2 shall be used.

#### **4.17. Noise**

The Plant shall be designed and constructed to reduce the operating noise level as much as possible. During periods of short duration or abnormal operation (e.g. during startup) higher noise level up to an additional 20 dB (A) may be acceptable at the discretion of the Employer.

Except as provided for below, the noise emitted by any single item of the Plant shall not exceed a sound pressure level of 85 dB (A) when measured at a distance of 1 m from the reference surface of that item in a horizontal direction and under the environmental conditions appropriate to the test requirements of ISO 3746 "Acoustic Determination of Sound Power Levels of Noise – Survey

Methods” or the equipment ANSI S1 36.

The Contractor shall carry out noise tests on Site if in the opinion of the Employer, the Plant is excessively noisy. Sound pressure levels shall be measured in dB (A) using a calibrated sound meter meeting the requirements of BS 4197 with a response speed set to “Slow”. The background noise level shall be at least 10 dB (A) below the operating noise level of the machine or other item of the Plant.

For major items of the Plant, the Contractor shall provide workshop certificates from the manufacturer covering noise level tests carried out on the items or type test certificates for similar items of the Plant.

If any item of Plant in its standard built, does not comply with the above requirement, the Contractor shall be required to reduce the sound pressure level by providing improved or additional silencers or fitting sound insulating materials to the item, until the requirement is met.

Noise levels in control rooms and offices shall not exceed 45 dB (A) with equipment such as printers in operation and in local plant control rooms it shall not exceed 70 dB (A).

The background noise level at any point along the boundary of the Site, arising from operation of the Plant shall not exceed 65 dB (A).

#### **4.18. Vibration**

All rotating elements shall be dynamically balanced so that the level of vibration at any point on a machine when operating at Site, either singly or with other machines, and at any speed throughout the operating range shall be within the limits of Class IV, Grade B as defined in BS 4675 Part 1. “Machine” shall mean a complete assembly including its drive shafting, motor and bedplate, generator, and compressor etc.

Pipe work, valves and other equipment connected to the machine or forming part of the operating system, shall be with provided adequate supports, brackets and fixtures, as necessary to restrict any induced vibration to a minimum under any operating condition.

Vibration measurements shall be taken on Site by the Contractor at various points on each complete machine as defined above.

Measurements shall also be taken on connecting Plant. If any item is found to be vibrating beyond the level considered by the Employer to be reasonably minimum for the particular Item, the Contractor shall take further steps to bring vibration to the required level. Equipment with unacceptable vibration levels may be rejected if the Contractor is unable to achieve satisfactory operation of the equipment involved.

#### **4.19. Corrosion and erosion**

The Contractor shall make proper provision for the prevention of corrosion and erosion in any part of his Plant. Such provision shall include the use of suitable materials, choice of operating speeds, design of components and type of protective coating and finishes. Particular attention shall be given to the Plant that

may be exposed to water from different sources with varying characteristics and possible galvanic reaction with dissimilar metals.

#### **4.20. Precautions against dampness**

Special precautions shall be taken to prevent corrosion due to humidity, rainfall and moisture.

All wall-mounted equipment shall be fitted with spacers to provide a minimum gap of 5 mm.

All holes in the equipment shall be effectively sealed against the ingress of water. All items exposed to weather or water shall be free of water traps. Where necessary drain holes shall be provided to prevent the accumulation of water.

All fixings, fastenings and spacers which may be submerged in a corrosive liquid shall be galvanized or sherardized, unless otherwise specified.

All electrical equipment which is not sealed against free movement of air shall be protected from condensation with anti-condensation heaters. In general these heaters shall be thermostatically controlled and switched off when heat is generated by the operation of the Plant.

In choosing materials and their finishes due regard is to be given to the conditions under which the equipment is to Work. Tropical duty materials should be used throughout the Plant. Iron and steel are to be painted or galvanized in accordance with the Specification. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms are to be treated in an approved manner to prevent rusting, Cores etc. which are built up of laminations or cannot for any other reason be antirust treated are to have all exposed parts cleaned and heavily enameled or lacquered.

When it is necessary to use dissimilar metals in contact these should be so selected so that the electrochemical potential difference is not greater than 250 milli-volts and if practicable the two metals are to be insulated from each other by an approved insulating material or by a coating of approved varnished compound.

The use of iron and steel is to be avoided in instruments and electrical relays wherever possible. Steel screws when used are to be zinc, cadmium or chromium plated or when plating is not possible owing to tolerance limitations, are to be of corrosion resisting steel. Springs are to be of brass, bronze or non-rusting material. Pivots for which non-ferrous material is unsuitable are to be of approved rustless steel where possible.

The use of wood within electrical and mechanical equipment is to be avoided as far as possible and, if used shall be of a type resistant to termite attack and fungal decay.

The use of hygroscopic insulating materials is not permitted except immersed in oil or otherwise suitably sealed to prevent ingress of moisture.

In choosing materials and their finishes due regard is to be given to the conditions under which the equipment is to Work. Typical duty materials should be used

throughout the Plant.

Springs are to be of brass, bronze or non-rusting material. Pivots for which non-ferrous material is unsuitable are to be of approved rustless steel where possible.

#### **4.21. Protective finishes**

The surfaces of Plant shall be fully protected against corrosion and erosion with the exception of steel or similar corrosion resistant material or where the surface is required to be clear for operational purpose, e.g at glands, bearing, etc.

Parts to be galvanized shall be designed to avoid overlapping surfaces and narrow gaps and pockets which may trap pickling acid. Thermal distortion or the creation of unacceptable residual stresses should not occur.

Nuts, bolts and fasteners shall be of stainless steel Grade 316 S312 or shall have corrosion, resistant finish. Galvanizing, sherardizing, or electroplating of fasteners shall be to BS 3353. Cadmium plating shall not be used.

The paint protection system shall be obtained from the same manufacturer and applied strictly in accordance with the manufacturer's instructions and requirements and in accordance with BS 5493 and 6160. The Contractor shall be responsible for cleaning surfaces and preparing them for protective treatment and protective coatings applied at the place of manufacture and at Site. Coatings shall not be applied to external surfaces at Site during rain, fog, mist or condensation or when wind borne dirt and dust are present or likely to be present before the coating is dry enough to be undamaged.

All items of plant shall be delivered to Site with their protective finish fully applied. Site painting shall be limited to the making good of damaged protective finish and the application of further decorative coats to provide a clean and uniform finish to the whole of the Work. Site painting shall not be carried out unless the surface to be painted is dry and has undergone surface preparation as instructed by the paint manufacturer. In general Site painting shall be applied only when ambient temperatures are above 16 degrees and relative humidity is less than 55%. If these conditions cannot be achieved, a special painting system may be applied with the approval of the Employer.

Mating surfaces shall have primary coats applied before assembly. The mating surfaces of structural steel shall be sealed during erection.

Care shall be taken not to paint over any nameplates, rating plates, labels etc. All bearing and gland surfaces shall be protected during final painting.

The protective treatment system shall enable any necessary repairs, whether during the Contract period or subsequently to be made simply, without need for special skills or equipment. "Two pack" product shall not be used on any of the Plant Item.

All coatings used for any part of the Plant in contact with water for potable use shall be non-toxic, non-carcinogenic, not impart taste, odor, color or turbidity to the water. Only materials included in the approved list of the UK water fittings and

by-laws scheme (operated by WRc) or in the “Current Statement of the Committee” on chemicals and materials of the construction for use in public water supply and swimming pools (issued by DOE) shall be used in places where they may come into contact with water to be used for potable purposes.

The following table gives the minimal acceptable finish system for different types of plant. Further detailed requirements for specific items of plant if given in the Specification shall take precedence over any requirement stated here:

Hand-railing, walkways and steel structure installed inside and outside buildings.	Hot dip galvanized/stainless steel where specifically mentioned.
Steel pipe work 100 mm dia. and larger.	Fusion bounded epoxy.
Steel pipe work under 100 mm dia. and smaller.	Hot dip galvanized.
Ductile iron pipe work.	Bitumen coating.
Steel surfaces other than pipe work in damp or wet environment.	Zinc rich epoxy or zinc spray followed by epoxy top coat.
Electrical switchgear in dry uncontrolled atmosphere.	Stove dried enamel or manufacturer's standard finish.
Electrical switchgear in damp uncontrolled atmosphere.	Stainless steel or GRP enclosure self-colored.

Table 2 -1: Minimal Acceptable Finish System

Paint finished shall include color coding taping (BS 1710) of pipes for chemicals, treated and raw water to the approval of the Employer.

#### 4.22. Water Compliance of Materials in Contact with Water

Any materials that come or may come in contact with water which is to become potable shall comply with one of the following.

- The UK Secretary of State for the Environment under Section 25 of the water supply (Water Quality Regulation 1989).
- The 15th Statement of the UK Department of Environment Committee on Chemical and Materials for use in public water supply.
- The American Food and Drug Association.
- Other internationally recognized and approved body.

Where a material does not comply with the above it shall be subject to the approval of Employer. Certificates confirming compliance with the above shall be submitted to the Employer and these shall form part of the approval/acceptance of the Plant.

#### 4.23. High lift pump sets



The Contractor shall provide for all the required components of the pumping Plant at Site in accordance with the Specification and Conceptual Drawings.

In selecting suitable pump sets for the stated performance, the Contractor shall ensure that as many components and items as possible are identical. Complete interchangeability of spares and other parts between all pumps is desirable.

All pumps shall be suitable for continuous operation at the performance specified and their duty levels shall be in the stable region of the pump characteristic curves. When required to do so, the pump shall operate satisfactorily in parallel with other pumps which may either be two or three or four in number.

Pumps shall be of vertical shaft type meant for dry / wet pit installation as required, coupled with vertical shaft motors at ground floor level. They shall be quiet in operation and free from vibration. All rotating parts shall be dynamically balanced to BS 5265 and shall be so designed and constructed as to be capable of running unattended for long periods.

The component parts of the pumps shall be constructed from carefully selected materials designed to avoid all metallic corrosion resulting from the interaction of water with dissimilar and incompatible metals.

Fully detailed catalogues of the manufacturer and pump performance curves shall be submitted with the Tender. These shall cover the full operating range of all pumps whether operating alone or in parallel. Curves shall be plotted for flow, head, input power, and overall pump efficiency.

The Contractor shall submit a schedule of technical particulars on a prescribed Performa with the guaranteed performance with his Tender. The guarantees of performance shall be achieved by the Plant under the condition of works tests and Site tests and shall be considered binding and not be departed from without the written consent of the Employer.

The pumps shall be fitted with renewable wear rings or sleeves in areas of close tolerance and where there is a high degree of wear.

Mechanical seals of cartridge or gland packing where specified, shall be used which shall be rated for continuous service without adjustments.

Pumps shall be capable of passing weed/algae present in lake water and shall be designed to avoid possible choking by weeds or other tough sinuous materials.

Unless otherwise specified, all bearings shall have a design running life of not less than 50,000 hours. Bearings shall be designed for loading 20% in excess of calculated maximum loading and shall be suitable for reverse rotation at 150% rated speed or the maximum reverse speed the pump can reach in installed conditions when driven backwards by reverse flow, if this is greater.

The rotating assemblies shall be statically and dynamically balanced to BS 5265 and designed so that the first critical speed of the pump and its drive is at least 50% higher than the normal operating speed.

#### **4.24. Pump performance guarantees**

Pump performance guarantees shall relate to the flow rate, the total head when tested at the manufacturer's works. Verification of factory test results shall form part of the Site test on completion.

The pump shall operate at its duty point within the acceptance tolerances for flow and total head laid down in Clause 9.4.1 of BS 5316: Part 2 (ISO 3555), 1997.

Each pump shall be tested at manufacturer's factory in accordance with BS 5316: Part 2 (ISO 3555) or other relevant standards in conjunction with one of the Contract motors.

Notwithstanding the requirements of BS 5316, the Contractor shall guarantee the pumps to operate safely, without cavitation's, undue vibration or wear over the complete range of duties in which the pumps will operate.

The tests shall be carried out on at least one pump set using the Contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.

Where similar drive shaft arrangements have been installed by the Contractor and have proven satisfactory in service, this requirement may be withdrawn subject to the approval of the Employer.

The tests shall be carried out - out of the performance from closed valve to the maximum quantity that can be delivered under abnormally low discharge heads when only one pump is operating.

Sufficient readings shall be taken at each test to produce accurate curves of the head, flow, pump speed and power required at pump coupling throughout the operating range of the pump.

Vibration and noise dB (A) levels shall be measured and shown to be acceptable. The contractor shall provide acceptable test certificates, showing that the NPSH requirements for the pump are sufficiently less than the NPSH available under all working conditions.

#### **4.25. Dry pit installation**

Pump casings shall be of the volute type, made of best quality close grained cast iron and shall be capable of withstanding all pressure surges that may arise during operation.

All pump castings shall be manufactured and pressure tested in accordance with the latest issue of BS 1452. Material grade BS 1452 – 400 or GGG – 42 DIN 1693.

Casings shall be split to permit their removal to inspect or withdraw the rotating parts without dismantling pipe work. Equally spaced tapped holes shall be provided in one of each pair of joint flanges to facilitate their separation when dismantling and dowels or guide pillars shall be provided to ensure correct alignment on reassembly.

The pump casings shall not be integral with the base plate, but shall be designed to permit the removal of either the complete pump or internal components without affecting the mounting of the base plate.

Easily replaceable wear ring shall be provided between impeller and casing parts.

Impellers shall be manufactured from best quality stainless steel. They shall be smooth, well finished, free from blow holes and imperfections, and shall be dynamically balanced.

Impellers shall be securely attached to their pump spindles in such a manner that they do not loosen or become detached when the pump is in operation, or when rotated in the opposite direction by reversed motor connections or by reverse flow.

Pump spindles or line shafting's shall be of stainless steel, machined, ground and fitted with renewable sleeves at the bearings and stuffing boxes. The shaft design shall be adequate without use of intermediate bearings, if possible.

All bearings shall be mounted in sealed dustproof housing and arranged for ease of lubrication.

The complete rotor and spindle assembly shall be designed such that the running speed is well below the critical speeds and shall not exceed the specified speeds without the written approval of the Employer.

The pump casings shall be sealed against leakage along the shaft by stuffing boxes having pre – lubricated soft packing which shall incorporate bronze lantern rings to facilitated efficient sealing.

The glands shall be split to facilitate accessibility and maintenance of the gland packing.

Support pedestals shall comprise of a base plate and separate pedestal of sufficient thickness and strength to rigidly support the weight and thrust of the whole pump and discharge pipe assembly without distortion or misalignment. A drain hole shall be provided in the pedestal base suitably piped to the nearest building drainage point.

Approved steel guards shall be fitted over all exposed rotating parts of the pump sets.

Motors shall be connected to the pumps through cardan shafts and the couplings shall be designed to allow the motors to be removed without the need to dismantle the whole of the shaft.

Intermediate bearings shall be provided on the shaft, if necessary. The Contractor shall include for all necessary bearing supports, brackets etc. These shall be fabricated where necessary and no intermediate structural concrete supports will be provided. The bearing fixings shall be adjustable for final alignment to allow for tolerance in the building structure. The bearings shall be designed to prevent the discharge of grease, ingress of dust and other harmful matter.

Shaft guards shall be provided over the whole length of the shaft. The guards shall be of the mesh type, made in sections and bolted together to form a continuous length with ends rigidly fixed to the pump and motor stool. It shall be

possible to dismantle part or whole of the guard without disturbing the shaft or motor. Cutouts shall be provided in the guard for access to the intermediate shaft bearings.

Each pump shall be equipped with the following minimum fittings:

- a. Air release valve
- b. Air release pipe mounted at the top of the pump delivery branch or pump – casing on each pump arranged to discharge into the pump tundish.
- a. Drainage pipe to allow drainage of gland seepage water from the glands, into the pump tundish which will be suitably piped to the nearest building drainage point in G.I pipe work.
- b. Compound suction and delivery pressure gauges.
- c. Engraved nameplates indicating the type, impeller diameter, and output at normal duty head, speed, and serial number of pump.
- f. Engraved duty plate to correspond with the pump control panel designation e.g. Pump No. 1. The characters shall not be less than 30mm high.

#### **4.26. Submersible pumps**

Submersible pumps shall be of the single entry design supplied complete with boltless self – aligning duct - foot assemblies giving automatic connection to the discharge pipe work. The pump casing shall be manufactured from close grained grey iron to BS 1452.

An oil filled casing shall separate the electric motor from the submersible pump. Mechanical seals shall be fitted to the pump shaft, which shall prevent water from entering the oil casing, and oil from entering the motor casing. A moisture detection system shall be provided to initiate an external alarm.

The motor housing shall be impregnated to protect the ingress of moisture.

The shaft bearings shall be sealed and lubricated for life.

The pumps shall be controlled and started from the main distribution board and be fed with three phase supply. Control shall be via adjustable float level switches mounted adjacent to the pumps.

The pumps shall be supplied with all necessary pipe work, including reflex and isolating valves and suitable lifting gear for lowering and removing the pump from the sump.

The pump impeller, which shall be of stainless steel, shall be designed to pass solids of sizes which may enter the drain chamber.

#### **4.27. Pipe work and fittings**

The term pipe work shall include pipe of any description and associated flanges, adapters, couplings, jointing material, fittings, fixings, supports, drain valves, traps

and the like, which are necessary to complete installation of pipe work systems associated with plant.

Pipe work shall conform to the requirements of the relevant British Standards. All recommended tests shall be carried out and certified in writing.

Adequate provisions shall be made to anchor, support, drain vent, pressure test, dismantle and clean all pipe work.

Pipe work systems shall be designed to withstand the maximum internal and external forces which could occur in service and under hydraulic test pressure in accordance with Section 5.8.9 and Appendix 1 of Water Research Centre's "Pipe Material Selection Manual" 1988 Edition. The configuration and method of support shall minimize bending stresses.

Systems shall be sized so that the maximum design flow through the pipe work will not produce cavitation's, erosion, excessive noise or vibration. Systems shall also be sized where practicable so that the minimum operating flow of fluid will prevent deposition of suspended solids. No forces developed within the pipe work system shall be transferred to civil structure.

None of the forces and movements transmitted by pipes to connected machines, apparatus and other components exceed the maximum permissible values given by the manufacturer of these items.

Special care shall be taken in the design of pipe hangers and supporting elements. They shall be arranged, dimensioned and fastened in such manner that no vibration and undue stresses appear during start-up, operation or shutdown and during field tests. The reaction forces and moments of the piping system shall be borne by fixed points. Loads on walls, foundations and other civil structures, are to be reduced to the minimum.

The Contractor shall provide suitable thimbles and flashing where pipelines pass through floors and walls. Floor thimbles shall be installed to provide 90mm projection above the finished floor surface.

Plastic pipes, flexible pipes and fittings shall be supported throughout their length.

Ductile iron pressure pipes and fittings shall conform to BS 4772 or equivalent unless otherwise specified and shall have flanged joints.

Pipe work shall be colour coded to the approval of the Employer. The normal direction of flow shall be clearly marked on the pipe near each valve, junction, terminal and other positions as required by the Employer. Where applicable, colour coding shall be added after protective coatings, lagging and cladding have been applied.

The pipe work shall be laid out and designed so as to facilitate the erection, painting and dismantling of any section for maintenance, and to give a constant and uniform flow of working fluid with a minimum of head loss. Where steel pipe work is used, the number of flanges shall be kept to a minimum and size of each unit of pipe work is to be determined by the ease of handling, installation and general appearances of the completed pipe system. Positions of flanges shall take into account any necessary concrete pipe support or thrust blocks.

Flexible or collapsible joints shall be provided where necessary to facilitate removal of Plant and / or to allow for differential settlement of building structure. Wherever practical, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipe work as a whole.

All pipes and fittings over 150mm diameter and within the confines of building structure shall be in steel. Minimum grade of steel shall be Grade B. All pipes and fittings under 150mm shall be manufactured either in steel or in ABS plastics in accordance with BS 3867.

Where steel and cast flanges are mated together, the steel flanges shall be machined over its full face after welding to its respective pipe. Whenever possible, standard fittings shall be used in preference to fabricated or special fittings.

Facilities shall be provided for draining pipe work systems and releasing air. The drainage fluid shall be piped into the appropriate drainage system.

Flanges shall conform to BS 4504 and shall be drilled in accordance with the appropriate pressure rating.

Where a pipes passes through a wall, or is subject to thrust, it shall incorporate a puddle flange which shall conform to the dimensions stated in BS 4504 but shall remain undrilled.

Large piping installation shall be provided with means of isolating sections to facilitate drainage

Fluid velocity shall not exceed 2.5 m/s in pump suction and discharge pipe work. It shall not exceed 2.5 m/s in delivery manifolds at the duty flow with a maximum of 3.5 m/s at the designed maximum flow.

All pipe work shall be tested at the manufacturer's Works in accordance with the appropriate British Standard and pressure rating to which it is manufactured.

All pipe work shall be hydraulically pressure tested to 1.5 times the maximum working pressure or the surge pressure, whichever is greater, after installation. For pump delivery pipe work, the maximum working pressure shall be taken as the closed valve head of the pump. The Contractor shall supply and fit all necessary blank flanges and equipment to carry out the test. Prior to the test the pipe work shall have been thoroughly cleaned out. Precautions shall be taken to remove all air from the system under test. The test shall maintain with the drop in pressure not exceeding 2.5% for a period of 30 minutes.

Buried pipes shall be designed to limit these deflections to avoid damage to the pipes or their protective coatings. The external design loads for buried pipes shall include earth pressure due to the weight of the backfill over the pipe and the surcharge from vehicular loadings.

#### **4.28. Steel Specials**

Steel specials shall have the same length and shall be compatible in all other aspects with the pipes with which they are to be used.

Flat tapers shall have one side of the taper at right angle to the end so that they may be laid with invert level or crown level as may be required.

Collars shall comply with BS 324 Clause 25.

Bends shall be of even curvature type only, unless otherwise approved by the Employer.

Specials shall be hydraulically tested in accordance with Clause 3.9 of BS 1640: Part 3.

#### **4.29. Pipe Fabrication and Installation**

- a. The Contractor shall setup his own pipe fabrication shop with all the power equipment and tools necessary to fabricate pipes in accordance with relevant standards and codes of practice. The Contractor's fabrication shop shall be prior inspected and accepted for reliability of facilities, equipment and location by the Employer. If certain manifolds or pipe appurtenances are to be sub-contracted to other fabricators, their shops shall be subjected to prior qualification by the Employer.
- b. All MS pipes shall be fabricated from new mild steel plates of required thickness conforming to ASTM A283D.
- c. Edges of plates to be joined by welding shall be formed to true cylindrical shape. The resulting edges for welding shall be uniform throughout the length of the plates and shall form a straight line.
- d. If it is necessary to reshape pipe after it has been welded, reshaping shall be performed by rerolling. Hammering will not be permitted. Sizing of pipe ends to come within specified tolerance will be permitted.
- e. Each end of the pipe shall be a circle so that two ends may form a perfect joint. The end of each section of pipe shall be accurately measured and shall not exceed the tolerances set forth below, provided, that such tolerances do not interfere with the making of the joint:
  - (1) For a distance of not less than 250mm from the end, the outside circumference of the pipe shall be accurately measured and shall not be less than 1.5mm smaller nor more than 3mm (upto 0.5 percent variation) than the circumference computed from the nominal dia. of the pipe.
  - (2) The ends of all pipe sections shall not vary more than 3mm at any point from a true plane at right angles to the axis of the pipes.
- g. All piping shall be fabricated accurately and closely aligned during installation so that stresses are avoided in bolting up or welding into final position.
- h. Flanges shall be oriented with the bolt holes, stranding the horizontal and vertical centerlines of the pipes. Precautions shall be taken throughout the fabrication process not to mar the gasket face on the flanges.
- f. The dimensional tolerances of the prefabricated piping parts shall not exceed the limit given in U.S standard PFI – ES – 3.
- i. All screwed pipes shall be accurately cut to lengths with no "springing" required

to fit the individual pieces.

- j. All pipe supports shall bear fully on supporting work etc., and shall be placed with centerline of support perpendicular to centerline of the pipe.
- k. Saddles shall not overlap pipe joints. Pipe saddles shall be welded to the pipe after the pipe run has been assembled, positioned in place and anchored.
- l. Welded steel inserts shall be manufactured of steel plates of required thickness. Pipe and fitting materials, method of manufacture and shop testing of pipes shall conform to the requirements of AWWA standard C 201 – 60T “Standard for Fabricated Electrically Welded Steel Water Pipes”

#### **4.30. Valves & Penstocks**

##### **4.30.1. General**

All valves and penstocks shall be of the highest quality from approved manufacturer having ISO 9000 certification whose products have proved reliability in service in similar installations.

Parts subject to wear shall be designed so that they may be easily replaced and shall be constructed of wear resistant materials.

Flanges on valves are to be full faced and drilled in accordance with BS 4504 PN – 16 or ANSI B16 – 1 Class 125. Back faces shall be fully machined or spot faced for nuts and washers.

Valves and penstocks shall open by counter clock – wise rotation of wheel on operating nut.

Where electric actuators are fitted directly onto valves or penstocks, they shall be pre-assembled and tested in the manufacturer's Works with all necessary limit switches and other devices pre – set before delivery to Site. Where the actuators are fitted on head stocks they shall be pre-assembled at the manufacturer's works prior to delivery to Site.

All valves shall be pressure tested in accordance with the appropriate British Standards or pressure rating to which they are manufactured.

Where necessary valves and penstocks shall be fitted with steel extension spindles or universal joints operating rods, headstock or spindle caps as appropriate.

All valves and penstocks arranged for keyway operation shall be supplied with the necessary cast iron hatch boxes.

##### **4.30.2. Material**

The physical and chemical requirements of valve and penstock components shall be as required by AWWA, ANSI, ASTM, or other standard to which reference is made.

Cast iron shall be equal to or exceed the requirements of ASTM, A 126, Class B or ASTM A48, class 40 and alloy cast iron shall conform to ASTM A439 type D2, with a maximum lead content of 0.003 percent.



Ductile iron shall conform to either ASTM A395 or ASTM A536.

Brass or bronze shall comply with the following:-

- a. Valve components of brass or bronze shall be made to ASTM or Copper Developments Association (CDA) recognized alloy specifications.
- b. Any bronze alloy used in the cold worked condition shall be capable of passing the mercurial nitrate test in accordance with ASTM B154 to minimize susceptibility to stress corrosion.
- c. Because of dezincification considerations, Grade B and C bronze may be used only for those parts not wetted by line content, such as operator components. All bronze parts subject to wetting by line content shall be inhibited against dealuminization by receiving a temper annual at 1200°F (650°C)  $\pm$  50°F (10°C) for one hour per inch of section thickness followed by cooling in moving air or by water quenching.

Steel bolting material conforms to ASTM A307. Carbon steel castings, when used, shall be ASTM A27, Grade U 60 – 30, or equal, while the stainless steel shall meet the requirements of ASTM A276 type 304 or ASTM A296 Grade WCB. Fabricated steel shall conform to ASTM A36 / ASTM A516 or better.

Elastomers shall comply with the following:

- a. Rubber shall be resistant to microbiological attack, copper poisoning and ozone attack.
- b. Rubber compounds shall contain no more than 8 ppm of copper ion and shall include copper inhibitors to prevent copper degradation of the rubber material.
- c. Rubber compounds shall be capable of withstanding an ozone resistance test when tested in accordance with ASTM D1149. The tests shall be conducted on the unstressed samples for 70 hours at 104°F (40°C) without visible cracking in the surface of the test samples after tests.
- d. Rubber compounds shall have a maximum compression set value of 18 percent when tested in accordance with ASTM D395 Method B for 22 hours at 158°F (71°C).
- e. Rubber compounds shall be free of vegetables oils, vegetable oil derivatives, animal fats and animal oils.
- f. Rubber compounds shall contain no more than 1.5 parts of wax per 100 parts or rubber hydrocarbon and shall have less than 2 percent volume increase when tested in accordance with ASTM D471 after being immersed in distilled water at 73.4°F (23°C)  $\pm$  2°F for 70 hours. Reclaimed rubber shall not be used.

#### **4.31. Gasket**

Gasket material shall be made of sheet asbestos, rubber composition or paper that is free from corrosive ingredients. O Rings shall be compounded to meet ASTM D2000 and have physical properties suitable for the application.

Paints used for coating valves shall comply with the following:

- a. Paint used for coating all the valves shall conform to the requirements of Federal Specification TT – W – 51 asphalt varnish Military Specification MIL C – 450 or equal.
- b. If special coatings are used by the manufacturer they shall be acceptable for potable water.

#### **4.32. Valve operating equipment and headstocks**

Unless otherwise specified, valves shall be provided with hand wheels and mechanical position indicators and shall incorporate integral locking devices. Pressure and flow regulating valves shall be lockable in any position. Handwheels shall be shaped to give a safe grip without sharp projections and be clearly marked with the direction of closing.

Gear boxes shall be totally enclosed and lubricated in oil bath. Thrust – bearing shall be arranged so that the gear case may be opened for inspection or be dismantled without releasing the stem thrust or taking the valve out of service. Oil and grease lubricated gearing, bearings and glands shall be protected against the ingress of dust and moisture. Suitable gearing and bearings shall be provided to enable the valve to be operated by applying a maximum push pull effort of 13 kg (total 26kg) at the rim of the hand wheels.

Headstocks shall have index pointers working over polished and engraved with 'open to close' position indicators fixed to the side of the pillars. The indicators shall have robust clear plastic protection plates to exclude dust from the mechanism. The height of pillars shall not be less than 750 mm measured from the base to the hand wheel at headstock and the base shall be drilled for fixing to structural steel members or concreted as approved.

Guide brackets shall be the split – bearing type and the maximum spacing between supports shall not be greater than 1500mm.

Where remote mechanical operation of ball, gate or butterfly valves is required, it shall generally be as indicated on the drawings employing headstocks or headstocks with operating spindle extensions.

Headstock for direct connection to valves or penstock shall be for use with non – rinsing stem valves. They shall be of cast iron and fitted with a position indicator. Stem bearing shall be gunmetal bushed.

Where operational conditions dictate, the hand wheel shall operate through a bevel gear.

Where headstocks are structurally mounted above a valve chamber, or otherwise distant above the valve, operating spindle extensions shall be provided between the valve and headstock. These shall be suitable for length adjustment during assembly on site and shall be fitted with universal coupling adjacent to the valve and to the headstock. The couplings shall be so oriented as to give a linear transmission of rotational movement between headstock and valve stem.

#### **4.33. Electrically operated actuators**

Electrically operated actuators shall operate valves or penstocks at opening and closing rates of 300mm per minute unless otherwise specified. Valve actuators shall not be rated at less than 20% in excess of the power required to operate the valve under maximum working conditions.

Actuator enclosure shall have a minimum protection characteristic IP67 to BS 4999.

Actuator electric motors shall be designed to operate on the supply voltage and frequency specified and shall provide the rated power output within the range of 6% of the supply voltage and 2% of the supply frequency. The short time rating of motors shall permit the successive full travel operation of valve from open to close and vice versa but shall not in any case be less than 15 minutes. Motors shall be provided with in built thermal protection comprising of a thermostat or other direct acting temperature sensors.

Each actuator shall be provided with a mechanically and electrically interlocked reversing contactor starter integral with the assembly. The control supply shall be internally derived from a control transformer.

The ratings of all volt free contacts shall be 250V, 15A ac and 50V, 2A dc inductive load switching unless otherwise specified.

Actuator shall be suitable for automatic or local control, for which push buttons shall be incorporated in the starter and for remote operation.

Separate terminal boxes shall be provided with the motor supplies, the heater supplies and controls.

In addition to contacts necessary for operation and control of actuator functions, the following facilities shall be provided on the actuators detailed below where specified.

##### **4.33.1. Type A electric actuators**

This type of actuator shall be suitable for both electric and manual local operation and electric remote operation and shall be provided with the following:

- a) An alternative system for manual handwheel operation.
- b) An interlock, to prevent engagement of the handwheel whilst the actuator is being power driven and positively disengage the manual drive when the power drive has started.
- c) LOCAL/AUTOMATIC/OFF OR LOCAL/REMOTE/OFF electrical rotary selector switch, for the transfer of control panel with changeover volt-free contacts for remote indication of switch position.
- d) Local "OPEN", "STOP" and "CLOSE" push button with facility for remote operation or automatic operation.
- e) Potentiometer for remote indication of valve position.
- f) One volt-free contact for remote indication of "motor running" condition.
- g) Limit switches at each end of travel having two changeover volt-free contacts for remote indication.

- h) Torque switches for mechanical overload protection on opening and closing with one changeover volt-free remote trip indication.
- i) Thermal overload protection
- j) One changeover volt-free contact for “motor tripped on over load” remote indication.
- k) Two changeover volt-free contacts for interlock circuits on the associated power plant.
- l) One changeover volt-free contact for “power supply to actuator failed” remote indication.
- m) Remote control available “monitoring relay with volt-free contacts”, phase discriminator for single phase and phase reversal relay.
- n) Two interposing relays to provide for three buttons OPEN; STOP/CLOSE remote control with facility to reverse in midtravel. The provision of this facility shall not prevent the connection of remote controls directly to the integral control supply where distances are suitably short.

#### **4.33.2. Type B Electric Actuators**

This type of actuator shall be similar to Type A actuator but remote operation facility will not be provided.

#### **4.34. Penstocks**

All penstock shall be of the flat back type unless otherwise stated and shall be watertight to 1.5 times the actual head or such head as they may be subjected to in operation, whichever is greater.

Frames and slides shall be of best quality cast iron or steel with gunmetal or bronze trim according to BS 1432 Grade 14 and BS 2874 Grade CZ 124 respectively. Frames shall be a single casting designed to accept all imposed thrusts. An adequate number of cast iron wedges shall be provided on the doors with suitably faced adjustable wedge blocks fixed to the frame. Stems shall be of stainless steel.

Weir penstocks shall have perfectly leveled cills and shall be complete with top seal unless otherwise stated.

Flush bottom penstock shall have a flush invert with adequate sealing arrangements.

The operating nut of the penstocks shall preferably be of gun metal conforming to BS 1400 G 1 and BS 1400 L G 2.

#### **4.35. Types of Valves**

##### **4.35.1. Gate Valves**

Gate valves larger than 50mm diameter shall generally comply with BS 5163 when used with water and BS 5151 when used with slurries or sludge.

Valves shall be of the non-rising stem type with flanged ends to BS 4504 PT 16.

The body, wedge, bonnet, stuffing box, gland and thrust bridge shall be of mechanize cast iron to BS 1452 Grade 14, the seats, nuts, faces and guides of

gunmetal to BS 1400 Grade LG 2-C and the stem of forged Bronze to BS 2872 Grade CZ 114 or stainless steel.

Valves shall be arranged for clockwise closing and be suitable for operation from the closed position by a maximum "push pull" effort of 13 kg(total 26 kg) at the rim of the hand wheel or tee key. Cast iron hand wheel of generous dimensions having CLOSED direction arrows casted upon shall be provided.

Each valve shall have a drain plug fitted at the bottom of its seating.

Stuffing boxes shall be designed to have soft packing fitted.

Unless otherwise provided for, valves shall be rated for 10 bar working pressure with the bodies capable of withstanding a test pressure of 15 bar and the seat 10 bar without leakage.

Gate valves, 50mm diameter and smaller shall be in accordance with BS 5154.

Valves used with water shall not contain bronze having more than 5% Zinc.

#### **4.35.2. Ball Valves**

Ball valves shall be of the full-bore asymmetric split-body type. The ball shall be trunnion mounted. Valves shall comply with BS 5159 for normal duties and BS 5351 for more arduous duties. The line valve bore shall have a diameter as to meet the inside diameter of the adjoining pipe work.

End flanges shall be cast or forged integral with the body.

The valve body shall be of cast steel ASTM A216 WCB or better and incorporate a drain tapping complete with drain tap. The ball shall be forged steel ASTM A0 105 with chrome or nickel plated surface finish.

Internal wetted valve parts shall be protected with fusion bonded epoxy coating system suitable for potable water; other parts shall be of stainless steel AISI 304 or better. The internal bore of the ball valve shall be chromium plated.

The design shall be such that the stem shall not be capable of ejecting whilst under pressure. Except for valves below 50mm, glands shall be of the one piece bushed or two pieced self-aligning type.

Body seals ring assemblies shall be designed to be renewable. Ball ports shall be cylindrical. Valves shall be operated by hand wheels, wrench or actuator and arranged for clockwise closure. Maximum force required to open / close valve shall not exceed 350N.

Valve seals shall be designed for minimal maintenance. Where valves are very infrequently operated (pipeline isolation application), seal life shall be similar to the design life of the valve as a whole.

Hand wheels shall be marked to show direction of closing. Valves arranged for manual control shall incorporate a valve position indicator.

Stops shall be provided at both the fully open and fully close operation.

Ball valves shall be designed when open to permit the free passage of pipeline scraper equipment.

The sealing between ball and body at both sides of the valve shall be accomplished by elastomeric material suitable for the medium being shut-off.

The seal surface shall be perfectly spherical and lapped. Chromium plating shall be perfectly applied and the Contractor will be responsible for any spelling.

The sealing between the stem and the cover shall be accomplished by means of O – rings, neck bushing and additional secondary sealant or equivalent. The O – rings shall be of a material suitable for the pressure and the temperature.

#### **4.35.3. Check Valves**

Check valves shall be of the tilting disc type with double offset disc. The valve size and design shall be selected to give optimum performance taking full account of the system within which the valve is to be installed specially when the system includes surge bypass or when the static pressure is high and the system has to bypass large volumes of water.

In case of possibility of shock due to sudden interruption in flow, causing rapid flow reversals, a hydraulic damping device having a time lag system for controlling the rate of closures of the valve disc and bypassing all up and down surges through the system, shall be provided . Alternatively surge suppressor vessels for controlling water hammer are accepted. The damping device shall be sized by computer programmed to match the characteristics of the application. In addition, the analysis shall cover the adverse effects of column separation, if caused due to up surge or down surge pressure on the pumping system alternatively. The Contractor shall also recommend additional equipment or device, if required for mitigation of the adverse effects of column separation. All computations and data shall be forwarded by the Contractor to the Employer for his review. For vertical installation, the valve shall be equipped with weight loaded arms on either one or both sides.

The valve shall be of the short body type, double flanged and pressure tested with a minimum of 15 bar. The seal shall be pressure tested at 10 bar and the rating shall be to DIN/BS 4504 T16. The valve shall generally comply to BS 5153 unless otherwise specified.

Corrosion protection shall be by an approved epoxy coating which shall be safe for potable water.

The maximum velocity through any check valve shall not exceed 2.5 m/s without the written approval of the Employer.

Material requirements shall be as follows or better.

Body or Disc	: Ductile cast iron SG GGG – 50 DIN
Body seat and disc facing ring	: Austenitic Cr Ni Steel
Sealing ring	: Elastic (NRB)
Valve shaft	: Ferric chrome steel containing min. 13% Cr.
Shaft bearing bushes	: Maintenance free (Steel / Tin / PTEF)

Shaft Seal : NBR O – Ring  
Lever arm : Steel  
Counter Weight : Cast Iron

Hydraulic damping devices shall be double acting and shall include a flow control valve. Body components shall be injected cast iron to C6 25 iuB or better and piston rod of ferric chrome steel to 1.4122.05.

Only manufacturer with proven valve design having minimum experience of 10 years with this type of valve and ISO 9000 certification shall be accepted.

#### **4.35.4. Butterfly valves**

Butterfly valves shall be of the double flanged drop tight closure offset, rubber seat type generally in accordance with BS 5155 or BS 3952 and AWWA C504 – 80 Class 150.

Valve seats shall be gunmetal to BS 1400 secured to the valve body by corrosion resistant screws.

Bypass valves and air release plugs shall be fitted on all valves of 200 mm or larger.

Valves shall be designed for watertight and airtight shut off and shall be suitable for mounting in any position.

Valves shall be mounted with shafts horizontal unless otherwise specified or shown on the drawings. Manually operated valves over 350mm bore shall be provide with hand wheels and bevel gearing. All valves shall be fitted with indicators to show the position of the disc.

In general, the material of construction chosen shall be corrosion resistant to the source water referred to in the Specification. All bolts, nuts and other fixings which will be in contact with the flow or with the ground shall be of stainless steel.

Valves shall be suitable for frequent operation as well as for operation after long periods of idleness in any position.

Disc edges shall be machined with rounded corners and shall be polished to a smooth finish. The valve disc shall rotate through an angle of 90 degrees from the fully opened to the fully closed position, and the seat shall be designed so as to allow the disc to close at an angle normal to the axis of the pipe. Adjustable mechanical stops shall be provided to prevent over travel of the valve disc. The stops, shaft, and disc fixing shall be capable of absorbing full operating torque, with a minimum design safety factor of five.

The shaft shall be made of stainless steel. Shaft seals shall be nitrile rubber O ring type. Packing shall fastenings set flush in the water passage to minimize flow resistance.

Valve seats which extend over the face of the flanges to secure the seal in place will not be acceptable. Each valve shall be tested in accordance with the requirements of BS 5155, for body, seat and disc strength test. Seat tests shall be carried out in each direction and the valve shall be drop tight. Disc strength tests

shall also be carried out in each direction.

Valves of 600mm and above shall be metal faced. It shall be possible to adjust the seat clearance to obtain as near a watertight condition as possible, without the need to remove the valve body from the pipe work in which it is fitted. The valves shall have metal seating. Body mounted replaceable stainless steel face rings shall be fitted and disc rims shall be hard metal plated where they contact the face rings.

Unless otherwise provided for, valves shall be rated for 10 bar working pressure with the bodies capable of withstanding a test pressure of 15 bar and the seat 10 bar without leaking.

Bypass for valves 400mm diameter and over shall be provided with bypass as follows:

ND 400:	50mm dia. bypass
ND 600:	80mm dia. bypass
ND 800:	100mm dia. bypass

#### **4.35.5. Flow control valves**

Flow control valves shall be designed for the operating conditions specified and shall be of the type specified for the particular application.

The valves shall be capable of controlling the required parameter of flow or pressure within  $\pm 5\%$  of the set value. The rate of response of opening and closing of the main valves shall be controllable at the valve. Means for external indication of the position of the valve element shall be fitted. Any hydraulic control system shall include isolating valves to permit maintenance or replacement without interrupting the supply.

#### **4.35.6. Ball float valve**

Ball float valves shall be fitted if required to prevent overflow. Ball float valves shall close slowly over a long period of travel and shall be consistent with the design for surge protection. Ball float valves shall be fitted inside the tanks and shall be of the Glenfield series 1040 or similar approved.

#### **4.35.7. Pressure relief valves**

Safety valves shall comply with BS 6759: Part 1. They shall be designed to blow off at the specified pressure and re-close and prevent further release of fluid after normal pressure conditions of service have been restored.

Shell material shall be from the materials listed in Table PE – 1 BS 1560: Part 2. Trim material shall be stainless steel ASTM A 743 Grade CF8 or better.

Flanged ends shall be class 900, raised face type complying with ANSI B 16.25 or Table PE – 1 or BS 1560: Part 2. But welded ends shall be in accordance with section 8 of BS 1868.

All valves installed above ground shall be furnished as far as necessary, with a bonnet pressure relieving system to protect the valve against damage caused by thermal expansion of the medium. This system may be either completely internal



or external using a spring loaded relief valve.

#### **4.35.8. Automatic air relief valves**

Automatic air relief valves shall be designed to meet the following conditions

- a. Discharge air during charging of the pipework
- b. Admit air during emptying of the pipework
- c. Discharge air accumulated at local peaks along pipelines under normal operating conditions.

Conditions a. and b. shall be met by employment of a large orifice capable of discharging large volumes of air at a high flow rate, and condition c. by a small orifice capable of discharging small quantities of air as they accumulate.

Valves with air intake or exhaust facilities shall have approved screening arrangement to prevent the ingress of foreign matter.

#### **4.35.9. Diaphragm valves**

Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS 4504.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional "O" ring seal of nitrile rubber or other approved material.

Diaphragm shall be composed of moulded reinforced, flexible material attached by studs. Diaphragm materials shall, where required, be composed of corrosion resistant material.

#### **4.36. Electric overhead traveling crane**

Overhead traveling crane shall comprise of a bridge assembly with hoist having cross traverse and long travel movements. It shall be complete with all necessary gantry beams, rails and fixings to the building superstructure. Crane and beams shall be of such dimensions as to conform to those shown on the Conceptual Drawings in respect to span, travel and hoist etc.

Crane bridge assembly shall be designed, constructed and tested in accordance with BS 12573 and BS 466 as appropriate. Bridge girders shall be constructed from BS 4360 and BS 4 structural steel. Safety end travel stops shall be fitted to prevent over travel of the hoist carriage and bridge assembly. Hoist assembly shall be supported on at least four flanged runners rotating in ball bearings. Hook block fitted with safety catch and having fully guarded rope sheave shall be of forged steel to BS 2903 and carried on a heavy duty thrust bearing fixed to the main trunnion allowing 360 degrees rotation of the hook.

Load chain shall be grade 40, 60 or 80 alloy steel to BS 1663, BS 3113, or BS 3114 as appropriate and contained in a suitably sized chain bucket fitted to the hoist assembly. Chain shall be sherardized Grade 30 mild steel to BS 590.

Crane shall be capable of travel and traverse movements when fully loaded with the heaviest item of the Plant during erection and maintenance.

Safe working load shall be clearly labeled on the crane and beams in characters easily legible from the working floor. Labeling shall include the date tested and test load which shall exceed the safe working load by factors appropriate to the compliance standard.

The load bearing capacity of the slings and shackles shall be suitable for the crane. The maximum tension in the ropes shall not exceed  $1/8^{\text{th}}$  of the calculated capacity of the rope. The ropes shall be of the standard type and galvanized wires shall be used. The eyes of the ropes shall be at least 15 times the diameter of the rope. Sufficient slings, ropes, shackles, lifting beams, etc. shall be supplied to handle all items of the Plant covered by the crane. They shall be labeled or marked with the safe working load (SWL) and other lifting equipment supplied shall be tested by the manufacturer at his works. The tests shall be carried out at 125% of safe working load, and test certificates shall be submitted by the Contractor.

The end carriage shall be of the welded box girder design. Buffers shall be provided at the faces of the end carriage. The end carriage shall also be fitted with wheel breakage supports designed to prevent derailment as well.

The crane running wheels and the crab running wheels shall be of the double flange type and shall be equipped with antifriction bearings lubricated for life. Jacking pads shall be provided at the end carriages to facilitate wheel removal.

Load chain shall be of sufficient length to enable the hook to be lowered to the bottom of the pump chamber and shall be provided with a chain collecting box to hold the slack chain.

The operation of the crane shall be from ground floor level by bridge-mounted pendant pushbutton controls. Controls shall be mechanically and electrically interlocked to prevent inadvertent operation of opposing motions. Maximum pendant control voltage shall not exceed 115 Vac. The pendant shall be supported independently of the electric cable and shall be arranged for extending operation when necessary.

The crane shall be fitted with limit switches to prevent excess travel, over hoisting and over lowering of the crane hook. Electromechanically fail safe brakes shall be incorporated on all power-operated motions.

Down shop conductors shall be of the fully insulated shrouded bus bar type. The current collectors shall have renewable contact pieces. Festoon cables may be used for the cross travel. A crane isolator pad lockable in the off position and incorporating a warning lamp, illuminated when the supply is on, shall be provided at the bottom of the access ladder. A second isolator shall be provided at the control cubicle located on the crane platform.

All motors shall be of the quick reversing type with electric mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the loaded hook. Facilities shall be provided for the

accurate location of the hook by means of 'inching' the cross travel and down shop travel motions.

The Contractor shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail-safe protection in the event of an interruption in the power supplies. All access ladders and platforms necessary to carry out maintenance and repair shall be provided and installed by the Contractor.

All electrical equipment shall be fully tropicalized.

Site test shall be carried out by the Contractor who shall supply the necessary materials for the test load. The test load shall be removed from site by the contractor after successful tests have been carried out.

#### **4.37. Access steelwork**

Access steelwork shall mean all ladders, platforms, covers, steel flooring and handrails supplied and fixed under the Contract. It also means all small areas of floor plating or similar covering that are necessary to cover gaps between items of Plant and surrounding structure, and any access ladders, platforms and handrails that must be attached to items of Plant to facilitate operation, inspection or maintenance which forms part of the Contract. This includes access steelwork to all hand wheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance.

Floor plating shall be of 'Durbar' or other non-slip pattern not less than 4.5mm thick (exclusive of pattern) and hot dipped galvanized after fabrication in accordance with BS 729.

Aluminum alloy flooring may be offered as an alternative, manufactured in accordance with BS 1470 material H 30 TB.

Hand railing shall be double rail 1100 mm high. On stairways, it shall not be less than 900mm high above the stairs, measured vertically from the nose of the tread.

Standards shall be double 38mm diameter solid forged steel to BS 4360 Grade 43A with 60mm diameter solid forged steel balls at handrail locating points drilled to give 1.5mm clearance to handrails. Each ball shall incorporate a concealed grub-screw with Allen type head to secure the rail. Standards shall have a minimum base width of 65mm; drilled for M 16 fixing bolts and set at maximum 1800mm center.

Handrails shall be 33.7mm OD x 3.2mm thick tabular steel to BS 1775 Grade 13. Joints shall be arranged to coincide with the spacing of standards where possible; otherwise they shall have butt joints with tabular steel ferrule, plug welded or fixed with a 5mm diameter countersunk head pin.

Removable sections of hand railing shall have half-lap joints secured with a countersunk head pin.

Chains across openings shall be 10mm x 3mm links per 100mm galvanized mild steel. The hooks and retaining eyes shall be securely fixed to the balls of the standards.

All components for hand railing shall be hot dip galvanized after manufactured in accordance with BS 729.

#### **4.38. Pressure Gauges**

Pressure gauges shall be of the Bourdon tube type with stainless steel wetted parts conforming to BS 1780. They shall have non-corrodible metal cases with stainless steel bezels and shall be not less than 100mm in diameter. Gauges shall be scaled in meters head of water, with zero representing atmospheric pressure unless otherwise specified. Lettering shall be black on white ground except for negative pressure on compound gauges which shall use red lettering. The range of the gauges shall be 30 – 50% higher than the maximum working pressure.

Diaphragms shall be fitted to all gauges subject to dirty or corrosive fluids. Snubbers shall be fitted to all gauges subject to pulsating pressure, alternatively glycerin filled gauges shall be supplied. The gauge shall be mounted to minimize damage from vibration. Each pressure gauge shall be fitted with an isolating valve at the point of connection to the main system and, where mounted remotely, the gauge shall also be fitted with a local isolating valve.

#### **4.39. Sump Model Test**

The object of the sump model test is to achieve good flow distribution and freedom from swirl vortices and air entrainment within the pumping system intake and all pipework under all pumping regimes upto full duty output plus a 20% safety margin.

The model shall include the pump sump and extend upstream a sufficient distance to accurately demonstrate hydraulic conditions at the pump bell mouths.

The model shall not be smaller than one tenth full scale. Surface finishes shall accord as closely as is practically possible with the theoretical requirements for representative boundary layer conditions.

The theory of scaling for the hydraulic model shall be based on the concept of dynamic similarity i.e. the motion of the fluid particles in the model will be reduced in magnitude but will be similar in motion to the equivalent particles in the full size structure.

The model shall be a direct scaling of proposed structure and operated so that the fluid motion is dynamically similar, in order that parameters such as water level velocity and flow direction shall be directly scaled up to predict actual values in the full size structure.

The velocity ratio between model and full size structure shall maintain Froude numbers for both. Where tests are being carried out to determine vortex formation, a 1.5 times Froude flow may be used making the model Reynolds number closer to that of the full size structure where turbulence and boundary layer development are more closely reproduced.

Modifications to achieve ideal hydraulic conditions shall, where practically possible, require no modification to the basic civil structural design and be limited to infill, benching or baffling of the existing designs.

The main frame of the model shall be constructed from exterior grade plywood and/or galvanized sheet steel for inspection purposes. Clear Perspex sheet shall be used to give a clear view of all areas of the model. Benching, infill and baffles shall be constructed in hard wood timber and for smaller areas putty or similar may be used. All materials shall be adequately protected till successful commissioning of the Pump House.

The pump suction bell mouth shall be modeled as closely as practically possible to the expected pump shape as indicated on the Drawings and shall include rotation meters. These in turn shall be connected to individual flow meters and flow control valves to allow any combination of the pump flow rate with differing inlet and outlet levels. Water inflow into the model shall be similarly controlled.

Before construction of the model, scope for modifications at site, fixed boundaries, etc. shall be discussed with the Employer and the model constructed accordingly.

The facility for flow visualization and photography shall be included at critical sections.

A photographic and dimensioned sketch record along with three (03) copies of video shall be made showing model construction and modifications and the hydraulic conditions at strategic flow rates and levels.

The model shall be instrumented to enable flow control from sluice gates and from pumps and dye or other tracers used to establish flow patterns.

The Contractor shall provide the opportunity for the Employer to witness a model test at the initial problem establishment stage. The Contractor shall give at least three weeks' notice of availability of the model for witnessing the test.

The Contractor shall conduct fully comprehensive tests on the model and make modifications where necessary prior to witness test by the Employer. These tests shall be fully documented and made available during the witness test together with drawings of any modification made.

Witness test will be limited to operating the model in the mode where hydraulic problem occur and demonstrating the effectiveness of correction modifications, of which there should preferably be more than one option.

During the later stages of construction and prior to witness test the model shall be offered for inspection by the Employer to discuss possible problem areas and corrective modification areas shall be discussed.

After satisfactory completion of the witness test the Contractor shall forward to the Employer a preliminary report in five copies showing full details of the approved modifications and a description of these modifications, together with fully dimensioned drawings in sufficient detail to allow detailed design to commence.

The preliminary report shall be submitted no later than 12 weeks after the Commencement Date.

Within two weeks of the approval of the preliminary report by the Employer, the Contractor shall submit 10 copies of the final report of the model test to the Employer after incorporating his comments. The final report shall comprise of a description of the hydraulic system, a statement of all criteria and basis for calculations, fully documented test results and calculations, description of tests carried out and modifications made, fully dimensioned sketches and drawings along with full photographic records showings model construction and hydraulic conditions.

#### **4.40. Manual Coarse Screen**

The manual coarse screen shall be of welded construction attached to build in steel support beams of mild steel to BS 4360 grade 43A spanning the width of the channel.

12 x 50 mm MS flat bar with spacing in between bar as specified shall be mounted into a sturdy frame. It should be possible to lift the whole screen assembly from its position without stopping the Plant operation. The screen shall be manually cleaned from an intermediate platform built in RCC by the civil contractor above the full supply level in the channel. An access ladder of mild steel of sturdy design to reach the intermediate platform from the ground level shall also be provided.

The screen assembly shall be inclined at 75° or as appropriate for the Contractor's design. The contractor shall provide two sets of suitable hand rakes with the screen.

A mechanical lifting arrangement for debris removal from the intermediate platform upto the ground level shall also be provided.

#### **4.41. Chain hauled raking bar screens**

The raking screen shall comprise of a bar screen and a separate raking mechanism.

The bar screen shall be of all welded construction attached to built in steel support beams of mild steel to BS 4360 Grade 43A spanning the width of the channel.

A concrete apron wall constructed by the civil contractor above the bar screen and extending up to deck level, will retain the screenings on the rake assemblies as they are elevated to the discharge point.

The raking mechanism shall consist of two side frames of mild steel to BS 4360 Grade 43A, connected by steel cross members above deck and anchored to the channel walls below deck and shall be retained in recesses cast in the concrete channel walls.

The side frames shall incorporate replaceable mild steel roller tracks which guide the main chain and maintain the rake assemblies in close relationship to the screening bar.

The screen head shall incorporate a horizontal mild steel head shaft to BS 970

Grade 080 M42 or similar fitted with two cast iron sprockets to BS 1452 Grade 260 from which the main chains are suspended. The head shaft shall be supported at each end by self-alignment roller bearings, sealed in grease packed waterproof housing which are retained in parallel slides to facilitate vertical adjustment by means of tension screws, to compensate for main chain wear. The main chain shall pass round the semicircular tracks at the lower end of the screen and comprise links to BS 4360 Grade 43A zinc plated pins and bushes to BS 970 Grade 080 M42 case hardened and water lubricated rollers of kemetal or similar.

The rake assembly shall be of mild steel to BS 4360 Grade 43A and shall be fitted with removable sections of the rake tines which penetrate between the screen bars.

A fabricated mild steel apron plate shall retain the screenings on the rake assemblies above the apron wall.

A scraper device shall remove the screenings from the rake assemblies and deposit them onto the discharge chute. The return of the scraper shall be controlled by dampers located at each side.

A manually reset torque limiter shall be provided between the motor and gear unit incorporating a limit switch to cut off the supply to the motor in the event of overload.

All bolts and screwed fittings shall be galvanized.

All parts not otherwise protected or manufactured from corrosion resistant materials including bolts and fixings shall be prepared and coated in accordance with BS 5493. At least one coat of each primer and two coats of coal tar epoxy shall be applied with minimum dry film thickness of 20 microns.

#### **4.42. Central flow band screens**

The screen shall consist of an endless bank of mesh panels contained within a vertical self-supporting frame. The water being screened shall pass in from the outside of the screen and out through an opening in the back wall of the screen chamber. As the band of mesh panels rotate the debris collected on the outside of the mesh it shall be lifted above deck level, where it shall be washed off into a debris trough or gulley.

The screen frame shall be weld fabricated in sections from mild steel plate and rolled steel to BS 1449 Grade HR 14 and BS 4360 Grade 43A respectively. The frame section shall be fitted with replaceable roller tracks, locating strips to guide the screening band and replacement sealing plates maintaining a close seal with the sealing fins on the main chain links. The sealing plates on the frame side adjacent to back wall of the screen chamber shall be extended to form a seal with the sealing angles attached to the wall. Roller tracks, locating strips and sealing angles shall be of mild steel to BS 1449 Grade HR 14. The bottom frame section shall be provided with a semi-circular track to guide the screening-band.

The head frame section shall incorporate a horizontal head shaft of mild steel to BS 970 Grade 080 M42 fitted with two cast iron sprockets to BS 2452 Grade 260,

over which the main chains shall pass. The head shaft shall be supported at each end by self-aligning roller bearings which will be retained in parallel slides supported by chain tension screws carried in the head frame.

The main chains shall comprise of links, incorporating a sealing fin on the inner link, connected by pins and bushes, and fitted with rollers which run on the roller tracks on the frame. The chain shall be water lubricated. The main chain links shall be of mild steel to BS 4360 Grade 43A sherardized finish, the pins and bushes shall be of stainless steel to BS 970 Grade 431 S29 and rollers kemetal or similar.

To prevent bypassing of the mesh a flexible neoprene seal shall be attached to the main chain link and arranged to run in contact with a low friction plastic sealing face fixed to the screen frame.

The mesh panels shall be bolted to the fabricated mesh supports which shall be bolted at each side to the inner link of the two main chains. A rubbish elevator shall be attached to the trailing edge of each mesh support and a sealing strip shall be incorporated between adjacent supports. Mesh panels shall be of stainless steels Grade 316 S16, mesh-support of mild steel to BS 4360 Grade 43A/BS 1449 Grade HR 14.

The mesh panels shall be washed as they pass the discharge above the debris gulley by washing jets positioned on a jet pipe inside the screen. The jet nozzles shall be attached to the jet pipe by a quick release connection for ease of cleaning. The jet pipe and nozzles shall be made of stainless steel to BS 970 Grade 316 and shall be fitted with a removable end cap for flushing purposes, a diaphragm valve for flow control and a pressure gauge. The complete unit shall be designed to withdraw through the side of the screen head frame to facilitate maintenance of the jets.

Debris and wash water shall be discharged into a stainless steel trough below deck level which will connect to the main discharge gulley.

The head frame section projecting above deck level shall be fitted with removable access panels and a stainless steel splashguard incorporating observation ports adjacent to the debris discharge point.

The screen shall be driven by a shaft mounted worm and wheel gear unit keyed directly to the head shaft, fitted with a flange mounted dual speed electric motor. A torque limiter shall be provided, incorporating a device to stop the motor in the event of an overload. All bolts and screwed fittings shall be stainless steel.

All parts not otherwise protected or manufactured from corrosion resistant materials including bolts and fixings shall be prepared and coated in accordance with BS 5493; at least one coat of each primer and two coats of coal tar epoxy shall be applied with minimum dry film thickness of 20 microns.