Maharashtra Industrial Township Limited (MITL)

Design, Construction, Testing, Commissioning, Operation and Maintenance of Infrastructure Works at Dighi Port Industrial Area (DPIA) Phase1 on EPC Basis

Request for Proposal cum Request for Qualification

Volume II: Technical Specifications

Part F – Standard Mechanical Specifications

July 2025

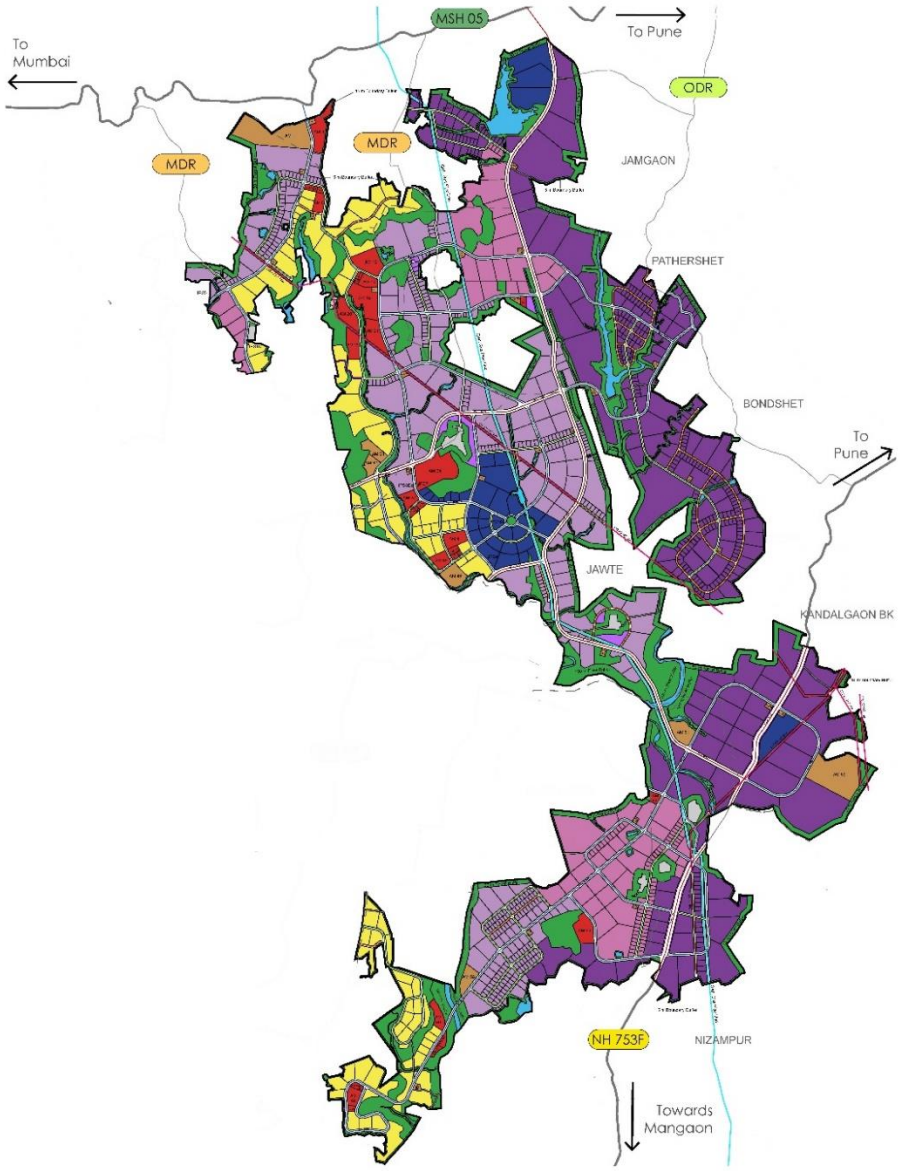

Table of Contents

1 Standard Mechanical Specifications 1
1.1 Scope 1
1.2 Standards 1
1.3 General Technical Specification Mechanical 1
1.4 Codes and Standards 2
1.5 General Design Criteria 10
1.6 Lubrication, Bearing, Seals and Gearbox 11
1.7 Fixing of Machinery 12
1.8 Alignment, Lifting, Dismantling, Noise & Vibration 14
1.9 Machine Guards 16
1.10 Name Plates and Labels 16
1.11 Surface Preparation and Painting 17
1.12 Field Installation Quality Control 20
1.13 Pump Design and Layout: 20
1.14 Mechanical Coarse Screens 32
1.15 Conveyor 57
1.16 Valves: General 76
1.17 Sluice Gates. 87
1.18 Open Channel Gates 90
1.19 Material Handling Equipment 92
1.20 Cast Iron Pipe & Specials 98
1.21 Polypropylene pipes 100
1.22 Polyethylene Pipe 100
1.23 HDPE Pipes 100
1.24 Ductile iron pipes and fittings 101
1.25 Mild Steel Pipe 101
1.26 Pipe laying. 107
1.27 Grit Classifiers 122
1.28 Primary & Secondary Clarifiers 130
1.29 Decanter Assembly 140
1.30 Cloth Media Disk Filter 142
1.31 U V System 144
1.32 Diffused Air Aeration System 144
1.33 Chlorination 162
1.34 Sludge Handling 165

1.35 Mechanical Mixers 183
1.36 Fans: General 187
1.37 Walkways, stairways and platforms 190
1.38 Structure. 190
1.39 Outdoor Stairways Shall Have Open Mesh Treads. 190
1.40 Ladder and Stairs 190
1.41 Railing 191
1.42 Access Steelwork 191
1.43 Odour Control System 192
1.44 Air Compressor 219
1.45 BIOGAS generating sets & accessories 229
1.46 Surface aerator 232

1 Standard Mechanical Specifications

1.1 Scope

This specification covers the general requirements for mechanical equipment's and installations at Project Site/ Works/Plants. Reference to any specific item does not necessarily imply that such plant is to be included in the Works. All Plant used for the Works shall, unless otherwise specified, comply with the provisions of this chapter.

Requirements that are particular to the installation are given in the Employer Requirement – Volume two (2). If the mechanical Specification requirements conflict with these general requirements, then the Employer Requirement — Volume two (2) shall take precedence.

i. This part of the Employer's Requirements defines the mechanical design requirements for supply, installation, testing and commissioning of equipment's/ items for the project.

ii. Prototype or unproven equipment's/items not having a well-established operation record shall not be provided. Only standard designs that are in regular and current production and manufactured for the service and site conditions specified, shall be offered. Equipment/items shall meet or exceed the design process requirements at site conditions listed in the specifications/drawings. It is accepted that the equipment offered as references may have been built to a previous edition of the design codes/standards.

iii. Equipment shall be commercially available, preferably in India, and with a proven track record of similar application(s).

iv. All materials of construction shall be suitable for the potentially severe environment conditions of the site and for operation in contact with the corrosive and abrasive nature of the intended service. If Effluent characteristics requires better MOC, same shall be updated. We recommend providing SS 316 MOC for wetted parts like valve trims, submerged ladder equipment etc.

v. All the contractor's vendors, sub-vendors, sub-suppliers shall work within a formal documented Quality Management System (QMS) that is at lease equivalent to the requirements of ISO 9001: 2008 /2015 quality management system requirements.

1.2 Standards

In cases where there is an Indian Standard, British Standard, NFPA, ASHRAE, International Standard or Code of Practice which is appropriate to any item of Plant supplied, any component incorporated in the Plant, the testing of the Plant or the installation of the Plant, then that Indian Standard, British Standard or NFPA or ASHRAE or Code of Practice or International Standard shall apply.

1.3 General Technical Specification Mechanical

a) This specification covers the general requirements for mechanical equipment and appurtenant or procurement and installation at the Project Site/ Works/Plants. Reference to any specific item does not necessarily imply that such plant is to be included in the Works. All Plants used for the Works shall, unless otherwise specified,

comply with the provisions of this chapter.

b) Requirements that are particular to the installation are given in the Employer Requirement. If the mechanical Specification requirements conflict with these general requirements, then the Employer Requirement shall take precedence.

c) This part of the Employer's Requirements defines the mechanical design requirements for supply, installation, testing and commissioning of equipment/items for the project.

d) Prototype or unproven equipment/items not having a well-established operation record shall not be provided. Only standard designs that are in regular and current production and manufactured for the service and specified site conditions shall be offered. Equipment/items shall meet or exceed the design process requirements at site conditions listed in the specifications/drawings. It is accepted that the equipment offered as references may have been built to a previous edition of the design codes/standards.

e) Equipment shall be commercially available, preferably in India, with a proven track record of similar applications.

f) The construction material of the equipment and accessories shall be suitable for the potentially severe environmental conditions of the site and operation in contact with the corrosive and abrasive nature of the intended service.

g) In case of any conflict in the specifications, the employer's decisions on the matter shall be final and binding. However, the following general order of precedence shall govern the technical scope of work:

- Local Laws and Regulations;
- Tender specifications and drawings;
- Applicable Codes and Standards;

h) All the contractor's vendors, sub-vendors, and sub-suppliers shall work within a formal documented Quality Management System (QMS) that is at least equivalent to the requirements of ISO 9001: 2008 /2015 quality management system requirements.

1.4 Codes and Standards

a) The design, manufacturing, fabrication, inspection, testing and installation of all the equipment/items supplied for the project shall conform to their corresponding National Codes & Standards (Bureau of Indian Standards) unless otherwise specified.

b) All equipment supplied and installed shall also comply with the statutory regulations (CPCB, SPCB, PESO, etc.) applicable for the location of the facility

c) International standards shall be applicable in the non-availability of national standards for any equipment/item.

d) Manufacturer's standards for equipment shall not be used unless approved by the employer.

e) In the event of a conflict between this specification and any national standard/international standards/codes/regulations, the more rigid requirement shall

govern the requirement.

f) Contractor shall use the latest edition of standards/codes/regulations at the time of their proposal submittal.

g) In cases where there is an Indian Standard, British Standard, NFPA, ASHRAE, International Standard or Code of Practice, which is appropriate to any item of Plant supplied, any component incorporated in the Plant, the testing of the Plant or the installation of the Plant, then that Indian Standard, British Standard or NFPA or ASHRAE or Code of Practice or International Standard shall apply.

Design features	ISO 10816:1995,
Steel Castings	BS. 3100
Grey Iron Castings	IS:210
Spheroidal Graphite Iron Castings	IS:1865 - 1991
Bronze	IS : 318
Aluminium and Aluminium Alloys	BS 1474-1987
Aluminium and Aluminium alloy Castings	IS:617-1994
Chromium Plating	IS:1986-1981
Fasteners	BS 6104, IS: 1363 to 1367, BS
	4320, BS – 970, BS: 1109
Forgings	IS:2004-1991
Bearings and Lubricators	BS:5512
Gearboxes	IS: 210, BS: 970
Handrailing	IS 4912 1978,
Safety chain	BS: 4942, BS: 729,
	BS: 4942 Part 2
Open Mesh and Chequered Plate Flooring	BS: 4592
Stairways	BS: 449 Part 2, BS: 4211
Locks	IS 15275:2003
General Standards	IS 816:1969, IS 15769:2008
	IS 10234:1982 or IS11790:1986
	IS 816, IS 822, IS 1024, IS 819
	IS 1261, IS 1323, IS 7307, IS 7310
Welding Consumables	IS 814:2004 or IS 1395:1982
	IS 1278:1972, IS 7280:1974
	IS 6419:1971, IS 6560:1996
Welding Procedure	IS 2825:1969
Electrically Welded Steel Pipes	IS 5389 -2000
Code of practice for laying of welded steel pipes for Water Supply	IS 5822
Welded Joints for Steel Pipelines	IS 816:1969, BS 2633
	IS 1182:1983 or BS EN 1435
Inspection and Testing	IS 3600:1985 Part 1 to 2,
	IS 3600:2009 Part 3,
	IS 3600: 1984 Part 4,
	IS 3600:1983 Part 5 to 6,
	IS 3600:1985 Part 7 to 9,
	IS 3613:1974,

	IS 7307:1974 Part 1,
	IS 2595:2008,
	IS 4260:1986, BS EN 1321:1997, BS EN 895:1995,
	BS EN 10208:2009 Part 1 to 2, BS EN ISO 15614- 1:2004+A1:2008,
	BS 4871:1985 Part 2,
	BS 4872:1985 Part 1
	IS 4853:1982
	IS 1182:1983
	IS 2595:2008
Consideration for Electroplating/Galvanizing	BS EN ISO 1456:2009, BS EN ISO 12540:2000, BS EN ISO 12944-5:2007
	IS 2629: 1985, IS 3655:1985
	IS 3656:1968, BS EN ISO
	6158:2011, IS 13238:1991
Painting and Protection	BS EN ISO 12944-5:2007
	IS 1477-1971, BS 3416:1991
	BS EN 10300:2005 BS EN ISO 2063:2005 IS 2629:1985
	BS EN ISO 6158:2004 or BS EN ISO 1456:2009
	IS 3655:1985, IS 2379:1990
PIPEWORK, COUPLINGS, VALVES, SLUICE GATE	IS 3950- 1979/2007
	IS 4111:1968, IS 2065:1983
	IS 7634, BS-4622:1970 BS-2035:1966
Buried Metal Piping Protection	IS 8329:2000
Carbon Steel Pipe and Fittings	IS 3589:2001 and 1239,
	ANSI B16.39, AWWA C200
Ductile Iron Pipe and Fittings	IS 8329: 2000, IS 5382:1985,
	IS: 12820-2004, IS 8329-2000
	IS: 9523-2000 or BS: EN 545
	IS: 12820-2004, IS: 5382 -
	1985, IS 9523-2000, IS 12288
Galvanized Pipe and Fittings	ANSI B 36.19, ANSI B 16.9
	ANSI B 16.5, ANSI B 18.2.1 ANSI B 18.2.2, IS:1239 IS:4736, IS:1879, ANSI B 18.2.1
Stainless Steel Pipe and Fittings	ANSI B 36.19, ANSI B 16.9
	ANSI B 16.5, ANSI B 18.2.1
	ANSI B 18.2.2, ANSI B 16.21,
	ANSI B 16.11
PVC Pipe and Fittings	IS 4985:2000, IS 4985:2000
	ASTM D2467, ASTM D2464
	ANSI B16.5
	BS EN 12201:2011
	IS 4984:1995, AWWA C901, AWWA C906, BS EN 1555:2002, IS 14885:2001
	ISO 4437:2007, IS
HDPE Pipes and Fittings	IS 4984-1995, IS 8630-2003, IS 14333,

	IS 12709:1994,
	AWWA C110 or AWWA C153
	IS 7634 – Part II
Copper Tubes and Fittings	ANSI B16.18 and B16.22, BS EN 12449:1999, BS EN 1254:1998, ASTM B88, IS
	2501:1995 or BS EN
	12449:1999
Cast Iron Drainage/Vent Pipe and Fittings	IS 1536:2001, IS 3114:1994,
	IS 1538 (Part I to XXII) - 1993, ANSI/AWWA C110/A21.10, ANSI B16.12
Joints and Couplings	AWWA C111A21.11
	AWWA C-219, IS: 8329 - IS: 1536, AWWAC110/A21.10 ANSI B16.1, MSS SP42, AWWA C606, ANSI B16.5, ANSI B16.21, BS 7874, BS EN 681-1 & 2, IS 12820:2004, IS
	11149:1984, BS 494, IS
	5382:1985, AWWA
	C111/A21.11, IS 2062:2011, BS EN 10311:2005, BS EN 10224, AWWA C-213,
	ANSI B16.39, BS EN 1092-
	1:2007, IS 6392:1971
Pipe Hangers and Supports	IS 8324:1988, IS 9323:1991, MSS SP58/SP-69/SP-89
	ANSI B31.1
General	ISO 7005, IS 6392 ,
	BS EN 1092-2/ BS 4504
Gate Valves	IS 14846:2000 or BS EN 1171:2002, IS 554:1999 &
	IS 8999:2003, BS EN 1982:2008,
	IS 1865, BS:970
Sluice Valves	IS 1486 - 2000
	IS 2906 - 1990
	IS 2685 -1971
Non-return Valves (Swing Check Pattern)	IS 1865, BS:970, IS: 318,
	IS 5312, BS EN 1092-2
	IS 210
Ball valves	IS 9890- 1981/2003
	BS EN 1983:2006,
	BS EN ISO 16135:2006, BS ISO 7121:2006
Air Valves	BS EN 1092-2, ANSI/ASME B
	1.20.1, IS 210
Pressure Relief Valves	BS 6759:1984 part 3,
	BS EN ISO 4126-1:2004 BS 1560: Part 2
Pressure Reducing Valve (PRV)	IS 9739 - 1981
Diaphragm Valves	BS EN 13397:2002
Corporation Cocks	BS 2580:1979

Plug Valves	BS 5158:1989, IS 10459:1983
Foot Valves and Strainers	IS 4038:1986
Butterfly Valve	IS:13095 – 1991, BS: 5155 IS 1865, BS 970,
	IS 2062,
Operator Headstocks/Pedestals	IS 3042:1965, IS 13349:1992,
	IS 9737:1981
Pneumatic or Hydraulic Actuators	BS EN 15714:2009 part 3 & 4,
	BS EN ISO 5211:2001,
Electric Actuators	IS 9334- 1986/2001
Sluice gates	AWWA C 560-00 /IS: 13349-
	1992, IS 210, IS 11625- 1986/2005
Pressure and Vacuum Gauges	IS 3624:1987, BS EN 837-1.4291666667
Pump Performance Guarantees	BS EN ISO 5198:1999,
	BS EN ISO 9906:2000 (ISO 3555:1997), IS 9137- 1978/2002
Submersible Pumps	IS 8304- 2002, IS: 210, BS 6500, IS 15310- 2003
End Suction Pumps	BS 5257, BS EN 1092-2/BS
	4504/ IS 1538, IS 13538- 1993/2000
Horizontal split case Pumps	IS:1520-1980, IS:325-1996, IS 13538- 1993/2000
Induction Motor	IS: 325/IS:9283, IS:9968
	IS: 9283-1979, IS: 3043:1966,
	IS: 4800
Agitators	IS 1030, IS 2004
Mechanically raked coarse bar screen	BS 2573, IS:3177
Chlorination system	IS:3177
COMPRESSORS and Exhausters	IS 5456-2006, IS 1092-1984, IS 9242- 1986
Air blowers	BS EN 1092-1, IS : 210
	ISO 1940
Air Receivers	BS EN 286-1 or IS 2825
Cranes and Lifting Equipment	IS/ISO 9373- 1989, IS 13834,
	IS 807- 2006, IS 3177- 1999/2006, IS 14473- Part 1- 1997, IS 14470- 1997
Electrically operated travel (EOT) crane	BS 2573, IS:3177, IS:2062, BS:4360, IS:807, BS:2573, IS: 2266, BS:466,
	BS:436, IS:4460, BS:72, IS 3177- 1999/2006
Electric operated hoist	IS: 3938, IS: 325, IS: 3938, IS 807- 2006, IS 3177- 1999/2006
Lifting Accessories	BS EN 818-1, BS 4942
Open Grid Flooring	IS 15836:2008, IS 2062:2006
Walkway Platforms, Access Steps, Ladders and Hand Railings	IS2629:1985,
Safety Showers and Eyewash	IS 10592:1982,
	DIN 12899:2009 Part 3,
	ANSI Z 358.1:2004,

	DIN 12899:2009-part 3
Fire Protection Water System	IS:5, IS: 5290, IS: 4927, IS:
	636, IS: 8423, IS: 903, 1984
	IS: 2871
Centrifugal Pumps (Permeate/Back pulse Pumps for Ultra Filtration	IS 13537- 1993/2002, BS: 970, IS: 318, IS 13538- 1993/2000,
Code of acceptance test for centrifugal, mixed flow and radial flow pumps- Class C	IS 9137-1978/2002
Technical specifications for centrifugal pumps – Class 2	IS 13537- 1993/2002
(Industrial applications) Code of practice for Selection, installation, operation, and maintenance of pumps	IS 10956- Part I to IV
Centrifugal, mixed flow, axial flow pumps Code performance of tests precision class	IS 13538- 1993/2000
Installation methods of positive displacement Hydraulic pumps and motors guidelines	IS 14602- 1999/2004
Method of presenting performance data for hydraulic pumps.	IS 14601- 1998/2003
Submersible pump set specifications	IS 8304- 2002
Hydraulic design of pump sumps and intakes guidelines	IS 15310- 2003
Part- I- Code of practice for ancillary structures in sewage systems- Manholes (1986) Part-II - Finishing Tanks (1985) Part-III- Inverted syphons (1985) Part-IV- Pumping stations & pumping mains (1968) Part-V- Tidal outfalls (1993)	IS 4111- 2007
Hyd. Fluid power- Positive displacement pumps, motors, and integral transmissions & determination of steady state performance.	IS 10069- 1992/2002
Technical supply condition of positive supply displacement pumps- reciprocating	IS 11745- 1986/2007
Method of sampling pumps	IS 10572- 1983/2005
Specifications for single faced sluice gates	IS 3042- 2003
Criteria for hydraulic design of sluices in concrete and masonry dams	IS 11485- 1985/2000
Code practice for selection, installation, and maintenance of sluice valves	IS 2685 – 1971/2003
Sluice valves (50 to 120mm)	IS 14846-2000
Specification for surface box for sluice valves	IS 3950- 1979/2007
Code of practice of surface quality of steel castings for valves, fittings, and other piping components (visual inspection)	IS 8092-1992/2000
Criteria for structural design of penstocks part 1 to 3	IS 11639- 1986
Resilient seated cast-iron air relief valves for wastewater work purposes	IS 14845- 2000
Swing check type Reflux (non- return) valves for	IS 5312-

wastewater works purposes- part-1 single door pattern -2004; part-2 multi door pattern-2007	
Specifications for general purpose for ball valves	IS 9890- 1981/2003
Specifications for diaphragm type valves for general purposes	IS 11791- 1986
Criteria for design and anchor blocks for penstocks with expansion joints	IS 5330- 1984/2005
Criteria for hydraulic design of penstock	IS 11625- 1986/2005
Criteria for structural design of penstocks Part-1- 1986- Surface penstocks (2005) Part-2- 1995 Buried/ Embedded penstocks in rock (2005) Part-3- 1996 – Specials for penstock (2005)	IS 11639
Electric Motor operated Actuators	IS 9334- 1986/2001
Electric solenoid operated actuators	IS 8935- 1985
Natural rubber compounds. See-part-for molded products. See-part-for extruded products.	IS 5192
Specs for rubber gaskets.	IS 11149-1984/2004
Rubber hoses.	IS 3549
Guideline for design and use for different types of Rubber seals for hydraulic gates.	IS 11855-2004
Specs for rubber sealing ring for gas mains, water Mains and sewers.	IS 5382-1982/2003
Specs for cold polymerized raw styrene-butadiene Rubber.	IS 5189-1985/2005
Part 1-2000-Plain bearings fits Part 2-Tolerances on form and position and surface Roughness for shafts, flanges and thrust collars.	IS 14803
Dimension requirements of rubber gaskets for mechanical joints and push-on joints for use with cast iron pipes and fitting for carrying water, gas and sewage.	IS 12820-2004
Technical supply conditions for threaded steel fasteners Part 1 to 20.	IS 1367-2002
Rolling bearings -Taper rolling bearing tapered rollers metric series specs.	IS 14691
Requirement for sludge dewatering equipment part 1to3	IS 10037-1981/2005
Method of ultrasonic testing of steel plates for pressure vessels and special applications.	IS 11630-2005
Recommendation for production rectification and repairs of steel casting by metal arc welding process.	IS 5530-1987/1998
Steel cylinder for compressed gases-code of	IS 8198-2004

practice.	
Code of practice for corrosion protection of light gauge steel sections used in buildings.	IS 4180
Specs for phosphate treatment of iron and steel for protection against corrosion.	IS 3618-1966/2002
Recommended practice for design and fabrication of iron and steel product prior to galvanized and metal spraying.	IS 6159-1998/2006
Steel checkered plates-specs	IS 3502-1998
Specs for heavy washers for steel structure	IS 6610-2001
Specs for hexagonal bolts for steel structure	IS 6639-2005
Tolerances for fabrication of steel structure	IS 7215-1974/2005
Pictorial surface preparation standard for painting of steel structures	IS 9954
Classification of environment condition-part 1 to 3 (14nos.)	IS 13736
Lifting appliances-rang of max. Capacity for basic model.	IS 6511
Testing of positive displacement type air compressors and exhausters-code of practice.	IS 5456-2006
Technical supply condition for sliding vane rotary air compressor	IS 11119-1984/2007
Technical supply conditions for reciprocating air compressor above 60kW.	IS 1092-1984
Rated pressure of air compressor	IS 9242-1986
Part-1 Compressed air for general use contaminants & quality classes-(2004) Part-2 Test methods for aerosol oil contents (2004)	IS 14642
Specs for air receivers for compressed air installation.	IS 7938-1976
Cast iron and malleable cast iron flanges for general engineering purposes.	IS 6418
Steel pipe flanges.	IS 6392
Flat gaskets for shell flanges.	IS 4870
Chlorinated polyvinyl chloride compound used for pipes and fitting specifications.	IS 15225- 2002
Specifications for UPVC pipes for soil & waste discharge systems inside the building including ventilation and rainwater system.	IS 13592- 1992
Un plasticized non-pressure polyvinyl chloride (PVC) pipes for use in underground drainage and sewage systems- specifications	IS 15328- 2003
UPVC injection moulded fittings for soil and waste discharge system, inside and outside buildings including ventilation and rainwater system.	IS 14735- 1999/2007
Cranes and related equipment — Accuracy requirements for measuring parameters during testing.	IS/ISO 9373- 1989

Part-1-1994 Cranes- Classification –General	IS 13834
Part-5- 2003 Overhead traveling and portal bridges cranes	
Design, Erection, testing (structural portion) of cranes and hoists- code of practice.	IS 807- 2006
Cranes- Condition monitoring Part-1- General	IS 14475- 1997
Part-1- Cranes- controls- layout & characteristics – general principles. Part-5- Overhead Traveling cranes & portal bridge works.	IS 13558- Part 1 to 5
Code of practice for heavy duty electric overhead Traveling cranes and gantry cranes other than steel work cranes	IS 3177- 1999/2006
Cranes – Inspection – General	IS 14473- Part 1- 1997
Part-1 Cranes – Design principle for loads & load combinations. Part-5 Overhead traveling and portal bridge crane	IS/ISO 8686
Code practice for heavy duty electric overhead traveling cranes including special service machines for use in steel works.	IS 4137- 1985/2006
Cranes- Test code and procedures.	IS 14470- 1997
Cranes and lifting appliances- Technical characteristics and acceptance documents.	IS 14471

1.5 General Design Criteria

1.5.1 Design Features

As far as practicable, all designs shall be as per the latest concepts and practices. The equipment shall be new and of robust design for a long reliable operating life. These shall be compatible for 24 24-hour per day continuous operation for prolonged periods in the climatic and working conditions prevailing at the site and with minimum maintenance. Particular attention shall be given to extra temperature and the rating of electrical and mechanical equipment, and cooling systems and the choice of lubricants shall be for the temperatures as specified.

Paints used shall be manufacturer standard but suitable duly as described. The equipment shall be designed to provide easy access to and replace components/parts, which are subject to wear, without needing to replace whole units. All Parts in contact with water shall have a life from new to replacement or repair of not less than five years.

Design features shall include protecting equipment against damage caused by vermin, dirt, dust, and dampness and reducing the risk of fire hazards. Equipment shall operate without undue vibration and noise reduction measures shall be adopted such that levels of 80 dB (A) at 1 Meter are not exceeded. 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 detrimental effect upon the performance or life of the plant.

All rotating elements shall be dynamically and statically balanced.

All equipment shall have name plates specifying the makes, models, ratings, and other pertinent information.

1.5.2 Material

All materials incorporated in the Work shall be the most suitable for the service conditions and duty concerned and shall be new and of reputed make/approved quality, free from imperfections and selected for long life and minimum maintenance. The Non-destructive tests if called for in the specifications, shall be carried out.

All submerged moving parts of the plants or shafts and spindles or faces etc. in contact with them shall be of corrosion-resistant materials.

All parts in direct contact with various chemicals shall be completely resistant to corrosion or abrasion from these chemicals and shall maintain their properties without ageing due to the passage of time, exposure to light, or any other cause. All materials shall conform to material standards as per BIS or any equivalent standard.

Only sound castings and forgings shall be incorporated into the Works. The welding, building up, filling, or any other processes to recover castings will not be permitted in respect of any casting associated with pumps, compressors, gearboxes, or other such plants subject to pressure or vibration.

Machined surfaces shall be free from blemishes and other surfaces shall be carefully fettled to remove any foundry irregularities including fused-on sand.

1.5.3 Workmanship

Workmanship and general finish shall be of first-class quality and in accordance with best workshop practice. All welds shall be as per IS, BS, ASME standards. All tolerances and clearances shall be as per good and sound engineering practices. Should any material be not considered acceptable by the Engineer, it shall be replaced.

1.6 Lubrication, Bearing, Seals and Gearbox

1.6.1 Bearings

All bearings shall conform to Anti-Fiction Bearing Manufacturers Association (AFBMA) standards. Bearings shall be selected for adequate load-bearing capacity, reliability, and long life. They shall be sealed for a minimum design life of 100,000 hours of operation at maximum loading or be fitted with automatic grease or oil lubricators. Lubrication points shall be grouped with separate nipple and pipe-feeding individual bearings. Lubrication points shall be easily accessible.

1.6.2 Gearboxes

Reduction gearboxes shall be robust and continuously rated and selected for reliability and efficiency over the required range of loadings.

Non-submersible gearbox drive casings shall be fitted with filling, level and drain points. Taps shall be fitted to the drain, and the gearboxes shall be positioned such that the oil may be collected in a container.

1.6.3 Seals

Gearboxes shall have a life of 100,000 hours, be selected in accordance with the American Gear Manufacturers Association (A.G.M.A) recommendations for horsepower calculation and service factor application and employ a standard reduction ratio.

Except where particularly specified, the Contractor shall select a seal compatible with the Plant and best suited for the worst conditions likely to be met when the Plant is in operation.

Seal materials shall be compatible with and/or resistant to the fluid, gas or any other substance being handled.

1.6.4 Glands

Glands shall be provided with renewable gland sleeves. Glands subject to abrasive liquors or negative pressures shall embody suitably positioned lantern rings and a clean water continuous flushing system, operative whenever the Plant is in motion.

Gland adjustment nuts shall be readily accessible for routine maintenance.

Gland's drain pipework shall be installed, incorporating Roding facilities and adequate inclines of 25 mm minimum diameter on water, and used water treatment plant and 12.5 mm on water supply plant, discharging to the nearest sump or drainage channel.

1.6.5 Lubrication

The equipment shall be lubricated by long-life lubricants such that the working life is not less than 3000 operation hours.

A complete schedule of recommended oils, and other lubricants, shall be furnished by the contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and names of the suppliers of the lubricants shall be submitted to the Engineer.

Lubricants shall be oil and grease. The contractor shall indicate indigenously available lubricants, with complete specifications.

Where the lubricant is grease, preference shall be given to a pressure system, which does not require frequent adjustment or recharging. Preferably, life lubricated grease-packed bearings shall be used.

Where more than one special type of grease is required, a grease gun for each special type shall be supplied and permanently labelled.

The Contractor shall tabulate all lubrication points, the recommended grease or oil, its grade, and the recommended service interval in the form of a chart. The Contractor shall include the supply. All necessary oils and lubricants for the initial fill and the first year's operation so that testing and commissioning may be carried out, without delay.

1.7 Fixing of Machinery

1.7.1 Fixing to Structures

Where any Plant included in the Works is attached to building structures, the magnitude of the applied loadings must be stated by the Contractor on his drawings. Cutting of steelwork will not be allowed. Drilling, welding or stud firing into tension flanges or other steelwork subjected to tensile loads will not be permitted on plate girders or any principal

steelwork member. Where attachments are allowed, proper clamps or straps will be required. The proposed attachment shall require the approval of the Engineer.

1.7.2 Foundation and Building Works

The Contractor shall satisfy himself, before installing the Plant, that the foundation levels, dimensions, and alignment are correct and shall level and adjust the Plant on its foundation preparatory to suitable bedding of bases.

Where fixings are used by the Contractor, he shall drill the holes, providing and fixing parts, to the approval of the Engineer.

The drilling through steel reinforcement shall not be permitted without the prior approval of the Engineer.

The Contractor shall supply foundation bolts, packers, frames and grillages necessary for the Works. Where these items are required to be built in, the Contractor shall ensure that both details and materials are available under the Schedule.

The Contractor shall make good any damage to concrete, brickwork or other finishes caused when undertaking his work. This shall be done to the satisfaction of the Engineer.

Grouting of machinery bedplates and supports shall be undertaken by the Contractor.

1.7.3 Shims and Packing

Packings and Shims shall be positioned close to and on each side of holding down bolts. Packings and shims shall be of flat stainless steel and so positioned as to be fully covered to a thickness of 60 mm after 'grouting in'. Alternatively, mild steel packs with zinc rich protective coating are to be provided.

1.7.4 Anchor Bolts

Expansion bolts or self-drill anchor bolts shall be to the approval of the Engineer and shall not be used within 100 mm distance of concrete edges. Epoxy resin anchors can be used under such circumstances.

Where expansion bolts are used, they shall normally be of the type having a loose metal shell for at least 80% of the embedded length which is expanded parallel to the bolt using a wedge at each end, the wedge at the lower end being part of or attached to the bolt.

Proprietary fixing bolts shall be fitted in strict accordance with the manufacturer's instructions and the Contractor shall be responsible for the provision of necessary equipment to drill and clean holes and for the actual drilling, cleaning, and fixing.

Anchor bolts shall be stainless steel 316.

1.7.5 Machinery Guards

Machinery shall be effectively guarded to prevent injury to persons and meet current safety regulations under IS 9474/BS EN 953/ ISO 14120.

Guards to parts of machinery which require regular inspection or maintenance shall be constructed of galvanized steel mesh or other corrosion-resistant material which enables the parts to be examined and shall be attached in such a way as to permit easy removal and replacement. Guards shall be attached by means of set bolts or studs in tapped

holes. Self-tapping screws shall not be used.

Where hinged access covers or doors are provided in covers or guards, they shall be interlocked with the electricity supply to prevent the operation of the machinery except when the covers are in position and fixed.

Warning notices labelled 'Danger - This equipment may start automatically', shall be fitted where appropriate.

1.7.6 Bolts, Screws, Nuts, Studs and Washers

Fixings to be used in conjunction with the works shall have thread forms which comply with BS 3643 Isometric screw threads, and BS 4190.

Exposed bolt heads and nuts shall be hexagonal, and the length of bolts shall be such that, when fitted with a nut and washer and tightened down, the threaded portion shall at least fill the nut and not protrude from the face thereof by less than two threads or more than four threads. Threading, machining, or cutting of threading rods at the site is not permitted.

Fasteners and fixings shall generally be manufactured from nickel-bearing stainless steel. Pipework flange fixings nuts and bolts shall be stainless steel.

Wood screws and fixings shall be of brass with round heads.

1.8 Alignment, Lifting, Dismantling, Noise & Vibration

1.8.1 Alignment

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

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

1.8.2 Lifting

Machinery shall be fitted with permanent lifting facilities. Large structures shall be provided with jacking points.

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

1.8.3 Dismantling

A method statement for the approval of the Engineer shall be produced by the Contractor for any plant removal, demolition of structures, support procedure, or protection measures for the existing plant that is not to be removed.

The redundant designated utilities within the demolition areas shall be properly disconnected and capped.

Any debris resulting from the demolition work shall be disposed of on-site at a designated tip or as mentioned in the particular specification.

All the demolition or plant removal work shall conform to the local authority regulations for

any contaminated or hazardous materials.

1.8.4 Noise

a) No item of Plant intended for installation in a building shall produce a sound pressure level exceeding 85 dB (A) when measured at a distance of 1.0 m from the reference surface of that item in a horizontal direction and under environmental conditions appropriate to the test requirements of ISO 3746 "Acoustic Determination of Sound Power Levels of Noise Services- Survey Methods".

b) An item of the plant shall include the driver, driven equipment and all other attachments that may produce noise.

c) The Contractor shall be responsible for carrying out all noise tests on Site.

d) Sound pressure levels shall be measured in dB (A), using a calibrated sound meter meeting the requirements of BS EN 61672-1 and BS EN 61672-2. The background noise level shall beat least 10 dB (A) below the operating noise level of the machine or other item of the Plant.

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

f) If an item in its standard build does not comply with the above requirement, the manufacturer shall be required to reduce the sound pressure level by providing acoustic enclosures, improved or additional silencers or fitting sound insulating materials to the item until the above requirement has been complied with.

Equipment such as blowers, compressors, diesel engines, etc. where reduction of noise emission to below 85 dB (A) at 1 m is impractical will be installed in a separate room constructed in or containing sound absorbing material or the same equipment shall be installed with suitable acoustic enclosure. Such areas shall be defined by the Contractor. The noise level shall not exceed 80 dB when measured 1 m from the outer wall of the room or structure or enclosure. These enclosures shall be aesthetically designed and corrosion-free as per the specification.

Wherever there is a risk of exposure of personnel to high noise levels, warning signs shall be put up and standard personal protective equipment shall be used. In such areas, the Contractor shall fit warning notices to each access door indicating that ear defenders are required and shall provide two sets of ear defenders in a suitable storage cabinet local to each entrance.

1.8.5 Vibrations

All the equipment shall be statically and dynamically balanced to avoid vibration. Mechanical vibration level shall be stated in the equipment technical data sheets and wherever necessary, the equipment shall be provided with vibration dampening mounts. At the time of operation, the mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 10816.

Equipment	Velocity of Vibration mm/sec

All rotating equipment not having reciprocating parts with motor KW less than or equal to 15 KW	1.12
All rotating equipment not having reciprocating parts with motor KW more than 15 KW and less than or equal to 75 KW	1.8
All rotating equipment not having reciprocating parts with motor KW greater than 75 KW	2.8

1.9 Machine Guards

a) All moving parts shall be protected by machine guards.

b) For this Specification, a machine guard is defined as a cover which is fitted over or adjacent to a moving part of the equipment (for example, a shaft coupling, a gear or belt drive, a counterweight or moving linkages) and shall comprise a casing (with or without a frame) and the necessary mounting fasteners.

c) Machine guards shall conform to PD 5304 and all other statutory requirements.

d) Guards shall:

- be made of sheet metal or chain mesh.
- be supported to minimize its vibration.
- be capable of ready removal and replacement.
- not restrict access to bearings or other items requiring inspection or maintenance.
- for guards located in areas of limited access, be of sectional construction and so arranged that access for maintenance can be obtained by manual removal of several sections.
- be provided with removable cover plates, where relevant, to provide access to overload protective devices specified to allow replacement or resetting of these devices without the use of tools.
- be fitted with a hinged inspection door, secured with wing nuts or dog cleats in the case where the guard covers a belt or chain to enable in-service, inspection of the drive without removing the guard.
- can withstand a pressure of 75 kPa from any direction without permanent distortion.

e) guards for personnel protection shall be provided for:

- all exposed couplings, gears and belt or chain drives.
- moving counterweights and levers.
- as set out in PD 5304 and statutory regulations.
- other moving parts as required by the contractor.

1.10 Name Plates and Labels

a) All plant, equipment, pipework, valves, and manholes shall be identified with tag numbers. Pipework shall be painted, or colour-banded and labelled.

b) Equipment shall be identified using engraved plates of a non-corrodible metal fixed onto the item using four screws. Engraved tags of a non-corrodible metal shall be used for the identification of small valves such as those on chemical facilities. Tags shall be of a uniform shape and shall be fastened by a jack chain. Engraved plates of non-corrodible metal fixed onto the handwheel shall be used to identify large valves and penstocks.

c) Chemical-resistant adhesive labels shall be used to identify storage tanks.

d) The Contractor shall ensure that each main and auxiliary item of Plant and equipment shall have permanently attached to it in a conspicuous position a nameplate and a rating plate. Upon these shall be engraved the manufacturer's name, direction of rotation, type and serial number of plants, and details of the loading and duty at which the item of Plant has been designed to operate. All indicating and operating devices shall have securely attached to or marked upon them designations as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes (Tag Nos.) as indicated on the drawings.

e) A nameplate shall be provided and mounted on or adjacent to each piece of chemical feed equipment to identify its function.

f) All valves shall have an identification plate bearing the valve number and a short description of the valve function.

g) On major items of plant and valves, details of, proposed plates, labels, and inscriptions shall be provided by the Contractor for approval by the purchaser.

h) Such nameplates, rating plates and labels shall be of a non-flame propagating material, either non-hygroscopic or transparent plastic, with engraved lettering in contrasting colours. Fixing shall be made through screws. No drive rivets or adhesives shall be used.

i) Nameplates shall be approximately, 25 by 75 mm, made from black-on-white phenolic material.

j) Letters shall be engraved to the white interior and shall be at least 4.8 mm high.

k) All the metal tags supplied shall be non-corrodible and shall be designed to withstand direct contact with process chemicals. The tag materials shall be suitable for outdoor installation and shall not deteriorate with prolonged exposure to sunlight or high temperatures up to 120^0C.

1.11 Surface Preparation and Painting

a) This painting specification aims to achieve life to first full maintenance of ten (10) years, not including regular maintenance touch-ups/repairs.

b) Paints shall be stored as per the painting manufacturer's recommendation to avoid exposure and extreme temperature.

c) All tools, tackles and equipment required to be used shall be suitable for the work and in good order.

d) Surface Preparation:

e) Mill scale, rust, rust scale, and foreign matter shall be removed fully to ensure such as a clean anddry surface is obtained. The following cleaning techniques are acceptable:

Type of cleaning involved	Minimum acceptable
Mechanical/Power Tool Cleaning	SSPC-SP-3 or Equivalent
Dry blast cleaning NOTE-1	Sa2½ / SSPC-SP-10 or equivalent
Water blast cleaning	SSPC-SP-12

f) Application of surface protective coating other than hot dip galvanizing shall be by one of the following methods, the choice being the Bidder's unless one method is specified or recommended in the manufacturer's instructions for use of the surface protective coating: -

- Brush
- Air Pressure Spraying
- Airless Spraying

g) All surface protective coatings shall be prepared and applied in accordance with the manufacturer's instructions. Copies of appropriate data sheets and of the relevant parts of this Specification shall be issued to all the supervisors and foremen concerned with surface preparation and coating. Where a manufacturer's instructions conflict with this Specification, approval shall be sought from the purchaser.

h) No thinners or cleaners shall be employed other than those recommended by the manufacturers.

i) The manufacturer's printed instructions concerning hot weather application shall be strictly adhered to.

j) No coat shall be applied until the preceding coat has dried as per the over-coating interval of the specific manufacturer's guidelines. The material shall be considered dry for recoating when another coat can be applied without the development of any film irregularities, such as lifting or loss of adhesion of undercoats. The drying time of the applied coat should not exceed the maximum specified for it as a first coat.

k) No paint shall be forced dried under conditions which will cause checking, wrinkling, blistering formation of pores, or detrimentally affect the condition of the paint.

l) No drier shall be added to paint on the job unless specifically called for in the manufacturer's guidelines.

m) The dried films of the specified surface protective coatings shall be free from bloom, sinkage, sheerness, wrinkling, sagging, curtaining, discolouration, and extraneous matter.

n) The dry paint film thickness shall be measured by an Elco meter.

o) All edges, corners, webs and inaccessible areas shall be stripe-coated before full application, to ensure integrity of DFT over surface areas.

p) Following the Painting Schedule to be used for equipment/items in the project.

Equipment	Surface Preparation	Painting Scheme	Total DFT Min - Max
Mechanical Equipment			
Un-Insulated Carbon Steel Substrate			
Fabricated Equipment (Pressure Vessels, Tanks etc.,), Pipe Support, Skid Frames and Equipment Support	Abrasive Blast Clean to SA 21/2	Primer Coat: Zinc Rich Epoxy Primer-50 □ Build Coat: High Build Epoxy MIO-125 □ Finish Coat: Aliphatic Urethane-75 □	225-250 □
Insulated Carbon Steel Substrate			
Fabricated Equipment	Abrasive Blast Clean to SA 21/2	Primer Coat: In Organic Zinc Silicate-75□ Build Coat: NA Finish Coat: Zinc Free High- temperature air curing finish coat-75	125-150
External Surfaces Carbon Steel Substrate – Rotating Equipment			
Centrifugal Pump Centrifugal Fan Positive Displacement Pump Filters Portable Pumps Compressor Electric Motors Agitators and Mixers	All These Items can be coated as per the manufacturer's Standards. In Choosing the standards, the manufacturer shall take care of the guidelines mentioned in the standard for the life of the coatings.		
External Surfaces Stainless Steel substrates			
All Equipment and Piping	Surface to be blast cleaned with "VASIL GRIT" or other suitable Aluminum oxide abrasive; NEED NOT BE PAINTED		
Piping Equipment (In-Insulated carbon steel substrate)			
Pipe Fitting Flange Valve	Abrasive Blast Clean to SA 21/2	Primer Coat: In Organic Zinc Silicate-75□ Build Coat: NA Finish Coat: Zinc Free High-temperature air curing finish coat -75	125-150
Structural Steel			
Ladder Platform Vessel Clip Handrail Stair Tread Open grid Flooring, Toe-Board/Floor Plates Cable Tray and Ladder Rack	Abrasive Blast Clean to SA 21/2	Hot Dip Galvanize to ISO 1461. Min Coating WT 610 grams/m^2 If not galvanized, specifications mentioned for Uninsulated Carbon Steel Substrate shall be followed.	
General Not Concrete Encased	Abrasive	Primer Coat: In Organic Zinc	250-275

Equipment	Surface Preparation	Painting Scheme	Total DFT Min - Max
	Blast Clean to SA 21/2	Silicate-75 Build Coat: High Build	
		Epoxy MIO-125	
		Finish Coat: Aliphatic Urethane-	
		75	
General Concrete Encased	Abrasive Blast Clean to SA 21/2	Primer Coat: In Organic Zinc Silicate-75 Build Coat: NA Finish Coat: Zinc Free High-temperature air curing finish coat-75	125-150
Stair Tread Open Flooring Steel Grating	Abrasive Blast Clean to SA 21/2	3 Coats of Bituminous Paints to BS 3416Type-1 applied by dipping. 3 Coats of Bituminous Paints to BS 3416Type-1 applied by dipping	

1.12 Field Installation Quality Control

a) Installation Supervision on site

- The mechanical equipment manufacturer shall furnish a qualified field installation supervisor during the equipment installation.
- The manufacturer's installation supervisor shall observe, instruct, guide, and direct the installing contractor's erection or installation procedures.
- The equipment manufacturer will be provided with written notification 10 days prior to the need for such services.

b) Installation Check

c) An experienced, competent, and authorised representative of the manufacturer shall visit the site of the work and inspect, check, adjust if necessary, and approve the equipment installation.

d) The purchaser/purchaser's representative shall be present when the equipment is placed in operation in accordance with the manufacturer's start-up requirements and shall revisit the job site as often as necessary until all troubles are corrected and the equipment installation and operation are satisfactory in the opinion of the purchaser.

e) The manufacturer's representative shall furnish a written report certifying that the equipment has been properly installed and lubricated; is in accurate alignment; is free from any undue stress imposed by connecting piping or anchor bolts; and has been operated under full load conditions and that if operated satisfactorily.

1.13 Pump Design and Layout:

1.13.1 Definitions

For this Specification the following definitions shall apply: -

Design duty	The total head to be developed and the quantity of fluid to be discharged when the pump is running at rated speed;
Static head	The difference between the free water surface level on the suction side of the pump and the delivery level;
External friction head	The head required to overcome friction external to the Works (Frictional loss in the transmission main) and the velocity head at the outlet of the pumping main;
Station losses	The friction losses in valves and pipes within the pump room;
Internal losses	The frictional losses in the pump suspension main and head bend up to the delivery flange of vertical wet well pumps
Total head	The sum of (b), (c), (d) and (e);
Design duty head	The sum of (b) and (c);
NPSHa	Net positive suction head available at the site.
NPSHr	Net positive suction head required by the pump.
LWL	Low Water Level at free water surface level on the suction side of the pump.
HWL	High Water Level at free water surface level on the suction side of the pump (during flooding)

1.13.2 General

- The head-flow characteristics of pumps shall be stable at the flow, between closed and fully opened valves, and the characteristics shall be steep enough for satisfactory parallel operation, under the specified conditions.
- Pump efficiency shall be well maintained throughout the specified duty range.
- For vertical shaft suspended pumps, the quoted pump efficiencies shall take into account shaft and rising main losses up to and including the pump discharge bend and pump coupling.
- Lubrication arrangements shall be designed to avoid any contamination of the pumped fluid.
- Pumps and associated pipe work shall be arranged so that air can be completely removed during priming, using air-release valves at high points, and complete drainage is provided from low points by drain valves.
- Arrangements for the easy handling of all pumping machinery shall be provided by using lifting lugs or eyes as appropriate.

1.13.3 Vertical Non-Clog Pump

1.13.3.1 General:

The pumps for the sewage pumping stations shall be Vertical Non-Clog Centrifugal (VNC) type with an extended motor shaft with a motor mounted on an elevated platform at least 2 m above the floor level of the dry well.

1.13.3.2 Features of Construction

- The speed of the pump shall not be more than 1000 rpm (irrespective of any other mention in the general specifications for the VNC pump.

- The impeller should be non-clog with a smooth passage and solid handling capability of 50 mm size.
- The pumps shall be designed for parallel operation, and the bidder to ensure that the design flow is obtained when all working pumps operate in parallel, and the individual pump shall be designed accordingly. Based on incoming flow conditions, an adequate no. of pumps shall operate automatically to cater to the pumping requirements.
- Bidder shall submit the performance curve for pumps working solo and in parallel for up to a maximum. no. of working pumps for review and approval during detailed engineering.
- The delivery line of the individual pump shall be brought up to the top of the wet well slab, and the header line shall be constructed on the wet well slab.
- The pump shall run smoothly without undue noise and vibration. Vibration shall be limited as per BS 4675 Part I.
- The motor shall be squirrel cage TEFC/TEFV type, suitable for three-phase supply continuous duty with class 'F' insulation with temp. rise limited to class B.

The efficiency of the pump shall be 80% Min. w/o negative tolerance.

1.13.3.3 Materials of construction:

Pump casing	: CI IS: 210 Gr FG 260 with 1.5 to 2% Ni. C.I
Discharge casing	: CI IS: 210 Gr FG 260 with 1.5 to 2% Ni. C.I
Impeller	: SS ASTM A 743 Gr CF8M/ SS
Shaft	: SS AISI 410 H&T
The primary seal (lower seal)	: Tungsten carbide or silicon-carbide faces
Secondary seal (upper seal)	: carbon Vs chrome steel
Fasteners	: SS AISI 304.
Guide pipe & lifting chain	: SS 304
Speed	: Below 1000 RPM
Protective Coating	: The pumps shall be epoxy painted.

1.13.4 Dry Pit Pumps

1.13.4.1 General

1. The head-capacity curve of the pump shall be continuously rising towards shut off with the highest at shut off.
2. Pumps shall be suitable and efficient for single as well as parallel operation between the maximum and minimum system resistances.
3. Pumps shall run smoothly without undue noise & vibrations. Noise level shall be limited to 85 dB(A) at 1.86 M at sites. Vibration shall be limited to class II C of BS 4675/ zones A & B of ISO 10816-1The pump set shall be suitable for starting with the discharge valve open or closed.

4. The pump set shall be capable of withstanding accidental rotation in the reverse direction.

1.13.4.2 Features of Construction

The pump shall be centrifugal, back pull-out, single-stage type.

1. Pump casing shall be robust in construction. Liquid passages shall be finished smooth and designed so as to allow free passage of solids. The volute tongue shall be straight across and filed to a smooth rounded edge. Casing shall be provided with a wearing ring.
2. A hand hole shall be provided in the casing to allow easy access to the impeller as well as to the casing throat. A casing drain connection with a stainless-steel collared plug shall be provided.
3. The impeller shall be non-clog type with smooth blunt edges and large waterways to allow free passage of the 50 mm size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy material.
4. The critical speed of the rotor shall be at least 30% above the operating speed. The complete rotor shall be balanced dynamically as per ISO 9906
5. Replaceable shaft sleeves shall be provided and shall be securely locked or keyed to the shaft to prevent loosening. The surface hardness of the shaft sleeve shall be a minimum of 400 BHN.
6. Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 40000 hours. Bearings shall be grease-lubricated or non-grease type.
7. Stuffing boxes shall be of such design that they can be repacked without removing any part other than the gland and lantern ring. Stuffing boxes drain with pipe connection, shall be provided at the lowest point so that no leakage accumulates in it.
8. The axially split type, lantern ring shall be sandwiched between packings and shall be easily removable. Grease shall be used for stuffing box sealing. Water will not be available for this purpose.
9. The pump and motor shall be coupled through a flexible coupling. The motor shall be mounted directly on the pump casing. It should be possible to lift the complete pump vertically through the opening provided at the motor floor level in the pumping station.
10. Tapings shall be provided at suction and discharge nozzles for pressure gauge connection. Water flushing arrangement shall be provided for cleaning of sludge pipeline, at its delivery side.
11. Impeller wear ring hardness shall be higher than that of Casing wear ring, at least by 50 BHN.

1.13.4.3 Material of Construction

The material of construction for the Centrifugal Dry Pit Pump shall be as follows:

Component	Material	
	Non-Clog Type	For clean water (for service water etc.)
Impeller	Stainless Steel: ASTM A 743 CF8M	Cast Iron to BS EN: 1561 Gr ENGJL-200 with 1.5 to 2% Nickel, or better
Casing	Cast Iron to BS EN: 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel	Cast Iron to BS EN: 1561 Gr ENGJL-200 with 1.5 to 2% Nickel
Shaft	Stainless Steel: BS:970 Gr 431 S29	Carbon steel or better
Shaft sleeve	Stainless Steel: ASTM A 743 CA 15 Hardness 400 BHN	Stainless Steel: ASTM A 743 CA 15 Hardness 400 BHN
Casing ring	Stainless Steel: ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15
Impeller ring	Stainless Steel: ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15

The Contractor shall furnish the material test certificates.

1.13.5 Submersible Pumps

1.13.5.1 General

- Submersible pumps shall be of the single-entry design and supplied with boltless self-aligning duck- foot assemblies giving automatic connection to the discharge pipe work.
- The total head capacity curve shall be continuously rising towards the shutoff with the highest at the shutoff point.
- Pumps shall be suitable and efficient for single as well as parallel operation between the maximum and minimum system resistances.
- The pumps shall be designed to handle solid sizes of up to 80 mm. Pumps shall run smoothly without undue noise and vibrations.
- The pump set shall be suitable for starting, with the discharge valve open and/or closed.
- The pump set shall be capable of withstanding the accidental rotation in the reverse direction.

1.13.5.2 Construction Features

i) Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, single stage type.

ii) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.

iii) A double mechanical seal shall be provided to protect the motor from ingress of liquid along the shaft. The preliminary and secondary seals shall be oil- lubricated with tungsten carbide or silicon carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. Sensors are to be provided to detect if leakage of liquid into oil housing is above 30% concentration.

iv) Double mechanical seals shall be provided to protect the motor from ingress of sewage along the shaft. the preliminary and secondary seals shall be oil- lubricated with tungsten carbide or silicon carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection.

v) The Impeller shall be a non-clog open/semi-open type for raw sewage and sludge

application and an enclosed type for clear water/treated sewage/filter rate pumping application with smooth blunt edges and large waterways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials. The number of impeller vanes for pumps up to 1000 m3/hr. shall be limited to two and shall be limited to three for pumps higher than 1000 m3/hr.

vi) The critical speed of the rotor shall be at least 30% above the operating speed.

vii) Pump sets shall have double bearings. The bearing life shall be a minimum of 40,000 hrs. of operation.

viii) Each pump shall be complete with a CI delivery connection arrangement, for fixing to the concrete floor of the suction well. All necessary SS fixtures required for guiding the pumps during lifting/lowering shall be provided. The installation shall facilitate the automatic installation and removal of the pump without a person entering the wet well. Each pump shall be provided with a SS-316 lifting chain, with suitable provision for engaging the hook of the crane at 1 m intervals.

ix) Each pump shall be provided with an automatic coupling device for attaching the crane hook to the pump at a low level, even whilst the pump is submerged, without the need for personnel to enter the wet well. This automatic coupling device shall easily and automatically couple and uncouple the hoist hook and be complete with the necessary accessories. All links and cables shall be multi-stranded SS.

x) The submersible pumps shall be suitable for operation with or without submergence.

xi) The pump shall start and stop automatically based on the level in the wet well.

xii) The synchronous speed shall not exceed 1500 rpm at 50 Hz supply.

1.13.5.3 Material of Construction

The material of construction for submersible pumps shall be as follows:

Component	Material
Impeller	SS: ASTM A 743 CF8M
Casing	CI, IS: 210 Gr FG 260 with 1.5 to 2 % Nickel
Shaft	SS: BS:970 AISI Gr 316
Bush	Bronze IS 318 Gr LT B2
Guide Rail Pipe	Bronze IS 318 Gr LT B2
Fasteners and Foundation Bolts	SS: BS:970 AISI Gr 316

- Material test certificates furnished by the contractor shall have the approval of the Engineer.
- The submerged cable shall be a multi-core flexible cord, Vulcanized rubber insulated with tough rubber sheath, and outer PCP sheath to BS 6500.
- Where both, thermal protection and moisture-sensitive devices are incorporated within the pump, both devices shall be brought out via separate conductors within the motor cable although, one such conductor may be common.

1.13.6 Centrifugal pump

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

ii) The design speed of any pump with a duty flow greater than 20 l/s shall not exceed 1500 rpm. The pump motor rating shall exceed the maximum pump power consumption over the operational range of the pump by at least 10%.

iii) The waterway through the pump shall be smooth in finish and free from recesses and obstructions. Impeller passageways shall be as large as possible. The leading edges of the impeller vanes shall be rounded and smooth.

iv) Water velocities in the pump suction side shall not exceed 1.5 m/s, and on delivery branches of a pump, the velocity shall not exceed 2.0 m/s when the pump is operating within its specified duty range. Within this working range, there shall be no discernible noise due to hydraulic turbulence or cavitation within either the pump or its associated pipework and valves.

v) The NPSH requirements of the pumps, based on the 3% output drop criterion, shall be at least 2 m less than the NPSH available at every working condition.

vi) The velocity of vibration shall be within 4.5 mm/sec. The combined noise level of the pump motor system shall be limited to 85 dB(A) at a distance of 1.0 m from the equipment, at the manufacturer's works / free field condition at the site after erection.

vii) The pump shaft shall be of SS BS:970 Gr 410S21 compatible with the impeller, which shall be of stainless-steel ASTM A743 CF8M, and the impellers and shaft sleeves shall be secured to the shaft through a key/s. The impeller retaining nut shall be fitted with a locking device. The pump casing shall be of cast iron to IS 210 Gr. FG 260, wearing rings shall be of bronze to IS: 318 Gr. LT B2 and shaft sleeve shall be of SS ASTM A 743 CA 15.

viii) All parts exposed to wear shall be adequately protected using renewable sleeves, bushes, wear rings etc. which shall be arranged for easy inspection, adjustment, or replacement without removal of the pump casings, pipework, etc, or the need to disturb the drive shaft alignment.

ix) The pump thrust shall be taken by a combined thrust and radial-type bearing assembly capable of taking the weight of the moving parts and the hydraulic load under all conditions of the operation, with a minimum life of 100,000 hours.

x) Bearing cooling arrangement if used, shall be designed on the closed-circuit principle; open discharge of cooling water into the pumping station drainage system is not permissible.

xi) The pump casing and other parts of the pump subjected to pressure shall be hydraulically tested by the manufacturer to at least one and a half times the maximum working pressure.

xii) Integral inlet & discharge flanges shall be provided and integral lifting lugs shall be incorporated.

xiii) Facilities shall be provided for the removal of air during priming and for draining.

xiv) Glands may be fitted with mechanical seals or conventional soft packing. The gland arrangement shall be designed for easy adjustment and removal of the seal.

xv) When soft-packed glands are used suitable means shall be provided for collecting and preventing splashing of the gland leakage water.

xvi) Drainage and gland leakage water shall be piped into the building drainage system.

xvii) The shaft of the pumps fitted with conventional packed glands shall be fitted with removable gland sleeves.

xviii) The rotating element of the pump and the motor shall be readily removable from the pump casing without the need to disconnect the adjoining pipe work.

xix) Rotating assemblies of the pumps of 100 mm dia. inlet and over shall be statically and dynamically balanced and shall be designed so that the first critical speed is at least 50% greater than the maximum operating speed.

xx) Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

xxi) On pumps of 75 mm inlet and over, tapping shall be provided at both the suction and discharge flanges of suitable size for pressure gauges.

1.13.7 Progressive Cavity Pumps

i) These pumps shall be used to handle the thickened sludge for transfer/feed applications.

ii) Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pumps to give a uniform positive displacement.

iii) Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion. A corrosion-resistant shroud shall be fitted to prevent fibre build-up on the shaft. Enlarged inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris.

iv) The shaft bearing shall be positively isolated from the fluid, to be handled by the pump.

v) The rotor material shall be selected and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome of other approved coating shall be not less than 250 microns thick and shall be diffused into the base material. The rotor shall generally be single-stage and shall incorporate not less than 3600 of twist, but for high-end applications, it may be necessary to use more than a single stage. The stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped.

vi) Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available

speed range.

vii) Pumps shall normally be driven by a fixed-speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in line on a common base plate. Alternatively, the drive motor may be top-mounted above the pump to minimize floor area and shall be connected by external V-belts and pulleys. V-belt drive shall have full guards of the type that allow the belts observed without the removal of the guard. Facilities shall be provided for ready adjustment of belt tension.

viii) Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections. All motor enclosures shall be provided with ingress protection to IP55. Motor anti-condensation heaters shall be provided and shall be suitable for use on a 220 Volts single phase, 50Hz supply.

ix) All bearings shall have a B10 design life of not less than 40,000 running hours and shall be designed for loading 20% in excess of the calculated maximum loading, pumps shall be fitted with individual dry- running protection to initiate pump trip. Dry-running protection by 'under-current' monitoring of 'pipeline- intrusive' device shall not be used.

1.13.7.1 Material of Construction.

Component	Material
Pump housing	CI IS 210 Gr. FG 260
Rotor	SS AISI 316 (hard Chrome Plated)
Shaft	SS AISI 316 (hard Chrome Plated)
Stator	Nitrite Black
Type of drive	V belt & pulleys
Base Plate	MS Fabricated
Seal Type	Gland Packing (Asbestos free)

1.13.8 Chemical Dosing Pumps

i) Chemical dosing pumps shall be piston diaphragm or mechanical diaphragm type. The pump may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate a positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute. The pump, motor and driving arrangement shall be mounted on a robust combined base plate.

ii) Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self-cleaning action. Ball and seat materials shall be resistant to abrasion.

iii) Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by an electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted, Pumps shall be driven by a flange-mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving step-less adjustment between zero and maximum stroke length. where flow proportional dosing is required the variation of output shall be achieved by varying the

speed of the pump motor and not the pump stroke length.

iv) The normal operating range of the dosing pump shall be not less than 6:1.

v) Mechanical Diaphragm: Diaphragm rigidly coupled to the drive train. Single suction pumps and discharge valves. Glandless. Accuracy: 3% of stoke.

vi) Piston Diaphragm pumps: Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: 2% of the stroke.

vii) Material shall be selected to suit the chemical being pumped. The liquid end shall be polypropylene, AISI 316 SS, Glass or Hastelloy C. Diaphragm material shall be butyl rubber, PTEE, or Hypalon and glans shall be PTEE or Neoprene.

viii) Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves. dosing pumps shall be provided with back-pressure loading valves and pulsation dampeners in the delivery lines, depending on the downstream conditions.

ix) A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe may be shut off or where the pressure may rise to an excessive point. the relief valve shall be sized to handle the system pressure and to discharge maximum pimp output freely and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on the pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bounded area. The open end of the return pipe shall be located where it is visible so that any relief valve leakage/operation can be detected.

x) Pump transferring/dosing chemicals to the system under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release or air where necessary.

xi) Unless otherwise specified flushing connection shall be provided at each inlet and flushing shall be manual. when flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to the point of application.

xii) Dosing Pumps and motor shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed, and oil bath lubricated. The gearbox shall incorporate the cams for the diaphragm drive and shall provide filling and drain connections and visible oil level indication.

1.13.9 Screw Pumps

General

i. Screw pumps shall comprise a welded steel fabricated central tube with a free start cold formed screw fabricated into a smooth continuous form, welded to the Centre tube, and designed for minimum deflection.

ii. When it is necessary for the central tube to be constructed of more than one length of plate, a welded joint shall not be positioned in the Centre of the flight but shall be positioned at each end, and all such joints shall be full penetration butt weld with fatigue design to BS 5400 Part 10. Tube end plates shall be manufactured from grade 43 steel and accurately machined to carry bearing stub shafts. The central tube shall be watertight.

iii. The spiral blades shall be formed from steel plates. The blades shall be secured to the center tube by a continuous weld and the periphery of the screw blade shall be finished to ensure a uniform clearance between the screw and trough.

iv. Bearing stub shafts of ample dimensions complete with machined location shoulders and mounting flanges shall be bolted to the tube end plates. Top stub shaft units shall extend through the bearing housings to receive the driven half coupling.

v. Where the upper stub shaft of the screw pump passes through the structure, substantial removable anti- splash closing plates shall be installed and sealed to the structure. Plates shall be not less than 3 mm thick mild steel, split for ease of removal.

vi. The screw pump shall have a speed of rotation not greater than that given by the equation $50 = ND^{0.667}$ where N is in rpm and D is the outer diameter of the screw in meters.

vii. Screw Pump Drive System

viii. The gearbox reducing the speed between the prime mover and the screw pump shall be of robust construction having the output shaft at right angles to the input and suitable for mounting on a plinth inclined at the same angle as the screw pumps to the horizontal. The concrete plinth shall be provided by the Civil Contractor in accordance with the Contractor's design requirements.

ix. The speed reducer shall be of the enclosed oil bath lubricated type fitted with oil-level sight glass, dipstick, filler and drain plug, large inspection covers and an oil breather.

x. Bearings shall be either splashed or forced lubricated.

xi. Efficient long-life shaft seals shall be fitted to all external shafts to prevent loss of lubricant. The speed reducer shall be rated for:

xii. Continuous operation, in the climate and temperature of the place of installation.

xiii. A gear design life of 100,000 hours at a service factor of 1.5 at the motor full load rating. All bearings shall be rated for a life of 100,000 hours at speed reducer full torque rating in accordance with AGMA 420.04 Specification and all other combined loadings and speed imposed by the screw.

xiv. Where speed reducer external cooling equipment is required, this shall be a separate system from any other cooling system.

xv. Screw pumps shall be driven through flexible couplings, of the pin and buffer type to prevent end thrust and radial loads being transmitted to the speed reducer. Couplings shall be arranged to allow coupling belts and buffers to be replaced without disturbing the drive or driven shafts.

xvi. A backstop device shall be fitted to the speed reducer shaft to prevent reverse rotation of the screw pump under the head of liquid in the flights when the screw pump motor is de-energized.

xvii. The screw pump shall be driven by a squirrel cage induction motor. The motor shall be protected IP 55. The motor shall be horizontally mounted.

xviii. Power transmission from the drive motor to the speed reducer shall be through multiple V belts. Pulley ratios and centers shall be selected to ensure the maximum belt contact and bosses shall be a tight fit on the shafts and have fitted keys.

xix. Drive motors shall be mounted on slotted slide rails with belt tensioning screws and locknuts provided for adjustment.

xx. The complete drive system shall be guarded to prevent accidental contact with moving parts.

1.13.10 Submersible Sump Drainage Pumps

i. Sump pumps shall be open-impeller, centrifugal-type, vertically mounted and closely coupled to their fully submersible electric motors.

ii. Sump pumps of 1.5 kW and under shall incorporate an integral level detector, control and motor starter and shall be powered only with a suitably fused three-phase or single-phase low-voltage supply and with supply isolation at the supply point.

iii. Sump pumps over 1.5 kW shall be controlled and started from the supply point. Control shall employ adjustable float-level switches mounted near the pump.

iv. Pumps shall be supplied with all necessary pipework to discharge to surface drainage. Each pump shall be provided with delivery reflux and isolating valves, and suitable lifting gear for lowering and lifting the pump from the sump.

v. Pumps weighing 40kg or more shall be lowered into the sump on guide rails and be located to their respective discharge pipework with an angle flange connection and self-locating clamps.

vi. Pump impellers shall be designed to pass solids of the sizes which pass through the inlet ports of the pump and shall be capable of pumping solids of up to 50 mm.

1.13.11 Pump Performance Guarantees

i) The pump performance guarantee shall relate to the flow rate, the total head, and the efficiency of the pump when tested at the manufacturer's works.

ii) The pump shall operate at its design point within acceptance tolerances for flow rate and total head laid down in BS EN ISO 9906:2000.

iii) Each pump shall be tested at the manufacturer's work in accordance with BS EN ISO 9906:2000 or other relevant standards in conjunction with one of the contract motors.

iv) This test shall be carried out on at least one pump set using the flexible coupling and contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.

v) Where similar drive shaft arrangements have been installed by the operator, and have

been proven satisfactory in service, this requirement may be withdrawn subject to the approval of the engineer.

vi) A test shall be carried out of the performance from the closed valve to the maximum quantity that can be delivered under abnormally low discharge heads.

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

viii) Vibration and noise dB(A) levels shall be measured and shown to be acceptable and shall have the Engineer's approval. The operator shall have engineer approval and provide acceptable test certificates, showing the NPSH requirement for the pump is at least 2m less than the NPSH available under all working conditions.

ix) in the absence of the approved test certificates the supplier shall carry out a test on one pump of each type to verify the NPSH requirement based upon the 3% output drop criterion and shall take approval of the Engineer.

x) The certificates shall be submitted to the Engineer immediately following each of the tests mentioned above. Performance curves shall also be incorporated in the operation and maintenance manual.

1.13.11.1 Single Pump Operation

i) Head / Quantity Curve

ii) Motor kW input/Quantity curve

iii) Overall efficiency/quantity curve

iv) NPSH required/quantity curve

v) Vibration and Noise dB(A) levels

1.13.11.2 Parallel Pump Operation

i) Head / Quantity Curve

ii) Motor kW input/Quantity curve

iii) Overall efficiency/quantity curve

iv) NPSH required/quantity curve

v) Vibration and Noise dB(A) levels

1.14 Mechanical Coarse Screens

1.14.1 "J" Type Trash Rack Bar Screens

1.14.1.1 General:

"J" type Trash Rake Screens shall be capable of performing the screening duties in sewage pumping stations and sewage treatment plants. These screens shall be suitable for operation in an inflow mixed up with large and medium-sized undefined floating waste. The screens shall be so constructed that there is no undue wear or deterioration during their operative life and so designed that repair and maintenance is kept to a minimum.

These screens shall be supplied along with accessories such as screen segments, guide frames, hand scraper assembly and all fasteners as required for the erection /installation of the screen guide frame, and an Electric Hoist for taking out and putting in the screen.

1.14.1.2 Design & Construction Details:

The screen segment consists of its sides, top & bottom frame members, back support stiffeners & vertical rectangular flats/bars of stainless steel.

i. The screen shall move vertically up or down in SS side guide channels that are either “securely fixed to the two vertical side walls of the inlet chamber by means of suitably sized and spaced anchoring plates & mechanical anchor fasteners” or “embedded in the two vertical side walls and bottom floor of the channel using grout” as per actual site requirement.

ii. Side guide frame length shall be from the invert of bottom level of the screen channel, up to the top of the screen channel floor level.

iii. The bottom member of the guide frame shall remain flush with the bottom level of the channel embedded in the bottom floor of the channel using grout as per actual site requirement.

iv. Screen Segment shall be provided with 2 Nos. SS lifting pins/rods at top, replaceable wear shoes of gunmetal (as required) & Stainless-steel rollers (2 Nos. at each side) to enable the screen to move smoothly in the guide channels. The framework shall be provided only on the downstream side of the screens.

v. The Vertical rectangular flats/bars for screens shall be of dimensions 50x10 i.e. 50 mm deep x 10mm thick spaced at 50 mm clear average bar spacing at an inclination angle of 90º to the horizontal plane.

vi. “J” type perforated tray/bucket shall be bolted to the bottom of the screen segment.

vii. One no. manual cleaning rake/comb shall be offered for screen for each screen to manually clean the screen while the screen segment is brought up/lifted, at the top of the channel level.

viii. A mild steel epoxy-painted lifting beam shall be provided to lift/lower down screen segments for screens having the same size at each location to move smoothly in the side guide channels.

ix. The provision of an EOT crane/monorail/tripod & arrangement, hoist supporting arrangement, any kind of mechanical cleaning/raking mechanism, collection bins/portable screen container, water jetting arrangements & trolley etc shall be provided.

1.14.1.3 General Material & Equipment Requirements:

The screens should be made of Stainless-Steel material to withstand the corrosive and abrasive sewage Environment. The screen manufacturer shall follow the proven manufacturing practice mentioned here under, to eliminate the possibility of corrosion. The manufacturer must have a quality system i.e. ISO: 9001-2015 in place to ensure the quality of the product.

i. The screens shall be manufactured in a stainless-steel clean area, in a plant,

where no ferrous material is cut, welded, or handled. This is required to ensure that no ferrous contamination/pick-up takes place leading to corrosion of the stainless-steel screens.

ii. To ensure the best workmanship, the screen manufacturer must have welding PQR, WPS & Qualified welders as per ASME Section 9. The manufacturer shall be required to provide workers' welding certification. The welding is to be done in such a way that corrosion, especially fissure corrosion, is avoided. Intermediate seam-welding and open fissures are not permitted.

iii. The manufacturer shall ensure that the entire welded joints are tested by Dye penetration test, by qualified inspectors.

iv. As an additional precaution the manufacturer shall have the facility for Pickling and Passivation to remove any ferrous contamination that might have taken place during manufacturing/handling/movement of raw and fabricated material.

v. Since the corrosion-resistant property of stainless steel gets reduced when exposed to heat while cutting by plasma, all the cutting of stainless-steel material shall be done using heat less water jet cutting procedure.

vi. All the stainless-steel material used on the assembled product shall be checked for correct chemical composition using Positive Material Identification equipment. This shall be re-verified at the time of inspection.

1.14.1.4 Material Of Construction:

The materials of construction of important components of "J" type removable trash rack screen shall be as stated below:

1	Screen Structure & Support Stiffeners	Stainless Steel ASTM A240 type 316
2	Screen Bars	Stainless Steel ASTM A276 type 316
3	Screen Lifting Pin/Lifting Rod	Stainless Steel ASTM A276 type 316
4	Guide Frames (at Two Sides & Bottom)	Stainless Steel ASTM A240 type 316
5	Replaceable wear shoes	Leaded Gun Metal
6	Roller Assembly	UHMWPE / Stainless Steel 316
7	"J" type perforated Tray	Stainless Steel ASTM A240 type 316
8	Screen Assembly Fasteners	Stainless Steel ASTM A276 type 316
9	Manual cleaning rake/comb/hand scrapper	Stainless Steel ASTM A276 type 316
10	Lifting Beam	Epoxy Painted Mild Steel IS 2062 Gr. E250 A / Br

1.14.1.5 Shop Testing:

The screen must be completely manufactured and subsequently offered for inspection at the manufacturer's works only. A screen assembled by a vendor and offered for inspection at the plant of a vendor / sub- contractor shall not be accepted. The screen shall be subjected to the following tests at the manufacturer's premises before dispatch:

a	Dimensional Check	Important Dimensions shall be checked with reference to the approved GA drawing. Variations in dimensions, if any, shall be within the permissible limits as per the applicable Indian/international standards.

b	Operational Test	The complete screen shall be offered for vertical up or down / horizontal movement in SS guide channels (only in the lower part of the guide frame) and tested in dry condition to verify interference-free movement and satisfactory operation.
c	Dye penetration test	A dye penetration test to be conducted at random to check the soundness of welding joints during the inspection. Both, the Procedure as well as a person conducting the dye penetration test should have been certified by the outside agency as per relevant standards.
d	Positive Material Identification Test	To ensure that Screens are made of Stainless Steel of specified grade positive material identification (PMI) test to be conducted for all important components like Bars and frames during inspection and PMI reports to be submitted to the client/corporation along with joint inspection report.
e	Review of test certificate:	Material test report/certificate shall be offered for review during the inspection.
f.	Review of WPS, PQR & Welder's qualification certificate	To be offered for review during the inspection and copy of same to be submitted to client / corporation along with joint inspection report.
g	Review of Material Test Certificates	Material test certificates for all important components of the assembly are to be furnished for review at the time of inspection.

1.14.1.6 Standard Finishing & Painting:

Stainless steel components shall be shot blasted after fabrication and then pickled and passivated on all surfaces to remove any ferrous contamination taking place during the process of welding, cutting, machining, and handling.

1.14.1.7 Miscellaneous:

Packing of screens and allied accessories shall be transit-worthy to avoid any possibility of damage during transportation to the site(s).

If required, the following shall be arranged: -

i. Collection bins & wheeled trolley, water jet sprayer to clean the screen,

ii. Chequered plate to cover the opening /cut-out on top of the channel as required.

iii. The provision of overhead Electric hoist/Manual Hoist with starter panel & all accessories & Hardware/EOT crane/Monorail/Tripod arrangement, Rope/Chain pulley block, any sort of lifting arrangement & Hoist supporting Arrangement.

1.14.2 Mechanical Front Rake Coarse Bar Screen

1.14.2.1 Scope:

The scope includes supplying, installing, testing, and commissioning mechanically cleaned bar screens with multiple rake blades manufactured from SS 304 stainless steel. The screen should include bars rake, dead plate, discharge chute, side frames, covers, rake blades, drive chains, sprockets and bearings, scraper assembly, drive motor, gear reducer, anchor bolts, controls and all accessories and appurtenances, etc. required for complete and proper operation with all accessories and hardware.

The mechanical coarse screen is to be installed in the screen chamber to arrest large and

medium floating or similar materials from sewage entering a pumping station.

The screen shall be installed in a suitable size screen chamber and shall be capable of operating as and when the liquid level difference between upstream and downstream levels reaches to pre-set value and should stop as the level difference decreases. An adjustable timer should also be provided to operate the screen periodically, should the level not reach the pre-set value. The screen shall be equipped with a torque protection switch, to avoid any damage to the screen mechanism.

The screen shall be manufactured from AISI 304 stainless steel shapes (rods, angles, and channels), pipes and sheets. Side frames and guides, bar rack, rake assembly, scraper assembly, shafting, discharge chute, fasteners and anchor bolts shall be made of this material.

All stainless-steel components and structures shall be chemically pickled to remove any residues that may be present on the material, as a result of forming, manufacturing, or handling. After pickling, the equipment must be washed with a high-pressure wash of cold water to remove any remaining surface debris and promote the formation of an oxidized passive layer, which is critical to the long life of the stainless steel.

Chains and sprockets shall be made of SS304 material. Chain rollers shall be made of polyamide.

The lower sprocket bearing shall have a stainless-steel casing including a shaft made of white cast iron and a ceramic (calcium carbide) friction bushing.

Upper sprocket bearings shall have a paint-coated cast iron casing and include ball bearings that are greased for life and shall be double-sealed with Nylon rings.

1.14.2.2 Performance & Design Requirements:

The Mechanical coarse screen is to be installed in the screen chamber for separation of floating, settling and suspended material from sewage by means of an inclined bar rack installed within the channel. There shall be multiple cleaning elements (rakes) depending on the depth of channel to clean the bar rack. Both ends of the cleaning elements shall be connected to drive chains.

Each chain shall be driven by a sprocket on a common shaft and a flange-mounted gear motor. The design will ensure proper meshing of the cleaning rakes with the bar rack to ensure high operating reliability.

The cleaning elements, attached to the chain system, shall be easily adjustable to different requirements. The cleaning elements, consisting of the rake and comb plate shall be screwed and replaceable.

1.14.2.3 The Mechanical Coarse Screen shall consist of:

i. Screen with bars, including head and foot connection profiles.

ii. Screenings apron, with discharge chute on top of the rack screen, equipped with a removable stainless-steel covering.

iii. The cleaning elements, consisting of the rake and comb plate, are screwed and thus independently replaceable.

iv. Bushed conveyor chains each deflected by two upper and lower chain wheels and guided in lateral profiles.

v. Guide tracks with connecting profiles for the reception of the bushed conveyor chains.

vi. Drive motor with overload protection.

vii. Screen frame with plate cover to support the cleaning mechanism including the plates required to fix and adjust the screen.

viii. An electromechanical torque control to reliably protect the screen against damage caused by overload and in addition emitting an electric signal.

ix. Chain wheel bearings.

x. Re-greaseable upper flange bearings.

xi. Water-resistant, maintenance-free lower ceramic bearings.

1.14.2.4 Construction:

i. The bar Screen shall remove floating materials from the incoming wastewater by means of a positively cleaned bar rack that is installed in a concrete channel. The screen shall retain floating materials at the bar rack. A multitude of rake blades shall remove and lift the floating materials to a discharge mechanism. The bar rack shall be cleaned by serious rakes engaging the bar rack from the upstream side at the bottom of the channel and then moving up along the bar rack. The floating materials shall be lifted above the channel and dropped on a discharge chute at the downstream side of the screen. Screens with single rakes shall not be approved.

ii. The bar rack shall consist of equally spaced, straight bars that are inclined from the horizontal with the inclination angle specified above. The lower ends of the bars shall be provided with a minimum 4 mm thick curved base plate such that the rakes positively remove all screenings from the bottom of the bar rack. The bar rakes shall be securely fastened to the frame of the screen and be readily removable.

iii. Bars shall have a Tapered bar profile with a cross-section of 10x5x50 mm.

iv. The bar screen shall be provided with a dead plate extending from the bar rack to the discharge chute. The dead plate shall be made of a minimum of 4 mm thick stainless-steel plate and shall be stiffened by structural members so that it is flat without undulation so that the tips of the rake's teeth ride at a distance between 1 to 2 mm over the dead plate. The dead plate shall be securely fastened to the side frames.

v. A Discharge chute shall be provided that fully encloses the discharge section of the screen. An access hatch with hinges and a handle shall be provided in the chute permitting easy access. The discharge chute shall be mounted to direct screenings into the appropriate receiving container or conveyor. The chute shall have a slope of a minimum of 45 degrees. The discharge chute shall be made of a minimum 2.5 mm thick stainless-steel plate.

vi. The frame shall be provided supporting all required loads. Side frames shall be made of at least 4 mm thick 304 stainless steel plates with a minimum of four axial edges.

The side frames shall be connected with each other, through channels having a minimum thickness of at least 4 mm and a minimum cross- section of 108 X 49 mm. The side frames shall be connected to support frames. The support frames shall be securely anchored onto the operating floor.

vii. The screen shall be provided with easily removable, sufficiently, stiffened covers made of 1.5 mm thick stainless-steel plates with edges on all sides. The covers shall be provided with turn locks and handles.

viii. Each side frame shall include separate roller tracks to guide the rakes. The roller tracks shall be bolted to the frame so that they can easily be replaced. The roller tracks shall be made of 4 mm thick L-profiles.

ix. The 4 mm thick neoprene strips shall be fastened to the side frames to seal the lateral gaps between the side frames and the channel walls.

x. Drive chains for the rakes shall be roller-type chains and be made of SS 304. The drive chains, chain guides, sprockets and their bearings shall be replaceable without removing the screen from the channel.

xi. Each screen shall be provided with four sprockets with a reference diameter of 327 mm.

xii. Rakes shall include rake bars made of 6 mm thick channel profile having a cross section of 110 x 86 mm

xiii. The rake blades shall have teeth matching and engaging the bars of the bar rack. The rake blades shall each consist of several pieces with teeth such that only one piece needs to be replaced in case that a tooth should be damaged.

xiv. A pivoting scraper mechanism shall be positioned at the point of discharge and shall be attached to the side frames. The scraper shall clean the rake on each pass and return to its resting position with minimal shock. The scraper shall be designed such that screenings do not wrap around the rake or scraper. The scraper shall be provided with a scraper bar made 3 mm thick channel profile with a minimum cross section of 40 x 70 mm and an adjustable 10 mm thick wiper made of polyethylene. The scraper shall be connected with the frame through a pair of minimum 500 mm long scraper arms that shall be made of at least a 4 mm thick channel profile with a minimum cross-section of 68 x 59 mm.

xv. A pair of shock absorber elements made of neoprene shall be provided.

xvi. The drive shaft shall have a diameter of a minimum of 80 mm and a wall thickness of a minimum of 4.8 mm.

xvii. The drive shaft includes an integral rocker arm assembly on the drive end that flexes if the screen rakes get jammed.

xviii. The rocker arm assembly shall consist of a drive unit mounted to a stainless-steel arm. The stainless-steel arm will be held in place by a flanged roller bearing connected to the drive shaft and two heavy-duty tension springs. The flange bearing shall be connected to the rocker's arm by four bolts. The rocker arm shall be maintained in the standard operating position by the two tension springs. If the

screen rakes experience a jam, the force will cause the rocker arm to rotate around the drive shaft, compressing one of the tension springs. This motion shall be limited by a rocker guide. When the rocker arm rotates out of the normal operating position a proximity sensor will send a signal to the PLC causing the motor to enter a self-cleaning mode. If the self-clearing mode should prove unsuccessful then the system shall initiate an alarm signal

xix. All stainless-steel parts must be completely passivated and submerged fully in the Pickling Bath.

xx. The motor can be equipped to run on frequency converters; therefore, can adjust the speed of the rakes to meet the necessary screenings conveying capacity.

xxi. Rake screens must use stainless steel covers as a standard.

xxii. The rake screen bar rack is put together with segments. A segment has a higher stiffness instead of a single bar. In case of damage, only the damaged segment must be changed, not the whole bars rack.

xxiii. The rake screen should be with the front rake system with a number of rakes considering channel depth.

xxiv. The rake-assembly shall be driven by an electric motor. The motor shall be rated for operation in a 50- degree Celsius environment. The motor should be of IP 65 protection type.

xxv. Screen construction should be such that, it should mount only on top of the channel wall. The frame will rest on the special supports installed on the wall along the depth of the channel. In case of maintenance, the screen should be able to be lifted out from the top with a crane. No personnel should go inside the screen chamber for any type of maintenance or repair work.

1.14.2.5 General

i. Mechanical Bar Screens should be fixed bar types that capture the debris with a minimum clear spacing between the bars no greater than 50 mm for the Coarse Screen, 10 mm for Intermediate Screen and 6 mm for fine screens.

ii. The Screen should be mechanically operated and suitable for installation in the screen channel, for removal of floating wastes coming along with sewage. The screens should be capable of screening out most of the medium and large floating materials such as plastic bags, floating debris, weeds, paper wastes, clothes, and rags etc. which are generally clogging the impellers of the pumps/equipment installed downstream of the screens.

iii. The mechanical screen should be sturdy against full blockage from waste and high force of water acting on the complete mechanical screen, the design of the mechanical screen should withstand all conditions.

iv. The operation of the screen shall be automatic through the timer. An ultrasonic-type differential level sensor shall also be provided to sense the head loss through the bar and give the signal to the travelling raking mechanism to start/stop its operation.

v. A complete electrical control system shall be supplied with each screen and shall be mounted independently, near to the screen installation. The system shall provide for total automatic operation of the screen with feedback from the level controller.

1.14.2.6 Fabrication and design features

i. Use a power grinder to dull and produce smooth edges.

ii. Use bolted field connections. Field welding will not be allowed.

iii. Design all components for continuous 24 hours per day service.

iv. The screen shall be constructed so as to mechanically remove the waste from the bottommost portion of the bar, using a travelling type multiple raking mechanism without shutting the water flow through the screen. The raking mechanism shall then travel up to the top of the operating platform and automatically discharge the waste through a discharge chute.

v. The screen shall have protection against overload conditions, which otherwise might damage the equipment.

vi. All screens shall be constructed and shipped as an integrated product comprising of frame structure and guides, rakes, dead plate, cog wheels/sprockets and chains, discharge chute & drive unit.

vii. The screen shall be supplied factory-assembled and duly tested at the manufacturer's works before dispatch. This integrated and factory-assembled screen shall involve minimum dismantling and assembly at site for erection.

viii. Upon receipt at the site the screen shall be installed resting on the channel floor and mechanically or chemically anchored to the parallel sidewalls of the channel (without making grooves in concrete or breaking open the concrete side walls and thereby weakening the civil structure) in a way that there are minimum chances of misalignment.

ix. All parts shall be designed to withstand the stresses that will be imposed upon them during handling, shipping, erection, and operation.

x. All stainless-steel fabricated materials will be pickled and passivated before dispatch to remove ferrous contamination, if any.

The screens should be of Stainless-Steel material to withstand the corrosive and aggressive sewage environment hence the screen manufacturer is expected to follow the best manufacturing practice mentioned hereunder to further eliminate the possibility of corrosion of the screen in such a corrosive atmosphere:

i. The manufacturer must have a quality system i.e. ISO: 9001-2015 in place to ensure the quality of the end-product.

ii. The screens should be manufactured in a stainless-steel clean area i.e. in a plant where no ferrous material is cut welded or handled. This is required to ensure that no ferrous contamination/pickup takes place because the stainless-steel surfaces subjected to ferrous pick-up get corroded.

iii. Further to this as an additional precaution the manufacturer of the screens must have the facility for Pickling and Passivation to remove any ferrous contamination that might have taken place during the manufacturing/handling/movement of raw and fabricated material.

iv. As screens are fabricated items hence to ensure the best workmanship. The screen manufacturer must have welding PQR, WPS & Qualified welders as per ASME Section 9.

1.14.2.7 Material of Construction & Specification:

All parts of the screen including fixed bars, rakes, screen frame, guide rails, dead plate, link type roller chains & sprockets, Cogwheel/sprocket, and discharge chute shall be constructed from stainless steel material grade Minimum SS 316 for long life in aggressive sewage environment. Suitable measures shall be taken to ensure the long life of the parts.

i. The bars shall be of flat profile having minimum 10 x 50 mm size with an average bar spacing of 10 mm.

ii. The bar rack shall be firmly anchored to the channel floor and supported by a dead plate at the top.

iii. The rake shall be made of Stainless-Steel SS 316.

iv. The complete screen frame shall be constructed with 4mm plate stainless steels of suitable grade.

v. The drive chain for the rakes shall be a link-type roller chain with a minimum breaking load of 63kN and made of stainless-steel grade AISI 316. This is very essential considering the highly corrosive sewage atmosphere.

vi. Drive chains, chain guides, sprockets and their bearings shall be replaceable without removing the screen from the channel.

vii. To effectively remove the debris from the bottommost portion of the screen, the screen shall be provided with a curved structure at the bottom of the screen.

viii. The dead plate shall be a of minimum 2 mm thick in stainless steel and shall be suitably braced to ensure rigidity and prevent caving/bending due to increased water flow in monsoon.

ix. The upper sprocket bearing shall be re-greaseable and flange-type.

x. Lower bearings shall be made of non-re-greaseable special ceramic bushes or better.

xi. The screen should have an integrated scraper for discharging the screenings to the discharge chute. The scraper/wiper shall be cushioned during travel to the rest position.

xii. The rake mechanism should be operated by a geared motor and suitable for automatic operation, controlled by a level sensor and an electric control cabinet.

xiii. A torque switch should be provided to protect the screen from damage resulting

from excessive torque.

xiv. After fabrication and assembly, the stainless-steel parts and all welded joints are to be further cleaned by acid pickling, and after that, they should be passivated to remove any ferrous contamination that might have taken place during manufacturing/handling/movement of raw and fabricated material.

1.14.2.8 Level Sensor

The level sensor shall be of ultrasonic differential type shall be provided.

1.14.2.9 Electrical motor

The drive shall be a Geared motor and the motor shall be of TEFC type with IP 55 protection & Class F insulation and be suitable for operation on 3 phase, 415V+/- 10%, frequency of 50 Hz+/- 5% and IE3 class efficiency as a minimum.

1.14.2.10 Control Panel

The control panel shall have IP 65 protection, be powder coated and shall be comprised of

- Mushroom head emergency stop.
- Overload relays for motor protection.
- PLC Circuitry to operate the screen with differential type ultrasonic level sensor.
- Selector switch to operate the screen in Auto, off and JOG mode.
- Provision to run the screen on a timer in case of failure of the level sensor.

1.14.2.11 Shop Testing

The screen must be completely manufactured and subsequently offered for inspection at the plant of the manufacturer only. A screen assembled by a vendor and offered for inspection at the plant of a vendor / sub- contractor shall not be accepted. The screen shall be subjected to the following tests at the manufacturer's premises before dispatch:

1. **Dimensional Check:** Important dimensions of the screens are to be verified with respect to the approved G.A. drawing.
2. **Operational Test:** The complete screen including its carriage, rake, drive system and motor shall be mechanically operated and tested in dry condition to verify interference-free movement and satisfactory operation.
3. **Positive Material Identification (PMI) test:** To ensure that Screens are made of Stainless-Steel Grade SS 316 positive material identification (PMI) test is to be conducted for all important screen components like Bars, Frame, Dead Plate during inspection and PMI reports to be submitted to client/corporation along with joint inspection report.
4. **Dye Penetration test:** Dye penetration test to be conducted at random to check the soundness of welding joints during the inspection. Both the Procedure as well as person conducting the dye penetration test should be certified by the outside agency as per relevant standards.
5. **Review of test certificate:** Material test report/certificate, Motor certificate, and Control

Panel certificate are to be offered for review during the inspection.

6. **Review of WPS, PQR & Welder's qualification certificate:** To be offered for review during the inspection and a copy of same is to be submitted to the client/corporation along with a joint inspection report.

1.14.3 Mechanically Operated Fine Bar Screen (Dip & Drop Type)

Mechanical Bar Screens should be fixed bar type, that captures the debris with a minimum clear spacing between the bars no greater than 6 mm for Fine Screens. The Screen bars should be selected/designed such that the deflection of the bar under normal operating force does not exceed 1.5mm. The bars should extend to at least 300mm above the liquid depth at peak flow in clean condition. Above this height, a dead plate of no less than 3mm should be provided up to the debris discharge height.

Debris accumulated on the bars should be carried to the discharge point with the help of a CAM-actuated, spring-loaded, bucket-mounted, polymer comb which will actively engage with the parallel bars and comb out the lodged debris. The Raking Mechanism should be driven by Transmission Roller Chains conforming to ASTM B29.1 or ISO 606. No part of the chain, sprocket, shafts, or bearings should under any circumstance get submerged while the Liquid depth in the screening channel is equal to or less than the designed peak flow when the screen is in clean condition.

Use of Rollers, Conveyors, and Chains should be avoided under all circumstances since they are highly prone to fibrous material pick-up, which leads to frequent breakdowns, due to chain breakage, caused by jammed rollers, and adding unnecessary torque to the screen mechanism.

The Movement of the raking comb should be such that the comb descends in an open condition with the teeth of the comb always pointing towards the bar and upon reaching the bottom of the screen bars, the comb should close shut with a force of no less than 300 N/m of channel width while commencing the upward stroke.

On reaching the discharge point, the debris should be unloaded from the bucket, preferably without using a scraper mechanism that tends to malfunction when larger, rigid debris is present in the bucket/comb. The collected debris should be dumped into a fully enclosed discharge chute. The raking comb should continue to the next combing cycle without reversing. This sequence of motion should be performed by the screen with mechanical means, such as fixed-setting cams and linkages.

The screen should be fully enclosed such that no damage can be caused to the screen by rogue debris. Motors, gearbox and bearing blocks should be contained within the enclosed screen while offering them easy access for maintenance.

The screen should be operated by a PLC-based local control panel with the following features.

1. Three primary operation modes should be present.
    a) OFF mode, where the screen will be shut and will not operate under any circumstances.
    b) Manual Mode, where the screen operates continuously without stopping unless

there is an error detected in the system.

1. Auto Mode where the screen stops in the parking position after each combing cycle and moves to the standby mode for the duration of the pre-set time unless the High Liquid level is detected, in which case the screen automatically shifts to the Manual Mode described above until the error is resolved. However, if errors are detected in the system in this mode, the screen will shut down.
2. Maintenance mode, which is activated by a separate maintenance key which hands motor control to a push button. This is required so that the screen can be inched into an ideal position for lubrication during maintenance.
3. An emergency stop mushroom switch is provided.
4. Warning hooters and status indication LED lights should be provided and programmed to function as described in the operation manual.
5. The PLC can detect and report malfunctions such as

a) Motor Overload

b) Input Power Error

c) Emergency Stop Activation.

d) Limit switch error.

The LCP can communicate using SCADA with the MCP and communicate the status of the screen, errors if any. The MCP will be able to communicate with the LCP and override the primary operation modes required.

1.14.4 Drum Screen (Ultra Fine Screen)

1.14.4.1 General Design Requirement

a) The automatic dram screen shall be composed of a screen, screw conveyor, washing unit, dewatering unit, and drive unit. etc.

b) The automatic dram screen shall have a2 mm opening and shall be used to block, scrape, wash, and dewater the suspended solid or scum in the influent or sludge.

c) This equipment shall be designed with sufficient safety factor in strength,

d) This equipment shall be of integrated type and constructed, such that it can be easily installed.

e) The difference in water level, the characteristics of the suspended solid, and the flow rate shall be considered in the design.

1.14.4.2 Fabrication

a) Drive unit:

   i. Cycloidal reduction gear or worm reduction gear shall be used as a drive unit. The drive unit shall transmit the power, by means of gear transmission or direct connection with coupling.

   ii. Gearbox shall be provided in case of gear transmission,

b) Screen:

i. The screen shall be made of a cylindrical stainless-steel drum. The screen shall have a smooth finish to prevent the attachment of screenings and shall be arranged with equal spacing.

ii. An electrical pole shall be installed in front of the screen to detect the overflow and control operation.

c) Rake:

i. The rake shall be connected with the screw conveyor along the same axis and shall rotate with it. The raked screenings shall be scraped down into the screw conveyor by the scraper.

ii. The rake shall be constructed such that the screenings never remain on the screen after raking.

d) Screw conveyor:

i. The impeller and shaft of the screw shall be a welded structure of stainless steel and shall endure the inclined stress,

ii. A dewatering device shall be provided at the upper portion of the screw conveyor, The dewatering device shall be sealed and shall have sufficient strength to endure the pressure of screenings and scum. The inspection hole and washing water pipe shall be provided for the dewatering device. The inspection hole shall permit easy inspection, and the washing water pipe shall be used to wash the casing for filtrated liquid,

e) Shaft and bearing:

i. The shaft of the screw shall be made of stainless steel and shall have sufficient strength to endure the incurred stress.

ii. The submerged bearing shall be an oil-less enclosed pneumatic type. For a bearing, installed above the water level, an automatic oiling device shall be provided.

f) Washing unit:

i. Washing nozzles shall be provided at the inlet of the screw conveyor in order to wash down the screening or scum with pressurized water.

g) Chute:

i. A stainless-steel chute shall be provided at the discharge part of the screw conveyor. The chute shall be constructed such that the screenings are blocked from being discharged.

1.14.4.3 Material of Construction

Screen	: Stainless Steel AISI316
Rake	: Stainless Steel AISI316
Screw conveyor	: Stainless Steel AISI316

Chute : Stainless Steel AIS1316

1.14.4.4 Protection Equipment

a) Mechanical protection: For cycloidal reduction gear, a built-in torque limiter shall be provided,

b) Electrical protection: An over-current detector with an instantaneous converter shall be provided in case mechanical protection is not provided.

1.14.4.5 Screen Electrical Equipment and protection monitoring equipment.

a) Electrical equipment shall conform to the Electrical Specifications

b) When equipment is located in a hazardous area, the equipment must be approved and certified for use in the applicable hazardous area classification.

c) Provide all necessary electrical components and wiring for a complete, functional system. Electrical components shall be provided in accordance with the electrical requirements. Where required, all electrical components shall be rated for hazardous areas. Hazardous Classification for Liquid Facilities. Component assemblies will include the following, but not limited to:

   i. Gear motor drives.

   ii. Control panels.

   iii. Non-fused disconnects.

   iv. Electric valves.

d) Unless specified otherwise, each screen shall be supplied with the manufacturer's proprietary local control panel incorporating stop/start/inching/reverse control functions as appropriate and in accordance with the ICA Specification.

e) Drive systems shall include a torque overload protection device, which will prevent mechanical damage in the event of the unit being jammed. The torque overload device shall auto-reset after the screen has stopped ready for manual restart of the drive. The torque overload device output shall be suitable for control and monitoring. Electronic shear pins or a similar system can be proposed and shall be approved by the engineer.

f) Thermal protection shall be provided for the motor overheating / short circuiting/signal phasing.

g) Limit switch shall be provided for screen mechanism over travel protection if necessary (i.e. Top travel limit stop out of flow switch/ bottom travel limit switch / over travel top limit switch).

h) All electrical connections to control devices such as integral switches, solenoids and instrumentation shall be made to a single terminal box, housed on the screen structure. The terminal box shall be fully complied with Electrical and ICA specifications.

1.14.4.6 Screen Local Control Panel

a) Control panel and motor starters shall be provided as part of the package, in compliance with Electrical and ICA specifications.

b) The system shall be robust and permit simple, easy disassembly and reassembly of any pieces which must be removed to service the screen, washer or compactor, such disassembly and reassembly shall not require any special tools or the removal of surrounding components.

c) All wiring, cabling, conduit, electrical plant and equipment, motors and installation shall be in full compliance with Electrical Specification.

1.14.4.7 Screens Instrumentation and Controls

a) All instrumentation and control components provided under this Section shall be in accordance with ICA Specification.

b) PLC and instruments shall conform to the relevant section of ICA specification PLC and instruments shall conform to the relevant section of electrical specification.

c) The equipment supplier shall provide all functions and associated equipment as necessary for the proper operation of the systems.

d) The sensor shall be capable of operating in temperatures from +10oC to +60oC and shall be impervious to submersion and shall have a high resistance to corrosive atmosphere.

e) The screen shall be operated in conjunction with wash & compactor system, screening conveyor, and penstocks as well as associated instruments. The integrated operation may be controlled with a plant PLC controller (by others) or the screen equipment package's PLC controller hosted in a Local Control Panel (LCP).

f) The minimum requirement for the Local Control Panel (LCP) shall be as follows:

   i. IP 65, Large Stainless-Steel Box, enclosure with suitable protection for housing in the location.

   ii. Local-Off-Remote selector switch for each drive.

   iii. Front panel mounted indicator lights for power on, motor run and trip (for each motor).

   iv. Forward-Off-Reverse switches.

   v. All other relays, switches and wiring necessary for screens and washing compactor operation.

g) Provide the following protection monitoring as a minimum: -

   i. Provide forward/automatic/reverse switches on each drive to allow manual reversing.

   ii. Provide hard-wired overload relays to shut off the drive in the event of jamming.

   iii. Provide hard-wired torque switches to shut off the drive in the event of jamming.

1.14.4.8 Condition Monitoring

a) In addition to the condition monitoring requirement stated in the Electrical and ICA Specifications. The following shall also be provided: -

i. Above pre-set high-pressure differential.

ii. Screen low wash water pressure.

b) Indicating lights and switches shall be provided in LCP as follows:

i. Screen in operation (locally and in LCP).

ii. Power on-off light (local only).

iii. Alarm conditions (locally and a common alarm to LCP).

iv. Emergency stop push buttons at the screen's LCP.

1.14.4.9 Site Testing

a) Prior to site testing, the Contractor shall provide the services of a qualified manufacturer's technical representative, who shall adequately inspect the installation and test the equipment furnished under this contract and instruct the Client's operating personnel in its maintenance and operation. The manufacturer's Certificate of Proper Installation Compliance report shall be submitted to the engineer for approval before any test commencement on site.

b) he screens shall be site tested after erection in the presence of the engineer and manufacturer's representative to confirm and verify the structural and mechanical compliance to the requirements specified. The site acceptance test shall include a demonstration that the screens operate continuously without vibration, jamming or overheating and perform their specified functions satisfactorily.

c) All labour, materials, and test apparatus necessary for conducting the field acceptance tests shall be furnished by the Contractor at no additional cost to the Employer.

d) A test shall be conducted on each unit and shall include the following as a minimum:

i. Before facility start-up, test complete assemblies for correct rotation, proper alignment, unobstructed movement, and connection.

ii. The electrical system shall be tested in accordance with electrical specifications.

iii. Leakage test for all pipework, joints, fittings, and hydraulic power packs.

iv. Measurements of temperature rise of the hydraulic fluid and power consumption of relevant plant and equipment.

v. Verification of reliable and smooth operation of the screen and all associated ancillary equipment i.e. pressure relief valves, pressure gauges etc.

vi. Test for a continuous 3-hour period under actual or approved simulated operating conditions without malfunction. If failure occurs, adjust, realign, and/or modify units as approved by the Engineer and retest if necessary.

vii. Upon completion of the test, test results shall be submitted to the Engineer for approval.

1.14.4.10 Tests on Completion

The screen assembly shall be subject to a complete commissioning procedure with the following additional requirements as a minimum.

i. 24-hour continuous operation before being put into operation.

ii. Smooth operation of all rotating bars ensuring no signs of fouling or resistance local to the top/bottom bearings of the hydraulic drive motors.

iii. Check for leakage from the hydraulic power pack and associated pipework, joints and fittings.

iv. Check temperature/consumption according to the data sheets.

v. Check the energy consumption provided by the supplier.

vi. All pipework restrained where necessary to avoid excess wear and tear leading to failure of flexible hoses caused by abrasion.

vii. Verification of reliable and smooth operation of all ancillary equipment associated with the hydraulic power pack, i.e. pressure relief valves, pressure gauges etc.

1.14.4.11 Screening Conditioning System

This specification covers the general requirement of the performance, design and construction of the screening treatment equipment in used water (wastewater) applications with all relevant statutory regulations and the latest edition of all relevant international, harmonized European and British standards and Indian standards and codes of practice.

The specification covers the following type of compactor equipment:

- Dewatering Compactors; and
- Washing Compactors.

1.14.5 General Layout Arrangement

The Contractor shall propose the general layout arrangement, taking into consideration the manufacturer's recommendation and the installation requirements, to ensure that a complete and functional system has been installed. The layout shall be subject to the approval of the engineer.

1.14.5.1 Design Specification

a) The performance, design, construction, and testing of the equipment shall comply with all relevant statutory regulations and the latest edition of international and Indian Standards.

b) The equipment and associated plant and instrumentation shall be suitable for the site location, environment, and operation condition.

c) The equipment shall effectively handle the screenings from the influent flow and shall be capable of automatic operation for long periods without operation personnel's attention under all weather conditions. The plant shall be robust and reliable in

operation.

d) The equipment shall be capable of withstanding high quantities of grit without excessive wear.

e) Unless otherwise specified in the specification, the process performance of the equipment (i.e. screening quality) is measured in terms of the reduction in volume, moisture content and BOD of the treated screenings, compared to the raw input screenings.

   i. Manufacturer shall state the following performance criteria in their equipment datasheet: -Screening's volume reduction (%)

   ii. Screening's moisture content reduction (%)

   iii. Average %DS (treated screenings) (%)

   iv. Average BOD (treated Screening) (Mg/l)

f) The plant noise level shall not exceed 85 dB(A) at a distance of 1.0 meters from the equipment center line (based on the equipment being mounted in semi-reverberant/free field conditions). An acoustic hood or cladding shall be provided, if necessary, to meet the noise level.

g) The weight of the individual components over 25 Kgs, that are likely to be removed for maintenance, shall either:

   i. Incorporate identified, permanent lifting points to give a safe balanced lift.

   ii. Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.

h) With respect to item (i) above, if lifting points are not designed for lifting the complete component, they shall be marked accordingly.

i) The compactor shall be fitted with lifting eyes for removal as a complete unit.

j) The compactor shall be designed such that operations personnel do not have to remove screenings from the screens unless otherwise specified.

k) The compactor shall be supplied with stainless steel or GRP covers. Hinged or removable sections shall be incorporated into the cover to allow easy access for maintenance without compromising operator safety.

l) The ingress rating of all exposed components which may be subjected to aggressive washing by hose from the wash water or cleaned from a steam cleaner with a degreaser additive, shall be minimum rated at IP 65.

m) All types of compactors shall be capable of operating in manual or automatic mode.

1.14.6 Screenings washer/press and discharge chute shall be provided complete as a unit.

a) Materials selection

i. The material of the plant and equipment and its associated components shall be suitable for the site location and operation environment. A corrosion protection

system shall be provided and submitted to the Engineer for approval.

ii. All assemblies and anchor bolts, nuts and washers shall be 316 stainless steel, as a minimum.

b) Support structure.

i. Support structure shall be of a robust design and adequately braced to ensure rigidity under all operating conditions.

ii. Support structures shall be constructed from corrosion-resistant materials or protected against corrosion by the application of paints or protective coatings.

iii. Support structures shall be locally reinforced around foundation bolt holes.

iv. Support frames shall be fabricated to withstand equipment and material loads.

v. Support frames shall be fabricated to be installed on the concrete floor or wherever indicated on the structural steel.

vi. All sharp corners of all cut or edges shall be smoothed, by a power grinder.

vii. All metal fabrications (i.e. frames, support structure etc.) shall be designed to prevent moister traps and collection of liquids and debris and, if appropriate, facilitate the application of paint system and protective coatings.

viii. The end of all mild steel sections shall be sealed, to prevent ingress of liquids, after corrosion-resistant coatings.

ix. The galvanizing shall comply with BS EN ISO 1461.

x. All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in used water shall be made of stainless steel 316, unless otherwise specified. If stainless steel is unsuitable for use, an alternative corrosion - resistant material shall be proposed for approval by the engineer.

c) Drive Systems

i. All drive system components (e.g., motors, gearbox, drive shafts etc.) shall be adequately supported.

ii. All drive shaft assemblies shall be designed for ease of maintenance.

iii. A protection system shall be provided to protect against jamming and other mechanical overloads. The motor shall be automatically tripped in the event of an overload.

iv. All drive components shall be adequately supported so that fatigue or stress does not occur.

v. The drive system shall be provided with a local inching facility, to release blockages.

vi. All electrical switchgear emergency stop switches and local control stations shall be as per the Electrical and Instrumentation and control specifications.

vii. The compactor drive until mounted at the bottom of the inclined screw trough and

shallbe enclosed.

viii. The compactor shall be directly driven by an electric motor coupled to a shaft-mounted gearbox.

d) Bearings and Lubrication

i. Equipment component combinations that are likely to come into contact and be subjectto relative motion shall be adequately lubricated or manufactured from materials with self- lubricating properties.

ii. Bearings shall be conforming to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

iii. Rolling element bearing shall be rated for a minimum L 10 life expectancy of 50,000 hours while operating at maximum load.

iv. Bearing housings or assemblies shall be provided with seals and self-aligning features, if appropriate, to prevent the ingress of dirt and water and/or accommodate misalignment.

v. Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.

vi. Where sealed-for-life bearings are not provided, Automatic grease dispensers shall provide a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender.

vii. Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safely accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.

viii. The requirement for lubrication pipework shall be as follows, as a minimum.

ix. It shall be 316 stainless steel or if greater flexibility is required, a suitable polymeric material shall be proposed, for approval by the engineer.

x. It shall be a minimum bore of 6mm and a maximum length of 2 m.

xi. It shall be adequately supported to prevent excessive sagging or distortion, and if necessary, be protected against vibration (e.g. vibration loops)

xii. Where sealed-for-life bearings are not provided, the method of bearing re-greasing shall be proposed for the Engineer’s approval. Lubrication points on bearing housing containing sealed-for-life bearings shall be fitted with caps to prevent inadvertent bearing re-greasing.

xiii. Automatic grease dispensers shall provide a clear indication of grease contents. The supplier shall provide the first fill of lubricants to all components/systems requiring lubrication. All bearings and lubrication pipework shall be fully charged with grease.

xiv. Alemite grease fittings or equivalent shall be provided at locations accessible from the operating floor for the lubrication of all moving parts of the compactor.

e) Gears and Gear Drives

i. Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured by AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L 10 bearing life of 100,000 hours and a minimum efficiency of 94 per cent.

ii. Gear speed reducers or increasers shall be of the enclosed type, oil- or grease-lubricated and fully sealed, with a breather to allow air to escape but keep dust and dirt out. The casing shall be made of cast iron or heavy-duty steel construction with lifting lugs and an inspection cover for each gear train. An oil-level sight glass and an oil flow indicator shall be provided and installed for easy reading.

iii. Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.

iv. Material selections shall comply with AGMA values and the manufacturer's recommendations. Input and output shafts shall be properly designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shall have two positive seals to prevent oil leakage.

v. Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and/or oil level indicator. The oil level and drain location shall be readily accessible.

vi. The oil filling and drain points shall be designed so that the oil can be easily drained and replaced, without spillage.

vii. Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply a matching key.

viii. The gearbox type, number of stages, manufacturer, service factor and final drive ratio shall be stated in the submitted date sheet.

ix. All gears shall run in oil, and oil pans shall have means for filling and draining the oil,without dismantling any of the screen components. Bearings:

Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

Except where otherwise indicated, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.

a) Guarding and covers

i. The screen shall be fitted with all necessary guarding and covers and shall be 316 stainless steels as a minimum unless specified.

ii. Guarding shall comply with BS EN ISO 12100 and BS EN 953 or equivalent.

iii. If access is required to components for process correction or maintenance, mobile guards shall be used if the foreseeable frequency of access is high. Movable guards shall be interlocked in accordance with BS EN 1088 or equivalent.

iv. Components that may require regular access to maintenance or condition monitoring shall be accessible without removing guards by means of access door or access hatches with padlocking and stainless steel, quick-release fixings.

v. All equipment shall be “locked out” to prevent automatic starting before any covers, or guards are removed.

b) Odour Containment

i. A suitable flanged connection to odour control ducting system shall be provided unless specified otherwise.

ii. A hinged panel shall be provided if specified. It shall be easy of access for inspection and maintenance. The hinged panel shall be airtight to prevent odour air escape and shall be interlocked with motors.

iii. The containment cover/ panel shall fully comply with the general specification Odour Containment Cover.

1.14.7 Dewatering compactors

The design of the screw compactor shall be such that the compacted screening materials shall have the following % reduction as a minimum:

a) Moisture reduction by 50%,

b) Volume reduction by 70%

c) Weight reduction by 65 %

The screw compactor shall consist of an inlet zone, compacting zone and discharged zone.

The screenings shall enter the inlet hopper where it is may be washed and then transported and compressed by the screw conveyor and discharged. As the screenings are compressed, the liquid drains out and discharges back to the inlet channel.

a) The dewatering compactor shall incorporate facilities to allow effective drainage if wash water (if required) and liquid is generated in the compaction zone.

b) The inlet zone.

i. The inlet of the dewatering compactor shall be designed to accommodate screening volumes higher than the transportation capabilities of the conveyors which feed the compactor. An access cover shall be provided in the inlet for maintenance purposes or the manual clearing of blockages.

ii. The inlet zone shall be designed suitable for the inlet hopper for receiving the screening materials.

iii. Spray system to wash the screenings shall be provided at the inlet zone, if required and shall be fitted before the compaction zone.

iv. Unless otherwise specified, the sheet steel components of the screw compactor

shall be stainless steel 316 as minimum.

c) Drainage and Compactor zone

i. As the screw rotates it conveys screenings up to the compacting zone. As the screw rotates the material, gravity and the surface friction react to force the water from the screenings. All water content shall be discharged back to the headwork channel.

ii. The screw conveyor shall provide all motive force necessary to push the compacted screenings material through to the discharge chute.

iii. The screw conveyor shall not extend into the screenings discharge chute.

iv. The screw conveyor shall be a helical shaft screw and shall be designed to withstand the subjected torsional forces impose during the operation condition.

v. The screw conveyor shall be in bi-directional rotation to remove any blockages.

vi. The screw conveyor shall have easily replaceable bearing shoes on the leading edge which shall support the screw through the trough and keep drain holes clean.

vii. Lower bearing shall be enclosed in a watertight assembly suitable for submerged operation in grit service and the bearing life shall according to the general requirements as above.

viii. The bearing shall support the screw through the trough and keep drain holes clean. The bearings shall be designed to withstand the thrust forces imposed.

ix. Local inching facility shall be provided for release blockages.

x. A local control panel shall be provided and shall be fully in accordance with Electrical specifications.

d) Conveying zone

i. Compacted screening material shall be automatically discharged from the discharge chute and the screening silo for disposal off-site.

ii. The discharge chute shall be designed and suitable for discharging the compacted materials to the conveyor for disposal off-site.

e) Wash water system.

i. If specified, a wash water connection and spray bar shall be provided before the compaction zone to improve the separation of fecal solids from the screening materials.

ii. The pipework and nozzles shall be 316 stainless steel and incorporate sufficient unions to allow easy dismantling for maintenance and replacement.

iii. Plant water (Wash water) supply pipes with a suitable non-clogging stainless-steel nozzle shall be provided for washing the screen trays. The nozzles shall be arranged to direct fan- shaped, overlapping sprays across the full width to ensure full washing of the trays. All pipe works and fittings shall be of stainless steel.

iv. Nozzle diameters shall be sized adequately and suitable for the specified wash water supply to prevent blocking.

v. Auto backwash strainer/filter for the plant water (wash water) source shall be installed if necessary and required to prevent blockage of the nozzles. Auto changeover basket filter shall not be used.

vi. Spray bars shall be adequately supported and shall be positioned to minimize the accumulation of screenings on their surface.

vii. Spray bars shall be removable from the outside of the compactor's support structure to permit maintenance.

viii. The plant water (wash water) pipe shall be extended outside of the head housing and shall be fitted with a control valve. The control valve shall be a tight shut-off type suitable for flanged connections and complete with a weatherproof electric motor actuator or solenoid valve as appropriate. The valve shall be a full bore, quarter turn and shall be actuated ball valves unless otherwise specified. A suitable strainer/filter shall be provided for the wash water to avoid blockage of the solenoid valves.

1.14.8 Washing Compactor

a) The washing compactor processes the wet screening in two stages, the washing and conditioning stage, and the compaction stage.

b) The washing compactor requirement is the same as the dewatering compactor with the additional of washing and conditioning stage.

c) The washing and conditioning stage consists of a pump located in the washing conditioning which thoroughly agitates and disintegrates the screenings in the wash water so that the content of the conditioned screening material can be transferred to the compaction zone.

d) The screw conveyor shall be the same dewatering compactor as specified above. Shaftless screw conveyors are not acceptable as the shaft is required to support flight and provide necessary torque and compaction.

e) Access cover shall be provided for inspecting and rotating the bearing without disassembling the equipment.

f) The wash water system which flushes the separated organic material through the drainage basket/section in solution or as small particles or as part of the washing conditioning stage shall be in accordance with the wash water section of this specification.

g) The compacted screenings shall be pushed through the compaction zone and the dewatered screenings shall be discharged into an outlet chute.

1.14.9 Material of Construction

Mechanism Housing	Stainless Steel of 316 Gr
Raking Mechanism	Stainless Steel of 316 Gr
Screen Bars and Dead Plates	Stainless Steel of 316 Gr

Chains	Stainless Steel of 316 Gr. With hardened parts of Stainless Steel of 410 Gr
Hardened Sprockets	Stainless Steel of 410 Gr
Hardened Shafts	Stainless Steel of 410 Gr.
Welded Shafts	Stainless Steel of 316 Gr.
Bearing Housing and Motors	Spheroidal Graphite Cast Iron
Gearbox	Cast Aluminum
Guide Wheels and Comb Element	Nylon
Fasteners	Stainless Steel of A4-70 Gr. (Stainless Steel 316 Gr.)
Circlips	Stainless Steel of 410 Gr. (Hardened)

1.15 Conveyor

1.15.1 General

a) This specification covers the general requirement of the performance, design and construction of the conveyor system in used water (wastewater) application with all relevant statutory regulations and the latest edition of all relevant international, harmonized European and British Standards and Indian standards and codes of practice. This specification shall also comply with: -

   i. The specific datasheet

   ii. The relevant process specification.

   iii. The relevant Electrical specification

   iv. The relevant Instrumentation Control and Automation (ICA) specification.

b) The equipment shall be provided with electric drive, wash water spray, control panel, anchor bolts, and all accessories and appurtenances specified, indicated on the drawings, or otherwise required for a complete and properly operating installation.

c) All equipment furnished shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer unless otherwise specified.

d) The proposed conveyors shall be selected taking into consideration their suitability and fit for use in the environment and service conditions intended.

e) Should there be any conflict between the General Specification and the Particular Specification, the specific specification will take precedence, and the Contractor shall inform the engineer for further confirmation prior to the Works proceeding further.

1.15.2 Belt Conveyor

The screening conveyor shall be common or multiple numbers for the screens as per the site requirement. The conveyor system shall be a combination of a horizontal conveyor and an upward inclined conveyor (if required) and shall have the capacity to transfer the maximum screenings anticipated at the peak flow. The discharge elevation of the dropping conveyor system shall be provided. The conveyor provided for the discharge of screenings shall be interlocked with all the screenings discharging onto the conveyor so that it operates when the screenings are discharged onto it and stops automatically after a time lag when the screen stops discharging the screenings on top of the conveyor.

Numbers	One
Conveyor type	Horizontal
Capacity	To handle screenings of peak flow
Speed	15 m / minute (maximum)
Type	Troughed (600 mm wide belt)
Belt	3 ply Z duck, 3 mm top, 1.5 mm bottom, rubber cover CR M –24

a) The belt conveyor shall be complete with a flat rubber belt, carrying idlers, return rollers, head and tail drums, side guards, loading end guards adjustable support legs, etc., suitable forthe application and environment as specified in the particular specification.

b) Fixed troughed belt conveyors shall be designed and constructed in accordance with BS 8438.

c) Where mobile or portable troughed belt conveyors are required, these shall be designed and constructed in accordance with BS 4531.

d) The design load used for designing the carrying idler sets shall be on the full cross-sectional capacity of the conveyor, taking into account the belt troughing angle, media characteristics, and pitch of the carrying idler sets. This design load shall also take into account any impact loads imposed on the belt.

e) The whole conveyor system shall be mounted on a steel support frame. Metal surfaces shall be galvanized after fabrication and painted in accordance with the relevant specifications.

f) A chute shall be provided to direct media from the discharge point of the upstream process/piece onto the tail (inlet end) of the conveyor without spillage.

g) A scraper, consisting of a spring-loaded, flexible rubber blade, or other approved device shall be provided to discharge media from the head (discharge end) of the conveyor into the downstream process/piece of equipment.

h) Where inclined conveyors are required, the angle of inclination shall not exceed 300 unless otherwise specified.

i) Where specified, conveyors shall be reversible.

j) The belt shall be supported by a sufficient number of roll idlers located at the centre spacing to ensure that belt sag does not exceed 2% of the belt span when transporting the maximum transported media volume rate. A take-up device shall be incorporated at the non-drive end to adjust belt tension automatically.

k) The pitch spacing of the idlers at the loading point shall be reduced to half the normal pitch.

l) Return idlers shall be spaced at intervals not exceeding 2.0 m.

m) The carting and return idlers shall be protected against the ingress of rags, grit, dust, dirt and other debris from the media and as far as practicable.

n) Provision shall also be made in the design of the conveyor for adjustment of the tail

pulley of the conveyor to ensure the squareness of the belt.

o) The Belt

i. The belt shall be manufactured in accordance with BS ISO 251 or BS EN ISO 14890 or equivalent.

ii. The usable width of the belt conveyor shall be not less than 500 mm. The conveyor shall incorporate a troughed belt having a width and running speed sufficient to remove the maximum number of materials to be deposited onto the conveyor.

iii. The belting material shall comply with the requirements of ISO 14890 and the belt edge clearance shall be in accordance with BS 8438 and shall be oil-resistant.

iv. Where necessary, conveyors shall be fitted with side plates to ensure the materials deposited are retained on the belt. A drip tray shall be fitted below the belt to collect and return liquids to the sewage flow or site drainage system.

v. A counterbalanced scraper shall be provided at the discharge end, having a renewable rubber blade arranged to remove all materials adhering to the belt face.

vi. Where the conveyor is required to be designed for chemical powder conveyance, it shall be able to contain all the chemical powder from the chemical bags so that no chemical powder would fall from the conveyor belt onto the floor during operation.

vii. The belt speed shall be designed to match the capacity of the bag-splitting machine. However, in no circumstances a belt speed greater than 18 m/min be accepted.

viii. In the design of belt speed, the inclination of the belt conveyor shall be considered, and a slatted belt instead of a flat belt shall be used if the inclination of the belt conveyor together with the designed belt speed may render the chemical bags to slide down or tip over from the conveyor.

p) Drive mechanism.

i. The belt drive shall consist of an electric motor transmission and drive pulley. The transmission shall incorporate a reduction gearbox, directly coupled to the motor and with a chain and sprocket drive to the drive pulley.

ii. Each conveyor shall be driven by a geared electric motor which shall be integral with the head drum. The motor shall have a degree of protection of IP 55 to BS EN 60034-5 and its design shall be suitable for intermittent operation. A mechanical overload protection and anti-run- back device shall be provided.

iii. The drive pulley shall be crowned and shall comply with the dimensions specified in the appropriate British Standard.

iv. A snub pulley shall be provided to ensure adequate belt wrap on the drive pulley.

v. The internal drum drive shall incorporate a proprietary, non-slip coating on the drum to prevent slippage between the drum and belt.

q) Condition monitoring and protection.

The minimum condition monitoring and protection requirements in addition to general electrical and instrumentation and control automation specifications are as follows: -

i. Belt wear monitoring system.

ii. A belt tension monitoring system

iii. A drive system overload protection system

Unless specified, Volt-free contact shall be provided for the transmission of alarm signals.

1.15.3 Screw Conveyor

The purpose of installing a Screw Conveyor with a washer & compactor at the discharge of mechanical screens is to trap, clean & compact the debris taken out by the mechanical screen.

The spiral shall be of sufficient weight to push the screenings and robust enough to start up with the trough having screenings existent.

The operation of the screw conveyor shall be properly interfaced with the screen such that when the screen starts its operation, the screw conveyor shall also start working with immediate effect to avoid clogging the screw conveyor. It is recommended that a control panel common for screens & screw conveyor shall be provided.

1.15.3.1 General Material and Equipment Requirements:

1. Fabrication and design features:
    i. Use a power grinder to dull and produce smooth edges.
    ii. Use bolted field connections. Field welding will not be allowed.
2. The shaftless screw conveyor with washing & compaction unit shall consist of an Archimedean-type spiral driven through a helical gear, a screw trough, a water catchment tray, compression chamber, outlet chute, wash water and water return pipework and trough support legs.
3. In order to avoid direct contact between the screw spiral & trough, liners made of UHMWPE shall be provided. These liners shall be provided in 2 colour shades so that when the upper layer of liners gets worn out, the upper liner can be replaced.
4. Top covers shall be provided with appropriate openings for screenings to fall into the screw conveyor coming from the screen discharge chute.

As screw conveyors are required in Stainless Steel material to withstand the corrosive and aggressive sewage environment hence the screw conveyor manufacturer is expected to follow the best manufacturing practice mentioned here to further eliminate the possibility of corrosion of screw conveyor in such a corrosive atmosphere:

i. The manufacturer must have a quality system i.e. ISO: 9001-2015 in place to ensure the quality of the end product.

ii. The screw conveyor should be manufactured in a stainless-steel clean area i.e. in a plant where no ferrous material is cut or welded or handled. This is required to ensure

that no ferrous contamination/pickup takes place because the stainless-steel surfaces subjected to ferrous pick up get corroded.

iii. Further, to this as an additional precaution the manufacturer of the screw conveyor must have the facility for Pickling and Passivation to remove any ferrous contamination that might have taken place during manufacturing/handling/movement of raw and fabricated material.

iv. As screws conveyors are fabricated items hence to ensure the best workmanship screen manufacturer must have welding PQR, WPS & Qualified welders as per ASME Section 9.

1.15.3.2 Material of construction:

The screw spiral, trough, covers, compression chamber, outlet chute, legs, water catchment tray and trough support shall be fabricated from grade 316L stainless steel.

1.15.3.3 Screw conveyor construction:

i. Screw spiral shall be made of a minimum 16 mm thick SS 304/316L/ST52-3 (low carbon steel).

ii. UHMWPE liners shall be provided between the screw spiral & trough to avoid abrasion between them. These liners must be provided in 02 layers of different colour shades, preferably black & white. The total thickness of UHMWPE liners shall be a minimum of 12 mm with the liner facing the screw spiral shall have a minimum of 8 mm thickness.

iii. The thickness of the trough shall be a minimum of 3 mm.

iv. Top covers shall be easily removable, bolted to the trough assembly & shall have a minimum thickness of 2 mm. Covers shall have an adequate number of handles for proper lifting.

v. Screw conveyor shall incline to 2 degrees to horizontal.

vi. Screw conveyor shall have legs adjustable up to 25 mm so as to provide flexibility for civil irregularities during installation.

vii. The integral screenings washing & compaction unit shall have a series of wash spray nozzles to wash the dirt out of the screenings. Approximately 125-160 l. p. m. wash water as per the manufacturer's recommendation shall be supplied at 5 bar pressure to both, the screw trough & compression chamber and shall discharge to a water catchment tray via a pipe connection. This water shall return to the main sewage flow for screening & treatment.

viii. The discharge chute shall be equipped with spring-loaded flap covers, made in SS 304/316L.

1.15.3.4 Electrical motor:

The drive shall be a Geared motor and the motor shall be of TEFC type with IE2 efficiency class, IP 55 protection & Class F insulation and be suitable for operation on 3 phase, 415V+/- 10% and frequency of 50 Hz+/- 5%.

1.15.3.5 Shop Testing:

The screw conveyor must be completely manufactured and subsequently offered for inspection at the plant of the manufacturer only. A screw assembled by a vendor and offered for inspection at the plant of a vendor / sub-contractor shall not be accepted. The screw shall be subjected to the following tests at the manufacturer's premises before dispatch:

Dimensional Check: Important dimensions of the screw conveyor are to be verified with respect to the approved G.A. drawing.

Operational Test: The complete screw conveyor including its screw spiral, drive system and motor shall be mechanically operated and tested in dry condition to verify interference-free movement and satisfactory operation.

Positive Material Identification (PMI) test: To ensure that Screw conveyors are made of Stainless-Steel Grade SS 304 positive material identification (PMI) test is to be conducted for all important screw conveyors components like screw spiral, and trough during the inspection and PMI reports to be submitted to client/corporation along with joint inspection report.

Dye Penetration Test: A dye penetration test is to be conducted at random to check the soundness of welding joints during the inspection. Both the Procedure as well as person conducting the dye penetration test should be certified by the outside agency as per relevant standards.

Review of test certificate: The Material test report/certificate and motor certificate are to be offered for review during the inspection.

Review of WPS, PQR & Welder's qualification certificate: To be offered for review during the inspection, and a copy of the same to be submitted to client/corporation along with the joint inspection report.

1.15.3.6 Layout

The Contractor shall propose the layout area together with the manufacturer's layout drawings, and installation requirements to ensure proper installation subject to the approval of the engineer.

1.15.4 Design Requirements

a) The equipment shall be able to convey sludge, screenings, slurry, or any other media in a neat, quiet, dependable, and nuisance-free manner as specified.

b) The equipment furnished shall have adequate capacity to convey the specified quality of materials without failure.

c) The maximum capacity of the system shall exceed the peak loading design capacity to avoid any overflow or over-spillage.

d) The equipment shall be able to operate 24 hours per day, at specified operating conditions.

e) The equipment and its drives must be able to start when loaded to maximum capacity with the material conveyed.

f) When in operation, no piece of equipment shall exceed 85 dB (A) measured 1m away from the equipment.

i. Installations and equipment shall be easy to maintain and keep clean. The equipment shall be capable of withstanding a daily washdown using high-pressure water.

ii. Each conveyor shall be assembled to the greatest extent possible in the manufacturer's shop to ensure proper fitting of parts. Assembled sections shall then be match-marked for field erection and disassembled prior to shipment. Deliveries shall be shipped in the maximum shipping lengths permitted.

g) Weight for each major heaviest component shall be submitted in the tender. The lifting strategy for the maintenance and erection of these heaviest components shall be stated clearly in the tender. Components weighing over 25kg that are likely to be removed for maintenance shall either:

-Incorporate identified, permanent lifting points located to give a safe balance lift.

i. Be designed in such a way that standard lifting accessories (e.g. slings) can easily be attached.

ii. If lifting points are not designed for lifting the complete component, they shall be marked accordingly.

iii. The complete unit shall include all necessary permanent safety devices such as machinery guards, emergency stops, and similar items required by local health and safety regulations.

iv. Material selection for the conveyor system shall be according to the media characteristics and the expected service lives of the specific type of conveyor components.

h) An inlet hopper shall be provided at the feed end, and a discharge chute equal to the full trough width shall be provided at the point of discharge.

i) Electric motors and electrical works shall comply with the electrical specifications.

j) To minimize the friction and wear, conveyor component combinations that are likely to come into contact and be subject to relative motion shall be adequately lubricated for manufactured from materials with self-lubrication properties.

k) All metallic items (such as fixing and fixtures etc.), which are routinely wetted or submerged or immersed in used water, shall be made of stainless steel 316 L unless otherwise specified. If stainless steel is unsuitable for use, an alternative corrosion-resistant material shall be proposed and approved by the engineer.

l) The conveyor system shall be designed to accommodate media volumes higher than the transportation capabilities of the conveyor.

m) Access cover for maintenance purposes and the provision of a flange connection to the odour and extraction pipeline shall be provided.

n) Conveyor inlet and outlet openings shall be designed to avoid Choking and blockage.

o) Outlet slide gate shall be provided where specified in the particular specification. The slide gate shall be electrically operated with a manually operated override unless specified. The pneumatically or hydraulically actuated slide gate can be proposed to the

Engineer for approval. Limited switches shall be provided for the actuated gate.

1.15.5 Supporting Structure and Frame Structure

a) The conveyor shall be of high quality and robust design for construction which, as a whole, will ensure satisfactory operation at all times under the conditions specified.

b) There shall be no projecting set screws or other parts to endanger workers. All devices required for compliance with local safety laws shall be provided.

c) Sharp corners of all cut or sheared edges shall be smoothed by power grinders.

d) The support structure shall be constructed from corrosion-resistant materials or protected by a suitable corrosion protection system. This shall be submitted and approved by the engineer.

e) The support structure shall be a robust design, and locally reinforced around foundation bolt holes. An adequate brace shall be provided to ensure rigidity under all operating conditions. The supporting structure shall be designed and endorsed by PE, and the detailed design with endorsement shall be submitted to the CLIENT/Engineer for approval.

f) All metal fabrications (i.e. frames, support structures, etc.) shall be designed to prevent the collection of liquids and debris and, if appropriate, facilitate the application of paint systems and protective coatings.

g) All welded, steel fabricated (frames, supports, structure, etc.) shall be continuously welded to prevent moisture traps. The ends of all mild steel sections shall be sealed to prevent ingress of liquids after corrosion-resistant coatings have been applied.

h) All metal fabrications shall be designed and assembled to avoid galvanic corrosion. If necessary, insulating washers and sleeves shall be used to prevent direct contact between dissimilar metals.

i) All galvanizing shall comply with BS EN ISO 1461.

j) All shafting or belts shall be of ample size and provided with suitable bearings for the service required. Suitable means for making adjustments to parts subject to wear shall be provided.

k) The discharge trough connected to the conveyor system shall be equipped with filling and/or discharge chutes, as required. Chutes shall be of welded construction and be fabricated from at least 3 mm-thick Type 304/316 stainless steel. The juncture of all joints in plates shall be continuously seal-welded inside and out so that chutes are watertight. External stiffening ribs shall be provided as required, limiting stresses and deformation in plates during shipping, installation, and operation.

l) The external surface of the trough and other exposed stainless-steel surfaces shall have glass-bead blasted surface finishes.

m) All conveyor support shall be based on the loading from a filled trough, the weight of the conveyor, and dynamic loading when operating.

n) Supports shall not restrict access to other process systems.

1.15.6 Drive and gearbox mechanism.

a) Each screw conveyor shall be driven by an electric motor connected to a gear reducer. Torque limiting coupling sensors and current monitoring facility shall be provided as mechanical overload protection devices to protect and prevent damage to the spiral and motor due to jammed materials, overloading conditions etc.

b) Motor power shall be as determined by the conveyor manufacturer to be adequate to drive the equipment under all operating conditions and shall be at least 10 per cent higher than the power required at the maximum operating point. Motor speed shall not exceed 1500 rpm.

c) The motors may be mounted horizontally relative to the screw centerline. Where space dictates, motors may be mounted vertically.

d) All necessary supports for the conveyors and the drive actuator shall be provided by the manufacturer with the conveyor.

e) All drive system components shall be adequately supported.

f) All drive systems shall be designed to withstand the maximum torque generated by the drive system.

g) Local control facility shall be provided for release and clean blockages.

h) Unless specified, the method of power transmission, shall be closed coupled. Chain and Belt could be considered if applicable and shall subjected to the engineer for approval.

1.15.7 Gearbox and Lubrication Mechanism

a) The gear reducer shall be mounted to the conveyor end. The drive system shall be designed to start the conveyor fully loaded. Drive size shall be as recommended by the manufacturer.

b) Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and/or oil level indicator. The oil level and drain location shall be readily accessible.

c) The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.

d) Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply a matching key.

e) The gearbox type, number of stages, manufacturer, service factor, and final drive ratio shall be stated in the submitted data sheet.

f) Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L-10 bearing life of 100,000 hours and a minimum efficiency of 94 per cent.

g) The gear reducer housing shall be cast iron with removable inspection covers, oil breathers, oil level indicators and oil drain plugs.

h) Gear reducers that are shipped from the factory without an initial factory oil fill shall be adequately treated or coated before shipment to protect the units during shipment and storage. Before installing the units, they shall be drained, flushed, and filled with oil.

i) All lubrication points shall be piped to a location accessible from a maintenance walkway and must be clearly labelled.

j) All gear reducers shall be commercially built, to minimum Quality Class No. II per AGMA Standard 390.03 Gear Classification Manual. Gear reducers shall be single or double- reduction, helical gear units with high-capacity roller bearings. Gear shall be made of alloy steel, protuberance hobbled, gas carburized, oil quenched hardened, steel shot peened and ground, with a surface hardness after grinding of Rockwell RC-60 or greater and meeting the requirements of AGMA Standard

k) Gear reducers shall be suitable for the loading conditions imposed on the input shaft in the mounting arrangement. The gear reducers shall be suitable for continuous duty service with moderate shock loading and sized at the gear reducer's output shaft speed for not less than the greater of:

l) 1.5 times the brake power at the gear-reduced output shaft or,

m) 1.2 times the nameplate motor power of the drive motor.

1.15.8 Bearing and lubrication

a) Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

b) Except where otherwise specified, bearings of process equipment shall have a minimum L-10life expectancy of 100,000 hours.

c) Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-grease.

d) Bearings of all rolling elements of the conveyor shall be of the sealed-for-life type.

e) Where sealed-for-life bearings are not provided, automatic grease dispensers shall provide a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender. The supplier shall provide the first fill of lubricants to all components/systems requiring lubrication. All bearings and lubrication pipework shall be fully charged with grease.

f) The automatic grease lubrication system shall be as follows:

   i. All grease-lubricated bearings with grease fed from a central automatic lubrication system. A central lubrication system shall be provided by others.

   ii. Grease shall enter the conveyor through a high-pressure stainless steel motorized valve. The valve shall be interlocked with the conveyor drive motor to open when the screw conveyor is operating.

   iii. Grease shall be injected into the bearings through a stainless steel, positive displacement type metering valve, adjustable and connected to the bearings with stainless steel tubing.

iv. Lubrication piping on the screw conveyor shall be at least 15 mm 18-gauge stainless steel. All stainless-steel tubing and piping shall be secured with stainless steel clips and screws.

g) Provide all grease-lubricated bearings pre-packed with grease and with pipework and nipples for manual greasing. Greasing nipples shall be located for easy access from the floor or access platforms.

h) Lubrication points on bearing housing containing sealed for life bearing shall be fitted with caps to prevent inadvertent bearing re-greasing, where sealed for life bearing is not provided, the method of bearing re-greasing shall be submitted to the engineer for approval.

i) The bearing seal shall be equipped with a grease escape to prevent over-pressurizing of the bearing.

j) Alemite grease fittings shall be provided at locations accessible from the operating floor for the lubrication of all moving parts of the screen except the chains, which shall be water lubricated. All gears shall run in oil, and oil pans shall have means for filling and draining the oil without dismantling any of the screen components.

k) Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safely accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.

l) The requirement for lubrication pipework for roller element bearings shall be as follows as a minimum: -

m) It shall be stainless steel or if greater flexibility is required, a suitable polymeric material shall be proposed to the engineer for approval.

n) It shall be a minimum bore of 6mm and a maximum length of 2 m.

o) It shall be adequately supported to prevent excessive sagging or distortion and if necessary, be protected against vibration (e.g. vibration loops)

1.15.9 Guarding and covers

a) Guarding shall comply with BS EN ISO 12100 and BS EN 953 or equivalent.

b) If access is required to components for process correction or maintenance, mobile guards shall be used if the foreseeable frequency of access is high. Movable guards shall be interlocked in accordance with BS EN 1088 or equivalent.

c) Hinged doors/guards that open in an upward direction shall be provided with supporting stays.

d) The hinged door guard shall be provided with full-length, stainless steel, Piano type, two-pin hinges.

e) Components that may require regular access to maintenance or condition monitoring shall be accessible without removing guards by means of access doors or access hatches with padlocking and stainless-steel quick-release fixings.

f) All equipment shall be “lockout” to prevent automatic starting before any covers or guards are removed.

g) A suitable flanged connection shall be provided along the cover for the connection of the odour control duct as specified in the relevant specification.

h) The conveyor shall be provided with a number of permanently secured, open mesh viewing panels to allow inspection of internal components while the conveyor is operational. The mesh panel shall be sized for finger protection to BS EN ISO 13854 or equivalent and be provided with hinged/quick-release solid, sealed covers.

1.15.10 Local control panels

a) Each conveyor shall come with a local control panel unless specified. The local control stations shall incorporate all necessary components (e.g. selector switches, pushbuttons, lamps, and indicators, etc.) and control systems to provide the following functions, as a minimum:

   i. Automatic and manual control of the conveyor

   ii. Local and remote indication of the operational and/or fault status of the conveyor

   iii. Interlocking of adjacent drives, as required

   iv. Controlled restart of the conveyor after mains failure

   v. Latching and/or resetting all conveyor protection and emergency stop systems.

b) The local control station and its associated electrical installation shall comply with the relevant specifications.

c) Each conveyor shall be furnished with an emergency trip cord and trip switch as part of the emergency stop system as specified above.

d) An emergency stop system shall be provided fully in accordance with the electrical specifications. It shall comprise stop push buttons of the ‘mushroom' head stay put type for short-length conveyors and for long conveyors, the emergency stop shall consist of a lanyard trip wire system running the full length of the conveyor.

e) The lanyard shall comprise an orange nylon rope supported in stainless steel eyes, anchored at one end and connected to a position limit switch in the emergency stop circuit.

f) The safety trip wire shall be provided along both sides of each conveyor. The trip switch shall immediately stop the conveyor when the trip wire is pulled.

1.15.11 Accessories

a) Equipment Identification Plates: Provide 2 mm-thick, Type 316 stainless steel identification plates securely mounted in a readily visible location on each separate equipment component and control panel(s). The plate shall bear 10m high engraved block type black enamel filled equipment identification numbers and letters. The nameplate shall state, as a minimum, the following:

   i. Manufacturer and date of manufacturer

ii. Model Nº

iii. Serial Nº

iv. Power rating for the drive

v. Pressure Rating of power Pack if applicable

vi. Major Component Weights

b) Lifting Lugs: Provide for equipment and components weighing over 40kgs.

1.15.12 Shafted Screw Conveyors

a) The conveyor shall comprise a shafted screw running in an enclosed “U” section tough.

b) The conveyor shall be fixed or mobile as per specification required. If a mobile conveyor is required, the extent of movement shall be in accordance with the specifications.

c) Screw conveyors shall be designed for horizontal, inclined, or vertical application as required.

d) The equipment furnished shall have adequate capacity to convey the specified quality of materials without failure and without exceeding 70% active trough area.

e) Fixed screw conveyors shall be designed and constructed in accordance with BS 4409 Part 1.

f) Where mobile or portable screw conveyors are required, these shall be designed and constructed in accordance with BS 4409 Part 2.

g) Unless specified, the maximum allowable conveyor speed shall be 25 rpm or 0.9 m/s, whichever is the lower.

h) The conveyor shall incorporate expandable grease-filled type shaft seals, which can easily be recharged with grease by maintenance personnel.

i) For conveyors handling screenings shall be designed to allow for any liquid entrained with the screenings to be returned to the main flow via a drainpipe at the bottom of the steel trough. Details requirements shall refer to the Particular specifications and the Screening Handling general specifications.

j) Conveyor Troughs:

i. Trough bodies shall be a minimum of 5 mm, Type 316L stainless steel plate, rolled to shape. Trough flanges shall be a minimum of 5 mm thick, Type 316L stainless steel rolled with or welded to the trough. Un-flanged trough sections shall not exceed 3 meters in length. Internal bolted stiffeners, where required, shall be a minimum of 5 mm, Type 316L stainless steel, and shall not interfere with material conveyance.

ii. Trough cover: -

1) Sufficient rigid construction to ensure that permanent cover distortion does not occur during their removal /replacement, with a minimum thickness of 2 mm.

2) Maximum length 1500mm unless specified.

3) Fixed covers requiring frequent removal/replacement shall be provided with minimum screw fasteners with captive nuts. Studs. The cover shall be a stainless steel 316L plate. Covers shall be gasketed and attached to the conveyor trough with stainless steel bolts.

4) Hinged or quick-release covers shall be interlocked.

5) They shall be effectively sealed to prevent the escape of odour. The seal/gasket materials shall be compatible and resistant to the liquid/material that is likely to be present in the conveyor operating environment.

6) Cover-sealing gaskets shall be arranged so as to prevent accidental displacement during over-replacement.

7) Handles to facilitate manual handling of the cover shall be provided if specified.

8) The trough shall incorporate flanged ends and bolted covers.

9) Type SS 316L flushing inlets and drain outlets shall be welded on the trough. Welded to the trough. The size of inlets and outlets shall be as manufacturer's design.

iii. Conveyor troughs shall be complete with saddle-type supports shaped to the profile of the screw conveyor trough and extending to a common fixed distance to the centerline of the screw. Supports shall not exceed 3.5 meters from center to center.

iv. End plates shall be a minimum of 10 mm thick, Type 316L stainless steel plates welded across the ends of the trough.

v. Discharge Chutes:

1) Chutes shall be designed to collect and/or convey the material without spillage, leakage, or material build-up.

2) Chutes shall be fabricated from a minimum 6 mm, Type 316L stainless steel plate. Connections shall be flanged and gasket, with 6 mm thick x 68 mm wide flanges.

3) Drop chutes longer than 500 mm, between connection flanges, shall include gasket flanges and at least four handles shall be provided on each chute section to facilitate removal. Handles shall be 13 mm diameter O rod, Type 316L stainless steel formed welded to the sides of the section. Drop chute sections shall not exceed 2.5meters in length or as approved by the Engineer.

4) Neoprene gasket or equivalent or better shall be provided to the entire top face of through top flange and stiffeners.

k) Wash the water System.

i. Where the wash water system is specified, the wash water connection and spray

nozzle shall be provided with the following as a minimum:

1) The pipework and nozzles shall be manufactured from corrosion-resistant materials, such as stainless steel 316 and incorporate sufficient unions to allow easy dismantling for maintenance and replacement.

2) Plant water (wash water) supply pipes with a suitable non-clogging stainless-steel nozzle shall be provided for washing the screen trays. The nozzles shall be arranged to direct fan-shaped, overlapping sprays across the full width to ensure full washing of the trays. All Pipework and fittings shall be of stainless steel.

3) Nozzle diameters shall be sized adequately and suitable for the specified wash water supply to prevent blocking.

4) Auto backwash strainer/filter for the plant water (wash water) source shall be installed if necessary and required to prevent blockage of the nozzles. Auto changeover basket filter shall not be used.

5) The spray bar shall be adequately supported and shall be positioned to minimize the accumulation of screenings on their surface.

6) Spray bars shall be removable from the outside of the compactor's support structure to permit maintenance.

7) The plant water (wash water) pipe shall be extended outside of the head housing and shall be fitted with a control valve. The control valve shall be of the tight shut-off type suitable for flanged connections and complete with a weatherproof electric motor actuator or solenoid valve as appropriate. The control valve be a full bore, quarter turn, actuated ball valve type unless otherwise specified. The strainer/filter shall be provided, if necessary, for the wash water to avoid blockage of solenoid valves.

8) Horizontal extension and ball valve shall not present a tripping hazard.

l) Conveyor Screw

i. Conveyor screws shall be sectional flight, stainless steel316L, 8 mm minimum thickness. Flights shall be fastened to the rotor by full and continuous welds on both sides of the flight.

ii. Rotors shall be 316L stainless steel tubing of sufficient wall thickness to give a maximum deflection of 2.4 mm between any two bearing support points. Each length of the rotor shall be 3 meters or less in length and made from single-piece tubing and not fabricated with butt- welding of two sections of tube. The end faceplates of the tube shall be a welded plate no less than 25 mm thick, drilled and tapped for bolted flanged connections. Flanges shall have a 3 mm or greater register relief fit matching the adjoining flange face.

iii. Bolts, nuts, and washers used to attach the rotors to intermediate drive and end bearing shafts shall be stainless steel, hex head, and flat washers.

iv. Spiral Fighting

1) Fighting shall be fabricated from stainless steel 316L. The design of spiral flights with stability to prevent distortion and jumping in the trough.

2) Flights shall be of uniform thickness, formed to the pitch of the screw flight within plus or minus 4 mm.

3) At its torsional rating, the stress in the spiral flighting shall not exceed 30 per cent ofthe yield strength value in the extreme gear of the flight material.

4) At 250 per cent torque of the motor nameplate kilowatt rating, the drive train shall not produce more torque than 250 per cent of the spiral flighting's torsional rating.

m) Conveyor supports:

i. Support Loads shall be based on a filled trough, the weight of the conveyor, and dynamic loading when operating.

ii. Coordinate support locations with facility structure. Supports shall not restrict access to other process systems.

iii. The supports shall be designed in conformance with the AISC Manual of Steel Construction and AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings. Limit maximum total deflection to less than 1/300 of the span. Supports shall be adequately braced to carry all horizontal loads. The supporting system shall be designed and endorsed by PE.

iv. The flange, webs, legs, or wall thickness of support framing shall not be less than 6 mm. Use tubular steel, pipe, flat bar or other members that provide a clean design which will minimize dust ledges and pockets.

v. The supports shall be shop-fabricated of structural carbon steel conforming to ASTM A36. Steel plate shall conform to ASTM A36 or A283. Bolts shall conform to ASTM A325. All bolts and appurtenances necessary for conveyor and hopper system erection, including anchor bolts, shall be supplied by the Contractor. A suitable anti-corrosion protection system which suitable for the application environment shall be proposed for SO approval.

n) Intermediate Bearing Assemblies:

i. Intermediate bearing assemblies shall include bearing housings, bearing supports, bearing spacers, seals, stub shaft with flanges, locking nuts, retaining clips, multi-ring flexible coupling, grease lubrication lines, and all interconnecting bolts and fittings. Intermediate bearing assemblies shall be all Type 316L stainless steel.

ii. Flexible coupling shall be all stainless steel 316L construction to accommodate the flexible action required at the intermediate bearing. Coupling shall interconnect the intermediate bearing stub shaft and screw shaft flange. Flexible connection shall not involve the use of plastic or elastomers to achieve the flexible action. Multiple-ring flexible coupling bolt holes shall have internal sleeve liners to prevent the bolt thread from engaging the multiple-ring coupling during installation or operation. The clamping surfaces of the

interconnecting bolt holes shall be reinforced to prevent damage to the multi-spring assembly from fittings or torque loadings during operation. Non-metallic materials are unacceptable.

iii. Bearing housing shall be fabricated from stainless steel 316L and designed to accommodate bearings, seals, stub shaft, and connection to the bearing housing support. Bearing housing shall be fabricated as two sections to centrally support the bearing and seals, permitting the removal of the complete intermediate bearing assembly, without the removal of the adjoining rotor center tubes, shafts, or bearings.

iv. Intermediate bearings may be supported by a hanger. Bearing housing supports shall be fabricated from stainless steel 316L as a single unit. Support shall be fabricated from box and channel sections. Mounting flanges shall be provided for the intermediate bearing housing and conveyor trough. The bearing hanger shall be supported by both sides of the conveyor trough through a minimum 6 mm-thick support bracket bolted through to the trough.

v. Stub shaft shall be used to connect adjacent rotors. The stub shaft shall be stainless steel 316L. The stub shaft shall have end flanges for connection to adjacent rotors. Flanges shall be 170 mm in diameter and 32 mm thick; all shall use six 16 mm interconnecting bolts and fittings. The flange face shall have a 100 mm diameter x 3 mm thick registered fit for connection of the rotor and stub shaft. The stub shaft shall be designed to be removable without removal of adjacent screw rotors and shall be equipped with all appurtenances required for bearings, spacers, seals, locking rings, and retaining clips.

vi. Provide spring-loaded lubrication retention mechanical seals on both sides of the intermediate bearings to prevent sludge contamination of bearings and grease leakage into the conveyed sludge cake.

vii. Bearing supports and bearing housing shall be fitted with an 8 mm diameter stainless steel 316L tubing grease lubrication line. Bearing housing shall be equipped with access ports allowing grease to enter the central bearing area of the bearing and seal assembly. Grease tubing shall be routed to prevent damage to tubing from conveyed material, and to prevent clogging or bridging of conveyed material.

viii. The intermediate bearing shall be free-floating roller bearings, transmitting thrust to the thrust end fixed bearings.

o) All other bearings and Lubrication shall be fully accordance to the general requirement of this specification.

p) Bearings shall accommodate both torsional loads and misalignment and longitudinal movement in two directions due to thermal expansion and differential loadings of screw conveyor rotors both upstream and downstream due to material flow.

q) Drive Mechanism

i. The screw conveyor drive shall consist of a close coupled motor and gear reducer troughend seal, and motor mount. The motor shall be protected to IP 56 as a

minimum.

ii. Reducer shall be a concentric shaft or combination helical gear and right-angle bevel gear type. Reducer selection shall be based on continuous operation with a minimum 1.50 mechanical and 1.00 thermal service factor as applied to the motor nameplate power. The gearing strength rating to catalogue rating ratio shall be 1.75 minimum and based on all applicable AGMA standards.

iii. Drive shafts shall be SAE 4140, 2025, ST 50, ST 60, C45, or equal. Shafts shall be complete with flanged ends and mating bolt holes to match the conveyor rotor flanged end plates.

iv. The shaft shall be integral with the shaft flange as a single-piece forging or as a welded shaft-to-flange construction. Maximum torsional stress and maximum combined stress at full motor power shall be less than 40 MN/m2 and 50 MN/m2, respectively.

v. Reducer features shall include a shielded grease purge seal cage to protect dual lip oil seals from the environment and accidental damage, breather assembly to prevent pressure build- up inside the unit, removable drive shaft assembly without removing the unit from the trough end, thrust plate assembly for gland seal system integral to the adapter for high-temperature abrasive materials, all steel fabricated motor mount which shall bolt directly to the screw conveyor reducer. Reducer housing shall be cast iron.

vi. The drive system shall be located at the feed end of the screw conveyor and function in a pushing mode unless otherwise specified.

vii. The drive shaft and sleeve shall be sealed with compression packing.

viii. Stuffing boxes shall be cast iron, completed with 12 mm x 12mm nominal Teflon-impregnated packing rings. Two rings for horizontal and inclined conveyors shall be provided as a minimum. Provide a packing ring with each stuffing box to adjust to tighten the packing onto the shaft. The packing ring housing shall be bolted to the screw conveyor through the end plate. Drive and non-drive shafts shall have wear sleeves in the stuffing box. Stuffing boxes shall prevent the leakage of media such as sludge or wash water under all operating conditions.

ix. Conveyor outside support bearings shall be spherical roller bearings, designed for a minimum 50,000 hours L 10 life, mounted in cast iron pillow blocks. Bearings shall be mounted outboard of the stuffing box assembly, with sufficient clearance to permit removal of the stuffing box bolts, cover and repacking without having to remove the bearing housing or bearing from the housing. Fit each bearing housing with stainless steel grease tubing with fittings located in an easily accessible position at the floor or access platform level.

x. Conveyor thrust-carrying bearings shall be fixed location type, with a spherical roller bearing mounted on the drive shaft, complete with bearing recess shroud.

xi. Condition monitoring and protection.

1) An inlet hopper high-level sensor

2) A wear plate/liner wear monitoring system

3) A shaft rotation sensor, to detect shaft or drive failure. This shall monitor rotation at the non-drive end.

4) A shaft misalignment sensor, to detect excessive bearing wear.

5) A drive system overload protection system

6) The wear plate/ liner monitoring system and shaft rotation sensor shall be positioned to avoid damage if the shaft fails or becomes misaligned.

7) Detect under speed or zero speed.

8) Non-contacting motion sensing unit.

9) Adjustable time delay for starting.

10) DPDT contacts rated 10 amperes at 230 V AC.

r) The location and mounting details of these sensors shall be as recommended by the conveyor manufacturer and approved by the engineer.

s) Motion sensors shall be the non-contacting type using a probe with a pre-amplifier and main electronic assembly.

t) The probe shall be totally enclosed so it is impervious to dust and moisture. The pre-amplifier, if part of the probe, shall also be sealed. The probe shall be able to detect a moving ferromagnetic material from 25mm to 50mm away. The ferromagnetic material shall be sensed during each rotation of the conveyor spiral, and the probe shall produce a voltage pulse. This pulse shall be processed by the pre-amplifier which is wired to the main electronic unit. The main electronic unit shall operate on a 230 V, single-phase, 50 Hz power supply. A 0to 60-second time delay shall be provided to allow the start-up of the screw conveyor. The output shall be two dry contacts for the remote alarm.

1.15.13 Shaftless Screw Conveyors

a) Where applicable, the design and construction of shaftless screw conveyors shall comply with the requirements of screw conveyors as stated above.

b) The conveyor shall comprise a shaftless spiral running in an enclosed trough.

c) The drive system shall be located at the discharge end of the screw conveyor and function in Pulling mode.

d) Centerless Spiral screw

i. Centerless spiral flighting shall be provided with an outer spiral and an inner insert spiral to increase the torque rating of the assembly and transport capacity.

ii. Spiral flights shall be formed from SS 316.

iii. The bar shall be formed in a spiral forming machine to the diameter and pitch required with a tolerance of ± 3mm from the theoretical for both pitch and diameter.

iv. Each formed section of the spiral shall not be less than 3m in length and shall be factory welded to a minimum of 6 m in length.

v. Field welds of spiral sections shall be done in strict accordance with relevant welding standards.

vi. The splice connections between spirals shall be full penetration welds. The connection of the spiral to the drive system shall be through a flanged bolted connection plate that is welded to the spiral, forming a smooth and continuous transformation from the flange plate to the spiral. The drive shaft shall be bolted to the spiral flange and shaft mounted into the gear reducer output shaft via a mild steel, hot dip galvanized bell housing.

vii. The spiral outside face shall be flat and smooth with the face parallel to the axis of the screw conveyor. The edges of the outside diameter face shall be rounded so as not to shave a sharp edge.

viii. The flight assembly shall be designed to prevent distortion when operating under the specified design conditions.

e) Internal wear liners:

i. The bottom half of the screw conveyor trough shall be lined with a replaceable wear liner. The wear liner shall be fabricated in sections not greater than 1.2m in length to permit ease of replacement.

ii. The wear liners shall be fabricated from UHMWPE with a minimum thickness of 12mm and with different colored wear indication layers.

iii. For an inclined angle of more than 30 deg conveying application, the trough shall fully line at all sides, compression fitted and held in place by 316L stainless steel liner retaining bars. The screw shall be fully contained to prevent lifting or misalignment.

iv. The wear liners shall be extremely wear-resistant and easily replaceable with snap- out/snap-in operation. The liner shall be secured at intervals not to exceed 1,000 mm, using Type 316L stainless steel retaining clips of approved design.

f) Where UHMWPE cannot be used due to specified design conditions e.g. high temperature/abrasion application, the manufacturer shall recommend suitable wear liner materials for CLIENT/Engineer approval.

g) A hardened steel shear plate will be installed at the interface point between the washer compactor discharge pipe and the centerless spiral screw conveyor internal wear liner to ensure that compacted material will be carried away by the screw flights without bridging or jamming as material enters the conveyor.

1.16 Valves: General

a) Valves shall be suitable for use with the fluid being conveyed at the temperatures and pressures required for the application. Generally, pressure designation shall not be less than PN 10.

b) Valves shall have integral flanges drilled as specified in BS 4504 where applicable.

Flanges to other standards shall be used only if approved and provided that any differences do not affect mating dimensions. The back faces of the flanges shall be machined.

c) Sluice valves and butterfly valves shall be suitable for flow in either direction.

d) Sluice valves shall comply with IS 14846, BS 5150 or 5163 as appropriate.

e) Butterfly valves shall comply with IS 13095 or BS 5155 / AWWA-C-504/1980

f) Reflux/check valves shall conform to IS 5312 -1986/2007 or BS 5153

g) Valves shall be suitable for frequent operation, and for infrequent operation after long periods of standing either open or closed.

h) The rubber used in valves shall be ethylene propylene rubber (EPDM) or styrene butadiene rubber (SBR). It shall comply with the requirements of IS 13095 or Appendix B of BS 5155, be suitable for making long-term flexible seals, and be resistant to anything causing deterioration of the flexible seal.

1.16.1 Gate Valves (Sluice Valves)

i) Gate valves shall comply with IS14846 or BS 5150 and be of the solid wedge-gate type with non-rising stems. Valves less than 600 mm in diameter shall be resilient-seated type unless otherwise specified.

j) Gate valves up to and including 1000mm nominal diameter shall conform to the requirements of IS 14846 or BS 5150 for copper-alloy faced or resilient-seated valves with solid or split wedge, except that gate valves up to and including 600mm nominal diameter may conform to BS 5163.

k) Valve spindles shall be of the internal non-rising type. The valve spindle seal shall be replaceable with the valve fully open and the main under pressure.

l) Valves 450mm and over shall be fitted with integral by-passes and gate jacking screws.

m) Valves below 80mm NB shall comply with BS 5154.

n) Valves of Dia 450 mm and above shall be provided with enclosed gear arrangements for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% above the maximum specified rating. Valves and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

o) All valves, spindles and hand wheels shall be positioned to give good access to operational personnel.

p) All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. the direction of rotation of opening and closing of the valve shall be indicated on the hand wheels. The material of construction of the Valve shall be as follows:

Component	Material
Body and Doors	CI IS 210 Gr. FG 260
Spindle	SS BS: 970 Gr 431
Seating rings	SS BS: 970 Gr 316

Back Seat Bush	Bronze IS:318 Gr LTB2
Shoe and channel linings	SS BS: 970 Gr 316

1.16.2 Kinetic Double Air Valve

a) The valve shall be capable of exhausting air from pipe work automatically when filled. Air being released at a sufficiently higher rate to prevent the restriction of the Inflow rate. Similarly, the valve shall be capable of ventilating pipe work automatically when being emptied. The air inflow rate is sufficiently high to prevent the development of a vacuum in the pipeline. The valve shall automatically release air accumulating in pipeline work during normal working conditions.

b) The air valve shall be of double orifice type with a large orifice for ventilation for the exhaust of the pipeline and a small orifice for the release of air under working pressure. The valve shall be suitable for maximum working pressure in the system. All air valves shall be provided with an isolating sluice valve and flanged end connection.

c) The air valve shall be designed to prevent premature closure before all air has been discharged from the line. The orifice shall be positively sealed in the close position, but float (Ball) shall only be raised by the liquid and not by a mixer of air and liquid. The sealing shall be designed to prevent the floats from striking after a long period in the close position.

d) All branched outlets including outlets for Air valves will be with compensation pads (Dia of Main / for branch Dia ratio greater than 3). The diameter of the compensation pad will not be less than 1.75 times the O.D. of the branched outlet. The plate thickness for pads will be the same as that of the main.

e) For outlets with an above ratio of less than three, then the joints will be of plate reinforcement type.

f) The aperture of valves must be properly designed for which the contractor shall submit design calculations for necessary approvals before the procurement of valves.

g) The air valve should be as per IS: 14845 of minimum PN 1.0 rating.

h) All branched outlets including air valve tees will be provided with one 15mm BSP coupling duly plugged for measurement of pressure in due course. The closing plug will be in Stainless Steel (AISI 304 or equivalent) with Hex. Head and will be provided with a copper washer for sealing.

i) All flanges will be drilled as per I.S. 1538.

j) The gaskets shall be of nitrile rubber.

1.16.3 Spring Loaded Dual Plate Check Valve

The valve shall be of a flanged type suitable for mounting on a horizontal pipeline.

Valves shall possess high-speed closing characteristics and be designed for minimum slam conditions when closing.

Dual plate check valves conform to API 594 and API 598. They shall have resilient sealing. The spring action shall optimize the equal closing rates of each plate, especially when the friction coefficients are uneven due to one plate resting upon one-another. The plates shall

not drag on the seat while opening. The plates shall not vibrate under full or partial flow conditions.

The minimum body-wall thickness shall conform to those given in Table 1B of API Standard 594.

The face-to-face dimensions of valves (including valves with ring-joint facings) shall conform to those mentioned in Table 2B of API Standard 594.

The spring of the valves shall be of SS 316 or better grade SS to ensure the long life of the valves up to at least 100000 cycles. The spring cycle test will be performed at the manufacturer's works to confirm the quality.

The valves shall be of a minimum PN 1.0 rating.

The valve body shall be furnished with a clearly visible, forged, machined-in, or die-stamped arrow to indicate the direction of flow through the valve.

1.16.3.1 Constructional Features

A Double-flanged, quick closing, slam spring-loaded dual plate generally conforming to API 594 for pressure rating as per requirement at the particular section of a size equivalent to the delivery pipe shall be provided with the following material of construction.

1.16.4 Reflux /Check Valves

Reflux/check valves shall be designed for rapid closing without slamming no later than the moment forward flow stops. The valve size and design shall be chosen to give the best performance possible, taking into account the system where the valve is installed. The effect of any surge vessel in the system as well as the static and dynamic heads, shall be included in the assessment. Valves shall conform to IS 5312 Part 1 & 2. Hydraulic passages and doors shall be designed to avoid cavitation.

If self-closing without slamming cannot be achieved, external mechanisms may be used to control the closure rate. Details of the mechanisms will be subject to approval. Valves of 450 mm and above shall be provided with supporting feet. Swing door valves of size 600 mm and above shall be of multi-door type. Maximum pressure drop across the valve shall be 0.4 mm WC.Valves shall preferably be fitted with resilient faces or seats. The material of construction of the valve shall be as follows:

Component	Material
Body & Door	CI IS 210 GR. FG 260
Body and door ring	SS ASTM A743 CF8, BS 970 GR. 316 S11
Hinge Pin	SS BS 970 431 S49
Bearing	Teflon

1.16.5 Butterfly Valves

The valves need flanged/ wafer type Butterfly valves as per IS 13095:1991 PN 16/BS:5155 PN16 non-rising stem, as per specifications below:

Pressure Rating: PN 16

- Type: Flanged/wafer/lugged wafer type

Body: Ductile Iron ASTM A536 with EPDM lining internally and externally, Electrostatically applied epoxy resin of 250 microns min.

- Disc: 316 Stainless Steel A STM A351, Type CF8M
- Body Seat Ring: EPDM
- Shaft and hand wheel: SS-410
- 'O' Ring: EPDM
- Internal hardware: SS-316

Valves shall be fitted with indicators to show the position of the disc, clearly marked with 'open' and 'closed' positions.

The valve shall be designed to hold the disc in any intermediate position between fully opened to fully closed without creeping or fluttering by manual and electrical operation.

1.16.6 Knife Gate Valves

1.16.6.1 General:

The construction of Knife gate valves shall be under the specifications mentioned hereunder. The Knife gate valves shall be capable of performing the isolation duties in wastewater treatment plants & pumping stations. These shall be suitable for use at the suction and delivery side of pumps as well as in branch lines in sludge handling application of treatment plants and pumping stations, and shall be so constructed that there is no undue wear or deterioration during their operative life and so designed that the maintenance is kept to a minimum. The contractor shall provide these valves manufactured by an ISO: 9001-2008 certified company manufacturing the underspecified product for at least 5 years.

1.16.6.2 Design & Constructional Details:

The Knife gate valves shall be manufactured generally as per the latest AWWA C520-14 standard. The valve should be bonneted up to 600 mm and bonnetless for higher sizes. Valves should be lug-type construction up to 600 mm in size and full-flanged construction for higher sizes. The valves should be provided with flange drilling suitable to mount between flanges as per ANSI B 16.5 150 with raised face or DIN PN10 or IS 1538- 1993 Table VI.

Other constructional features and details of components of the required valves are to be as under:

i. The valve body should be of Cast ductile iron construction as specified. Valves up to 600 mm in size should be designed to withstand 10 bar pressure and valves above 600 mm in size should be designed to withstand 4 bar pressure generally applicable in sewerage pumping stations and treatment plants. If the line/system pressure is more than 4 bars then the valve design/material of construction should be suitably modified to meet this requirement when specifically pre-informed by the client.

ii. The valve should be provided with a gate made of stainless steel of grade as specified and the gate should have a bevelled knife edge at the bottom to cut through and easily enter the solids settled in the bottom and ensure positive shut-off/closure in the sewage environment.

iii. The Valve should be designed for sealing in a unidirectional flow application.

iv. The valve should be provided with a replaceable type of flexible sealing arrangement to offer drop-tight shut-off. The seals should be made of EPDM rubber and should be held in place by an easily removable type seal retainer ring. The sealing system should be field-replaceable at the site.

v. The valve housing should have integral as-cast tapered lugs provided for pushing the gate towards the flexible rubber seal only at the verge of closure to avoid seal wear and achieve drop-tight shut off. The surface of the gate coming in contact with the seal should be polished & buffed.

vi. The bonneted valves up to 600 mm in size shall have a glandless design to avoid repeated tightening/replacement of gland packing. The stuffing “O” ring seal should be pressurized by a thrust washer from both sides and should be pressurized/tightened by a thrust retainer nut.

vii. The bonnet-less valve above 600 mm in size shall be provided with sufficient ply of gland packing in the in-built stuffing box to seal the rear opening. The packings should be of graphite synthetic yarn to reduce friction and offer a higher life. Provision shall be made to enable tightening the gland packing by means of a pusher arrangement to minimize the leakage through the back of the valve. Replacement of gland packings should be possible in the installed condition of the valve without there being line pressure.

viii. The spindle should be double start / single start and non-rising type for compact & safe operation. Gate opening indicating arrangement should be provided to find out the extent of gate opening /closing.

ix. The operation of the valves shall be motorized.

x. In case the valve is to be operated from afar then it shall be provided with joining couplings, extension spindle, spindle guides and mounting pedestal with suitable anchor bolts/anchor fasteners on the platform.

1.16.6.3 Material Of Construction:

The material of construction for various components of valves shall be as under.	
Body	: Ductile iron to BS 2789 Grade 420/12
Seal Retainer ring	: Stainless steel to ASTM A351 Gr CF: 8
Inlet Seal / Rubber Seals / O rings	: EPDM Rubber
Knife gate	: SS BS:970 Gr 316
Spindle	: SS BS:970 Gr 316
Assembly bolts, nuts and fastener	: SS BS:970 Gr 316
Spindle nut	: Brass/DI
Bracket / Adapter plate	: Mild Steel to IS: 2062 grade A, Epoxy Painted
Packing	: Synthetic yarn with PTFE

1.16.6.4 Painting:

The following painting procedure shall be adopted for the valves:

i. Surface Preparation: Blast clean to near-white metal finish.

ii. Finish Painting: Suitable coats of epoxy paint to achieve a minimum DFT of 100 microns inclusive of priming. Primer painting / pre-painting before leakage testing shall be allowed.

1.16.7 Telescopic Valves

i. The telescopic valve shall be a proprietary item of proven design manufactured in CI and adjustable to cater for 1000 mm variation in level.

ii. The bell mouth height shall be controlled by a hand wheel operated from the top of the chamber.

iii. The bell mouth, pipework, spindle, and headstock shall be robustly constructed with adequate cast iron brackets. 1

iv. The ball mouth shall be connected by swept tees to a CI sludge outlet pipe of 300 mm diameter.

v. The material of construction shall be as follows.

Component	Material
Bell Mouth	CI IS: 210 Gr. FG 260
Piping	CI IS: 210 Gr. FG 260
Spindle	SS 316
Hand Wheel	CI IS: 210 Gr. FG 260

1.16.8 Automatic Air-Relief Valves

i. Air valves shall be provided for installation at high points or changes in gradient in pipelines, and elsewhere as specified or shown on the Drawings, to achieve the following: -

(a) To exhaust air automatically during filling, the air is released fast enough to prevent back pressure restricting water inflow.

(b) To ventilate a pipeline automatically during emptying, the air inflow is fast enough to prevent the development of negative pressure.

(c) To release air automatically during normal working.

ii. Conditions (a) and (b) shall be met by using an orifice capable of handling large volumes of air at a high-flow rate in either direction. Condition (c) shall be met by using a small orifice capable of discharging small volumes of air as they accumulate.

iii. Valves shall have approved screens to prevent the ingress of foreign matter.

iv. Air valves shall be of one of the following types: -

(a) Double valves shall combine both large and small orifices in one valve. The large orifice shall be sealed by a float, and the valve shall be designed to avoid premature closing of the valve by the discharging air. The small orifice shall be sealed by a float at all pressures above atmospheric, except when air accumulates in the valve body.

(b) Single large orifice type for automatic ventilation or exhaust of pipeline.

(c) Single small orifice type for automatic release of air under normal working pressure.

v. Large orifice air valves, including those incorporated in double air valves, shall be constructed so that the airflow holds the valve open during the discharge of air, at all flows, including sonic velocities. When coupled to their respective isolating valves, they shall be capable of admitting or exhausting the required quantities of free air without the pressure differential across the combined air valve and isolating valve exceeding 0.5 bar.

vi. Small orifice air valves, including those incorporated in double air valves, shall be capable of discharging not less than 0.5 m^3/min of free air when the pressure in the pipeline is at the maximum working pressure.

vii. Balls or floats shall be of ABS, vulcanite, rubber-covered metal or stainless steel, and shall operate automatically at all pressures up to the test pressure. Orifices shall be bronze or stainless steel.

viii. Air valves shall be designed so that each float seats against its orifice or causes the orifice to be closed without leakage at all pressures between 0.2 bar g. and the specified test pressure. Balls and seats shall be designed to minimize adhesion of the ball to the seat. They shall be of a type proven to be suitable for the specified duties.

ix. Each air valve shall be provided with an isolating valve. Air valves with a connection to the main pipeline not exceeding 25 mm diameter shall have an integral lever-operated isolating ball valve. All other air valves shall have a separate resilient-seated, double-flanged, lever-operated butterfly valve.

x. Each small orifice or double air valve shall be fitted with a test cock in the valve body for verification that the small orifice air valve is operating properly.

xi. The body ends shall be flanged with raised faces and drilled to BS 4504 for the nominal pressure specified.

1.16.9 Ball Valves

Ball valves shall conform, where applicable, to IS 9830-2003 or BS5159. Multi-piece bodies shall be used where work on the ball and seats, when installed, may be needed. If valves need removal for servicing, one-piece bodies may be used.

Seat materials shall be chosen for long life, with erosion and corrosion resistance.

Ball supports shall be of the floating ball or trunnion type. If line pressure is too low to ensure a positive leak-free seal, built-in seat loading devices or specially shaped seating shall be used to ensure sealing.

1.16.10 Pressure Relief Valve

i. Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of the present maximum allowable pressure. The valves shall be drop tight under normal operating conditions.

ii. The valve operation shall be achieved by the interaction of the inlet pressure and

an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valves.

iii. The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weight or from a spring.

1.16.11 Pressure Reducing Valves

i. Pressure reducing valves (PRV) shall be constructed of cast iron to BS EN 1561: 1997 Grade 220/260 or ASTM A 126 Class B. The ported guide, seat ring and trim shall be of gun metal to BS EN 1982: 2008 Grade LG2C or stainless steel to AISI grade 303. The valve shall be capable of operation in any position and shall incorporate only one flanged cover at the valve top from which all internal parts shall be easily renewable. Valves shall be double flanged. All controls and piping shall be of non-corrosive construction.

ii. Pressure reducing valves shall be capable of maintaining a constant downstream pressure from a higher constant or variable upstream pressure and they shall be drop tight under no flow conditions.

iii. The valve operation shall be achieved by the interaction of the inlet pressure, outlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

iv. The pilot valve or relay system shall be actuated by a diaphragm connected to the outlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

v. Body ends shall be flanged and drilled to BS EN 1092-2.

1.16.12 Electric Actuator

Actuators shall be suitable for the medium, climatic, environmental and pressure conditions of the system in which they are to be fitted. Actuators shall be provided with:

i. AC Electric Motor.

ii. Reduction gear unit.

iii. Torque switches mechanism.

iv. The limit switch mechanism, complete with a set of limit switches, and \two spare sets for the suitable position.

v. Hand wheel, for manual operation.

vi. Valve position indicator.

vii. Hand-auto lever with suitable locking arrangement.

viii. A single-phase space heater in the switch compartment.

ix. Blinking light throughout the valve operation.

x. Junction box for terminating power and control cables.

xi. With additional accessories for integrating with the PLC system.

The actuator shall be suitable for operation on 415V, 3 phase, and 50 Hz power supply. The motor winding insulation shall conform to class B as per the relevant BS and the motor shall be protected by suitable thermal overload relays. The actuator shall be capable of producing not less than 1 1/2 times the required operator torque at the required time cycle, of valve operation. The transmission shaft connecting the actuator to the valve shall be provided with 2 bearings one at the actuator end and one at the valve end with universal couplings at suitable places. The required numbers of switches/contacts meet the requirements for the PLC system.

The electric motors shall be of the squirrel cage type as per IS 325 with insulation to IS 1271 Class B. The windings shall be impregnated to render them non-hygroscopic and oil-resistant. All internal metal parts shall be painted. The motor shall be rated for 15 minutes. They shall also be suitable for operating on the specified electric supply and shall satisfactorily open and close the valve under variations of the electric supply specified.

The motor shall be protected by a suitable overload protection device.

The reversing contactor starter and local controls shall be integral to the valve actuator. The starter shall comprise mechanically and electrically interlocked reversing contactors of appropriate rating fed from a 110 Volt control transformer. The common connection of the contactor coils at the transformer shall be grounded. HRC cartridge-type primary and secondary fuses shall be provided.

Local control shall comprise pushbuttons for open, close and stop operations and a Lockable Local/Remote/off selector switch. The control schematics shall be subject to approval.

Internal wiring shall be 650/1100-volt grade PVC insulated stranded copper conductor of a minimum of 1.5 sq. mm for control circuits and a minimum of 4 sq mm copper for the power circuit. Each wire shall be number identified at each end. The terminals shall be of stud type. Cable entries shall be suitable for PVC- insulated/sheathed, armoured cables. A separate terminal box shall be provided for the heater. A separate terminal box shall be provided for cabling to control circuits.

The actuator enclosure shall be fully weatherproof and hose-proof to IP 67 and shall be fitted with an anti- condensation heater, which shall be switched off when the motor is running.

The torque switch mechanism shall function as follows to stop the motor on closing or opening of the valve, or upon actuation by the torque when the valve disc is restricted in its attempt to open or close.

The torque switch in the closing direction shall interrupt the control circuit if mechanical overload occurs during the closing cycle or when the valve is fully closed.

The torque switch in the opening direction shall interrupt the control circuit if mechanical overload occurs during the opening cycle or when the valve is fully open.

The mechanism shall facilitate adjustment of the torque that the switches are required to operate.

Non-adjustable limit switches shall stop the motor and give an indication when the disc has attained the fully open or closed position.

The adjustable limit switches shall have control rated 2A, 48 V DC for specified system interlock, at the desired value position in both the opening and closing directions.

Motor operators shall be provided with clearly visible local valve position indicators mounted on the operator assembly to indicate whether the valve is fully open, fully closed or in an intermediate position.

Settings and emergency operations shall be possible with the use of a hand wheel. The Handwheel shall be of stainless steel and the drive mechanically independent of the motor drive and any gearing should limit the operating torque at the hand wheel to less than 15 kg and be such as to permit emergency manual operation in a reasonable time. During electric operation, the hand wheel shall not rotate.

Actuators shall be adjusted at the manufacturer’s works, to ensure that they provide the correct, fully, open position and fully closed position. Mechanical adjustable stops shall be provided to prevent over-travel of the valve in the open and closed positions.

1.16.13 Valve Packaging and Installation

1.16.13.1 Marking and Packing

Each valve shall be indelibly marked with the diameter and pressure rating and carry a unique reference number to enable each item to be clearly identified with works fabrication records; works test certificates, delivery notes and the like.

Wherever possible, the identification marks shall be painted on the outside of the item, but where there is not enough smooth surface area for the identification marks, they shall be put on rust-proofed metal tags secured to the item with galvanised wire or chain (not through flange holes).

Valves shall be packed in the `closed' position except that uncarted resilient seat gate valves for transport to tropical areas shall be in the `open' position.

1.16.13.2 Valve Handling

The Contractor shall provide all equipment needed to handle and install valves and associated equipment without damage to any coatings. The equipment shall include lifting beams, reinforced canvas slings, protective padding, cradles and the like. Wire rope or chain slings shall not be used for handling these items.

Temporary packing, coverings or crates provided for protection in transit shall not be removed (except for inspection purposes after which they shall be replaced) until immediately before installation.

1.16.13.3 Valve Installation

Valves shall be installed and commissioned in accordance with the manufacturer's instructions. After installation, valves shall be cleaned, gates, discs, seats and other moving parts closely inspected, foreign matter removed, and the valves checked for ease of operation. Moving parts shall be lightly greased or otherwise treated in accordance with the manufacturer's recommendations.

Unless otherwise specified or directed by the employer’s representative, butterfly valves shall be enclosed in chambers, installed with the shaft, horizontal, and supported. They shall be

installed so that when the valve is opening the lower portion of the disc moves in the direction of the main or normal flow.

Unless shown otherwise on the Drawings, gate valves shall be installed, with their shafts vertical.

Gate valves without external gearing, and not otherwise required to be in a chamber, may be buried. The buried part of the valve shall be protected as specified. Unless otherwise specified, backfilling shall be to just below the top of the valve or shaft shroud, and a surface box shall be provided.

Jointing, sleeving, external wrapping, anchor and thrust blocks, valve chambers, valve marker posts and the cleaning and disinfection of valves shall be executed as specified for the associated pipeline.

1.17 Sluice Gates.

The construction of sluice gates shall be in accordance with the specification and generally as per AWWA C 501 or IS 13349. The sluice gates shall be capable of performing the duties set in the specification without undue wear or deterioration. They shall be constructed so that maintenance is kept to a minimum. All parts of the sluice gate, including mechanism components shall be designed for the heads specified with a minimum safety factor of five. All sluice gates shall be of the raising spindle type.

All sluice gates shall be electrically operated. Specifications of all types of gates shall be approved if provided by the Contractor, the actuator specs shall be approved by the Employer's representative.

1.17.1 Constructional features

The sluice gates shall be the standard design of the manufacturers and robust construction. The special features shall be as follows:

1.17.2 Frame:

The frames shall be of ample section and cast in one piece. All surface-forming joints and bearings shall be machined. The frame shall be of the flange back type and machined on the rear face to bolt directly to the machined face of the wall thimble.

1.17.3 Guide:

The guide shall be bolted to the frame or cast integrally with it and machined on all bearing and contact faces. The length of the guide shall be such that it should support the gate upon the horizontal line of the stem nut pocket. Arrangements shall be such that they should support the gate upon the horizontal line of the stem nut pocket. Arrangements shall be made to prevent lateral movement of bolted-on guides. They shall be capable of taking the entire thrust produced by water pressure and wedging action. Wedges or wedge facings shall be attached to the guides at the point where, in the closed position, they will make full contact with the wedging surface on the slides.

1.17.4 Seating Faces

The seating faces shall be of full width, solid section. They shall be secured firmly by means of counter-sunk fixings in finished grooves in the frame and slide faces in such a way as to

ensure that they will remain permanently in place as well as free from distortion and loosening during the life of the sluice gates.

1.17.5 Wedging devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices required providing contact between the slide and frame facing when the gate is closed position. All faces shall be machined accurately to give maximum contact and wedging action. Wedges shall be fully adjustable with suitable adjusting screws and lock nuts and so designed that they will remain in the fixed position after adjustment.

1.17.6 Gate slides

The slide shall be with strengthening ribs where required and a reinforced section to receive the seating faces. The slide shall have tongues on each side extending its full length and tongues shall be machined accurately on contact surfaces. Surfaces of the slide that meet the seat facing and wedges shall be machined accurately. The maximum allowable clearance between the slide and slide gate shall be 1.6 mm. An integrally cast stem nut pocket with reinforced ribs shall be provided above the central line of the slide.

1.17.7 Stem nut and Lift nut

A gate shall be provided with lower fixed stem nuts for connecting the stem to the slide and a revolving lift nut located in the lifting mechanism in the headstock. They shall be of ample design to endure the thrust developed during gate operating under maximum gate operating condition loads in opening and closing directions. The stem nut and slide shall be constructed to prevent the turning of the stem nut in the pocket of the slide. The stem nut shall be threaded and keyed or threaded and pinned to the stem.

1.17.8 Stem

The operating stem shall be designed for tensile strength to withstand 90 kg effort on the crank and for a critical buckling compressive load assuming a 36 kg effort on the crank. The threads of the stem shall be machine cut or rolled and of the square or acme type. The number of threads per inch shall be such as to work most effectively with the lift mechanism used. The top of the stem shall be provided with a stop collar. The stem shall be provided with a polycarbonate cover fixed to the headstock.

1.17.9 Stem coupling

The coupling shall be threaded and keyed or threaded and bolted and shall be of greater strength than the stem.

1.17.10 Stem guide

Stem guides shall be cast, with bushings and mounted on cast brackets. Guides shall be adjustable in two directions and so constructed that when properly spaced, they shall hold the stem in alignment. The number of stem guides shall be such that the unsupported length of the stem shall not exceed one hundred times its diameter.

1.17.11 Lifting Mechanism

Sluice gates shall be operated through a suitable lifting mechanism, which shall incorporate

gearing if required. The lifting mechanism shall be suitable for operation by one man under all conditions. The lifting mechanism shall incorporate a strong locking device, suitable for use with a padlock or padlock and chain. The manual operation shall be of the hand wheel crank-operated type and shall have a lift nut threaded to fit the operating stem. The crank shall be removable. Ball or roller thrust bearings shall be provided above and below the flange on the lift nut to take the load developed in opening and closing the gate with a torque of 14 kg-m on the crank. Fittings shall be provided to lubricate gears and bearings. The design of the lift mechanism of the hand- operated gates shall be such that the slide can be operated with a torque not more than 7 kg-m on the operator after the slide is unseated from wedges based on the operating head. The maximum crank radius shall be 380 mm.

1.17.12 Gears and bearings

All gears and bearings shall be enclosed in cast iron housing with labyrinth seals. The lifting mechanism shall be of cast iron pedestal, machined and drilled, to receive the gear housing, and suitable for bolting to the operating floor. The gates shall close with clockwise rotation of the crank. The direction of rotation to close the gates shall be indicated on the lift mechanism. A suitable means shall be provided for lubricating the stem threads directly adjacent to the lift nut. An inspection cover shall be provided to access the lift nut and gearing.

1.17.13 Fasteners

All anchor bolts, assembly bolts, screws, nuts etc., shall be of ample section to safely withstand the forces created by the operation of the gate.

1.17.14 Wall thimbles

The wall thimbles shall be made of cast iron and supplied along with the gate. The wall thimbles shall provide a rigid mounting and be designed to prevent the warping of the gate frame during installation. The cross- section of the thimble shall have the shape of the letter ‘F’. The front, or mounting flange, shall be machined and attached to the thimble with bolts and studs. The depth of the wall thimbles shall not be less than 300mm. To permit entrapped air to escape as the thimbles are being encased in the concrete, holes not less than 35 mm diameter at not more than 600 mm span, shall be cast or drilled in each entrapment zone formed by the reinforcing ribs or flange and water stop.

1.17.15 Material of Construction

Frame, Guide, Thimble, Stem Bracket, Wedges,	C I conforming to IS 210 Gr 260 Guide
Door Sealing faces	bronze conforming to IS 318 Gr LTB 2
Spindle	SS AISI 431
Natural or synthetic rubber conforming to IS: 1855	
Anchor bolts	SS conforming to IS 6603
Hand wheel	Cast iron
Stem cover	Polycarbonate transparent tube.

1.17.16 Parameters

Type	Rectangular rising spindle.
Size:	As per requirement
Applicable code:	IS 13349
Class	1
Maximum seating head:	as per design
Unseating head:as per design Maximum distances between gate centers:	
Line and operating platform:	as per design.
Tests	Seat clearance checks, moving tests, leakage tests and Hydrostatic tests as per IS 13349/ AWWA C 501 shall be conducted at the Manufacturer's works in accordance with the Inspection category.

1.17.17 Headstocks

Where remote operation of penstocks, gate or butterfly valves is required they shall generally be as shown on the Drawings, using headstocks or headstocks with operating shaft extensions.

Headstocks for direct connection to valves or penstocks shall be for use with non-rising stem valves. They shall be cast iron and fitted with position indicators. Stem bearings shall be gunmetal bushed.

If operational conditions require, hand wheels shall operate through bevel gears.

If the installation requires, extensions shall be provided between penstock or valve and headstock. Extension lengths shall be adjustable during assembly on Site. Universal couplings shall be fitted next to the valve and the headstock, and the two couplings shall be arranged to give a linear transmission of rotational movement between the headstock and penstock shaft.

1.18 Open Channel Gates

1.18.1 General:

The construction of cast iron open channel gates shall be as per IS 3042 or equivalent standard. The open channel gate shall be capable of performing the isolation duties in wastewater treatment plants for those applications where the height of the water is at least 300 mm less than the height of the opening/shutter.

They shall be so constructed that there is no undue wear or deterioration during their operative life and so designed that maintenance is kept to a minimum.

1.18.2 Design & Constructional Details

The open channel gate shall comprise a frame suitable for mounting in the parallel side walls of the channel. The frame shall be a self-contained type with a yoke on top for mounting the operating arrangement. The shutter shall move within the frame guides and be provided with

a suitable connecting arrangement to enable connection to the spindle.

Water sealing on the sides and bottom shall be effected through non-corroding seating faces secured in grooves of frames and remaining in forced contact with the corresponding sealing arrangement mounted on the shutter. The bottom sealing arrangement shall be a flush-bottom type to ensure that the invert level of the channel on either side of the gate remains flush with the invert of the gate.

The spindle shall be raising type and provided with a stop nut to avoid over-closing of the gate. The rising spindle shall be provided with a transparent scratch-proof and UV-resistant polycarbonate cover tube to protect the threaded portion from the effects of dust, dirt and rain. The operating arrangement shall be electrical with manual override.

1.18.3 Material Of Construction:

The material of construction for various components shall be as under. Gate frame, shutter/Door: Cast iron IS 210 FG 260

Side Guides: Cast iron IS 210 FG 260

Door Sealing faces: Bronze, conforming to IS 318 Gr LTB 2 Assembly bolts, nuts and fasteners: Stainless Steel ASTM A 276 type 304 Stem & connecting pin: SS AISI 431

Yoke: Mild Steel to IS: 2062 grade A, epoxy painted.
Headstock: Cast Iron IS 210 FG 260

Spindle cover tube/pipe hood: Polycarbonate

1.18.4 Painting:

The following painting procedure shall be adopted for the gates:

Surface Preparation: Blast clean to near-white metal finish using shot blasting.
Priming: 1 coat of Epoxy primer.

Finish Painting: Epoxy paint for gate assembly. Minimum DFT 250 microns inclusive of priming. Yoke & Headstock are to be provided with red oxide primer and epoxy Grey paint having a minimum DFT of 150 microns, inclusive of priming.

1.18.5 Shop Testing:

Following shop tests at the manufacturer's place will be conducted.

a.	Movement Test	The Movement test should be conducted in an assembled condition using stems & headstock. The gate should be operated once from full closed to full open and back to full closed condition with a maximum. The force of 135 Newton-meters on the crank or hand wheel.
b.	Dimensional Check:	Important Dimensions shall be checked with reference to the approved GA drawing.
c.	Seat clearance check:	With the gate in closed condition, a 0.1 mm thick feeler gauge should not pass through the sealing faces.

d.	Material Testing:	Material test certificates for components, such as Frame, Side guides, Shutter, Rubber seals, & Spindle to be furnished for review at the time of inspection.
e.	PMI test:	Positive Material Identification (PMI) test to be conducted for Seating/Sealing faces, Rubber Seal Retainer Bar & Stem/ Spindle during the inspection.
f.	DFT measurement:	DFT of Paint with reference to approved G.A. drawing to be measured with a paint thickness measurement gauge during the inspection

1.19 Material Handling Equipment

1.19.1 Electrically Operated Hoists

Electrical hoists shall be complete with a hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust proof push button station, operator panel, all wiring, limit switches, etc.

The electric hoist shall confirm to IS: 3938 and suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. The main girder shall be single unit, welded or joint is not accepted.

Drums shall be machined grooved right and left with grooves of a proper shape for the rope used.

Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built up from steel billets and welded together to form a one-piece gear section.

The load chain on a pulley block shall be of alloy steel of grade not less than 80 and shall be calibrated to IS 6216: 1971.

Hoist ropes shall be extra flexible, improved plough steel rope with a well-lubricated hemp core and having six strands of 37 wires per strand with a minimum ultimate tensile strength of 1.6 X 106 KN/m2.

Hooks shall be solid, forged, heat-treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

The hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. breaks shall apply when either the motor controller or the main power switch is in the "OFF" position or in the event of power failure.

Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS: 325. Pendant control switch, controllers and resistor, controls, electrical protective devices, cable and conductors, earthing guards etc. shall be as per IS: 3938. limit switches shall be provided for over-hoisting and over- lowering. The electrical hoist shall be of class II duty.

25% overload test, speed tests, limit switch tests and brake tests shall be conducted for the hoist and trolley at the manufacturer's works.

1.19.2 Hand-operated Hoist and Trolleys

The manual hoist shall be complete with a hand chain, trolley, pulley block, hook, hand and load chains, brakes, and other accessories. They shall comply with the latest applicable standards, regulations, and safety codes in the locality where the equipment will be installed.

Each hoist shall be operated on a monorail (I-beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and as per IS 3109/BS 1663/BS 3114. The load wheel is to be made of heavy-duty malleable castings. the hand chain should be as per BS 6405, and the hand chain wheel may be made from pressed sheet steel with roller-type guarding. Gears shall be cut from solid cast or forged steel blanks or stress-relieved welded steel construction. Pinions shall be of forged carbon steel or heat-treated alloy steel. strength, Quality of steel, heat treatment, face, pitch of teeth and design shall be as per BS-436, BS-545 and BS 721. Spur and helical gears must comply with BS 436, and worm with BS 721. The bearing must be ball and roller type as per IS 2513 / BS 2525-32. Proper lubricating arrangements are to be provided for the bearing and pinion. The brakes for the lifting gear shall be automatic and always in action.

The proof testing of each chain pulley block is to be carried out as per the latest applicable standards. the safe working load is to be marked in such a way that it is visible from the operating level.

1.19.3 Manually Operated Travelling Crane

The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. The steel used shall be tested quality steel conforming to IS 2062. The girder shall have enough strength to carry the test load without causing undue stress or deflection.

The long travel bridge wheels shall be rimming toughened, heat-treated carbon steel or low alloy steel or CI. they shall be double-flanged type. The wheels shall have antifriction ball/roller bearings. The Wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied.

1.19.4 Trolley and Chain Pulley Block

The chain pulley block shall be operated on the lower flange of the bridge girder.

The load chain shall be made of alloy steel as per IS:3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.

The hand chain for the hoisting and traverse mechanism shall hang well clear of the hook, and both chains shall be on the same side. the hand-chin wheel shall be made from pressed sheets and provided with roller-type guarding to prevent snagging and fouling of the chain.

All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat-treated alloy steel. Gears shall be as per BS 436/IS: 4460.

The trolley track wheels shall be rimming toughened, heat-treated carbon steel or low alloy steel or CI and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.

The travelling trolley shall be made of rolled steel as per IS: 2062. The side plates of the trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. the two side plates shall be connected by means of an equalizing pin.

Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.

The lifting hooks shall be forged, heat-treated alloy or carbon steel of rugged construction. they shall be single-type provided with a standard depress-type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swivelling shall be provided. The hook shall be as per BS: 2903/IS: 3815.

The break for the lifting gear shall be automatic and always in action. It shall be a screw and friction disc type self-actuating load pressure brake. Breaks shall offer no resistance during hoisting.

A ratchet and pawl mechanism shall be provided to arrest the full load from lowering due to gravity. The ratchet and pawl shall be of steel, hardened and tempered to attain the required wear resistance and toughness.

1.19.5 Jib Crane

A fixed jig crane shall be provided for lowering/removal of equipment/parts to/from the reactor tanks floor and transferring the same outside the reactor area. The crane capacity shall be 1.25 times the maximum weight to be handled or 1.5 tons, whichever is greater.

The lift and reach of the crane shall be suitable for the equipment/parts to be handled. The crane shall be capable of being swiveled by 360 deg. All material used in the construction shall be corrosion resistant, and the MS used shall be galvanized. Rope chains and pulleys shall be of SS construction. Hardware shall be of SS

316. The jib crane shall also be provided for submersible pumps in the reactor tank and the thickened sludge sump.

1.19.6 EOT Crane

The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall be confirmed to BS 2573, IS: 3177 or relevant internationally approved standards.

The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access the walkway with a safe hand railing as required along the full span length of the bridge girder. The steel shall be of tested quality as per ASTM A36, except that plates more than 20 mm thick shall conform to IS 2062, BS 4360 or relevant international standards. All antifriction bearings for bridge and trolley track wheels, gearboxes and bottom sheaves on the hook shall be lubricated manually by hand-operated grease pump through respective grease nipples.

The wheelbase and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevents skewness. Bridge and trolley track wheels shall be of forged steel double-flanged type. The wheel dia. and rail sizes shall be suitable for the wheel loads. The crane rail shall be manufactured from wear-resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolleys from running off the bridge shall be abutted against the ends of rails and welded to the girders. A bridge and trolley stop to match the wheel radius shall be provided before the buffer stops.

All exposed couplings, shafts, gears, wheels, pinions, chain drives, etc., shall be encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100,000 operating hours. Electromagnetic or hydraulic thrust breaks shall be provided for the main hoist. One electromagnetic brake shall be provided for each of the cross-travel and long-travel motions.

The hook shall be solid forged, heat-treated alloy or Carbon Steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS: 2903 / BS: 3017 or relevant internationally approved standards and shall have a safety latch to prevent the rope from coming off the hook. Hoist rope shall be extra flexible, improved plough galvanized steel rope with well-lubricated hemp core and having six strands of 37 wires per strand with a minimum ultimate tensile strength of 1.6 X 106 KN/m2 of right-hand Ordinary laid construction. The ropes shall have a safety factor of 6 on the specified working load and shall also conform to the IS: 2266. Rope drums shall be grooved and shall be either cast iron, cast steel or welded steel as per IS:3177, BS:466.

Gears shall be cut from solid cast or forged steel blanks or shall be stress-relieved welded steel construction. Pinions shall be forged carbon or heat-treated alloy steel. The strength quality of steel, heat treatment, face, pitch of the teeth, and design shall be confirmed to BS: 436, IS 4460 and BS: 721.

A nameplate showing the capacity, year of manufacturing and rated capacity of the crane, in a figure not less than 150 mm height, shall be placed on each side of the crane girder.

The deflection test shall be done as per IS:3177.

All accessory and auxiliary electrical equipment, including drive motor, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant, push button station, protective devices, operation devices, cables, conduits, etc, necessary for the safe and satisfactory operation of the crane shall be provided.

Power to the crane shall be provided by down shop conductors manufactured from high-conductivity hard-drawn copper. Conductors shall be completely shrouded such that they have no exposed current-carrying surfaces. The type of button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:

- "start" and "stop".
- Long travel -' Right' and 'left'.

- Cross travel 'To' and 'Fro'.
- Hook 'Hoist' and 'Lower'.
- Red indicating lamp for supply 'ON' indication.

A pendant-type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent overtravel for each of the following:

- for the "UP" and "Down" motion of the hook.
- Long travel motion.
- Cross travel motion.

Crane structures, motor frames and metal cases of all electrical equipment, including metal conduit and cable guards, shall be earthed. All motors, brakes, limit switches, panels, drum controllers, and resistor sets shall be provided with two studs for earthing.

All motors shall be of the quick-reversing type with electrical or mechanical brakes suitable for the duties specified. All movements shall be electrically powered, suitable for operating with the hook loaded. Facilities shall be provided for the accurate location of the hook by means of inching the cross-travel and down-shop travel motions.

Sufficient slings, ropes, shackles, lifting beams, etc. shall be supplied to handle all items of plant covered by the crane. they shall be labelled or marked with a safe working load and the purpose for which they are intended.

The crane and all slings, ropes and other lifting equipment shall be tested by the manufacturer at their place. The test shall be carried out at 125% of the safe working load, and a test certificate shall be supplied.

The operator 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 a power failure. All access ladders and platforms necessary to carry out maintenance and repair shall be provided and installed by the operator.

All electrical equipment shall be fully tropicalized.

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

1.19.7 Monorail Hoists (Electrically Operated)

The design, manufacture, shop testing, erection, testing & commissioning at the site of the Monorail Hoists (Electrically Operated) shall, in general, conform to the latest revisions of the following Indian Standards. In addition to other standards mentioned elsewhere in the tender documents, subject to any modification & requirement specified hereinafter.

- IS: 2266 Specification for steel wire ropes for General Engineering purposes.
- IS: 594 Technical supply conditions for wire ropes and strands.

- IS: 1835 Specification for Round steel wire for ropes.
- IS: 3938 Specification for electric wire rope hoists.
- IS: 7847 General Characteristics of lifting hook.
- IS: 3815 Specification for point hook with shank for general engineering purposes.
- IS: 807 Code of practice for design, Manufacture, erection & testing (Structural Portion of cranes & hoists)

Electric hoists shall be complete with hoisting motors wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motor wire rope drum, wire rope, hook, necessary gearing sheaves, electromagnetic brake for hoisting motion, weather and dust-proof push button station, contractor panel, all wiring, limit switches, etc.

Electric hoists shall conform to IS: 3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand the surrounding atmospheric conditions without any deterioration.

The Capacity of the monorail hoist shall not be less than 50% above the weight of the heaviest item envisaged to be lifted during erection and maintenance.

Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction, or built up from steel billets and welded together to form a one-piece gear section. Hoist ropes must be made from extra flexible, improved plough steel wire, incorporating a well-lubricated hemp core, and consisting of six strands containing 37 wires each, with a minimum ultimate tensile strength of 1.6 × 10^6 kn/m².

Hooks shall be solid, forged, heat-treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress-type safety latch.

The hoisting motor shall be equipped with electrically released, spring-set, friction shoe-type brakes having torque capable of holding 125% of the full rated hook load. The brake shall apply when either the motor controller or the main power switch is in the “OFF" position or in the event of power failure.

The drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS: 325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards, etc., shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

The electric hoists shall be of Class II duty.

25% overload test, speed tests, limit switch tests, and brake tests shall be conducted for the hoist and trolley at the manufacturer’s works.

Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthling guards, etc., shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering conditions. The girder carrying the electrical hoist and the support columns shall have enough strength to carry the test load without

causing any deformity under full load conditions and stress.

1.20 Cast Iron Pipe & Specials

Providing and supplying lowering, laying to line, level, and slope, centrifugally cast iron (spun) pressure pipes (LA Class Strictly confirming to IS 1536/1989 with latest amendment) and jointing with specials such as Tees, Bends, Reducers including and other safety provision, cutting the pipes and making joints and hydraulic testing after laying etc. comp.

The Cast Iron pipes shall be LA Class conforming to IS 1536/1989 with the latest amendments bearing the ISI Mark.

The pipes shall be free from defects resulting from raw materials, loading, handling, carting, and unloading. The pipes shall be free from load, bents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of the barrel.

Each lot of pipes supplied by the contractor must be accompanied by the test certificates as specified in IS 1536/1989 with the latest amendments. The contractors shall have to arrange for the inspection/testing of the pipes at the manufacturer's factory at the contractor's own risk and cost.,

Each pipe shall have cast, stamped, or indelibly painted on it the following marks.

a) Manufacturer's name, initials or identification mark.

b) The nominal diameter.

c) Class reference.

d) The last two digits of the year of manufacture.

e) I.S. Certification mark.

The materials shall be carted to the site by the contractor very carefully. The handling, while carting the pipes, specials, valves, etc., shall be done carefully.

In case of heavy pipes, specials, etc., lowering shall be done with the help of the chain pulley block.

1.20.1 Flanged Joints:

Flanged joints should be made by painting the facing of the flanges with red lead freely and belting up evenly on all sides.

A thin fiber of lead wool may be very useful in making the joints watertight, where the facing of the pipes is not true.

Where packing must be used, it should be of rubber insert cloth, three-ply and of approved thickness. The packing should be of the full diameter of the flange, with proper pipe holes and bolt holes cut and even at both inner and outer edges.

Where the flange is not fully faced, the packing may be of the dimension of the facing strip only. Its proper placement should be tested before another pipe is joined.

1.20.2 Testing

After each section of the pipeline has been completed, it shall be tested for water tightness

before being covered. This can be done by closing each end by means of a reliable gauge. When the pipe is laid on any appreciable gradient, the test should be carried out at the lower end of the section. Any leaking joints should be made good, and the above test reapplied until no further leaks are apparent. CI Double Flanged Pipes / Piping within the pump house shall be tested for 150 % of the maximum system pressure. The items include all materials and labour required to carry out the work as detailed above.

1.20.3 Cast Iron Fitting & Specials

Providing and supplying at the site of work C.I. fittings/specials conforming to IS 1538/1993 with latest amendments.

The contractor shall have to procure required cast iron specials such as Tees, Bends of required degrees, reducers, collars, caps, plugs, tailpieces, etc., necessary for the completion of this item, as per site conditions.

The C.I. fittings and specials shall conform to IS 1538/1993 with the latest amendments.

The fitting shall be stripped with all the precautions necessary to avoid warping or shrinking defects. The fitting shall be free from defects other than any unavoidable surface imperfection which results from the method of manufacture, and which does not affect the use of the fittings.

The fittings shall be such that they could be cut, drilled or machined.

The mass of C.I. fittings/specials shall strictly conform to IS 1538/1993 with the latest amendments.

The contractor shall have to procure the required C.I. fittings or specials as per the site conditions and as per the direction of the Engineer-in-charge.

1.20.4 Dismantling Joints

CI Double flanged Dismantling joints shall be installed in such a manner that valves can be dismantled without stress to the joints. Dismantling joints shall be suitable for installation with all valves of different diameters.

The dismantling joint shall be designed for a hydrostatic pressure of 10 kg/sq.cm. The sliding flange shall be machined smooth and shall slide at least 30 mm to fully disengage the mating flange. All the fasteners for the dismantling joint shall be of SS 304. These shall be completely leakproof with proper gasket arrangement. Flange dimensions shall conform to the latest relevant IS code. Flanged specials shall be supplied with required nuts, bolts and rubber gaskets.

1.20.5 Expansion Bellows

The pipework installation shall be so arranged to offer ease of dismantling and removal of pumps or other major items of equipment. Stainless steel AISI 304 expansion bellows, which can take radial and axial misalignment of a minimum of 1 per cent of valve nominal size, with tie rods, shall be included in the suction and delivery pipework of all pumps as well as on the delivery header for easy dismantling. All loose flanges shall be secured to fixed flanges by suitable tie bolts. All pipework shall be adequately supported with purpose-made fittings. When passing through walls, pipework shall incorporate a puddle flange or other suitable sealing

device. The final outlet connection of the pipework shall match the connecting point of the transmission main.

1.21 Polypropylene pipes

Three-layer PP-R (Polypropylene Random copolymer) pipes PN-16, UV stabilised & anti-microbial fusion welded, manufactured as per relevant IS code, having thermal stability for hot & cold water supply shall be used. The fittings shall include all PP–R plain & brass threaded polypropylene random fittings.

1.22 Polyethylene Pipe

Polyethylene pipes shall comply with the following Indian Standards /BS 6437. The welding method shall be adapted to international standards and the contractor shall obtain the approval of the Engineer before proceeding with such works.

i. IS: 4984: High-Density Polyethylene Pipes for Water Supply.

ii. IS: 2530: Methods of test for polyethene moulding materials and polyethene compounds.

iii. IS: 7328: High-density polyethylene materials for moulding and extrusion.

iv. IS: 7634: Laying & Jointing of Polyethylene (PE) Pipes.

v. Other codes not specifically mentioned here, but pertaining to the use of HDPE pipes form part of these Specifications. Relevant Indian Standards shall be applicable where BS Standards are referred hereunder.

1.23 HDPE Pipes

a) HDPE Pipes of class PE – 80, PN – 4 shall be used. All pipes shall be ISI marked, and manufactured as per IS 14333 – 1996 (Amended up to date). The pipes shall be procured only after approval of the manufacturer by the Engineer.

b) All the tests as specified in the relevant IS code shall be performed by the contractor at the manufacturer's place in the presence of the Engineer's representative and /or by the consultant's representative. The contractor/firm shall submit the names of the manufacturers of HDPE pipes from whom he is going to procure the pipes for verification of his ISI mark and previous experience in the field of manufacturing of pipes. The bedding below the pipeline shall be provided as per approved pipe bedding drawings. The backfilling shall be done only after the inspection of joints by the Engineer is completed and approval given.

c) The HDPE Pipe manufacturer shall submit test certificates for raw material used for each lot of HDPE Pipes duly supported by purchaser invoices at the time of supply/inspection.

d) Employer reserves the right to inspect the Pipe Manufacturing unit if required to evaluate the capability and quality assurance before approving the make of pipes.

i. The Colour of the HDPE pipe shall be black.

ii. No reworked material to be used.

iii. The pipes shall be supplied in straight lengths of a minimum of 6 meters.

iv. The internal diameter, wall thickness, length and other dimensions of pipes shall be asper IS: 14333.

e) The manufacturer should provide the test certificates for the tests conducted for each lot of pipes dispatched. The acceptance tests can be performed in the in-house laboratory of the pipe manufacturer. The Employer will depute his representative who will check and approve each lot of the pipes manufactured before they leave the factory after ensuring that they are meeting the required specifications.

f) Jointing between HDPE pipes and specials shall be done as per IS: 7634 part II. The method of jointing between the pipes to pipes and pipes to specials shall be with butt fusion welding using semi-automatic, hydraulically operated, superior quality butt fusion machines which will ensure good quality butt fusion welding of HDPE pipes

g) The HDPE Pipes shall be laid in accordance with the latest IS 7634 Part-2. The pipe shall be laid over 150 mm of thick sand bedding. After installation, the pipe shall be provided all around with a 150 mm sand cover and then backfilled with the excavated material up to the formation level.

1.24 Ductile iron pipes and fittings

a) All Ductile iron pipes shall be class K-9 conforming to IS: 8329. All Ductile iron fittings shall conform to IS: 9523.

b) Socket and Spigot type shall consist of an elastomeric rubber ring gasket for forming an integral joint between pipes or pipe and fitting shall conform to IS: 12820. Flanged Joints, wherever specified in the drawings, shall conform to IS: 8329.

c) All pipes and fittings shall be internally lined with sulphate-resistant higher volumes of slag/blended cement mortar in accordance with ISO 4179/IS: 11906. Higher volumes of slag/blended Cement mortar lining shall be applied at the factory in accordance with the above-mentioned standards. Pipe linings shall be inspected, and any damage or defective areas shall be made good to the satisfaction of the Engineer.

d) On completion of the work, the contractor shall remove any oil stains or paint spots, leaving the pipes and fittings in a clean and acceptable condition.

1.25 Mild Steel Pipe

1.25.1 Technical Specifications for MS Pipeline.

This specification covers the requirements for procurement, supply, manufacture/fabrication, transportation, stacking at the site of works, laying, jointing, testing and successful commissioning of all welded Mild Steel pipeline, appurtenances, specials, etc., below/above ground, including associated civil works required for the same.

1.25.2 Standards

Submerged Arc welded Hot finished mild steel Bevelled pipes to be manufactured, supplied and delivered under the scope of this contract shall be manufactured in accordance with and

conforming to IS-3589 and/or IS-5504. Pipes shall be applied with Internal & External Protection as per technical specification and as per relevant IS codes (latest revision/amendments).

The following details, standards, and codes are part of this specification. All standards, specifications and codes of practice referred to herein shall be the latest edition, including all applicable official amendments and revisions.

Special attention of the Contractor is drawn to the relevant sections and clauses of the National Building Code of India and BIS Codes (latest editions along with amendments), and the same should be followed strictly in addition to the specification and conditions stipulated in this section.

If for items for which specifications are not specified in this volume and IS specifications shall be applicable, and in case of any discrepancy Employer's Representative's decision will be final and binding.

The following list includes various Indian Standards which are referred to in the specifications and used in construction works. These standards are to be strictly adhered to unless otherwise applicable in the relevant context. These standards are to be followed both in respect of materials, equipment, methods, procedures, etc. and for all the works included in the tender.

It is obligatory that only the latest edition of the standard is referred to and followed, along with all amendments and revisions issued with respect to the standard under consideration. This list is not exhaustive but contains only the standards that are very frequently used in construction works. If a standard exists for a particular item of material or equipment or code of practice, the same shall be followed, whether the same is included in this list, specifications, or other parts of the tender documents or not. Some Indian Standards are referred to in the specifications/drawings/other parts of the tender documents, and they are supplementing this list if they do not find a place in the list.

IS : 2062	Hot Rolled Medium and High Tensile Structural Steel- Specification
IS : 814	Covered Electrodes for Manual Metal Arc Welding of carbon and C-Mn steel.
BS EN 499	Welding Consumables. Covered Electrodes for Manual Metal Arc Welding of Non-Alloy and Fine Grain Steel. Classification
AWS : A-5.1	Specification for Mild Steel Covered Arc Welding Electrodes.
IS : 3613	Acceptance Tests for Wire Flux Combinations for Submerged–Arc Welding.
AWS : A-5.17	Specification for Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding. IS :1377 -Technical Supply Conditions for Threaded Fasteners
IS : 1367	Technical Supply Conditions for Threaded Steel Fasteners (Parts 1 to 3).
IS : 2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming-specification
IS : 102	Ready Mixed Paint, Brushing, Red Lead, non-setting, Priming.
IS : 816	Code of practice for use of Metal Arc Welding for General Construction in mild steel.
IS : 4353	Submerged Arc Welding of Mild Steel & Low Alloy Steels – Recommendations.
IS : 817	Code of practice for Training and Testing of Metal Arc Welders.
IS : 1182	Recommended practice for Radiographic examination of Fusion -Welded Butt Joints in steel plants
IS : 2595	Code of Practice for Radiographic Testing.
IS : 3658	Code of Practice for Liquid Penetrate Flaw Detection

IS : 5334	Code of practice for Magnetic Particle Flaw Detection of welds.
ASTM E 94	Guide for Radiographic Testing
ASTM E 709	Guide for Magnetic Particle Examination.
ASTM E 165	Test Method for Liquid Penetrate Examination.
IS : 3600	Methods of Testing Fusion Welded Joints and weld metal in steel (Parts 1 to 9)
IS : 4853	Recommended Practice for Radiographic Inspection of Fusion Welded Butt Joints in Steel Pipes.
IS : 3589	Seamless or electrically welded steel pipes for Water Gas and Sewage (168.3 to 2540 Outside Diameter)
IS : 6631	Specification for Steel Pipes for Hydraulic Purposes
IS : 7343	Code of practice for ultrasonic Testing of Ferrous Welded Pipes and Tubular Products
IS : 2598	Safety Code for Industrial Radiographic Practice
IS : 5822	Code of Practice for Laying of Electrically Welded steel pipes for water supply
IS : 1608	Metallic material tensile testing at ambient temperature
IS : 9595	Metal Arc welding of Carbon and Carbon-Manganese Steels – Recommendations
IS : 2825	Code of Unfired Pressure Vessels
IS : 5504	Specification for Spiral Welded Pipes
IS: 10748	Hot-rolled Steel Strip for Welded Tubes and Pipes -Specification

1.25.3 Pipe Ends

The pipe shall have beveled ends to an angle of 30°+5° measured from a line drawn perpendicular to the axis of the pipe. The root face shall be 1.6+0.8 mm. The root face of the bevel may be prepared by hand finishing if required.

1.25.4 Length of Pipes

The random length of pipes shall be 5 to 6 meters. In specific locations, smaller lengths can be accepted as per the Employer's Representative.

1.25.5 Straightness of Pipes

Finished pipes shall not deviate from straightness by more than 0.2% of the total length checking for straightness shall be carried out using a taut string or wire from end to end along the side of the pipe to measure, the greatest deviation.

1.25.6 Testing of Pipes

The main tests among others to be conducted on each pipe shall be as per IS-3589 and/or IS-5504 with its latest version.

1.25.7 Sampling of pipes

The sampling of pipes shall be as in IS: 4711 with the latest version/amendment or as directed by the Employer's Representative.

1.25.8 Other Tolerances

As per IS-3589 and/or IS-5504 with the latest version (Except for wall thickness). M.S. Pipes shall be welded either longitudinally or spirally. Before fabrication of pipes and specials/fittings is commenced, the copies of the mill sheets and the manufacturer’s test certificates for plates and other materials required for fabrication shall be submitted by the Contractor to the Employer’s Representative for his approval.

When instructed by the Employer's Representative, the Contractor shall supply free of charge to the Employer's Representative for testing suitable samples of the materials to be used/used in the Works.

1.25.9 Welding

All components of a standard shell, either straight or bent, etc., shall be welded by use of an automatic arc welding machine, by a Submerged Arc welding process, with alternating current. Manual welding shall not be permitted except for sealing runs/ field weld joints and such other minor works at the discretion of the Employer's Representative. The strength of the joint shall be at least equal to that of the parent material. The contractor shall use radiographic quality electrodes and carry out the welding procedure specification (WPS) and Pre-qualification Requirement (PQR). For welding the contractor shall ensure the use of the standard current and arc voltage required for the machine. For this purpose, samples of welded joints shall be prepared and tested in the presence of the Employer's Representative. The values once determined shall be maintained throughout the work, and if any modifications are to be made, a written permission of the Employer’s Representative shall be obtained. In the case of thin sheets, electric arc welding may not give satisfactory results, and gas welding shall be resorted to. Gas welding shall be subject to the same specifications and tests as those for electric welds. Welding should be carried out inside as well as outside. The contractor should engage all qualified welders for field welding with at least a 6G level qualification. The contractor should submit such a qualified welder's list before taking up welding work. All welding shall conform to the requirements of IS 4353 latest version All longitudinal and circumferential joints shall be double welded butt joints. Field joints shall be from the outside, with a sealing weld from the inside. End preparation for such welding shall conform to IS: 2825.

All circumferential welds involving plates of unequal thickness shall be so kept that the inside surfaces of plates match to provide streamlined joints without alteration in the internal diameter. As far as practicable, welding of dissimilar thicknesses of shells shall be carried out in the shops. The welding shall be of the best workmanship, free from flaws, burns, etc., and the Contractor shall provide for his electrodes and equipment, ovens to keep the electrodes at the desired temperatures and dry. In order to maintain a good standard in welding, welders shall have to undergo testing. Such testing shall be organized by the Contractor before they are entrusted with the job. Qualification standards for welding procedures, welders and welding operations shall conform to the requirements of IS: 7307 and IS: 7310 (latest) and/or ASME section-IX (latest). Periodical tests as regards their efficiency shall also be taken at intervals of about 6 months and those found inefficient shall be removed from the job. Only those who pass the test shall be posted for the job.

If an incompetent welder has already welded some pipes, all welding done by him previously shall be fully checked by X-ray in addition to the regular X-ray inspections. The defects if any shall be set right to the satisfaction of the Employer's Representative. All such check tests and rectifications of defects shall be entirely at the cost of the Contractor. No pipes or steel sections shall be erected unless the work of the welder concerned has been proved to be satisfactory. Site welds shall be done by specially selected welders.

A record shall be maintained showing the names of welders and operators who have worked on each joint. Hand welding shall preferably be carried out by a pair of welders so that, by

observing proper sequence, distortion can be avoided. A joint entrusted to a particular individual or a pair shall be, as far as possible, completed by them in all respects, including the sealing run. No helper or other unauthorised person shall be permitted to do any welding whatsoever. In case of infringement of the above, the persons shall be punished as directed by the Employer's Representative

The welded joint after welding should not become brittle or sensitive to blows, and there should be no loss of toughness due to welding or heat treatment. The material after welding and heat treatment is to be tougher than the base metal and is to retain its original ductility. No allowance will be made for the thinning of the weld and the weld should at no point be less than the nominal thickness of the plate.

Upon receipt of the order and before the start of fabrication, the Contractor shall submit to the Employer’s Representative for his approval the “welding procedure" he intends to use in the shop work. Similarly, before the start of the field welding, the procedure must be submitted to the Employer’s Representative for approval. Manual welding shall be adopted only when machine welding is not possible.

1.25.10 Ultrasonic Test of Welded Joints

100% of the welded length in each pipe shall be subjected to an ultrasonic test at the factory. The acceptance/rejection criteria shall be as per API 5L (American Petroleum Institute). The ultrasonic test shall be conducted using the relevant ASME code. (American Society of Mechanical Engineering). The person who conducts the test shall have a certificate as per ISNT or ASNT Level-2 (American Standards and Testing).

1.25.11 Radiographic test of welded Joints

In the case of field joints, a minimum of 10 % of the weld length of each joint at random shall be subjected to a radiography test.

In case of failure of joints, the contractor shall be required to carry out radiography of thrice the number of segments failing during the radiography test. Even after such radiography testing, if any one of the segments fails, the contractor shall be required to carry out radiography of the full joint.

The weld ripples or weld surface irregularities, on both inside and outside, shall be removed by any suitable mechanical process to a degree such that the resulting radiographic contrast due to any remaining irregularities cannot mark or be confused with that of an objectionable defect. The radiograph shall be made in strict accordance with the latest requirements and as per the latest and most efficient technique, either with X-ray or gamma-ray equipment.

The photographs are to be marked in such a way that the corresponding portion of the welded seam can be readily identified. All radiographs will be reviewed by the Employer's Representative to identify the defects and determine those which must be removed. Defects that are not acceptable shall be removed by chipping,machining or flame gouging to sound metal, and the resulting cavities shall be welded. After rectification, the joint is to be radiographed again to prove the quality of the repair. The radiographs will be judged as acceptable or unacceptable by the Employer’s Representative based on the latest standards prescribed by the Indian Standard specifications.

All X-rays shall be made with equipment and by personnel furnished by the Contractor. Films

shall be developed within 24 hours of exposure and be always readily accessible for inspection by the Employer's Representative. The Contractor shall provide for the use of the Employer's Representative suitable X-ray viewing equipment. X-ray films shall be properly maintained by the Contractor and shall be handed over to the department on completion of the Contract. All films shall be identified by the number, and a chart prepared to indicate the location of the joint each X-ray photo represents. In the event of additional radiographic inspections required for any work associated with the pipe erection, such inspection shall be performed by the Radiographer at the discretion of the Employer's Representative.

1.25.12 Radiographic Inspection of Welded Joints

All welded joints are to be radio-graphed and shall be examined in accordance with:

IS : 2595	Code of Practice for Radiographic Testing
IS : 4853	Recommended Practice for Radiographic Inspection of Fusion Welded Butt Joints in Steel Pipes
IS: 1182	Recommended Practice for Radiographic Examination of Fusion

The reinforcement on each side of all butt-welded joints shall not exceed 1.5 mm.

A complete set of radiographs and records as described in IS: 2595 Clause 14, for each job, shall be retained by the Contractor and kept on file for at least five years.

Radiographers performing radiographs shall be qualified in accordance with SNT-TC-1A. Supplements and Appendices "Recommended Practice for Non-destructive Testing Personnel Qualification and Certification" published by the American Society for Nondestructive Testing, as applicable for the technique and methods used.

Final acceptance of radiographs shall be based on the ability to see the prescribed penetrometer image and the specified hole. Sections of welds that are shown by radiography to have any of the following types of imperfections shall be judged unacceptable and shall be repaired.

i. Any type of crack, or zone of incomplete fusion or penetration,

ii. Any elongated slag inclusion which has a length greater than 6 mm,

iii. any group of slag inclusions in a line that has an aggregate length greater than the thickness in a length of 12 times the thickness, except when the distance between the successive imperfections exceeds 6L, where L is the length of the longest imperfection in the group

iv. Rounded indications in excess of those specified by the acceptance standards given earlier.

The destructive test of pipe joints on the field shall be carried out as per IS 3600. For every 200 m length of pipeline laid, one destructive test of the field joint shall be carried out.

The welded joints shall be tested for Tensile test, Bend test & tree-panned plug-in accordance with the procedure laid down in IS No. 3600 of 1966 and the latest version of all parts of the code "Code of procedure for testing of fusion welded joints and weld metals in steel".

Test pieces shall be taken by the contractor from the welded joints at the position on

fabricated pipes pointed out by the Employer's Representative.

The sample so taken shall then be cut to the exact shape and dimensions machined as described below and handed over to the Employer's Representative for testing.

1.26 Pipe laying.

1.26.1 Bedding

Bedding for the pipeline shall be of two different classes, depending on the soil strata as per the direction of the Employer's Representative.

When the soil strata in the trench is soil (other than soft or hard rock), the trench shall be properly compacted, and no extra bedding shall be provided. The bottom of the trench shall be prepared in such a way that the profile of the pipe shall touch the bottom of the trench at 120º from the center of the pipe. This profile of pipe at the bottom of the trench for uniform support shall not be made more than 2 days prior to the actual laying of the pipe.

When soil strata in the trench are rocky or consist of any unsuitable material which is likely, in the opinion of the Employer's Representative, to cause damage to the pipe, then sand/murmur bedding shall be provided. The bedding material shall be clean, well graded, and free from topsoil, clay, or vegetable matter and approved of the Employer's Representative. If the material supplied is unclean, it shall be washed. In no case shall it contain more than 3.5% by dry volume or 5% by wet volume of clay, loam or silt be accepted. Tests specified for determining silt and organic impurities, as described in IS 383, shall apply.

The bedding shall be done as under:

v. The filling and compaction shall be done up to the appropriate depth.

vi. The bedding shall be compacted, at optimum moisture content and by mechanical equipment with suitably shaped tamping feet/ plate, to 90% modified proctor density.

vii. The compacted fill shall be re-excavated in a profile to match the pipe profile to form a "cradle" which will provide a 120-degree uniform support to the pipe.

viii. The appropriate depth is such that after re-excavating the fill minimum of 150 mm of sand bedding material shall remain below the bottom center of the pipe.

ix. The profile of pipe in compacted fill for uniform support shall not be made more than 2 days prior to the actual laying of pipe.

1.26.2 Laying Program.

The Contractor shall submit a detailed bar chart for the procurement and laying of the pipeline, which shall be subject to the Employer's Representative's approval. In preparing this bar chart, the Contractor shall plan his activities such that the laying of pipes shall closely follow the procurement schedule, and no pipes shall remain stacked at the site for more than one month or as decided by the Employer's Representative. The Contractor shall submit the procurement schedule of pipes and fittings for the Employer's Representative's approval.

Together with the chart, he shall submit a methodology describing how he will carry out this Work within the contractual period and the required resources in terms of construction

equipment and other facilities that he shall utilise to complete the work.

The pipes and specials supplied shall be transported by the contractor to their respective positions at the risk and cost of the contractor and installed in their respective position. Conveyance from a stacked place until the pipes and specials etc., are lowered and laid into trenches or on a pedestal shall be done by the contractor at his own cost. The pipe can be assembled in the position either by providing cranes, portable gantries, shear legs or any other equipment approved by the Employer's Representative, and pipes shall be laid conforming to IS-5822-1994. Normally, not more than 2/3 pieces of total length not exceeding 24m shall be aligned

tacked and kept in position on temporary supports. Further work shall not proceed until those pipes are fully welded. The free end of the pipeline shall be held in position by two ceilings to avoid deflection due to temperature variations during the day. Preferably, the assembly of pipes tack welded with runs of welds should be done, or continuity of work can be maintained by adding more pipes on the second day in a similar manner after completion of welding of previous joints during the night.

1.26.3 Lowering and Jointing

The pipe shall be lowered into the trenches by removing only one or two struts at a time. It shall be seen that no part of the shoring is disturbed or damaged, and if necessary, additional temporary struts may be fixed during the lowering operations. It shall also be necessary to see that the coating of the pipe is not damaged in any way during the lowering and assembling. After the pipe is lowered into the trench, it shall be laid in the correct line and level by using the levelling instruments, sight rails, theodolite, etc. Care shall be taken to see that the longitudinal joints of two consecutive pipes at each circumferential joint are staggered by 90°. While assembling the pipes, the ends shall have to be brought close enough to leave a uniform gap not exceeding 4 mm If necessary, a marginal cut may be taken to ensure a close fit of the pipe faces. For this purpose, only experienced cutters who can make uniform and straight cuts shall be permitted to cut the faces of the pipes. No extra payment shall be made for such marginal cutting. There shall be no lateral displacement between the pipe faces to be joined. If necessary, spiders from inside and tightening rings from outside shall be used to bring the two ends into contact and alignment. It may also be necessary for this purpose. In no case shall hammering or longitudinal slitting be permitted. When the pipe is properly assembled and checked for the correct line and level, it shall be finally supported on wooden beams and wedges and tack-welded. Some portion of the trench may be refilled at this stage to prevent the pipeline from losing its alignment. The tack-welded circumferential joints shall then be welded fully. Only experienced welders, who shall be tested from time to time, shall be permitted to carry out the welding work.

On completion of the pipe jointing and external protection, the trench and the welding pits shall be cleaned of guniting rebound. The welding pits shall be filled and compacted in 150 mm layers with the bedding material.

Except for routine welding of joints, no other work shall be done in the absence of the Employer's Representative.

The components of the exposed sections of the pipeline, such as plates and pedestals, shall be so designed that the centres of the plates and pedestals shall coincide with the mean

temperature of the locality. For this reason, all work such as fixing flanges, plates, etc., in true alignment and correct position and tack welding pipes shall be done at the mean temperature. For ascertaining the temperature, the Contractor shall provide mercury cups, fix them to the pipe shell from outside, and provide thermometers of the required type and range. No extra payment shall be made for this.

1.26.4 Providing Steel Props Inside the Pipeline

In order to effectively provide cement mortar lining to the inside of the pipes and to avoid difficulties during the work, the roundness of the pipes must be maintained circular till the lining work is taken up. To achieve the same, steel adjustable screw-type props of the screw or similar approved make consisting of a minimum of six legs shall be fixed inside the pipe. The deflection of the Pipe should be limited to 2% of the average diameter. In no case shall the limit be exceeded, even under the full load, in the case of pipes laid underground. The design and drawings of the props that the contractor intends to use should be approved by the Employer's Representative before starting the work. While laying the pipes underground, the Contractor shall provide this propping arrangement from inside to maintain circularity. These props shall be fixed vertically and at intervals of no more than 1.8 meters or as directed by the Employer's Representative. If the Employer's Representative finds it necessary, they must be fixed in any position. The props should be kept in position at least for three days after the encasing of the pipe in that section is completed or till refilling is done to the full height of fill over the pipe in case the pipes are not encased. The props shall be removed only after obtaining permission from the Employer's Representative. The height of earth fills over the pipe top shall normally be such as to avoid flotation under submerged conditions and have a minimum earth cushion of about 1.20 meters over the pipe, whichever is greater. It is also necessary that, in the case of a buried pipe, adequate side supports from the backfilled materials are developed to keep the diametric deflection within the specified limits. Backfilling of the excavated trenches, particularly below the pipe and along the sides, shall, therefore, have to be done with proper care and compaction as desired.

1.26.5 Refilling of Trenches

On completion of the pipe laying operations and successful field testing of joints in any section, for a length of about 200 m and while further work is still in progress, backfilling of trenches shall be started by the Contractor with a view to restricting the length of open trenches.

All backfill material shall be free from cinders, ashes, slag, refuse, rubbish, vegetables, or organic materials, lumpy or frozen material, boulders, rocks or stones or other material which, in the opinion of the Employer’s Representative, is unsuitable or deleterious.

Unless otherwise specified or permitted by the Employer’s Representative, all backfill material shall be compacted by mechanical means using equipment with suitably shaped feet/ plates. At the time of placing the backfill, the Contractor will be responsible for ensuring that the optimum moisture content is achieved so that the required degree of compaction is achieved. If necessary, the Contractor will be required to add water to the backfill material in such a manner that the moisture content is uniform throughout each layer during compaction.

Backfilling shall be done with fine-grained soils with less than 25% sand content, placed in layers of 150 mm. The backfilling material shall be deposited in the trench for its full width on

each side of the pipe, fittings, and appurtenances simultaneously. The column of backfill along the sides of the pipe shall be compacted by mechanical means up to 90% modified proctor density. Care shall be taken to ensure that mechanical compacting equipment is not used from the top of the pipe up to 300 mm above the crown of the pipe.

If suitable material for refilling is not available from already excavated material, the Contractor shall import material of approved quality as directed by the Employer's Representative.

Care shall be taken during backfilling so as not to injure or disturb the pipes, joints or coating. Filling shall be carried out simultaneously on both sides of the pipes so that unequal pressure does not occur.

The Contractor will be responsible for ensuring that the water content of the soil shall be kept as near the optimum moisture content as possible. Regular measurements of the field dry density shall be taken by the Contractor at various levels in the backfilling as required by specifications and the Employer's Representative. Any backfill which fails to achieve the required degree of compaction shall be re-excavated, replaced, and re-compacted to the required density, all at the Contractor's cost.

Only mechanical compaction shall be done unless otherwise specified or approved by the Employer's Representative. No mechanical plant other than approved compacting equipment shall run over or operate within the trench until backfilling has reached its final level or approval for the Employer's Representative has been obtained.

Walking or working on the completed pipeline shall not be permitted unless the trench has been filled with the specified bedding and backfilling up to a height of at least 300 mm over the top of the pipe, except as may be necessary for tamping, etc., during backfilling work.

The trench shall be refilled to build up to the original ground level, keeping due allowance for subsequent settlement likely to take place. The surface of the refilled excavations shall be left slightly higher than the adjacent ground and shall be maintained by the Contractor to a smooth, even slope.

Should any subsidence take place either in the filling of the trenches or near about it during the works the Contractor shall make good the same at his own cost. All the surplus excavated stuff (including rock) will be the Contractor's property, and he will be responsible for making proper arrangements for the disposal of the same.

1.26.6 Field Hydraulic Testing Procedure

After the work of laying of pipeline is completed and before putting it into commission, the pipeline shall be tested in the field, if so, directed by the Employer's Representative, both for its strength and leakage. The procedure for the test shall be as follows:

For Pressure testing, the pipeline shall be divided into sections as defined by the Employer's Representative.

The Sectional Field Hydraulic Test shall be carried out after the pipeline section to be tested has been laid, jointed, and backfilled to a depth sufficient to prevent flotation, but leaving the joints exposed which have not been tested. The sections to be tested shall be to the approval of the Employer's Representative and shall not be longer than 0.5km to 1.0km when either

the pipeline is laid adjacent to or underneath the carriageway or when the section includes an air valve chamber. The joints between each tested section shall be left exposed until the pipeline has successfully passed the Tests on Completion. The Field Hydro testing shall be carried out such that the whole length of the proposed pipeline is covered.

In addition to the above requirements, the Contractor shall perform a hydraulic test on the first 0.5km length of the pipeline to be laid under the contract. This test shall be undertaken within one month of the Contractor commencing the laying of pipes. Should the pipeline fail the test or the Contractor fail to undertake the test, all laying and welding work shall come to a halt until that section of the pipeline passes a hydraulic test.

Each length of the pipeline to be tested shall be capped or blanked off at each end and securely strutted or restrained to withstand the forces which will be exerted when the test pressure is applied. Testing against closed valves will not be permitted. Washout valves shall be fitted with blank flanges, and these, together with in-line valves, shall be left open. Air valves already fitted shall be permitted to function during the test.

Proposals for testing where thrusts on structures are involved, even where thrust flanges on the piping are installed, shall be submitted, with the calculations of the forces to be carried to the Employer's Representative for approval.

The method of filling the pipeline with water shall be approved by the Employer's Representative. The length under test shall be filled, making certain that all air is displaced through an air valve installed at the top of the blank flange situated at the high end of the line. The length shall then remain under constant moderate pressure, 10 to 20m head of water, for several hours until the pressure can be maintained without additional pumping.

The pressure shall then be slowly increased at a maximum rate of 1 bar per minute to the full test pressure, and pumping discontinued for 3 hours or until the pressure has dropped by 10m, whichever occurs earlier. Thereafter, pumping shall be resumed and continued until the test pressure has been restored. The quantity of water pumped to restore the pressure shall be the measure of leakage from the discontinuation of pumping until its resumption. This test pressure of 8 bar shall withstand the test for 24 hours.

The pipe length shall pass the test if the leakage is not more than 0.33 litres per mm diameter per kilometre per 24 hours for each 100m head of pressure applied.

Notwithstanding the satisfactory completion of the hydraulic test, if there is any discernible leakage of water from any pipe or joint, the Contractor shall, at his own cost, replace the pipe, repair the pipe or re-make the joint and repeat the hydraulic test.

No pipeline shall be accepted until the leakage on any length is not more than the rate of leakage specified above, and all sources of leakage have been rectified.

The Test on Completion shall be carried out after all the pipeline sections have been satisfactorily tested and the joints between each section have been completed to provide a continuous test length between contract interfaces.

Pipelines shall be tested as above except where the Employer's Representative issues such instructions as are necessary for testing parts of the Works that have been designed for stresses limited by considerations other than those applying to the pipeline systems.

1.26.7 Test Pressures

Test pressures are to be measured in bars at the Centre of the blank flange situated at the lowest end of the pipeline under test. Unless otherwise specified or shown on the drawings, pipeline field test pressure shall be as per the relevant IS codes and standards.

Test pressures for sections of the pipeline containing air valve chambers shall be such that the pressure at the chamber does not exceed the valve design pressure as specified by the manufacturer.

1.26.8 Internal Cleaning of Pipeline

Wherever directed by the Employer's Representative, internal surfaces of pipes, specials, etc. of all sizes shall be thoroughly cleaned by repeated hosing with water and simultaneous rubbing with gunny cloth.

Further, when a section of the pipeline has been laid and all the work inside it has been completed to the satisfaction of the Employer's Representative, its internal shall be cleaned of all dirt, debris, dust, or other deposits.

Pipelines shall be cleaned by repeated hosing of copious quantities of water on the pipe surface and simultaneously rubbing the surface with a gunny cloth. Cleaning with metal cleaning solution, acid, and wire brushing, scrapers, or sandpaper will not be permitted.

Cleaning of laid pipelines will be restricted to cleansing and scraping out of debris and dirt only.

Cleaning shall be done to the satisfaction of the Employer's Representative. The section of the pipeline once cleaned shall not be entered into for any purpose later. Sufficient precaution shall be taken to prevent the ingress of any dirt, debris, or dust inside the section. Failing this, the section shall be cleaned again at the discretion of the Employer's Representative.

In the case of the above-ground pipeline, the length of the section to be taken up for cleaning shall be decided in consultation with the Employer's Representative from the point of view of ventilation, etc.

In the case of a buried pipeline, a section shall be taken up for cleaning after the work of backfilling around and over the pipeline is completed and the spiders have been removed from inside.

During the pipe laying operation in the adjoining section, the Contractor shall take all precautions to prevent ingress of water, mud, debris, dirt, dust, etc. in the cleaned section, failing which the section shall be cleaned again at the discretion of the Employer's Representative. Where deemed necessary by the Employer's Representative, suitable closures shall be provided at the open end or the ends of the cleaned sections. Payment will be made for the work under the relevant items of the Bill of Quantities.

At die end of a season's work, closure shall invariably be provided at all the open ends to protect the Pipeline from ingress of subsoil water, mud, muck, etc.

No separate payment will be made for the work of cleaning and providing closures. The rates quoted for laying the pipes, painting, etc., shall include the cost thereof.

1.26.9 Internal Cement Mortar Lining

This Specification covers the requirements of providing materials and application of in-situ cement mortar lining by mechanical and/or hand application to the internal surfaces of the pipeline in straight sections, long/short radius bends, vertical shafts, and all specials, etc. Laid below ground level, at the surface, to be installed under this contract. After successful completion of the field hydraulic test of the pipeline, the Contractor shall take up the in-situ cement mortar lining to the internal surface of the pipeline. The work shall be started only after obtaining the written approval of the Employer's Representative in this respect.

The work shall be carried out through an access opening by a machine that progresses uniformly through the pipe, applies mortar against the pipe surface and mechanically traverses to obtain a smooth transition of joints. The lining of bends, specials, and areas adjacent to valves shall be machine sprayed as far as practicable and hand-travelled. The all-access openings shall be replaced in position after lining them by hand. The pipeline will be restored to the satisfaction of the Employer's Representative.

AWWAC602	American Water Works Association (AWWA) Standard for Cement Mortar Lining of Water Pipelines - 4 in. and larger — In Place.
IS-3696	Safety code for scaffolds and ladders (Part 1 & II)
ASTM - C40	Test for Organic Impurities in Sands for Concrete

All pipes and fittings shall be internally lined with cement mortar in accordance with IS: 11906/AWWA C602.

Employer's Representative shall have the right to inspect the source/s of material/s, the operation of procurement and storage of material, Cement mortar batching and mixing equipment and the quality control system. Such an inspection shall be arranged if found necessary, at the expense of the contractor, and no additional payment whatsoever shall be made for the same. Employer's Representative’s approval shall be obtained prior to starting of lining work.

Cement shall be Portland cement in accordance with IS 8112.

Sand used for lining shall be tested with standard sieves as per IS 460 and requirements specified in IS 11906.

The minimum cement content shall be 1000 kg/m3, and the water: cement ratio by mass shall be between 0.3 and 0.45:1.

The mortar shall stop 100mm back from the faces of any joints. The end faces shall be vertical.

The contractor shall make sure that proper mobilization of the necessary equipment, etc., making access openings wherever required and curing of the mortar-lined pipes, including testing, patching access holes, etc., as described in the following pages. The main items of the work will be generally as follows:

1.26.10 Surface Preparation for Cement Motor Lining

The interior surface of the pipe to be lined shall be cleaned to remove all rust, chemical or other deposits, oil, grease and all accumulations of water, dirt, and debris. The cleaning of the surface shall be carried out with the use of suitable chemical or mechanical means to the

approval of the Employer's Representative. The extent of cleaning shall be to the satisfaction of the Employer's Representative.

All loose mill scale, dirt, rust, and accumulation of construction debris shall be removed from the interior of the steel pipeline. The pipeline shall be cleaned by use of a power-driven cleaner incorporating revolving brushes on rotating arms.

Immediately before the travel of the lining machine through the pipeline, all foreign material shall be removed. This includes sand and loose mortar that might have accumulated since the work of surface preparation work was completed.

1.26.11 Mix Proportion for Cement Mortar Lining

The proportion of sand to cement shall not be more than 1.0 part sand to 1.0 part cement by weight. Mortar composed of cement, sand and water shall be well mixed and of proper consistency to obtain a dense, homogeneous lining that will adhere firmly to the pipe surface. The cement mortar mix shall comply with the

strength and density requirements specified in IS 11906/AWWA C602. No admixtures shall be permitted unless approved by the Employer's Representative.

1.26.12 Thickness of Cement Mortar lining

The lining shall be uniform in thickness. The lining thickness shall be **10mm** with no negative tolerance and a positive tolerance of 3mm.

1.26.13 Mild Steel Pipe Internal Lining Procedure

The lining shall be placed by the centrifugal method in one course by a machine travelling through the pipe and discharging the mortar at a high velocity overall pipe section and long radius bends. The discharge shall be from the rear of the machine so that the freshly applied mortar will not be marked. The rate of travel of the machine and the rate of mortar discharge shall be mechanically regulated to produce uniform thickness throughout. The mortar must be densely packed and shall adhere to the pipe wherever applied.

Mortar lining shall be mechanically troweled except for the places where hand troweling is expressly permitted by the Employer's Representative.

The lining machine shall be provided with attachments for mechanically troweling the mortar. Both the application and troweling of the mortar shall take place at the rear of the machine so that the freshly placed and troweled mortar will not be damaged. The trowel attachment shall be such that the pressure applied to the pipe will be uniform and produce a lining of uniform thickness with a smooth and even finished surface free of spiral shoulders. The finished surface of the machine, placed troweled lining in the pipe shall be examined according to the procedures as laid down in Indian Standards or any other International Standard whichever is stringent.

Ridges or uneven build-up caused by irregularity in the travel rate of the machine shall not be allowed.

The thickness of the lining shall be ascertained frequently during the placing of mortar and troweling using an approved non-destructive method.

In the stretch of pipe that has been lined and troweled in each day’s run, ten places shall be

selected in straight sections of the pipe by the Employer's Representative. In each of the ten places, the thickness of the lining shall be re-measured by non-destructive means as directed by the Employer's Representative.

Defects in lining, including but not restricted to sand pockets, voids, over-sanded areas, blisters, cracked and dummy areas, and thin spots, shall be removed, and the area shall be repaired to the full required thickness of the mortar lining. Defective areas encompassing the full diameter of the pipe shall be replaced by a machine. Defective lining rejected at the time of lining shall be removed before the initial setting of the mortar. Defective lining rejected after the initial set shall be replaced or repaired by the most practical method as determined by the Employer's Representative.

Hair cracks or cracks up to 0.25 mm in width and not over 300 mm in length in finished linings may be considered acceptable at the discretion of the Employer's Representative, but larger cracks shall be repaired or removed and redone all as directed by the Employer's Representative.

Cement mortar lining of bends, specials, areas closely adjacent to valves and other such places where machine placing may not be practical shall be performed by hand. The Employer's Representative may order the correction of any defect by hand application. The entire procedure of applying cement mortar lining shall be subject to continuous inspection by the Employer's Representative, but such inspection shall not relieve the contractor of the responsibility to furnish material and perform work in progress in accordance with this standard. All cement mortar lining not applied in accordance with these specifications shall be subject to rejection by the Employer's Representative. The lining so rejected shall be removed and replaced or repaired by the contractor at the cost of contractor.

The Employer's Representative shall have free access to all areas, places or facilities concerned with the furnishing of material or the performance of work under the provisions of this standard.

The contractor shall furnish the Employer's Representative reasonable assistance, without charge, in carrying out the inspection duties and specifically in obtaining information with respect to the character of the material used and the progress and manner of the work.

1.26.14 Pipe Internal Lining Inspection Procedure

The Employer's Representative shall inspect the pipeline following the application of the cement mortar lining to identify defective areas in the lining, to determine the quality of the lining and to determine compliance with this standard.

Every precaution shall be taken to prevent injury to the lining should the lining be damaged through the fault of the contractor. At any time before completion of the contract, such damage shall be repaired conforming to these standards, at the contractor's expense. The repair of damaged lining not attributable to the contractor shall be carried out and paid for on an extra-work basis.

1.26.15 Access Openings for Cement Mortar Linings

The contractor may utilize existing specified manholes, flanged outlets, and pass holes for access and material feed points during the lining operations. All-access openings shall be removed and or replaced in accordance with specifications. Mortar lining of closure and

adjacent areas shall be applied by machine or hand methods. Access to the pipeline for placing field-applied cement mortar lining may be obtained by one or more of the following methods: -

Temporarily omitting short "roll out" sections of pipe.

Deferring the installation of the closing sections of the pipe until after completion of the lining. Cutting "half cap" openings in the completed openings.

Cutting temporary feed point manholes in the installed pipeline.

Preparation of pipe surfaces: The interior surface of the pipeline shall be cleaned prior to the placement of cement mortar lining. The pipe interior surface shall be free of oil, grease, and accumulations of water. All loose mill scale, air, rust and construction debris shall be removed from the interior surface of the new steel pipeline. This may be accomplished using a stiff street broom in the large pipe or a drag brush in the small pipe. Shot or sandblasting is not required.

1.26.16 Hand Application of Cement Mortar Lining

Cement mortar for hand work shall be of the same materials as the mortar for machine-placed lining.

The areas to be lined shall be thoroughly cleaned as specified earlier and, if necessary, shall be moistened with water immediately prior to placing the hand-applied mortar.

Steel finishing trowels shall be used for the hand application of cement mortar, except at bends, the outer edges of hand-troweled areas may be brushed in order to reduce the abutting offset.

All hand-finishing work in a section of the pipeline shall be completed within 24 hours after completion of the machine application of mortar lining in that section. If necessary, application of mortar lining by machine shall be delayed or stopped to assure compliance with this schedule.

Hand-placed mortar shall have a uniform and smooth surface with smooth transitions to adjacent machine-placed linings.

Hand-placed mortar shall have a uniform surface with smooth transitions to the adjacent machine-placed lining.

Materials for cement Mortar for hand work shall be of the same materials as the mortar for machine-placed lining.

Cleaning: Areas to be lined shall be thoroughly cleaned. If necessary, shall be moistened with water immediately prior to placing the hand-applied mortar.

Troweling: Steel finishing trowels shall be used for the hand application of cement mortar, except at bends. The outer edges of hand-troweled areas may be brushed in order to reduce the abutting offset.

Timing: All hand-finishing work in a section of the pipeline shall be completed within 24 hours after completion of the machine application of mortar lining to that section. If necessary, the application of mortar lining by machine shall be delayed or stopped to ensure compliance with this schedule.

Special Requirements at Openings: Laterals and connections to the pipe being lined shall not be left obstructed by the lining operations. Openings in the pipeline for manholes, outlets and blow-offs shall be temporarily closed and covered with removable coverings or other suitable devices to prevent the intrusion of the cement mortar into such openings. On completion of the lining, the contractor shall remove all such covers and shall repair any lining damaged in the process.

1.26.17 Tests of Cement Mortar Used for Lining: Field Tests.

The following field tests shall be carried out by the contractor at his own cost to determine the quality of the mortar.

1.26.17.1 Slump Test

Fresh Mortar mixed in power mix may be taken for slump tests; the water content shall be as minimal as possible. The slump test should be done once a day or as directed by the Employer's Representative using the freshly mixed mortar immediately prior to the mortar being fed to the lining machine. The slump shall not exceed 25mm to 30mm. The test should be made in accordance with ASTM C-143. In the event of failure, in respect of the above test, the site Employer's Representative will take suitable action, including stoppage of the work.

1.26.17.2 Cube Test

After the slump test is carried out, cubes of cement mortar of the size 10cm x 10cm x 10cm shall be taken out. Each block shall be removed from its mould as soon as practicable and cured under conditions of temperature and humidity identical to those in which the lining of the pipe is cured. The number of tests shall be at least 4 cubes for each age and each water-cement ratio. The work cube strength of the test cube shall not be less than 300 kg/cm2 after 28 days of curing or 170 Kg/cm^2 after 7 days of curing. The density of the test cube shall not be less than 2300 Kg/m^3.

The casting of the cubes shall be done on all the days of mortar lining. The contractor shall make the arrangements for a cube testing machine at the site. Failure of the cube test may entail partial or whole demolition of such / work, penalties for the contractor concerned and /or other similar steps. In case of any dispute, the decision of the Employer's Representative shall be binding on the contractor.

1.26.18 Specials and Appurtenances: General

Specials, such as tees, Y-Pieces, bends, tapers, and dished ends, shall necessarily be in steel and shall be manufactured as per standards and tested in the same manner as the pipe. Small branches, single-piece bends, etc., may be fabricated at the site, care being taken to ensure that the fabricated fittings have the same strength as the pipeline to which they are to be joined.

Specials shall be fabricated from IS 2062 Grade B Steel to the dimensions shown on the drawings. Specials, such as tees, Y-pieces, bends, tapers, etc., shall necessarily be in steel and shall be in accordance with IS 7322/BS 534/AWWA C208 and ASME standards and tested and laid in the same manner as the pipes.

Standard fittings shall be used wherever possible in preference to fabricated fittings. Standard

fittings shall be manufactured in accordance with the standards specified above. Where fabricated fittings are supplied, with the approval of the Employer's Representative, they shall be fully workshop fabricated and tested in accordance with the above standards.

Tees and Branches on steel pipelines must be reinforced by welding reinforcement collars around the base of the branch, and in the case of large diameter branches, increasing the main pipe wall thickness or making use of crotch plates.

The specials and fittings shall be designed by the Contractor and the design calculations (as per the relevant codes) and drawings shall be submitted to the Employer's Representative for approval. For oval-shaped collars, the width shall be at the narrowest point. All other fittings, tees, branches, crosses, and bends are to be designed by the fabricator.

1.26.19 Bends

Bends shall be fabricated taking into account the vertical and horizontal angles for each case.

The bends shall have welded joints, and the upstream and downstream ends of each bend shall have a straight piece of variable lengths as required.

Bends shall be designed with a deflection angle of a maximum of 2º between segments.

When the point of intersection of a horizontal angle coincides with that of a vertical angle, or when these points can be made to coincide, a single combined or compound bend shall be used, designed to accommodate both angles. The combined bend should have a pipe angle equal to the developed angle, arrived at from the appropriate formula.

All joints in bends shall be thermally stress relieved as specified.

Details of thrust collar anchor bolts, holding down straps, saddle plate etc. should be furnished together with full specifications in the Contractor’s fabrication drawing.

1.26.20 Manholes

Manholes shall be placed as per the locations indicated in the construction drawing and as directed by the Employer's Representative. Manholes in the pipeline shall be placed in a suitable position in the top quadrant.

The Contractor shall fabricate different parts of the manhole in conformity with relevant IS specifications, well-established practices and as directed by the Employer's Representative.

The thickness of the Mild steel plate used for the construction of the manhole shall be as indicated in the drawing or as directed by the Employer's Representative. The measurement of the manhole and payment shall include all fabrication and welding to the main pipe and shall be paid based on quantity.

1.26.21 Closing or Makeup Sections

Closing or make-up sections shall be furnished at appropriate locations on the line to permit field adjustments in pipeline length to compensate for the shrinkage in field welded joints, differences between actual and theoretical lengths and discrepancies in measurements.

1.26.22 Test Heads

Test heads may be ellipsoidal, standard dished as per ASME code or hemispherical heads. They shall be welded in the shop and removed after the test. Allowance should be made in

the length of the pipe section receiving the test head for the welding, removal of the head and preparation of the plate edges for the final weld after testing.

No separate payment will be made for such test heads. The rate quoted for the hydraulic test shall be deemed to cover the cost of such installations.

1.26.23 Flanges

Flanges shall be provided at the end of pipes or special locations where valves, blank flanges, tapers/reducers, etc., have to be introduced. The flanges received from the manufacturers shall have the necessary bolt holes drilled. The Contractor shall assemble the flanges in the exact position by marginal cutting, if necessary, to get the desired position of the valves, etc., either vertical or horizontal and shall then fully weld the flanges from both sides in such a way that no part of the welding protrudes beyond the face of the flanges. In case the welding protrudes beyond the flanges and if the Employer's Representative orders that such protrusions shall be removed, the Contractor shall file or chip them off. If required and when directed by the Employer's Representative, the Contractor shall provide and weld gusset stiffeners, as directed on site.

1.26.24 Blank Flanges

Blank flanges shall be provided at all ends left unattended for the temporary closure of work and for commissioning a section of the pipeline, or for testing the pipeline laid. For temporary closure, non-pressure blank flanges consisting of mild steel plates and tack-welded at the pipe ends may be used. For pipes subjected to pressures, the blank flanges or domes suitably designed as per the Employer's Representative’s requirements shall be provided.

1.26.25 Stiffener Rings

The Contractor shall provide stiffener rings wherever directed by the Employer's Representative. The Contractor shall weld the same to the pipes with one circumferential run on each side.

1.26.26 Straps

Wherever pipe laying work is done from two faces and/or has to be done in broken stretches due to any difficulty met at the site, the final connection has to be made by introducing straps to cover gaps up to 30cm in length. The straps shall also be provided as per the procedure of fixing expansion joints by the method described in these specifications. Such straps shall be fabricated in the field by cutting pipes, slitting them longitudinally and slipping them over the ends to be connected in the form of a collar. The collar shall be in two halves and shall have an inside diameter equal to the outside diameter of the pipe to be connected. A minimum lap of 8cm on either end of the pipe shall be kept, and fillet welds shall be run both internally and externally in the circumferential joint. The longitudinal joints of the collar shall be butt welded. All fillet welds shall have a throat thickness of not less than 0.7 times the width of the weld.

1.26.27 Anchor/Thrusts Blocks

Anchor/Thrust blocks shall be provided at horizontal bends, vertical bends or/ at intervals on pipelines as directed by the Employer's Representative /Consultant. The provision of Anchor Block/Thrust Block shall be finalized during the execution, and the same shall be shown on the L section drawing released for construction, indicating the Chainages/at which the Anchor

Block is to be provided. The anchorages shall be made from concrete and constructed to the dimensions shown on the Released Construction Drawings.

Where the faces of Anchor/Thrust blocks are shown to bear against undisturbed ground, the Contractor shall take all necessary measures to ensure that such bearing is given over the full dimensions shown.

Welded pipelines shown on the drawings as having tied couplings and flanges shall require anchor blocks only at the positions specifically noted on the drawings.

Where possible, the base of the thrust block shall be cast against solid rock in order to prevent any settlement. Any material overlying the rock shall be excavated and replaced with class M20 mass concrete. In the event of no rock being encountered, the base of the thrust block shall be cast against undisturbed ground. Any ground which, in the Employer's Representative's opinion, is unsuitable shall be excavated and replaced with class M20 mass concrete.

1.26.28 Epoxy painting.

Unless otherwise specified, pipes and fittings above ground shall be painted externally. The shop-applied painting is to be stopped 150 mm short at each end of the pipe to facilitate field welding and then made up on-site following testing of the joint.

Painting shall be generally in accordance with the general painting specifications mentioned elsewhere in this document, except for the following.

All pipes and fittings on bridges shall be painted externally with zinc-rich epoxy primer and epoxy paint. Both shop and site applications are to be done by airless spray equipment. Paints of reputed make and approved by the Employer's Representative shall be used. Thinning or heating of paints will not be permitted except with specific approval from the Employer's Representative and in accordance with the manufacturer's instructions.

Each lot of primer and paint used by the Contractor shall be accompanied by certified copies of the test results on hardness, impact heat resistance and resistance to corrosion carried out by manufacturers in accordance with relevant Indian or International standards.

Surface preparation shall be in accordance with the manufacturer's instructions, but as a minimum, the pipes shall be abrasive blast cleaned to BS 7079 Grade Sa 2.5 or equivalent to achieve a surface roughness profile of 40–50 microns. The primer shall be applied within 2 hours of surface preparation before flash rusting can occur. Two coats of Zinc-rich epoxy primer shall be applied by spray equipment on the pipes and fittings.

The priming coat shall be uniform in thickness and free from floods, runs, sags, drips, and bare spots. Any bare spots or defects shall be recoated with an additional application of the primer. All defects shall be rectified as per the instructions of the Employer's Representative.

Though the priming coats become touch dry in 10 to 15 minutes, the finishing coats with epoxy paints shall be applied after allowing the film to cure for at least 48 hours. The final dry film thickness shall be a minimum of 500 microns. This may be achieved by applying in 2 to 4 coats.

On completion of the work, the contractor shall remove any oil stains or paint spots, leaving the pipes and fittings in a clean and acceptable condition.

1.26.29 Inspection and Testing

The entire procedure of applying the paint as specified will be rigidly inspected right from the cleaning stage to the application of the final coat by the Employer's Representative. If, at any time, it is found that the procedure of applying the paint or defects noticed, all such painting work done shall be rectified or redone by the Contractor at his own cost, as directed by the Employer's Representative.

Samples of the paint brought by the Contractor shall be sent to the testing laboratory for testing, as directed by the Employer's Representative. If any sample is found to be not conforming to the specifications, the entire consignment to which the sample may pertain shall be rejected. Samples shall be taken at intervals at the option of the Employer's Representative. All the costs incidental to such testing shall be deemed to be included in the rates quoted by the Contractor.

1.26.30 Pipeline Joints: General

Unless detailed otherwise, all pipes and fittings shall have welded butt joints as detailed in the specifications. Where shown on the Drawings, flanged joints or collar sleeve joints shall be provided.

1.26.30.1 Sleeve collar joints.

The use of sleeve collars shall generally be limited to the jointing of pipes at tie-ins. The thickness of the external steel sleeve collar shall be not less than that of the pipe itself, and the length shall be a minimum of 300 mm. The sleeve shall be joined to the pipe with an internal full-depth structural weld and external sealing welds to allow the joint to be gas tested. A gas testing hole shall be made at each end of the sleeve, and for the purpose of gas testing, at the joints.

1.26.30.2 Flanged Joints

Flanges shall comply with IS 7322/BS 4504. The nominal pressure rating shall be at least equal to the highest-pressure rating of the pipes or fittings to which they are attached, but with a minimum PN 1.0. The Contractor shall fabricate flanges meeting the requirements of pipe sizes under this contract or otherwise to suit the abutting valves or other connections if they are not readily available. Flanges shall be provided with all necessary nuts, bolts, washers, and gaskets, as specified herein. The Contractor shall also supply in suitable containers sufficient graphite grease for application to the bolt threads when joints are made.

Slip-on Type Couplings

Slip-on type couplings shall include the following couplings:

(i) Straight flexible couplings.

(j) Stepped flexible couplings.

Slip-on type couplings shall be procured from approved suppliers whose fittings meet the same Specification.

The preparation of pipe ends for slip-on type couplings shall be in accordance with the requirements of and the tolerances specified by the joint manufacturer. Couplings shall be installed fully in accordance with the manufacturer's recommendations.

Slip-on type couplings shall be protected if buried with Denso mastic and Denso tape wrapping or similar approved material applied in accordance with the manufacturer's recommendations. Flexible joints shall be harnessed or tied where shown on the Drawings. Flexible couplings shall be supplied with transit protection.

1.27 Grit Classifiers

1.27.1 General Design

a) The equipment and associated plant and instrumentation shall be suitable for the site location, environment, and operational conditions.

b) The equipment shall be effectively handling the grits from the influent flow and shall be capable of automatic operation for long periods without the need for personnel under all weather conditions. The plant shall be robust and reliable in operation.

c) The equipment shall be capable of withstanding high quantities of grit without excessive wear.

d) The grit classifier shall be designed to receive pumped concentrated grit from the grit removal plant.

e) The grit classifier shall be sited as close as reasonably practicable to the grit removal tank and the grit transfer pumps.

f) The complete classifier unit shall be self-supporting and suitable for bolting to prepared foundations.

g) Adequate and sufficient lift lugs shall be provided.

h) The complete drive assembly, screw conveyor, and lower bearing assembly shall be designed so that the screw can be raised for inspection without the need to disassemble any components, or to drain the classifier tank.

i) The complete drive assembly shall be pivoted at the shaft centerline so that the screw assembly can be raised for periodic inspection.

j) The safety guard shall be provided to prevent objects from coming into contact with moving parts while the classifier is in operation.

1.27.2 Grit Classifier Tank

a) The classifier shall consist of a 316 stainless steel grit settling tank with a screw-type grit conveyor.

b) The grit settling tank shall be mounted on 316 stainless steel supports.

c) The tank shall be designed to provide a settling compartment where grit separation takes place, with a minimum full water depth of 150% of the screw diameter, unless otherwise specified.

d) The classifier tank shall be designed to prevent the build-up of grit and to aid in drainage.

e) Each classifier tank shall be fitted with a grit discharge opening, located such that accumulated grit at the top (dry) end of the screw conveyor shall exit the tank in a vertical down direction through the grit discharge opening.

f) Each classifier tank shall be supplied complete with 316 stainless steel fabricated feed box(s) to facilitate the introduction of underflow from the hydro cyclone into the classifier.

g) The water and organic material shall be returned to the main flow via a flanged pipe.

h) The dewatered grit shall be discharged at a high level from a chute.

i) Flange connections shall be provided for inlet and return water and organics.

1.27.3 Feed Box

a) The feed box shall be fitted with a wear protector, coated with neoprene to protect against abrasion and to function as a splash guard. The wear protector and splash guard shall be internal to the feed box such that no splashing will be allowed outside the feed box. Radial flow diffusers shall not be acceptable.

b) The feed boxes shall have hinged covers to provide for inspection of the hydro cyclone without disturbing the cyclone piping or alignment. The quick-release security clips (316L stainless steel) shall be provided for the hinged covers.

c) The feed boxes shall be designed and located to minimize short-circuiting to the overflow weir of the classifier and to handle maximum hydro cyclone underflow discharge.

d) The feed boxes shall be designed to dissipate energy generated from the hydro cyclone underflow.

1.27.4 Screw Type Conveyor

a) The grit shall be removed from the bottom of the settling compartment and discharged by means of a screw-type conveyor.

b) The screw shall be made from pre-formed heavy 316 stainless steel flight sections welded to the shaft and fitted with replaceable wearing shoes.

c) The screw shall be supported at the top by a combined radial and thrust bearing, and at the bottom by a radial bearing.

d) The bottom bearing shall be of a proven design for the application and sealed to prevent the ingress of grit and water.

e) The screw shaft of the conveyor shall be designed with a maximum stress and reliability of 20 years minimum.

f) The screw conveyor shall be rigidly supported at both the upper and lower ends, so that the screw conveyor is mounted above, and does not contact the classifier tank. Sufficient clearance shall provide between the screw conveyor and the tank bottom, to eliminate tank wear, and providing a drainage area for the conveyed grit.

g) The upper end of the screw conveyor shall be connected to a cycloidal motion speed reducer. The cycloidal speed reducer shall be designed so that all torque is transmitted by rollers and shall be capable of withstanding shock loads of 500% of rated loading.

1.27.5 Wash Water System.

a) A high-pressure water wash system shall be provided to facilitate grit washing within the grit collection hopper. The high-pressure water wash system shall be fitted with isolation valves and motorized valves. The provision of the pressure booster set shall be included if the wash water supply via the existing wash water supply facility is insufficient to provide.

b) Wash water delivery pipework shall incorporate screwed connections at an accessible level.

1.27.6 Drive Mechanism

a) The screw classifier shall be driven by a directly coupled shaft-mounted geared motor.

b) The screw shall be driven by a squirrel cage induction motor through a reduction gearbox and shall accordance with Electrical Specification.

c) A rotation detection device suitable for control and monitoring, shall be fitted to the screw.

d) The classifier spiral guard shall be provided in two pieces for ease of removal and to minimize the weight of any single piece.

1.27.7 Hydro Cyclone

a) Each cyclone shall consist of a heavy-duty cast iron volute feed chamber with one fabricated steel cylindrical section with conical sections as a minimum.

b) Each section of the cyclone shall be individually lined and protected from the high-velocity grit by a neoprene liner. The cyclone shall be constructed so that any section of the liner can be replaced independently.

c) A hinge and quick disconnect clamp shall be provided between the apex assembly and lower cone section to allow removal of material which may clog the apex, without disconnecting any piping on the cyclone itself.

d) The inlet feed to the cyclone shall be PN 16 flanged.

e) The cyclone vortex shall be made of Ni-Hard with a minimum hardness of 500 Brinell.

f) A suitable tapped pressure gauge connection shall be provided for each cyclone inlet feed. A diaphragm-protected pressure gauge shall be provided.

g) The cyclone underflow shall feed into the classifier for washing and dewatering and be sized so that the proper hydraulic loading is provided to the classifier.

h) Adequately vented to prevent siphoning shall be provided for the overflow.

i) Suitable and adequate lifting lugs shall be provided.

j) Mounting for the cyclones shall be made of 316 stainless steel.

k) 316 stainless steel mounting plate shall be provided and shall be oriented such that the cyclone underflow discharges directly into the classifier feed box.

1.27.8 Scrapper-type conventional grit mechanism.

1.27.8.1 General

The flow from the screen channel shall be allowed into the Grit Chamber for the removal of grit/inorganic matter by means of an RCC square tank each designed as per the relevant IS code of practice. The RCC tank with bypass arrangement, Grit Chamber of each designed for 50% of peak flow, Capable of removing grit of particle size of 0.15 mm and above and sp. gravity of 2.65. The surface loading rate, settling velocity and other design parameters shall be as stated.

The Grit Chamber shall consist of a series of vertically adjustable type fiber-reinforced plastic (FRP) baffles at the inlet as per mechanical specifications and the flow shall be admitted through these baffles. Baffles shall be designed to provide an oval shape of 80mm breadth at one end where the sleeve is inserted, and MS pipe should travel throughout the baffle depth to connect to the bottom sleeve to rest so tilting the baffle becomes easy. The chamber should be square in shape. Provision of a suitable weir shall be made so that the flow beyond the chamber is discharged over the weir to the outlet channel. Pen-stock gates at the inlet of each tank shall be provided. This shall be provided with an RCC staircase with a pipe hand railing to have access to the tank. Necessary pipe railing shall also be provided on both sides of the walkway platforms of the Grit Chamber. There shall be no dead zones or short-circuiting in the tanks. The Grit Chamber shall be equipped with a scraper mechanism for collecting and scraping the grit into the grit washing channel. The grit washing and drying mechanism shall be classifier with a Screw or raking type mechanism. The washing channel shall be in an inclined position and provided with the classifier mechanism as specified in the mechanical specification. The inclination should be 25° in the case of the screw classifier and 15° in the case of the Reciprocating Raking type classifier.

The contractor shall supply a total of 3 trolleys suitable for tractors (2 for each grit chamber and 1 spare trolley) for the collection of Grit. The grit is guided to trolleys providing a GI (2mm) chute of adequate opening. The chute shall be extended up to 2m above ground level or directed by the engineer-in-charge during execution.

The Grit Collector mechanism shall be suitable for mounting in the RCC tank. The mechanism shall consist of the superstructure, torque arms with rake blades and scoops, central rotating vertical pipe shaft, drive head with a dial indicator for torque indication and geared motor/motor and gearbox coupled to the drive head by means of chain & sprocket. A series of adjustable baffles (flow deflectors) shall be provided at the inlet of the grit chamber for proper flow distribution.

1.27.8.2 Scrapper Drive Mechanism

The drive mechanism shall consist of:

a) Feed Deflectors

b) Collection Mechanism

c) Screw Classifier

d) Organic Return Pump

The superstructure shall span the entire tank diameter and support the detritor mechanism. Mounted on the bridge is a drive head of sufficient torque rating and is coupled to a geared motor and gearbox through a chain & sprocket for power transmission. Coupled with the drive head is a center shaft. Attached to the center shaft are two (2) numbers of torque arms

provided with rake blades and scoops. The grit settled in the tank bottom shall be raked outwardly by the torque arms and dropped into a sludge hopper from where it will be lifted by the rake / Screw classifier for disposal. A stub arm shall be used, which ensures, steady scraping operation of the Rake arm with the help of intercross bracing or tie angles. The mechanism shall be driven by a geared motor/motor and gearbox combination coupled to the rake classifier by a chain & sprocket arrangement.

1.27.8.3 Classifier

i. Type MS Rake cemented trough or

ii. Screw classifier with MS trough to suit the diameter of the screw is mandatory

iii. Floor slope Outward slope to classifier minimum slope 1: 1 00 or 35 mm whichever is more

iv. Grit removal by central Scrapper towards Classifier Hopper

v. Driver TEFC Motor with Insulation of Class F and Protection IP 55

1.27.8.4 Organic Return Pump

i. Type of Organic Return Propeller type Screw Pump Mechanism suitable for low lift and non-clog design

ii. Propeller MOC SS 304 / SS 316

iii. Driver TEFC Motor with Insulation of Class F and Protection IP 55

1.27.8.5 Design Criteria

i. Objective: To remove sand and grit particles

ii. Size of particles 0.15 mm

iii. Specific Gravity of particles 2.65

iv. Removal efficiency of 90 % plus of particles having a particle size of 150 microns and 2.65 specific gravity at a design temperature of 25 °C.

v. No. of Grit Chambers 1 (W) Mechanical + 1 Mechanical (S)

vi. Design Flow (Each Grit 50% of peak flow with an infiltration Chamber

vii. Surface Overflow Rate 959 m3/m2/day

viii. Detention time (min) 60 sec at peak flow with infiltration

ix. Drive Type Insulation & Protection

- Type TEFC
- Insulation Class F
- Protection IP 55

1.27.8.6 Material of Construction

S No.	Description	MOC
1	Mechanism Support	RCC
S No.	**Description**	**MOC**

S No.	Description	MOC
2	Drive Assembly Base Frame	MSEP
3	Chain Guard	MSEP
4	Collection Mechanism: Vertical Shaft/ Rake Arms/ Blades/ Scoop Box Assembly	MSEP/ SS304/ SS316
5	Weir Plate	SS304 / SS316
6	Feed Deflectors	MS- FRP
7	Drive Head	CI
8	Bridge	RCC

1.27.9 Vortex-type grit mechanism

The flow from the screen channel shall be allowed into the grit chamber for the removal of grit/inorganic matter by means of the RCC tank designed as per the relevant is code of practice. A mechanical vortex-type grit chamber shall be provided. Grit chambers shall be designed for peak + other flow. Mechanical grit chamber shall be capable of removing grit of particle size of 100 microns and above and sp. Gravity of 2.65.

The surface loading rate, settling velocity and other design parameters shall be as stated earlier. The grit chamber shall be of RCC M30 grade construction with a suitable RCC foundation, with the necessary water-tightness test.

The inside surface of the grit chamber shall be provided with 20 mm thick waterproof plaster in cement mortar 1:3. The bottom of the chamber shall be provided with a 40 mm thick screen. The outside surface shall be provided with 20 mm thick double coat sand-faced plaster in cement mortar 1:3 with exterior emulsion as per the civil specification.

The chamber should be curved into a vortex shape. The mechanical grit chamber shall be of curved vortex type, so the screened wastewater that enters at the bottom of the grit chamber will rotate tangentially.

The grit chamber shall be equipped with a constantly rotating stirrer, which helps the wastewater circulation within the grit chamber, ensuring a constant velocity of rotation within the complete grit trap system even under dry weather conditions.

Due to the constant radial rotation, the solids are very quickly collected within the Centre of the grit chamber from where they then pass into the bottom of the grit collection tank.

The grit-free wastewater then exits and flows onto the next treatment step. Centrifugal or airlift pumps can then deliver the collected solids from the grit collection tank into a grit classifier or grit washer, where the solids can then be subsequently separated and dewatered, and organic particles removed.

1.27.9.1 Mechanism

Turning drive shaft, driven by the bull gear, material 1.4307 (316) or better. 4 pcs. Stainless steel paddles with hard cast iron welding, fixed on the drive shaft. The paddles should be adjustable in all directions, interlocked with counter screws. Central tubing was prearranged for the airlift pump with a funnel in the grit discharge area. The central shaft ends with a flange. Removable floor plate over grit storage chamber with minimum opening 75 mm to storage chamber, design plate assembly in two sections with lifting lugs, plate thickness minimum 10 mm.

A totally enclosed squirrel cage motor with at least IP 55 protection in accordance with VDI/ISO standards.

Gear reducer to include anti-friction bearings with high overhung load properties and double lip oil seals. The drive unit and motor bearings have a minimum bearing life of 100.000 hours. The tunable bearings supporting the paddle assembly have a minimum bearing life of 20 years. Grit from the grit washing unit should be guided with the help of a screw conveyor to the grit collector.

1.27.9.2 Degritting Tank Mechanism, Classifier and Grit-Washing.

Removing different types of grit, clay, sand, metal, etc. from the tank mechanism, classifier and washing of grit, etc.

i. It shall incorporate the following

ii. Removing different types of grit, clay, sand, metal, etc. From tank mechanism: The different types of grit, clay, sand, metal, etc. Settled in a tank shall be scrapped at a collection point by a scraper mechanism.

iii. It shall be designed for continuous operation. The mechanism will be coupled to a suitable motor-gearbox assembly.

iv. The collected grit shall be elevated to the top of the tank with the help of a classifier. While the grit is being elevated from the tank bottom, a suitable arrangement for grit washing with plain tap water shall be made.

v. All moving parts shall be abrasion-resistant.

1.27.9.3 Grit Washer

The grit mechanism will be suitable for installation in a round tank and will comprise the following:

i. Grit collection mechanism.

ii. Organic return pump.

iii. Classifier cum washing mechanism.

The grit contained in wastewater is usually removed in grit traps by gravity or centrifugal force to protect downstream equipment.

1.27.9.4 Function

No additional screening must take place upstream of the grit washer. The plant must be able to handle mineral grain sizes up to 30 mm.

The grit/water mix must centrally flow into the grit washer.

Grit classification and washing must take place in one tank, i.e. preceding longitudinal grit traps are not permitted.

i. Surface overflow rate (incl. Wash water) must be < 25 m/h.

ii. The grit washer must be equipped with a circumferential over-fall weir on the outside.

iii. Overflow weir load must be < 15 m^2/h.

iv. The combined addition of water and air or fixed bed plants is not permitted.

v. The grit washer must have a separate organics discharge ≥ dn 100.

vi. The grit washer must have a clogging-free perforated membrane sandwich plate at the lowest point of the wash cylinder for the best water distribution in order to achieve the best wash results.

vii. Grit level measurement must be carried out by means of a hydrostatic pressure probe.

viii. The grit washer must remain in full function (wash and discharge grit) even during feeding from the grit trap.

ix. The grit removal screw must be a stainless-steel screw supported on both ends.

x. Shaftless spirals or screws made of “special steel” are not permitted.

xi. The grit removal screw trough must not have guide bars or plastic shells.

xii. The grit washer must be acid-treated in a pickling bath and passivated

xiii. The complete grit washer must be made of at least 1.4307 stainless steel material.

xiv. The stirrer must be made of at least 1.4307 full stainless-steel material ≥ 30.

1.27.9.5 Grit washer

i. The grit washing machine should achieve high grit separation efficiency through optimum utilization of the tank volume due to the defined and calculable flow path based on the Coanda effect in the inlet combined with the preceding vortex chamber.

ii. After solids separation, the organic particles are washed out in the bottom part of the tank by means of a grit fluidized bed.

iii. The wash water is added across the entire wash zone cross-section. To achieve constant washing results, the system should work with a uniform, constant up-flow velocity in the wash zone.

iv. Washout is supported by a slowly running stirrer. As a result, the lighter organic particles are separated from the dense mineral particles.

v. Organic material should be additionally removed via a separate automatically actuated organics discharge located above the grit fluidized bed.

vi. The washed grit should be removed and at the same time dewatered by a sturdy grit transport screw supported on both ends in a trough. There should be a special arrangement of the screw flights for plug-free operation. The screw should be impulse-pause operated in dependence on the fed amount of grit, which is measured by a pressure probe.

vii. Organic loss should be less than 3%

1.27.9.6 Classifier Mechanism

The classifier mechanism shall comprise of a screw driven by a suitable motor. The material of construction of the mechanism shall be SS 316, and the diameter shall be a minimum of

400 mm. The length of the screw shall be such that the grit can be elevated up to the discharge end. A SS puddle pipe shall be provided in the concrete trough at the discharge point of wet grit. Classifier Mechanism: The mechanism shall consist of the following:

i. Chain and sprocket with guard.

ii. Reciprocating rake with hangers of a screw mechanism.

iii. A.C. Motor.

iv. A local push button shall be provided.

1.27.9.7 Organic Return Pump

Vertical Propeller pump with suitable motor, starter, etc. Shall be provided. The design of the pump and the piping on the inlet and outlet sides has to be such that there are a minimum number of bends, as they are liable to be choked with organic matter.

One set of push buttons shall be provided near the pump set, and one starter in the terminal sewage pumping station. The suspended organic matter washed in the de-gritting system will be returned to the distribution chamber. The impeller shall be SS CF8M, and the shaft shall be SS 316.

In the event of tripping of working grit removing equipment (motor), the sizing of this equipment (including motor) shall be done in such a way that it shall take the overhead to remove the excess grit collected after starting the tripped grit removal equipment.

1.28 Primary & Secondary Clarifiers

1.28.1 Design Specification- General

i. Sedimentation sludge scraper equipment shall be designed to suit process requirements for rectangular or circular tanks as appropriate.

ii. The performance, design, construction and testing of the equipment shall comply with all relevant statutory regulations and the latest edition of all relevant international and Indian Standards.

iii. The equipment and associated plant and instrumentation shall be suitable for the site location and environment and shall be fit for the operational condition.

iv. The equipment shall be designed to collect sludge from the tank floor and scum from the tank surface and transfer it to a hopper or channel for disposal unless specified otherwise.

v. The equipment shall be designed for continuous automatic operation in an exposed environment. Maintenance requirements shall be minimized by the use of sealed-for-life bearings. Where lubrication is required, lubrication points shall be readily accessible

vi. The equipment shall provide permanent safe access for operation and maintenance. Where tanks are elevated, stairs or access ladders from ground level shall be provided.

vii. Materials

viii. The material of the plant and equipment and its associated components shall be suitable for the site location and operational environment. A corrosion protection system shall be provided if required and necessary and shall be submitted to the engineer for approval.

ix. All Handrails, anchor bolts, nuts and washers shall be of 316 stainless steel.

x. All sealants used shall be suitable for the purpose.

1.28.2 Support Structure

i. The structure shall be constructed in steel. All welds shall be continuous. The height from the top of the tank wall to the bridge walkway shall not exceed 450mm.

ii. Support structure shall be of a robust design and adequately braced to ensure rigidity under all operating conditions.

iii. The bridge structure shall have two parallel beams of steel channel section, positioned to present a flat surface at the outside edge of the bridge.

iv. All the structural calculations, including the design of handrails and floor plates, shall be designed and submitted to the engineer for approval, if asked for.

v. Support structures shall be protected against corrosion by the application of paints or protective coatings.

vi. Support frames shall be fabricated to withstand equipment and material loads.

vii. All metal fabrications (i.e. frames, support structure, etc.) shall be designed to prevent moisture traps and prevent the collection of liquids and debris and, if appropriate, facilitate the application of paint systems and protective coatings.

viii. The ends of all steel sections shall be sealed to prevent ingress of liquids after corrosion-resistant coatings have been applied.

ix. All galvanizing shall comply with BS EN ISO 1461 if required and necessary.

x. All metallic items (such as fixing and fixtures, etc.), which are routinely wetted or submerged, immersed in wastewater shall be made of stainless steel 316 L unless otherwise specified.

1.28.3 Scraper Bridges

i. The steel bridge shall be designed in accordance with the relevant codes and standards. The bridge support beams shall be channels, with their flanges facing inwards, or I-section beams. Unless otherwise specified, the bridge support beams shall be continuous (i.e. no joins positioned at mid-span or locations of high stress/moments). The structure shall be designed and submitted to the engineer for approval if asked for.

ii. The bridge structure shall not be constructed from any type of hollow steel section. Steel section thickness shall not be less than 8 mm.

iii. Joints shall not be positioned at mid-span or locations of high moments.

iv. Bridges shall be designed to support a combined loading made up of the following components:

v. Loads associated with self-weight, walkway flooring, the sludge and scum collecting mechanisms, sludge loading on the blades, raise/lower drive, bridge travel drive, pump and pipework shall be taken into design calculation.

vi. Maximum vertical deflection of beams is no more than 1/360th of the span.

vii. The structure shall absorb the reactive torque of the complete drive unit, together with a maximum loading created when the tank is either full or empty. The structure shall be able to withstand any imposed loads occurring during start-up after a prolonged shutdown.

viii. Internal cross bracing shall be provided to stiffen the structure and give additional resistance to twisting movements generated from the scraper blades and any peripheral drive forces.

ix. Walkways and handrailing

x. A bridge walkway shall provide access from the tank periphery to the centre of the tank. The walkway shall have a minimum clear width of 1200 mm between hand railings. A full bridge/half bridge shall have access to the centre of the tank from either end.

xi. The walkway and handrail shall comply with this specification.

xii. The flooring shall form a continuous walkway for access to carry out routine servicing and maintenance.

xiii. Flooring shall be sectional, with each floor section individually secured to the bridge main beams.

xiv. Removable section panels shall be provided as necessary to allow access to the plant below the walkway for inspection and maintenance.

xv. The maximum deflection of an unfixed flooring section shall be 1/200th of its longest length.

xvi. Guide rail shall comply with BES EN ISO 14122-3 or equivalent.

xvii. Access ladders shall be completely integrated with the hand railing on each side. The ladder shall be permanently fixed to the bridge and shall overhang the tank wall.

xviii. All bridge-mounted equipment shall be located within the main bridge structural members at or above walkway level to allow ready and safe access from the walkway to all items of the plant requiring maintenance.

1.28.4 Scraper Mechanisms

i. Scrapers shall operate at speeds which shall not disturb the settlement of solids in the tanks.

ii. The blade shape shall cause the minimum disturbance to settled sludge when in the raised position, during the return travel.

iii. The scrapers shall be constructed so that they can be operated when the tank is empty without detriment to the equipment.

iv. Renewable wear ring strips may be neoprene, rubber or brushes, depending upon application and shall be fitted to the blade to provide a continuous contact surface, which shall be adjustable.

v. Where rubber is used, backing strips shall be fitted to support the fixing of the rubber-wearing strips. The backing strips shall not project beyond the tip of the scraper blade, and the rubber-wearing strips shall not project by more than three times their thickness.

vi. The assembly shall be secured by means of stainless-steel fasteners with a PTFE washer as a minimum or equal and better compatible material.

vii. Chain and flight-type scrapers shall provide a continuous sweep of the tank floor and shall be able to operate with the tank full or empty. Two pairs of endless chains wall wall-mounted on sprockets at a low level inside the tank, shall carry the buoyant scrapers. The drive unit shall include a motor-driven speed-reducing gearbox comprising primary and secondary gears within a common housing such that lubrication arrangements are common to both sets of gears. The drive unit shall be mounted adjacent to the tank wall and shall have an endless chain arranged to drive the submerged transmission shaft which shall drive both wall-mounted chains. The primary drive chain, the twin immersed chains carrying the scrapers, and the associated sprockets shall be manufactured from nylon or a similar non-corrosive, wear-resistant material. Continuously or intermittently submerged metallic parts shall be non-corrosive stainless steel or material suitable for the application.

viii. Mechanisms for fixed bridge scrapers shall be equipped with a sufficient number of scraper flights, arranged in echelon formation, to deflect sludge progressively towards the draw-off point.

ix. Chain and flight-type scrapers shall have multiple flights mounted on endless chains. There shall be at least one pair, but the number provided shall depend on the size of the process tank. Each scraper shall be arranged to scrape the tank floor and convey the sludge into the sludge hopper at one end of the tank. The ends of the tubular boom shall be securely fixed to the scraper chains with stainless steel bolts.

1.28.5 Scum Removal System

i. Scum removal system for fixed bridge scraper, if specified, shall have a scum sweep blade attached to the scraper bridge and shall sweep the entire surface of the tank. The blade shall be shaped to induce the surface scum towards the tank periphery.

ii. Scum removal systems for travelling bridge scrapers shall sweep the surface of the tank and shall discharge the scum into a collection trough. The blade shall be raised/lowered in conjunction with the scraper blade, and the relative position will depend on the direction of travel.

iii. Scum board, if specified, shall be fitted across the outlet end of the tank. Dimensions and fixing details shall correspond with those for circular tanks.

iv. Chain and flight scrapers shall be effective scum removal by using flights attached, or part of the scraper blades skimming the surface during the return journey.

v. Weir plate

vi. The weir shall be 316L stainless steel, minimum thickness of 6 mm for CETP and STEP application and an MS of a minimum 8 mm thickness for WTP application.

vii. The weir plates shall be securely fixed to the wall of the tank outlet channel. The fixings (anchor bolts) shall be made of stainless steel and have high pull-out load and high shear load characteristics. Fixings shall allow adjustment of the weir level by +/-25mm.

viii. Twin sealing strips shall be provided between the weir plates and the wall of the tank outlet channel. These shall be sufficiently thick to accommodate minor irregularities in the wall and be made of a material that will not deteriorate due to contact with the influent.

1.28.6 Bearings and Lubrication

i. Equipment component combinations that are likely to come into contact and be subject to relative motion shall be adequately lubricated or manufactured from materials with self-lubricating properties.

ii. Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

iii. Rolling element bearing shall be rated for a minimum L10 life expectancy of 50,000 hours while operating at maximum load.

iv. Bearing housings or assemblies shall be provided with seals and self-aligning features, if appropriate, to prevent the ingress of dirt and water and/or accommodate misalignment.

v. Lubrication points on bearing housing containing sealed-for-life bearing shall be fitted with caps to prevent inadvertent bearing re-greasing.

vi. Where sealed-for-life bearings are not provided, Automatic grease dispensers shall provide a clear indication of grease contents. The minimum capacity/life of the automatic grease dispensers shall be as specified in the tender.

vii. Lubrication points on bearing housing shall be readily accessible without the need to remove guards or covers. If lubrication points are not readily and safely accessible, they shall be connected via lubrication pipework which are readily accessible lubrication points, installed on a common battery plate. The spacing of the lubrication points on the battery plate shall allow the retrofitting of automatic grease dispensers if required.

viii. Automatic grease dispensers shall provide a clear indication of grease contents, and the supplier shall provide the first fill of lubricants to all components/systems

requiring lubrication. All bears and lubrication pipework shall be fully charged with grease.

ix. Fixed bridge scrapers shall include a flanged motor-driven helical worm gearbox. The secondary output shaft will be connected to the scraper mechanism. An adjustable overload device shall be incorporated in the secondary gear train to protect the equipment, and this shall be complete with a torque limiter and safety cut-out switch for connecting directly to the control circuit of the motor starter.

1.28.7 Gears and Gear Drives

i. Unless otherwise specified, gears shall be of the helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor (thermal and mechanical) of 1.7, a minimum L 10 bearing life of 100,000 hours and a minimum efficiency of 94 %.

ii. Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.

iii. Gearboxes and motors shall have an ingress protection rating conforming to BS 5420: IP 55 classification.

iv. Material selections shall comply with AGMA values and the manufacturer's recommendations. Input and output shafts shall be properly designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shall have two positive seals to prevent oil leakage.

v. Oil lubricated gearbox shall be fitted with oil filling and drain points and where appropriate, an oil breather and /or oil level indicator. The oil level and drain location shall be readily accessible.

vi. The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.

vii. Where gear drive output shafts connect to couplings or sprockets, the gear drive manufacturer shall supply a matching key.

viii. The gearbox type, number of stages, manufacturer, service factor and final drive ratio shall be stated in the submitted date sheet.

ix. All gears shall run in oil, and oil pans shall have means for filling and draining the oil without dismantling any of the screen components. Bearings:

x. Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

xi. Except where otherwise indicated, bearings of process equipment shall have a minimum L-10 life expectancy of 100,000 hours.

1.28.8 Drive Units and Control Panel

i. All drive system components (e.g. motors, gearbox, drive shafts etc.) shall be adequately supported.

ii. The drive shall be maintainable from either the walkway or from outside the

tank. If the drive is maintainable from outside the tank, portable access equipment shall be provided, if necessary.

iii. All drive shaft assemblies shall be designed for ease of maintenance.

iv. A protection system shall be provided to protect against jamming and other mechanical overloads. The motor shall be automatically tripped in the event of an overload.

v. All drive components shall be adequately supported so that fatigue or overstress does not occur.

vi. The control panel shall be provided and shall fully comply with the Electrical and ICA specifications.

vii. Loss of motion protection shall be provided and shall be proposed to the Engineer for approval.

viii. The speed of the bridge at the periphery of the tank shall be 1.5, /min to 2.1m/min.

ix. All control devices shall be readily accessible for maintenance. Sensors, limit switches, etc.

x. Effective guards shall be fitted to all revolving shafts, couplings, end carriage wheels and sprockets in accordance with BS 5304.

xi. Central bearings

xii. The central bearing and pivot arrangement shall be provided between the tripod and the bridge, comprising a grease-lubricated slewing ring bearing (ball or roller type) to allow rotational movement and a stainless-steel axle, supported in self-lubricating plain bearings, to allow the bridge to pivot in the vertical plane.

xiii. All bearings shall be capable of accommodating the deflection of the bridge and any irregularities in the bridge support structure and /or undulations in the running track.

xiv. The bearing support plate shall be fixed above the tripod top plate. Fixing holes shall be slotted at 90° to those in the tripod top plate, to allow a minimum of +/- 25, universal adjustment for centralising the bearing assembly.

xv. Diffuser

xvi. The system shall have a diffuser drum, supported from the bridge and concentric about the centre of the tank. The depth shall be 1500mm with a 200 mm freeboard.

xvii. The drum shall be manufactured from glass-reinforced plastic (GRP), with wall and flange thicknesses not less than 6mm. All surfaces shall be smooth and crevice-free free and all cut edges shall be sealed.

xviii. Two diametrically opposed cut-outs shall be provided in the diffuser drum wall, complete with scoops to assist continuous scum removal from inside the drum. Each cut-out shall be 150mm minimum width x 75mm minimum height above and below the normal top water level.

xix. To ensure a rigid construction, the drum shall have stiffening flanges at top and bottom edges, and intermediate points, if necessary. Diffuser drums with segmented construction shall have externally bolted flanged joints. Sufficient fasteners shall prevent joint separation. All bracings shall be external to the drum. The internal area of the drum shall be clear of any obstructions other than picket fence supports, and these shall be without flat surfaces that would prevent solids from settling into the hopper.

xx. The drum assembly, when in an empty tank, shall withstand wind loads of up to 40m/sec.

1.28.9 Center Assembly with Drive Unit

i. The drive assembly for each clarifier shall consist of a drive motor, helical gearbox, steel roller chain drive, Intermediate worm gear assembly, turntable type internal spur gear, visual torque indicator, overload alarm and cut-off actuating system.

ii. The drive motor shall be a 3-phase, 50-cycle, and 415-volt supply with variations in voltage and/or frequency.

iii. The power transmission between the first reducer and the intermediate worm gear assembly shall be through a chain and sprocket drive, which shall be enclosed in a fibreglass chain guard.

iv. The intermediate worm gear assembly shall consist of a case-hardened and ground alloy steel worm (EN353/equivalent hardness 50-52 Rc) and cast-iron worm wheel (IS: 210 grade FG260), all placed within a graded cast iron housing (IS: 210 grade FG260) complete with oil fill, level and drain fittings.

v. The main pinion and pinion shaft shall be keyed to the worm gear and made as an integral unit from forged alloy steel (AISI 4142/Equivalent 43-44 Rc).

vi. The main internal spur gear assembly shall be of a turntable-type construction and with an internal spur gear. The turntable base shall be made of cast Iron (IS: 210 grade FG200), and the main spur gear shall be of cast high tensile alloy steel (IS: 2644 –Gr2 240-250 BHN final hardness).

vii. The turntable will be mounted on top of the center column and will have positive levelling features.

viii. The spur gear shall be running on a built-up large diameter precision bearing assembly consisting of high chrome alloy steel bearing balls (AFBMA Gr 500, 62-65 Rc) and four replaceable hardened alloy steel inserts (AISI 4140/equivalent 36-38 Rc final Hardness) pressed into the annular grooves in the gear and turntable base all running in an oil bath. The base will have a provision for a dust seal complete with oil fill, level and drain fittings.

ix. All gears and bearings shall run in an oil bath. Readily accessible lubricant fill and drainpipes with necessary fittings shall be provided.

x. The drive worm shaft shall be free to move horizontally within the limits afforded by a calibrated compression spring at the thrust end. The worm shaft movement shall be transmitted to the drive control by a pin contacting the cam support and

camshaft, thereby actuating the pointer. The pointer shall indicate the relative torque load on a 0 to 100% graduated scale. Four cams and limit switches shall be included. Cams shall be independently adjustable over the full torque range. Two limits switches shall be shop-adjusted to sound an alarm and stop the drive motor at predetermined torque settings.

xi. Switches and cams shall be mounted in a weatherproof steel box having conduit terminal strips.

xii. The drive shall be designed for an adequate torque rating with the main gear and pinion set designed for a yield torque of at least four times the duty-rated torque. The drive main bearing shall be designed for a B10 bearing life of a minimum of 20 years with continuous operation and full total rotating mechanism weight.

1.28.10 Feed Well

There shall be a rotating feed well surrounding the inlet RCC column. It shall be integrally attached to the scraper drive assembly and the scum scraper assembly for uniform movement. The diameter of the feed well shall be 22% to 25% of the diameter of the clarifier so as to limit the downward velocity below 1.5 m / sec as calculated on the full plan area of the feed well at peak flow. The immersed depth of the feed well shall be 55 % to 65 % of the side water depth of the clarifier. The material of the feed well and all fixtures, either partly or wholly exposed to the atmosphere or fully submerged, shall all be of SS 316. In any case, the thickness of the sheet used for the fabrication of the feed well shall not be less than 5 mm.

1.28.11 Center Cage

i. The center cage shall be of steel box truss construction and shall be provided with connections for the sludge rake arms and feed well supports. It shall be bolted to the main gear, which shall rotate the cage with the attached rake arms, and feed well. The main gear attachment to the cage shall have provisions for adjustment to ensure levelling of the cage. Structural members as well as non-structural members shall all be spliced 30 cm on both sides of the wastewater interface with SS 316 members to prevent corrosion from the waterline that may propagate to the whole assembly.

ii. Walkway and Handrails

iii. The effective width of the central walkway within the bridge shall be a minimum of 1m wide. Handrails shall be provided for the full length of the width of the walkway. The walkway shall be supported by the drive platform at the center and the tank walls at its outer end and shall be designed to withstand all normal operating loads. It shall consist of beams of welded steel construction, with the walkway of galvanized grating floor plate supported by the cross members. A toe plate of 150 mm height made of 5mm thick shall be provided on both the running edges. The height of the protective hand railing & piping shall be 1000 mm from the walkway up to the top row of piping, and the steel member supporting this piping shall not project for more than 10 cm above this level and shall be finished with bevelled edges. The piping shall be in two rows of aluminium, thick-walled and equally

spaced vertically. The horizontal spacing of the steel members supporting these pipes shall not exceed 1.5 m center to center. These shall be integrally welded to the steel tensile members of the bridge.

iv. Sludge removal rake arms with sweeper blades and squeegees.

v. The sludge rake mechanism shall be a full-diameter installation of either the parabolic or radial alignment of the scraper in the plan. In either case, the assembly shall be dynamically balanced in design and erection. The material shall be of SS 316 truss construction with steel raking blades and adjustable neoprene squeegees. The blades shall be spaced to ensure complete raking of the tank bottom twice per revolution and push the sludge to the sludge pit at the centre. The rake arms shall be attached to the cage with provision for adjusting their slope. The rake arm truss and blades shall be fabricated from rolled/formed steel sections having a minimum thickness of 6 mm and designed to meet the full torque capacity of the central drive. All the structural members and the clarifier scraper mechanism shall be in SS 316. The top speed of the arms shall be not more than 3.5 m per minute.

1.28.12 Overflow Weirs

The weirs shall be of masonry construction finished true to level with pilasters at about 50 cm centers.

1.28.13 Skimmer and Scum Box Assembly

There shall be 2 radial scum skimmers aligned along a diameter equipped with dedicated scum boxes. The scraper assembly shall consist of a vertical SS316 plate supported from one rake arm and extending from the feed well to a recessed adjustable pivoted scum scraper with neoprene wipers at the tank periphery. The material of construction of the scum scraper shall be SS 316. The scum box shall be supported from the tank wall and connected to the scum sump through a 150 NB diameter scum pipe and shall be made of a minimum 5 mm thick welded SS316 plate to serve as an integral section of the tank's scum baffle. The assembly shall have a scum trough, vertical sides and a sloping ramp. A flexible connector shall be provided for the scum outlet piping in the tank wall. The scum scraper shall maintain contact with the scum baffle as it travels around the tank periphery. Upon approaching the scum box ramp, it shall trip the scum in an enclosure consisting of the scum box ramp at the bottom and the baffle and scum scraper on three sides. The trapped scum shall be carried up the ramp and into the scum trough. The scum baffles shall be curved with a minimum of 3 mm thick SS 316 plates.

1.28.14 Fasteners

i. All fasteners in contact with sewage/wastewater shall be SS 316 and others of hot-dipped galvanized steel.

ii. Travelling Scraper– Chain and Flight Type

iii. The flight and chain type scraper shall meet the following additional requirements:

iv. End carriages and rails.

v. The bridge shall be provided with two end support carriage assemblies, each of

which shall house the runner wheels and drive arrangement.

vi. The carriages shall be fabricated from carbon steel and adequately braced to withstand all imposed loads. A continuous skirt and covers shall be provided all around the carriage to protect against operator injury. Sections of the skirt and covers shall be removable to permit inspection and maintenance.

vii. The drive arrangement shall ensure that the bridge does not tilt or crab due to uneven wind and sludge loadings. A positive drive arrangement (e.g. rack and pinion) shall be provided in addition to the running rails.

viii. The rails shall form the track for the runner wheels. If the drive system is of the “rack and pinion” type, this may be integral with the guide rails or be a separate rail. The rails and/or drive rack shall be designed such that water cannot be trapped. The drive pinion should be readily accessible for replacement and should be designed to wear in preference to the drive rail.

ix. Limit switches and end stops shall be fitted to all running rails.

1.28.15 Drive System

i. The motor/gearbox unit shall be suitable for a two-speed operation. The drive motor shall incorporate an electromechanical brake designed to operate when the motor is stopped.

ii. The output of the gearbox shall be transmitted to the drive wheels located at each end carriage via drive shafting. Auto-resetting torque limiting protection devices shall be provided between the gearbox and the drive shafting.

iii. Gears shall be oil lubricated, and the gear housing shall incorporate an oil filling point, oil breather, oil level sight glass, drain plug and drip tray sized to accommodate one oil change.

iv. Scraper and skimmer blade arrangement

v. The scraper mechanism shall scrape sludge, scum and grease into the specific outlet located at the inlet end of the tank.

vi. The scum skimmer blade arrangement shall be bridge mounted to move floating material towards the appropriate end of the tank. The arrangement shall be designed to ensure the minimum unskimmed dead area at each end of the tank.

vii. The blades shall be fixed to provide continuous, rigid support. The scum blade shall be capable of being raised clear of the top water level.

viii. Each end of the scum skimmer blade shall be provided with a renewable side wall scraper.

All blades shall have renewable, reversible abrasion abrasion-resistant wearing squeegee strips. The length of each squeegee strip shall not exceed a third of the blade length.

1.29 Decanter Assembly

1.29.1 Decanter Assembly

Mechanical floating decanter and related equipment accessories as described herein for

each basin. Each decanter shall consist of an integral flotation unit, a stainless-steel movable weir assembly, and an electric motor-driven actuator to open and close the weir. Swing-type decanters in SS 304 Material of Construction are acceptable.

1.29.2 Performance

Each decanter shall be capable of withdrawing decant fluid beneath the liquid surface, regardless of liquid depth, down to the minimum allowable water level. The decanted liquid shall be drawn through an adjustable weir. The weir shall be circular in shape and permit liquid to enter the decanter from the entire 360 degrees without obstruction or equivalent.

1.29.3 Weir Actuator

The Weir actuator shall include a reversible electric motor-operated linear actuator. The actuator shall be capable of operating with a closing force and shall operate from a 415-volt, single-phase, 50-hertz source. Adjustable limit switches shall be included to permit adjustment of the weir opening. A spring shall be included to provide for travel after the weir has closed and provide the desired closure pressure. A corrosion-resistant removable cover shall be included to protect the actuator and motor during normal operation. The power section is painted steel. Power cable shall be provided from the NEMA 4X junction box of the unit to the basin wall. Supply of junction box/disconnect at the basin wall shall be the responsibility of the installing contractor.

1.29.4 Weir

The weir shall be constructed of 316 stainless steel, be circular or rectangular in shape, and shall include vortex control baffles permanently affixed to the weir. The weir shall be attached to the actuator through a removable single shaft or linkage, which shall also function as the torque restraint.

1.29.5 Floatation

Each unit shall be equipped with a modular float constructed of fiber-reinforced polyester filled with closed-cell polyurethane foam having a minimum 2.0 lbs/ft3 density. The float shall be completely sealed to prevent the foam from being in contact with the external environment. Float shall have appropriate eight reserve buoyancy to ensure stability and to provide the support flotation required during decanter servicing. A urethane-type or equivalent seal shall be moulded into the bottom of the float assembly to receive the decanter weir.

1.29.6 Decanter Discharge Pipe

Each decanter shall include a 316 stainless steel elbow flange and 316 stainless steel flanged flexible joints, and others. The installing contractor shall provide a valve with a hose bib connection on the decant line between the decanter and the decant valve. All piping, supports, gaskets, and hardware beyond the terminating flange of the decant pipe flexible joint shall be supplied by the installing contractor.

1.29.7 Decanter Restrained Mooring System

Each decanter shall include a stainless-steel mooring frame attached to the float. Stainless steel mooring post assembly with base plate shall be provided to assure consistent location of the decanter in the basin. The mooring post shall be filled with concrete by the installing

contractor.

Stainless steel dewatering support posts, consisting of vertical pylons with base plates and pipe dewatering support posts with pipe saddles and base plates, shall be provided. Each support with a base plate shall be affixed to the basin floor with 316 stainless steel adhesive anchors. Top and bottom mooring post supports constructed of stainless steel shall be provided for attachment to the basin wall by the installing contractor.

1.29.8 Decant Flow Control Valve

Furnish one electrically operated butterfly valve for each basin to control the decant rate. Valves shall be electrically operated butterfly valves with ANSI Class 125# flanged end ASTM A-536 ductile iron body, ductile iron disk with a 316 stainless steel edge, fully lined EPDM seat vulcanized in the body, 316 stainless steel shafts assembled and tested with 415 volts, three-phase, 50 cycle open/close service electric actuator. The valve actuator shall include a compartment heater. Each valve shall include a manual override with limit switch feedback to the microprocessor in both the open and closed positions. Field wiring and junction/box disconnect shall be provided by the installing contractor.

The bidders are encouraged to propose alternative types and designs of Decanters with proven technology and successful operation for the last 5 years and a minimum 15 number of installations.

1.30 Cloth Media Disk Filter

A cloth media disk filter (CMF) is designed to maximize solids removal over a wide range of particle sizes. Its thick, pile construction allows filtered solids to be stored, unlike micro screen media, to extend the time between backwashes. A uniquely designed cloth fiber backing support structure promotes thorough cleaning of the media for optimum performance. For the given application, we have suggested a specific cloth media Disk filter model to achieve the desired result. The general description of CMF is as under:

1.30.1 Filter Disk Basin

Each filter shall be installed in a concrete basin (In the client's scope) or a MS/SS basin (specific models only). Determination of the overall footprint will depend on the configuration of the valve and pump room, effluent chamber, influent, effluent, and overflow channels. Each filter will be provided with a manually operated butterfly drain valve.

1.30.2 Basin Mounting Brackets and Hardware

Each filter basin will be fitted with stainless steel mounting brackets to accommodate the attachment of the filter components to the inside of the basin. All mounting brackets will be installed on the inside wall of the basin with stainless steel wedge anchors and hardware.

1.30.3 Drive Assembly

Each filter will include an adjustable drive assembly with a gearbox, drive sprocket, drive chain with stainless steel link pins, and a stainless-steel chain guard. The gearbox will be parallel in-line helical type, with a drive motor.

To reduce energy demand, the drive assembly will rotate the disks only during backwash.

1.30.4 Center Tube Assembly

Each center tube assembly will include a stainless-steel center tube weldment, driven sprocket, wheel assemblies, stainless steel disk segment rods, and frame and cloth assemblies. The driven sprocket will be multi-segment. All fasteners will be stainless steel.

1.30.5 Filter Cloth Assemblies

Basin(s) will include cloth disk assemblies mounted on the centre tube. Each cloth disk assembly will be comprised of individual segments, each consisting of a cloth media sock supported by a frame with corrosion- resistant assembly hardware. Cloth/frame assemblies will be constructed such that each segment is easily removable from the center tube, without special tools, to allow for removal and replacement of the cloth at the point of installation.

Cloths will be of microfiber pile construction having an active filter depth of 3 to 5 mm to provide additional collisions between solids particles and the media within the media depth, resulting in the capture of solids across a broader particle range. The cloth depth will also provide storage of captured solids, reducing backwash volumes while maintaining an operational head loss.

Effective submerged filtration area which is defined as only the portion of the disk that is submerged during filtration, is 100 %. Any disk area that is not submerged cannot be considered an effective area.

Filtered effluent will be used for backwashing. The filter flow path will be from the outside of the disk to the inside.

1.30.6 Backwash System

The backwash function will incorporate a pump that draws filter effluent through the cloth as the media rotates past the fixed backwash shoe, thereby removing accumulated solids from the cloth surface. Each disk will be cleaned by a minimum of two backwash shoes, one on each side. The backwash shoes will remain in a fixed position. The backwash shoe will be in direct contact with the cloth to ensure effective media cleaning.

1.30.7 Backwash/ Waste Pump Assemblies

Each backwash/waste pump assembly will include backwash/waste pumps, valves and gauges.

1.30.8 Valves & Solid Waste Removal System

Each filter unit will include backwash valves. Each filter will include a solids waste removal system consisting of perforated manifold, mounted on the floor of the filter basin. The manifold will be designed to siphon settled solids for waste Discharge through the backwash/waste pump. The operation of the solids waste removal system will be automatic with user-adjustable intervals and duration through the operator interface.

1.30.9 Pressure-based level Transducer.

A pressure-based level measurement system (a.k.a Hydrostatic type) will monitor the water level in the filter basin. The transducer will utilize a diffused silicone semiconductor sensor protected by an integral stainless- steel diaphragm with seal fluid. The transducer output will be a 4-20 mA signal over a 0-5 PSI range. The

Electrical connection will be a 2-wire, loop powered through a shielded integral cable. It will be provided with a mounting bracket and hardware.

1.30.10 Float Switch

A float switch will be furnished to indicate the emerging overflow level as a redundancy to the Pressure Level Transducer. The float will contain a non-mercury switch, chemical-resistant polypropylene casing hermetically sealed and a PVC conductor cable.

1.31 U V System

The details of the components UV disinfectant system shall be as described below:

1. Reactor Chamber:

The reactor chamber, meant to house the other three fundamental components of the UV disinfectant system shall be an enclosed structure made of stainless steel, designed for the required flow rate of the treated effluent.

2. Ultraviolet (UV) Lamp:

The mercury lamp shall be low pressure but high-output UV lamp radiating the germicidal UV-C wavelength as required for disinfection of the treated effluent and it shall be installed in the system in a way as such it may not pronounce a hazard to mankind or Biodiversity.

3. The Quartz Sleeve:

The Lamp, protected with a quartz sleeve, shall be inserted into this long cylindrical tube made of glass to keep it safe, from the flow of water. The UV system will be provided with a self-cleaning system for glass tubes.

4. Ballast/ Controller Unit:

The ballast/control unit shall be of the capacity to maintain the electrical output to the UV lamp such as needed to emit the UV radiation of required intensity. The control unit will be equipped with a feeding cable, switch gear and internal wiring for the system.

Fixing of the unit will be made in the channel in a way such as to facilitate the maximum surface area of the glass tubes to be in contact with the treated effluent. A regular preventive maintenance, of the UV system, shall be undertaken by the contractor as prescribed by the manufacturer.

1.32 Diffused Air Aeration System

This section of the specification sets out the minimum requirements of the design and selection of diffused air aeration system equipment.

i) The pipe works, instrumentation and diffusers shall be correctly sized to deliver the required quantity of air at the available pressure to meet all operating conditions. The pipework to the tank shall be sized for 125% of the required oxygen transfer capacity to cater for the higher loadings.

ii) The aeration header shall be designed for removal/replacement from/to the reactor without taking the reactor offline or dewatering the reactor. The operator shall be required to demonstrate the removal and replacement of the headers with the reactor

online.

The Blowers shall be provided to provide adequate oxygen into the reactor tank for aeration. The blowers shall be capable of developing the required total pressure at the processing unit-rated capacity for continuous operation.

1.32.1 Aeration Equipment

1.32.1.1 Diffuser Manufacturer Interface for Aeration Equipment

The manufacturer shall supply complete aeration equipment for each grid below the aeration tank coping level. Equipment to be supplied by the diffuser manufacturer above the coping shall be extensions of equipment necessary to provide a complete aeration system below the coping. This will include equipment such as diffuser pressure monitoring systems and airlift purge systems.

1.32.2 Aeration Grids

i. Each grid shall be designed to be geometrically similar with respect to manifolds, distribution headers, diffuser holder elements, drain lines, sump, airlift purge, and pressure monitoring systems.

ii. Minimum one (1) pressure monitoring system shall be provided for each aeration grid.

iii. Condensate/water purge lines shall be provided for each aeration grid. The purge lines shall allow operators to be able to visually inspect the colour of the purge fluid to verify the integrity of the diffusers and distribution piping.

iv. The aeration grid for the mixed liquor channel shall be removable, even while the channel is full ofmixed liquor and operational. Grid piping shall be in sections and connected by quick coupling dismantling joints. A lifting davit shall be provided for removing the pipes.

1.32.3 Drop Legs

i. SS316 drop legs shall be provided, terminating in flanged connections above the tank coping level. The drop legs shall be designed to ensure adequate cooling of air is provided before entering the aeration distribution piping and diffusers, such that temperatures do not exceed manufacturer recommendations and that diffuser life guarantees are in no way compromised.

ii. Sufficient and adequate expansion joints and insulating flanges shall be provided to prevent thermal movement exerting stress on fixed supports and structures.

1.32.4 Air Manifolds

i. The air is supplied through the main air piping to each aerated zone. Each zone shall be equipped with a flow control valve and each dropper shall be equipped with a manual isolation valve. The flow control valve shall be selected and sized to provide accurate flow control over the air flow rate range required to achieve the specified SOTR range. It shall notbe simply a line-size valve.

ii. Air manifold shall be located at the end of distribution headers only.

iii. Connections shall be provided to enable effective in-situ cleaning of each aeration grid and its associated diffusers with the zone remaining full of mixed liquor.

iv. Provide a minimum of one drain line and airlift purge system for air manifold and distribution headers. The purge systems shall include collection sumps within the manifold and distribution piping to ensure the piping can be fully drained and purged of liquid while the diffuser system is operational.

v. Manifolds shall be provided for long-term exposure to 60 degrees C mean-wall temperature.

vi. An expansion/contraction system consisting of fixed or flanged joints and guide supports shall be included. Guide supports shall allow for longitudinal movements.

1.32.5 Distribution pipe and distribution Headers

Distribution headers with identical diffuser holder spacing shall be provided for all grids located in the aeration tanks. Orient distribution headers perpendicular to air manifolds and parallel to the direction of process flow. All distribution headers and fully submerged distribution pipes shall be Schedule 80 cPVC, unless otherwise specified. Fabricate in sections up to a maximum length to suit the specified area in the drawings, with fixed joints, non-rotational joints, or flanged joints. Fabricate with the diffuser element holder's factory solvent welded to the crown of the header. Attach diffuser elements to distribution headers to resist 200 Newton Meters applied torque about the polar axis of the holder and 135 Newton Meters about the longitudinal axis.

1.32.6 Diffuser Assemblies

i. Membrane disc diffuser assemblies shall be provided including diffuser elements, O-rings, retainers, PVC holders, and factory solvent welded to distribution headers. Additional elements shall be provided as required to meet the specified performance.

ii. The Diffuser assemblies in diffuser holders shall be installed as specified to meet the system and aeration tank performance requirements, for each grid. Where diffuser assemblies are not provided, an orifice plug for the diffuser holders shall be provided.

iii. Diffuser elements not installed shall be packaged for long-term storage.

1.32.7 Membrane Disc Diffuser Assemblies

i. Membrane disc diffuser elements shall meet the tensile strength, elongation and hardness to ensure reliability and performance during the operational lifespan. The diffusers shall be free of tears, voids, bubbles, creases, or other structural defects. Free of loose or unbonded material, cracks, chips, spalling, or other structural defects. Diffuser elements shall be free of any material soluble in used water.

ii. Uniform distribution of air bubble release across the active surface (horizontal projected area) of the diffuser element when submerged in water.

iii. The membrane diffuser shall have an integral check valve function to prevent the backflow of used water into the aeration grid.

iv. Dynamic Wet Pressure (DWP) systems shall be proposed to the PURCHASER for approval.

v. Sufficient strength to support a hydrostatic load equivalent to the specified water depth with a safety factor of two.

vi. PVC Diffuser Element Holders shall comply with the following.

- Air plenum chamber below diffuser element.
- A mechanism to attach the diffuser element to the element holder.
- Provide complete peripheral edge support for the membrane disc diffuser element. Retaining Devices shall comply with the following:
- Securely hold and seal the membrane disc diffuser element to the element holder.
- The diffuser assembly and the retaining device shall prevent air escape at the diffuser element-sealing interface.
- Vertical edges of diffuser elements shall not be exposed to liquid.
- Sealing of the membrane diffuser shall provide a long-term positive seal and prevent air escape except through the active area of the diffuser element.
- The force applied to the diffuser membrane shall be able to be monitored/optimized during installation. Each diffuser element holder shall have an airflow control orifice.

1.32.8 Tube Type Diffuser Assemblies

The membrane diffuser shall be developed specifically for releasing a 1~3 mm fine bubble in the used water treatment plant. All materials have been selected for their ability to withstand the effects of the chemical, and bio-chemical agents and 0~100°C used in used water tank. The diffuser can be placed in an evenly distributed grid system over the entire aeration tank bottom. Air can be easily through the air orifice and integrated non-return valve into the used water. The air orifice design to maintain the diffuser standard airflow input prevented the max. air enters to damage the diffuser membrane. The membrane shall be secured onto the support dish with a constricted flex rim and retaining ring designed to increase the tension on the point of engagement as the diffuser air rate increases.

Air diffuser assemblies shall be of the tubular, non-clog, fine bubble type with a flexible perforated air release membrane. Disc and panel diffuser designs are not acceptable. The perforations shall be die-cut I-shaped. The diffuser membrane shall be constructed from EPDM/PU and be suitable for continuous or intermittent aeration. Each membrane shall be held in place by two 316 stainless steel band clamps. The membrane shall include UV inhibitors and compounds designed for resistance to chemical attack, weathering, fatigue, and ageing. The diffuser assemblies shall have double backflow prevention to prevent liquid from passing into the aeration header. Backflow prevention shall consist of self-sealing slits and membrane clamping over the circumference of the diffuser support pipe. The membrane exterior surface shall be smooth as to inhibit biological film growth. The membrane shall inflate during aeration and deflate when the airflow is discontinued, further restricting biological film growth.

The membrane shall be clean in place with water from a high-pressure wash. The diffuser membrane shall have a thickness of 1.9 mm +/- 0.2 mm and shall meet the following Specifications:

a) Durometer, Shore A: 45 +/- 5.

b) Minimum Tensile Strength: 1,160 psi.

c) Elongation at Break: 500% +/- 100%.

Each membrane shall have a 28 mm wide non-perforated strip at the top and bottom of each diffuser to reduce bubble coalescence and improve air distribution.

All Diffusers shall be fixed type.

The tube diffuser shall be of non-buoyant design. An EPDM gasket shall be used to provide an airtight seal between the air header and the manifold piping. Diffuser mounting saddle/grommet shall be of injection moulded nylon. Diffuser designs that thread directly into the air distribution header or fittings without the distribution of diffuser loads to the pipe shall not be acceptable.

The materials of construction for both the support disk/tube and membrane diaphragm are non-corrosive and UV resistant. The support dish shall be upward-facing convex plastic (Glass-filled reinforced Polypropylene) for working without any acid dosing requirements, and an integrated non-return valve designed for back-flow prevention while airflow is interrupted. The membrane diaphragm, which covers the dish, is made of high-grade EPDM/PU resistant to the usual sewage ingredients. The membrane shall be further fastened to the support dish with a U-type retaining ring without special tools for fastening or replacement of the membrane.

The fine bubble aeration system will comprise:

a) Stainless Steel (SS316) drop legs and headers.

b) SS316 Manifold and air distributors,

c) SS316 diffuser holders and retainer rings.

d) Stainless Steel Supports and anchors

e) Bolts, nuts and gaskets for aeration system flange connection.

f) Air distribution purge system

g) Membrane tubular diffusers with integral O-rings, gaskets and subplates.

The following design features will be incorporated into the fine bubble aeration system:

a) Fabricated manifold with fixed threaded union joints for connection to the air distributors.

b) Manifold sections connected fixed threaded union or flanged joints to prevent rotation or blow apart.

c) Manifold distributor connections and support designed to resist thrust generated by expansion/contraction of air distributors over a temperature range of 70 Deg C.

d) Air distributors perpendicular to the air manifold.

e) Fabricated distributors with single diffuser holder's solvent welded to the crown of the air. distributor for complete air seal and strength

f) Distributors and holders are designed to resist a dead load of 90kg applied vertically to the outer edge of the diffuser holder.

g) Air distributor sections joined with positive locking fixed threaded union or flange-type joints for all submerged header joints to prevent blow apart and rotation. Bell and spigot, slip or expansion type joints are not acceptable for submerged joints.

h) Threaded union joints are designed with a spigot section connected to one end of the distribution header, a threaded socket section connected to the mating distribution header, an "O" ring gasket, and a threaded screw on the retainer ring. Solvent welding shall be done in the factory.

i) Air distributor support spacing at a maximum of 2400 mm.

j) All supports are designed to allow for thermal expansion and contraction forces over a temperature range of 70°C and to minimize stress build-up in the piping system.

k) Supports are designed to be adjustable without removing the air distributor from the support.

l) Diffuser assembly comprising of diffuser membrane with integral 'O' ring, sub-plate, holder, retaining ring and airflow control orifice.

m) Integral check valve incorporated into the membrane diffuser assembly.

n) PVC support plate incorporated to form an air plenum under the diffuser and support for the membrane when the air is off.

o) Retainer ring threads designed with a minimum cross-section of 3 mm to allow for one complete turn to engage threads.

p) A liquid purge system to drain the entire submerged aeration piping system for each aeration grid, including airlift purge educator line and manual control valve.

q) Two parts by weight of titanium dioxide per 100 parts of resin will be added to PVC compounds for manifolds, air distributors, joints, and PVC diffuser assembly components to minimize ultraviolet light degradation.

r) All PVC joints will be factory solvent welded. Field solvent welding will NOT be permitted.

s) Diffuser membranes will be manufactured of EPDM/PU with precision die-formed slits.

t) Carbon black will be added to the EPDM material for resistance to ultraviolet light.

u) The maximum tensile stress on the diffuser will be limited to 10 psi (69 kPa) when operating at 2.4 SCFM/sq. ft. (43.9 SCFM/per sq m) of material. Proportionately thicker material is to be furnished for larger diameter disc diffusers to limit the maximum tensile stress and to resist stretching.

1.32.9 Pipe Supports

a) All support and welded parts shall be fabricated from type 316 stainless steel unless otherwise specified.

b) Header vertical adjustment shall be continuous and possible without removing air piping from the support. The header adjustment shall be within ±15 mm lateral and ±52 mm vertical.

c) Each air piping section shall have a minimum of two supports and additional supports as necessary to maintain the level. Support height shall be sufficient to provide diffuser elevations as specified. Each support shall provide a bearing surface contoured to fit 360 degrees of air piping. The bearing surface shall be a minimum of 52 mm wide for manifolds and 40 mm wide for distribution headers.

d) Drop leg Supports:

e) Sliding Supports:

   i. Locate sliding supports directly adjacent to expansion joints. Locate sliding supports at the horizontal ends of the drop legs. Maximum spacing between sliding supports shall be 2.5 m in vertical and horizontal runs of piping.

   ii. Sliding support shall allow for longitudinal movement of the pipe due to thermal expansion. Supports shall allow a 3 mm clearance around the drop-leg to permit pipe movement.

   iii. Design sliding supports to resist uplift due to buoyant forces with a minimum safety factor of 5.0.

   iv. Attach sliding supports to walls and floors with appropriately sized anchor bolts consistent with other sections of this specification.

f) Anchor Supports:

   i. Locate one anchor support for each drop-leg as described herein.

   ii. Anchor support shall be adequate to resist longitudinal and lateral pipe movement due to thermal expansion at the stated differential temperature described herein.

   iii. Anchors drop-leg to the wall with appropriately sized anchor bolts consistent with other sections of this Specification.

g) Air Manifold Piping Supports:

   Maximum spacing between supports of 2.5 m. Resist the thrust generated by the expansion or contraction of air distribution headers. Include manifold hold-down, guide straps, anchor bolts and supporting structure. Guide straps shall resist the uplift force per support without exceeding the design stress.

h) Air Distribution Header (Guide) Supports:

   Maximum spacing between supports of 2.25 m. Allow longitudinal movement of the header section to prevent stress build-up in the header due to thermal expansion/contraction forces. Consists of a self-limiting hold-down and sliding mechanism. The sliding mechanism shall provide minimum resistance to the movement

of the air distribution header under a full buoyant uplift load. The mechanism shall provide 3 mm clearances around the header and be self-limiting if the mechanism is over-tightened. The design shall consider the maximum horizontal thrust that will initiate the movement of the header relative to the mechanism under a full buoyant uplift load.

i) All support shall be designed and endorsed by the contractor and submitted to the purchaser for approval.

1.32.10 Testing Requirements

Factory Materials Testing:

a) The following Quality Control test shall be performed at the point of manufacture, before membrane perforation.

   i. Durometer Hardness Test, Shore A, per ASTM 2240.

   ii. Tensile Strength Test, per ASTM D412

   iii. Minimum Modulus of Elasticity Test, per ASTM D412

b) The following Quality Control test shall be performed at the point of manufacture, after membrane perforation.

   i. Dynamic Wet Pressure Test

   ii. Air Flow Uniformity Test

c) Any other test deemed necessary to prove the integrity of the membrane.

1.32.10.1 Field Functional Test:

i. Conduct bubble testing on each aeration grid with a water level of 300 to 500mm above the diffusers. This test shall demonstrate an even distribution of fine bubbles across each aeration zone and a complete absence of large bubbles that may indicate leaks in piping, diffuser defects, incorrect diffuser membrane seating, etc.

ii. Conduct flow, pressure and mixing tests on each aeration grid of the aeration tanks.

iii. Perform under actual or approved simulated operating conditions. Airflow shall be measured by treatment plant instrumentation.

iv. Test for a continuous 3-hour period without malfunction.

v. Adjust, realign, or modify units and retest if necessary.

vi. Pressure Test: Measure air pressure in the drop leg above the top of the aeration tank coping, and at maximum airflows and submergences as per process specification.

1.32.10.2 Mixing Test:

i. Perform at the minimum recommended airflows for each grid as per Performance Requirements of process specifications/datasheets.

ii. Select three vertical lines and two depths in each basin.

iii. Take three Samples at each of two depths along each vertical line.

iv. An independent testing laboratory approved by the purchaser will perform a residue test on each Sample. The mean value of the total residue for three Samples at each depth will be used to determine conformance with requirements.

v. All testing and sampling procedures shall be submitted to the purchaser for approval prior to the test commencing.

vi. Contractor to provide safe access for all field functional testing.

1.32.10.3 Factory Oxygen Transfer Performance Test:

i. mass transfer test, at the manufacturer's test facility or an independent test facility, shall be required to verify the aeration equipment's clean water Standard Oxygen Transfer Rate (SOTR), at the maximum condition stated in process Specifications/datasheets. This testing shall be for the specific diffuser density/pattern and depth for each of the different aeration zone designs.

ii. A graph will be prepared from this data to be used in determining the expected performance of the diffusers at other flow conditions. This graph will consist of SOTE per meter of submergence depth plotted versus Nm^3/hr. per diffuser. The Contractor shall notify the purchaser at least 30 days prior to conducting the oxygen transfer performance test.

iii. The aeration equipment's SOTR shall equal or exceed the SOTRs required to meet the maximum design condition specified in process Specifications/datasheets.

iv. All mass transfer tests, used as a basis for verification of the aeration equipment performance shall be done by non-steady-state re-aeration. A mass transfer test shall consist of three re-aeration test runs. The SOTR for each flow condition shall be the average of the SOTRs obtained for each re-aeration test run. Sodium sulphatic by cobalt shall be used to strip residual dissolved oxygen between re-aeration test runs.

v. All performance testing shall be conducted in test facilities provided by the manufacturer or as approved. The test facility shall be capable of providing the side water depth and diffuser submergence specified hereinbefore. The diffuser density (diffusers per square meter of tank area) shall be equal to the diffuser density required for each aeration grid tested.

vi. The testing procedures, to be used in determining the oxygen transfer capacity of the aeration equipment, shall be as described in the ASCE Standard for the Measurement of Oxygen Transfer in Clean Water. Specific details of the test procedure shall be submitted for review and approval by the purchaser.

vii. The testing procedure may include a 5% variance in the air rate required to achieve the specified SOTRs.

1.32.11 Performance Testing Results:

i. Obtain approval of test reports from the purchaser prior to shipment of any equipment.

ii. In the event that the aeration equipment fails to meet the dissolved oxygen Performance Requirements, specified the purchaser shall have the right to require

the Contractor to modify or replace the aeration equipment to enable said system to meet the Performance Requirements. Field testing of the modified or replaced aeration equipment shall be performed to ensure compliance with the dissolved oxygen requirements.

iii. A report documenting the procedures used and results of all performance tests, including factory and field tests, if required, shall include all initial measurements, computations, and results, and shall be submitted to the purchaser.

iv. Any publication or release of the performance testing data referencing the purchaser shall be done only with the prior approval of the purchaser.

1.32.12 Special Installation Requirement

i. Appropriately skilled representatives of the diffuser system manufacturer shall be present during system installation to confirm all design requirements are met, the installed system is adjusted to within the correct tolerances, and no damage is caused to diffuser membranes or other systems. The diffuser system manufacturer shall provide written approval of the system installation and that the installation is compliant with the requirements for all performance, life and other guarantees.

ii. Piping and diffusers shall be adequately protected from exposure to UV light and heat before the filling of the tanks with mixed liquor.

1.32.13 Air Blowers (Screw Type Air Blower)

The blower should be air-cooled, low-speed speed and highly energy efficient. Rotor RPM should not exceed more than 2500 RPM of Bare Screw Blower. The rotors should be designed with a wide-diameter shaft to reduce the deformation caused by internal and external loads, thereby ensuring the blower works efficiently even in harsh conditions. The bearing should be designed considering the increased lifetime, and the seals used on the conveyed gas side and lubricating oil side should be “Wear Free”.

Air blower shall be designed to perform satisfactorily under specified start-up conditions, max. Differential pressure operation and relief valve setting pressure up to trip speed. All the compressor casings shall be air-cooled type.

Air blower shall consist of the following accessories:

i. Screw Blower with special coating screws.

ii. Lubricating system: Splash Lubrication

Base support with suction filter and reactive suction silencer integrated. There should not be any absorptive material used in the Silencer.

i. Belt drive transmission, POLY-V type.

ii. Discharge silencer.

iii. VSM Relief Valve.

iv. Check valve.

v. Electric cabinet for auxiliary power supply.

vi. Acoustic sound enclosure with hot air extraction fan.

Gas : AIR

Spec. Weight (Kg/m3) : 1.08

Capacity at discharge (m3/h) : As per the datasheet

Dif. Press. (mbar) : As per the datasheet

Inlet Press. (mbar a) :1007

Outlet Pres. (mbar a) : As per design

Dif. Temp. (°C) : Vendor to Specify

nlet Ambient. (°C) :40

Outlet Temp. (°C) : Vendor to Specify

Noise Level Dba : 85 ± 3%

Shaft Power (kW) : Vendor to Specify

Speed (rpm) : As per design requirement

Motor IEC : Vendor to specify

Power (kW) : Vendor to specify

Voltage (V) : 415+/- 10%

Poles: : Vendor to specify

Frequency (Hz) :50

Turn Down Ratio% % of full capacity at rated pressure:

Vendor to Specify

Tolerance : Capacity ± 5%, Shaft Power ± 5%

Material of construction of various parts

Casing : Cast Iron UNI-EN 1651 G250

Rotors : Carbon Steel C40 EN 10083/1 with Teflon Coating

Gears : UNI-EN 10084 18 NiCrMo5

Shaft : UNI-EN 10084 18 NiCrMo5

All the necessary accessories and protections of the compressor etc., are to be provided, which are helpful to the smooth running of the process of the plant.

1.32.13.1 High Efficiency and High-Reliability Bet Drive

The belt drive must be designed keeping in mind, an auto-tensioned arrangement which helps the belt to take care of elongation at a later stage. A Poly-V Belt Drive or a better-than-this belt drive is recommended to reduce the flapping issue.

1.32.13.2 Motor with Self-Tensioning System

All Blowers units need to be shipped with the motor mounting system locked, preventing

vibration and stress on the bearing and belt during handling/freight. To achieve the correct belt tension, locking plates have to be removed when commissioning the Screw-Blower.

1.32.13.3 Noise Enclosure

The noise enclosure is designed with optimized Air passages and sound reduction capacity. Once installed, the enclosure is completely separate from the blower, so there is no transmission of vibration moving to the enclosure body. Fresh Air circulation inside the enclosure keeps the operating temperature cool, provides greater efficiency with normal operation. The electric motor-driven cooling fan must be located at the blower air end and discharge silencer, which is the warmest area of the enclosure, to dissipate the heat from the noise enclosure. Noise enclosures must be equipped with doors and key lockers for ease of maintenance and allow the installation of additional units, side-by-side.

1.32.13.4 Lubrication System

Splash Lubrication system to be used in Bowers. It should be simple, and compact with minimal maintenance.

1.32.13.5 Inlet and Discharge Silencers

Inlet Silencer

The suction side silencer should be reactive in nature, i.e. there should not be any adsorptive material used. The design of the silencer should be such that it accommodates the filter inside. The filter used should be a cartridge type for ease of maintenance.

Discharge Silencer

Adsorptive discharge silencers, in accordance with Directive 97/23/CE (PED) as in-line accessories, combine the most effective noise reduction with no contact between the air and the sound-absorbing material.

Immediate Oil Level Check

The blower should have a provision to check the indicative oil level on the Noise Enclosure.

1.32.13.6 Instrumentation

The blower must come with a clogging gauge for the suction filter and a discharge pressure gauge.

Bidders shall take note that the screw blowers shall be supplied with the VFD of approved make of VFD only. Custom-built / manufacturer standard VFD shall not be accepted. Further, each VFD / panel of screw blower shall be provided with a harmonic filter (passive filter as recommended by VFD manufacturer or equivalent) to limit total harmonic distortion in compliance with IEEE 519 rating for individual and total harmonic voltage and current distortion. The power factor shall be > 0.95 in the operating range from 50% to full load. The Point of Common Coupling (PCC) for all voltage and current harmonic calculations and measurements shall be the input terminals to the harmonic mitigation equipment. Total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE 519 by not exceeding 5% and by limiting the individual harmonic voltage distortion to less than 3%. Total Harmonic Current Distortion (THID) shall be less than 5% at full load and less than 8% at 50% load. Total Demand Distortion (TDD) of the current at the input terminals of the harmonic mitigation equipment shall not exceed the limits as defined in Table 10.3 of IEEE 519 but shall not exceed 8% even when Table allows for more relaxed limits.

1.32.13.7 ontrol Panel

The blower must be supplied with a control panel having below features:

i. Suction Pressure
ii. Discharge Pressure
iii. Oil Level Sensor
iv. Emergency Stop
v. Start & Stop
vi. Possibility of RS-485 Modbus communication of Data

1.32.14 Turbo Air Blower

Air blower shall be capable of operating continuously and satisfactorily at all design points mentioned in the tender without surge, vibration, hunting or excessive heating of the blower equipment.

Air blower shall consist of the following accessories:

i. Single/Multi-stage Centrifugal Turbo Blower
ii. Air Cooled Motor
iii. Base frame and fabricated acoustic enclosure supplied with noise-attenuating media
iv. Pneumatically operated Blow-off Valve and integral Blow-off Valve Silencer
v. Discharge check valve and discharge expansion joint
vi. Inlet air filters
vii. Local control panel

Gas	: AIR
Capacity at discharge (m3/h)	: As
per datasheet Dif. Press. (mbar)	: As
per datasheet	
Inlet Press. (mbar a)	1007
Outlet Pres. (mbar a)	: As per design
Dif. Temp. (°C)	: Vendor to Specify
Inlet Ambient. (°C)	40
Outlet Temp. (°C)	: Vendor to Specify
Noise Level Dba	: 85 ± 3%
Shaft Power (kW)	: Vendor to Specify
Speed (rpm)	: Vendor to Specify
Motor IEC	: Vendor to Specify.
Power (kW)	: Vendor to Specify

Voltage (V) : 415 ± 10%

Poles : Vendor to Specify

Frequency (Hz) 50

Turn Down Ratio % of full capacity at rater pressure: Vendor to Specify Tolerance : Capacity ± 5%, Shaft Power ± 5%

All the necessary accessories and protections of Air Blower, etc., are to be provided, which are helpful to the smooth running of the process of the plant.

1.32.14.1 Enclosure

i. Each blower should come with an enclosure.

ii. Enclosure shall be capable of attenuating noise levels emitted from the package to eighty-five (85) dBA at one (1) meter distance from the package ± three (3) dBA, free field. Noise attenuation of the discharge piping, silencers and inlet piping (if applicable) shall be the responsibility of the contractor.

iii. The blower shall be mounted on a sturdy steel base frame with forklift slots on each of the four (4) sides and four (4) suitably sized eye bolts welded to the enclosure allowing the unit to be placed on any level floor capable of taking the weight of the unit, no foundation or fixation should be required.

iv. Enclosure shall be designed for ease of inspection and maintenance of all blower system components. Hinged or removable panels shall provide access to the blower and the auxiliary systems. Doors shall have a welded, reinforced perimeter frame and a welded support structure to prevent sagging or misalignment.

1.32.14.2 Electrical

i. The Blower will be given 415 Volt (V), 3-phase, 50 Hertz (Hz) power connection.

ii. The blower should be compatible with External VFD.

iii. Bidders shall take note that the turbo blowers shall be supplied with the VFD of an approved make of VFD only. Custom-built / manufacturer standard VFD shall not be accepted. Further, each VFD / panel of turbo blower shall be provided with a harmonic filter (passive filter as recommended by VFD manufacturer) to limit total harmonic distortion in compliance with IEEE 519 rating for individual and total harmonic voltage and current distortion. The power factor shall be > 0.95 in the operating range from 50% to full load. The Point of Common Coupling (PCC) for all voltage and current harmonic calculations and measurements shall be the input terminals to the harmonic mitigation equipment. Total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE 519 by not exceeding 5% and by limiting the individual harmonic voltage distortion to less than 3%. Total Harmonic Current Distortion (THID) shall be less than 5% at full load and less than 8% at 50% load. Total Demand Distortion (TDD) of the current at the input terminals of the harmonic mitigation equipment shall not exceed the limits as defined in Table 10.3 of IEEE 519, but shall not exceed 8%

even when Table 10.3 allows for more relaxed limits.

1.32.14.3 Motor

i. Blower shall be equipped with a 415 Volt (V), 3-phase, 50 Hertz (Hz),

ii. The motor shall be rated for continuous operation in ambient air temperatures up to 50°C.

iii. The motor shall have an insulation rating no less than Class H, Temperature Class B.

iv. The motor shall be capable of operation at the rated voltage with a variance of ± 10 per cent of the nameplate frequency.

v. The motor shall be capable of continuous operation at full load and rated frequency with a voltage variance of ± five.

vi. (5) per cent of the nameplate voltage 6. The motor shall be suitable for VFD operation.

1.32.14.4 Local Control Panel (LCP)

i. The blower LCP shall be PLC/microprocessor-based with a processor. The LCP shall be mounted in the electrical enclosure.

ii. LCP shall be supplied with a suitable power connection. LCP shall contain all instruments and equipment provided as part of the blower package.

iii. LCP shall have an emergency stop button so that, in the event of an emergency, this button can be used to stop the blower immediately.

iv. LCP shall perform the following functions:

1. Monitor and display all temperature, pressure, and vibration data readings.
2. Shut down the blower and report conditions regarding temperature, vibration or surge that endanger the blower or drive.
3. Modulate (increase/ decrease) blower flow as commanded by the MCP.
4. Report to MCP all status indicators, including:
   a) Run status (On/ Off)
   b) Not available (Locked out or failed)
   c) Speed (RPM)

1.32.14.5 Surface Preparation and Shop Painting

Machine carbon steel or iron surfaces that are not painted shall be protected by coating with a corrosion-resistant compound.

Enclosures shall be prepared and powder-coated on all interior and exterior surfaces with the manufacturer's standard powder coating and standard colour.

1.32.14.6 Factory Performance Testing

Performance Testing

i) Upon completion of assembly, the blower package unit(s) shall be performance tested. If required by the OWNER, the test shall be witnessed by a representative of the OWNER at the expense of the OWNER or Bidder. The witnessing party shall sign, stamp and date the test procedure and results, certifying that the assembled systems were tested together, as a system, in the SUPPLIER's facility.

ii) Performance test should be in accordance with ASME PTC-10

iii) Functional testing of the entire package, instrumentation, ancillary components, and LCP shall also be performed.

iv) All test equipment shall be calibrated and certified by an independent test agency no more than twelve (12) months prior to the test date.

v) The measurement of power consumption with the power meter shall be measured with all of the components inside the enclosure and all doors closed, as in the normal operation condition.

vi) Test Report shall present computations in accordance with the appropriate section or testing codes, with performance curves showing flow, pressure, and power inputs.

vii) The Test Report shall be submitted for approval prior to equipment shipment.

The following practice shall be performed to ensure and verify performance guarantees.

i) System Description: To determine overall power consumption (power to package) the system shall consist of a blower, motor, variable speed drive, filters, and air-cooling system to cool the motor and the inverter including external piping, wiring, instrumentation and appurtenances up the point of connection to the OWNER's equipment.

ii) Blower unit(s) shall be capable of operating continuously at any point between the minimum and the maximum flows without surge, vibration, idling or excessive heating.

iii) The Test Report shall include a certified factory test performance curve showing flow and pressure at 100%, 70% and 50% of full speed. The factory test curve shall also include curves for package demand power

1.32.15 Aeration Diffusers

i) The air diffuser system consists of a tube-type porous membrane of Acid-resistant silicon-based rubber with a diameter not exceeding 65 mm size, single-piece injection moulded PP support tube and SS clams. However, the contractor may propose diffuser sizes (60 OD/ 90 OD) as per the manufacturer's recommendations.

ii) The entire diffuser has to be manufactured, assembled, and tested on factory premises & no site work is permitted.

iii) A flat surface facing upwards as a membrane shall not be accepted.

iv) The aeration tank is used to remove oxygen-consuming organic matter from the effluent by biological treatment. Diffused aeration is used for air supply. The bubbles produced from the diffuser are of extremely small size, between 0.5-0.8 mm, thus the total surface area that interacts is large and the contact time of the bubble is large due to the slow rise of bubbles. The system is thus extremely power-efficient in terms of oxygen

transfer efficiency. The flow of a fine bubble of 0.8 mm in size provides a gentle mixing, which prevents flock shear.

v) A Fine Bubble diffuser consists of a porous membrane made of acid-resistant silicon-based rubber. Each diffuser is fully supported over the length and circumference of the single-piece injection moulded polypropylene (PP) tube with a RIDGE on the top to hold the membrane in position against the velocity generated in the wastewater.

vi) No drilled holes on the support tubes are permitted and only channel-type of arrangement for entry of air into the membrane is desired. Air opening on the membrane should be 0.8-1 mm with staggered perforation.

vii) The diffuser will be retained in place by two clamps. It is fitted to the pipe lateral by a CLIPIN arrangement. The Laterals are connected to a pipe header. The wetted parts of the system shall be made of non-corrosive material, specifically SS 316. During a power shutdown at the CETP, the membrane will contract and lose around the PP support pipe and means shall be provided to prevent any backflow.

viii) Each diffuser shall consist of the following: Minimum 65 m OD PP injection moulded support pipe.

a. Porous membrane made of silicon-based rubber lateral.

b. RCC support block with SS 316 clamping.

c. Flexible hose pipe (Drop pipe for each diffuser assembly) / fixed grid type diffusers

d. Floating or electromechanically positioned with subsurface withdrawal and positive solids and scum exclusion mechanism. Fixed decanters or surface withdrawal is not allowed.

e. PP ropes for lifting and guide position.

f. Hose clamp

g. pipe connector

h. GI barrel nipple with connector for connection with pipe

ix) Complete diffuser shall be assembled at the original factory level and site fabrication of diffuser is not acceptable.

x) All hardware accessories including clamps, fasteners, fan hooks, and eye bolts, should be of SS 316 material only.

1.32.16 Air Supply Pipe Work

1.32.16.1 General Design Criteria

Many factors need to be incorporated into the design of the air distribution pipework to minimize the potential for noise problems to occur. Factors to be considered in the design of the air pipework to minimize noise level shall include:

i. The diameter of the pipe works to keep the velocity low.

ii. The connection of the blower discharge pipes to the manifold should be “wye”, not

at right angles.

iii. No blind flange at the end of the manifold.

iv. The manifold shall be designed to ensure air travels in one direction.

v. The air pipe work shall be designed to minimize changes of direction and use large radius bends.

vi. Flexible connections shall be provided between the diffuser assembly nuts and the main air supply pipework to allow for any differential movements.

vii. Expansion and contraction shall be fully allowed for in the design and installation of the air distribution pipe work.

viii. Rain taps shall be provided on the air pipework to allow the draining of moisture.

ix. The pipework and the support brackets shall be galvanized steel.

x. Pipework shall have inbuilt flexibility, such as packer flanges, for reasonable construction tolerances on the structures to which it is attached.

The pipe shall be designed to ensure the efficient operation of the aeration system and compliance with the noise limitations. All valves in the air delivery system shall be correctly selected for the duty. Calculations of Cv (Head loss coefficient) values for the range of flows and pressure losses across each valve should be prepared to ensure that each valve has an adequate range of controllability for the duty.

However, the air piping submerged in sewage has to be in SS316 conforming to IS specification. Two spare drop pipes with diffuser elements shall be supplied by the Operator, one for each compartment. This will be used to replace the choked diffuser drop pipe or on a preventive basis on rotation. The choked one will be attended to and used as a spare drop pipe.

1.32.16.2 Air Supply Headers

The air supply headers run from the main air distribution pipework to the downcomers. Pipework shall have inbuilt flexibility, such as packer flanges for future modifications and to allow for reasonable construction tolerances on the structures to which it is attached. An isolation valve for each main air supply pipe shall be installed at the point of connection to the main distribution pipe work. The design of the main air supply header shall incorporate all components necessary to enable the easy connection of the main distribution pipework to the main air supply header.

1.32.16.3 Blower Discharge Pipe Work

The Discharge pipe work from each blower shall be connected to a common manifold. Flexible connections shall be provided between the blower assembly units and the discharge pipework to allow for any differential movements. The design of the manifold pipe work shall incorporate all components necessary to enable an easy connection to the main distribution pipe work.

1.32.16.4 Air Flow Measurement

The amount of air being supplied to each air supply header shall be measured by the installation of flow- measuring devices. The flow measuring devices shall be suitable for the

intended application. The sensor assembly shall be supplied with suitable fittings which shall enable easy removal during maintenance. The accuracy of the flow meter shall be within 5% of the minimum design flow rate. The installation shall provide an adequate length of straight pipe upstream and downstream of the flow meter to ensure the accuracy of the meter is attained. Pressure and temperature sensors shall be provided to measure the pressure and temperature of the air in the pipe, upstream of the flow measurement device. Pressure and temperature compensation measurements shall be provided for volumetric correction if the control air is based on airflow rate.

1.32.16.5 Pressure Gauges

Pressure gauges of an approved type shall be installed on each main distribution pipework and main header.

1.32.16.6 Leak & Pattern Testing Diffuser System

The diffuser system shall be visually tested by filling the tanks with clean water to level 1 m above the top of the diffuser assembly units. Air shall then be passed through the diffusers and a visual assessment of the diffuse operation shall be made.

1.32.16.7 The visual assessment shall include the following minimum inspection:

i. hecking all diffusers for installation level within the required tolerances.

ii. Checking that all joints along the diffuser headers have been made airtight.

iii. Checking the required air distribution of diffused air is achieved across the entire tank floor.

1.33 Chlorination

Chlorine solution diffusers shall be supplied and installed at the dosing point. Treated sewage shall be dosed with chlorine gas at concentrations not more than 10 mg/l. Effluent from the chlorine contact tank shall not have more than 1 mg/l of residual chlorine.

1.33.1 Chlorinators

i. Vacuum-type chlorinators shall be supplied with one duty and a standby unit.

ii. Chlorinators shall be free-standing, floor-mounted, and shall have a turndown ratio of 10: 1 over the full range of works operation.

iii. The dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10 mg/l scale and a manual dose setter over the complete range.

1.33.2 Motive water pumps and Injector.

i. Motive water pumps (1 working + 1 standby) shall be installed.

ii. The pumps shall draw their supply from the bore well/plant water supply.

iii. The pumps shall be installed outside the chlorination room and shall be made from material resistant to corrosion by chlorine

iv. Two injectors shall be provided, each serving a duty/standby pair of chlorinators. The injectors shall be located near the point of dosing, i.e. upstream of the Chlorine contact tank.

1.33.3 Inline Vacuum /Venturi type chlorine injectors

i. In line with Venturi type, which shall mix Cl gas metered from the Chlorinator into motive water from the Booster Pump. All wetted materials shall be constructed of Grade 2 Titanium (unalloyed).

ii. The motor shall be a chemical duty type

1.33.4 Chlorine

Chlorine shall be supplied as the liquid from a nominal 1-ton chlorine tonner.

1.33.5 Tonner Room

i. Storage shall be provided for chlorine tonners sufficient for at least one month's usage at normal rates of application.

ii. The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.

iii. Tonners online, tonners on standby and full and empty tonners shall be stored separately in the tonner room.

iv. Four sets of tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles. Tonner shall be provided with a suitable capacity chain pulley block (Min. 2 Tonne)

v. The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.

vi. Operation of the crane system shall be from the floor level using independent push-button pendant controls operating at a 230 volt 50 Hz AC supply.

vii. Two lifting beams shall be provided (a duty and a spare) and a tonner weigher to be suspended from the crane hoist.

viii. When the pressure in the duty chlorine tonner falls to less than 1 kg/cm2, the automatic changeover device shall operate to isolate the empty tonner and to bring the full standby tonner online.

ix. A pit and alkali absorption system shall be provided to contain and neutralize chlorine in the event of a leak. The system shall comprise a pit located in the tonner storage room and accessible by the overhead crane system. The pit shall be surrounded by a removable guard railing. The pit shall be kept full with a neutralizing solution of lime. The pit shall be capable of holding side by side two chlorine tonners. A provision shall be made to drain the pit. The tonner shall be provided with a suitable capacity chain pulley block (Min. 2 Tone) and Neutralization Pit for the suitable capacity to handle the leakage of the Chlorine Tonner to be constructed in the vicinity of the tonner in the Chlorine room.

x. In addition to the above Automatic chlorine leak absorption system (Gas Scrubber with NaOH dosing) shall be provided adjacent to the Tonner room. The process shall be designed to contain and neutralize chlorine gas vapours in response to gas leaks or catastrophic cylinder failure. The system should be able to absorb

99.99% of the chlorine gas entering the scrubber. When a leak occurs, the pump and fan shall start automatically.

xi. The fan shall provide sufficient vacuum to contain the chlorine gas and deliver it to the scrubber. The pump shall circulate the concentrated caustic solution over the scrubber packing to absorb all the chlorine gas.

xii. $_2$Special consideration shall be given to any floor drainage system in the tonner building; adequate traps shall be provided to ensure that chlorine gas cannot escape. All leader tubes carrying cables or pipes out of the building shall be sealed at either end to prevent any chlorine gas from leaking out.

1.33.6 Chlorination Room

i. The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access.

ii. Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

1.33.7 Chlorine Leak Detectors

i. One Chlorine Gas Detector shall be provided with a Single Detection Cell located in the Chlorine Tonner room

ii. Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in a Local Language and English.

1.33.8 Ventilation System

Each area where chlorine is stored or used as gas or liquid shall be provided with a forced ventilation system. Air intakes shall be sized to allow uniform ventilation and positioned to prevent possible recirculation. Exhaust air shall be ducted from a low level and discharged at a high level.

An air change rate of four per hour under normal conditions and a minimum of twenty changes of air per hour shall be used in the event that a chlorine leak is detected.

Exhaust fans shall be heavy-duty industrial patterns manufactured from chlorine-resistant materials. Ductwork shall be manufactured from U-PVC extruded sheets or circular sections.

Ducts shall be designed in accordance with the relevant Indian standard specifications.

1.33.9 Safety Equipment

i. Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.

ii. The equipment shall include:

   a. Two sets of approved self-contained breathing apparatus, each comprising an air set, carrying harness, face mask, valves and ancillary equipment. Each set shall be provided with three 1200 litre capacity, 140 mm diameter, air tonners.-

b. Two numbers of Canister type Gas Masks

c. Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline with Suitable Air Tonners along with airline hose.

d. Emergency Repair Kit suitable to handle Gas leakage from Chlorine Tonner

e. Two `instant action' resuscitators.

f. Four sets of safety clothing in various sizes, each comprising PVC overalls, Wellington boots with steel toe caps, goggles, gloves and safety helmets.

Note- All the Safety Equipment should be as per the applicable IS standard for Chlorination as per the CPHEEO, and in addition to the above list as per the requirement.

i. Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC-coated steel cabinet in approved locations on the outside of the building.

ii. Two emergency showers shall be provided and shall be installed outside on either side of the tonner room.

iii. The shower shall be operated automatically by a quick-acting hand or foot valve.

iv. Four eyebaths shall be supplied. Two eyebrows shall be adjacent to each of the showers.

v. Water for the showers, etc., shall be drawn from the service water supply.

vi. A telephone will be provided close by outside the building for emergencies.

1.33.10 Chlorination Power & Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for:

i. Display status and values associated with the chlorination systems;

ii. Duty pump selection;

iii. Announce alarms associated with the chlorination systems;

1.34 Sludge Handling

As sludge is generated from different process units depending upon the process adopted, it is advised to provide sludge handling units and equipment like sludge thickeners, Digesters, centrifuge or vacuum-filter- press or screw press or bag filters, combo-machine and other ancillary units which are suitable for the process, and which is sustainable from Operation & Maintenance point of view. The units and equipment shall be selected accordingly, which occupy less power, space, chemicals, and maintenance.

1.34.1 Thickener Mechanism

1.34.1.1 General

Gravity Sludge thickener shall be Circular (radial), fixed bridge, central turn table type or central drive.

1. The circular reinforced concrete thickeners tapering at the bottom shall be provided for the thickening process. Design shall be such that the sludge after thickening can be extracted from the bottom of the hopper portion. Interstitial liquid flows through the peripheral weir at the top. Tanks shall be deep enough to allow the sludge to settle by gravity. At least 50 cm freeboard shall be provided. Provision shall be made for the collection of thickened sludge and pumping it to the dewatering units.
2. A full / half-diameter bridge with a central drive shall be provided with a central platform for the installation of the scrapers, their drives, a local control panel and a radial scraper system with bottom scraper blades, suspended from the bridge.
3. The thickener shall have a half or full-diameter fixed bridge complete with a walkway for personnel access to the center, access stairs to ground level and hand railing, a central drive motor-driven sludge scraper complete with all necessary controls, delivery pipework, a stilling well and overflow steel weir plates. Handrails shall be of tubular construction and made of 32 NB pipes.
4. The scraping gear shall be supported from the tank base and a fixed bridge carrying the central electrical drive for the rotating gear. The equipment, including the driving motor, gears, shafting and scrapers, shall be designed for continuous operation and sized for the most hazardous operating conditions, including starting from rest with an accumulation of sludge in the thickeners. The electric motor, gearbox, etc., shall be provided with a sunshade.
5. The main drive shall be in Cast Iron and shall be enclosed in a dustproof enclosure with oil bath lubrication. Suitable overload protection for the drive shall be provided to ensure that the sludge does not overload the equipment, and an emergency stop pushbutton shall be provided. The scrapers shall be fitted with over-torque protection to alarm in the event of a failure.
6. Structural design calculations shall be submitted for all structures, including scraper arm, bridge, etc. and the calculation for drive head selection, including the Torque Rating. A V-notch weir shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means of clamping plates and fasteners. The hydraulic equipment will consist of an inlet pipe which runs along the bridge to the central feed well of the thickener or through the bottom of the RCC center pier; a sludge draw-off pipe with a manual & Motorized Knife Gate valve for intermittent operation according to an adjustable timer; a drain pipe with a manually operated gate valve for the complete emptying of the unit; a discharge pipe/channel from the peripheral collecting channel to the main channel leading to the Supernatant sump.
7. The sludge thickener mechanism shall be suitable for installation in a circular RCC tank and shall include the following:
    i. The mechanism supports a beam spanning the diameter/radius of the tank.
    ii. Walkway and handrail from the edge to the centre of the tank
    iii. Drive mechanism

iv. Reduction gearbox

v. Chain and sprocket with guard

vi. Vertical shaft/center cage with scrapper arm and picket fence

vii. Skimmer Scum Baffle and Scum trough

viii. Overflow weir

ix. Vertical pickets

x. Torque Indicating Device

1.34.1.2 Material of Construction

Description	MOC
Tank	RCC
Bridge	MSEP
Handrail (32NB pipe)	MSEP / SS 304 / SS 316
Feed well	MSEP / SS 304 / SS 316
Centre cage / Vertical shaft	MSEP / SS 304 / SS 316
Rake arms/blades/pickets	MSEP / SS 304 / SS 316
V-notch weir	MSEP / SS 304/ SS 316 / FRP
Squeegees	Neoprene
Scum & skimmer assembly	MSEP / SS 304 / SS 316
Hardware – underwater	GI/ SS 304/ SS 316
Hardware – above water	SS 304/ SS 316

1.34.2 Dewatering Centrifuges

The Dewatering Machine and its peripheral equipment shall include but not necessarily be limited to the following:

1. Powder or liquid Coagulant storage tanks.
2. Mixers and solution tanks.
3. Coagulant service tanks.
4. Supply line & flush line.
5. Chemical feeding pumps.
6. Water supply pumps.
7. Sludge feeding pumps.
8. Dewatering Centrifuge
9. Belt conveyor.
10. Cake hopper.
11. Flow meters for feeding Sludge and for feeding chemical solution.
12. Control valves on the sludge feeding line and the Chemical feeding line.
13. Drain system

Dewatered cake shall be conveyed by a belt conveyor to the cake hopper to carry out for

reuse.

To select the type of dewatering machine, the Contractor shall provide technical information to show the client the performance to obtain his approval in advance.

1.34.2.1 Decanter Centrifuge

1. The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.
2. The bowl and scroll shall be made from stainless steel AISI 316 materials. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard-coated material.
3. The whole rotating assembly shall be enclosed by Stainless steel (AISI316) fabricated casing incorporating a Centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.
4. The rotor shall consist of a solid bowl which is conical-cylindrical in shape, and which rotates about a central shaft. An inner scroll shall be provided to convey separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.
5. The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable, greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced, and test certificates shall be provided.
6. Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.
7. The bowl shall be provided with an adjustable 360° peripheral weir at its cylindrical end to control the depth of the Centrate in the rotor.
8. The fixed outlet castings of the rotor shall be designed to collect the Centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.
9. The centrifuge shall be mounted on heavy-duty vibration isolators, located between the machine and the supporting steelwork or foundations, to dampen vibrations and prevent vibration transmission. Two-axis vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.
10. Flexible connections shall be provided on the sludge-fed system and the Centrate system at the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

Variable Speed Drive

A variable speed drive shall be provided to accelerate the rotor to operational speed and maintain that speed during the centrifuge's duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple 'V' notch belt drive.

Differential Scroll Drive

i. The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed from the outer bowl. The differential speed shall be adjustable.

ii. The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.

iii. For safe operation, the contractor shall provide a control panel showing the proper Sequence of operation with interlocking.

iv. Chutes and interconnecting piping shall be provided with flexible joints (minimum 10 mm flexible in all directions) to avoid vibration.

1.34.2.2 Vibration Isolation and Monitoring

a) Each centrifuge unit shall be mounted on rubber, hydraulic or spring-type isolators. The number, capacity and vibrator constant of the isolators shall be as recommended by the isolator manufacturer for the load and impact resulting from the operation of the centrifuge provided. If required, each isolator shall be provided with built-in levelling bolts and built-in resilient shocks to control oscillation and withstand lateral forces in all directions. The isolator shall be self-levelling or designed for internal levelling and adjustment. Rubber inserts shall be oil-resistant synthetic rubber. Housings shall be welded steel, and springs shall be oil tempered high carbon chrome vanadium steel. After installation, the isolators shall be inspected and adjusted by a factory-trained representative of the isolator manufacturer or the Contractor. A maximum of 0.15 mm of displacement at operating speed will be acceptable under dry-run Factory test conditions. Vibration monitoring shall be accomplished with a solid-state sensing device mounted on the centrifuge base. Pipe and chute connections to the centrifuge shall be through flexible connections.

b) Movement between interconnecting structures, piping, cables, etc., shall be avoided. To ensure proper installation and to prohibit the propagation of vibration through connecting pipes or chutes, connections to the unit shall be through flexible connections with physical and chemical characteristics suitable for the service. Flexible connectors shall be provided for, but not limited to, the following items:

i. Flocculent piping.

ii. Sludge feed piping.

iii. Hydraulic oil lines, if applicable.

iv. Oil lubrication lines, if applicable.

v. Centrate and cake discharge flange connections.

c) Flexible centrate and cake discharge connectors shall be of black moulded neoprene, 2-ply fabric reinforced with polyester cord and complete with Type 316 stainless steel backup flanges and hardware shall be provided for each centrifuge. Other flexible connectors are to be Contractor’s standard corrosion-resistant materials.

d) A vibration monitoring system shall be provided for each centrifuge to perform the following functions:

i. Measure vibration through the sensing of the appropriate combination of displacement, velocity, and acceleration. As a minimum, one field-mounted sensor shall be installed on each centrifuge. The sensor shall be rigidly attached to or near one of the two main bearings.

ii. Vibration monitoring equipment shall comply with General Specifications for Vibration Monitoring System and Analysis. It shall provide configurable relay contact outputs to enable the following basic warnings and alarms:

1) Sound a warning and shut the sludge feed down if the vibration reaches a certain preset level.

2) Sound a warning and shut the unit down if the vibration reaches a separate preset level.

iii. Provide an adjustable time delay during start-up to account for initial acceleration and feed-induced vibration; and

iv. Provide an adjustable time delay during operation to account for momentary excursions due to process changes.

1.34.2.3 Polymer Injection and Sludge Conditioning In-Line Mixer

Each centrifuge shall be provided with a polymer injection point. The polymer injection point shall be located at upstream of the sludge conditioning in-line mixer, for the controlled, variable mixing energy, mixing of polymer solution into the sludge feed line upstream of the centrifuge. Sludge conditioning in-line mixer to be of the centrifuge manufacturer's standard design and either of the variable orifice type or other design acceptable to the Board. The Contractor shall design the sludge and polymer feed systems according to the characteristics of the mixers provided and the pressure drop deemed necessary by the Contractor. Simply teeing the polymer supply piping into the sludge piping in lieu of a mixer shall not be acceptable.

1.34.2.4 Sample Points

a) Provide functional sample connections for centrate and thickened/dewatered sludge from the centrifuge case or chute. The sample connections shall enable centrate and dewatered sludge sampling from the centrifuge operating floor. The sample connections shall be pipe inserts integrally mounted through the centrifuge case to enable representative sampling while not interfering with the rotating elements of the centrifuge. All sample pointsshall include drained containment trays under the sample point to contain spillages.

b) Centrate sample connections shall be a nominal 25 mm diameter Type 316 stainless steel pipe with a ball-type isolation valve discharging to a drain funnel and identical stainless-steel pipe draining the centrate sample back through the casing and into the case centrate discharge compartment.

c) The thickened/dewatered sludge sample connection shall consist of a Type 316 stainless steel pipe with a hinged cap, complete with a pipe insertion device, to enable periodic grab collection of a representative sample of thickened sludge/dewatered cake from the centrifuge operating floor. The sludge sample

connection shall be located and sized to allow insertion of a nominal 50 mm diameter Type 316 stainless steel pipe insertion device during operation and testing for safely collecting a representative sample without contacting moving parts or resulting in spillage of sludge.

1.34.2.5 Anchor Bolts

Anchor bolts shall be 316 stainless steel.

1.34.2.6 Sound Pressure Levels

Sound pressure levels shall not exceed 85 dB(A) measured at 1 m around each centrifuge.

1.34.2.7 Painting

Non-stainless-steel surfaces shall be factory primed and finish painted in accordance with System No. 18 as elaborated in the General Specification for Painting and Protective Coatings.

1.34.2.8 Fabrication

The centrifuge shall be assembled in the factory to check for proper fit and for factory testing, mating parts marked and then disassembled for shipment.

1.34.2.9 Electrical

a) Centrifuge Control Panel (CP): Each centrifuge shall include a single Centrifuge Control Panel (CP) located in the LV Switch room, that shall house the forced oil lubrication system motor starter (if any), the main and back drive variable frequency drives, controller for the centrifuge and back drive, and equipment as described in Instrumentation and Controls section below. The panel shall conform to the requirements of fi6.4 Instrument and Control Panel Construction, and General Specification fi5.40 - Low Voltage Variable Frequency Drive Systems. CPs shall be of both right-handed and left-handed configurations as required to accommodate the efficient layout of panels and wiring within the LV Switch room.

b) Field Cabling

   i. Cable connections to all the components on the centrifuge or major subsystems (lube oil, back drive, etc.) that will interface with the Centrifuge Control Panel to an IP 65 terminal junction box located on the centrifuge frame.

   ii. Label all terminals and provide a terminal strip suitable for all identified connections, plus 25 per cent spare. Separate terminal strips shall be provided for power, control (230 V discrete signals), and analogue signals.

c) Main and Back Drive Motor

   i. Provide squirrel-cage AC induction motors meeting the requirement of General Specification fi5.38- Low Voltage AC Induction Motors, and as specified herein.

   ii. The motor shall meet the following specific requirements:

      1) Nominal Speed: 1,500 revs/min.

      2) Enclosure Type: TEFC or IP 54.

      3) Mounting: Horizontal.

iii. Provide motor as specified below:

1) With the motor at ambient temperature (COLD), it shall be capable of making three complete starts in succession with coasting to rest between starts. With the motor running (HOT), it shall be capable of at least two restarts within 1 hour after any shutdown. The motor insulation temperature rise shall not be exceeded.

2) A motor thermal protection system consisting of thermistors, a compatible relay and relay contact, and a suitable enclosure, is required.

d) Main Drive and Back Drive Controllers: Main Drive and Back Drive motors shall be controlled by variable frequency drives:

i. The systems shall be sized in accordance with the Contractor's design requirements and shall be as specified in the General Specification for Low Voltage Variable Frequency Drive Systems.

e) Centrifuge Control Panel Power Requirements

i. Each CP shall include two main incoming circuit breakers labelled as "Main Power Supply "and "Control Power Supply" respectively. The circuit breakers shall be sized to accommodate the load as described below:

1. The main power supply shall provide power to motor drives and all ancillary systems.

2. The control power supply shall provide power to the centrifuge controls system and all instrumentation and shall be powered from the nearest UPS Distribution Board.

1.34.2.10 Instrumentation and Controls

1.34.3 General

a) Instrumentation and controls provided under this section shall be in accordance with the requirements and component qualities specified in fi6 ICA General Specifications.

b) For each centrifuge, provide all instrumentation and control components required for a complete and functional centrifuge. The instrumentation and control components provided under this section shall be part of the overall Centrifuge Control System described in fi6.17 for PLC hardware and fi6.12 Instrumentation.

c) Each centrifuge shall include, as a minimum, the following major control components:

i. Programmable logic controller (PLC), power supplies, I/O modules, and ancillary equipment.

ii. Standard software and application software for the PLCs.

iii. Centrifuge Control Panel sized adequately for all required motor starters, variable frequency drives, controllers, PLC equipment, and fiber communication equipment, and ancillaries.

d) Provide network interface to the Plant Control System PLCs as shown on the Drawings.

e) Application Software: The centrifuge manufacturer shall provide all application software

programming and system configuration necessary to make the PLCs, PLC data highway, communication processors, LANs, Ethernet switches, and communication interfaces fully functional, as described herein.

1.34.4 Centrifuge Control Panel (CP)

a) Enclosure: As described in the electrical section above.

b) Functional: Consists of PLC, its network interface to the Plant Control System and other communication equipment as needed to make this system fully functional.

c) Functional Requirements: The centrifuge PLC shall contain all application software, necessary to safely start and stop the centrifuge.

d) Status Information, Alarms, and Analogue Values: The following values shall be available for remote display at the MCS:

i. Status Values

1) Centrifuge main drive ON/OFF status.

2) Centrifuge back or screw drive ON/OFF status.

3) Centrifuge CLEAN-IN-PLACE status.

ii. Alarms

1) Centrifuge TROUBLE alarm. Centrifuge TROUBLE alarm shall be active if any one of the following conditions exist:

a) Main drive High Amperes.

b) Centrifuge Speed High.

c) Back drive High, and High torque or High hydraulic pressure.

d) Left/right bearing High, and High temperature.

e) Centrifuge High and High vibration.

iii. Analogue Values

1) Centrifuge bowl speed.

2) Centrifuge scroll speed.

3) Centrifuge differential speed.

4) Main drive motor current.

5) Main drive torque or hydraulic pressure.

6) Bearing temperatures.

7) Vibration.

8) Centrifuge sludge feed flow.

9) Centrifuge sludge feed flow control valve position.

10) Centrifuge polymer feed flow.

11) Centrifuge polymer feed flow control valve position.

1.34.5 Local Control Station (LCS): Provide a local control station for each centrifuge.

a) Enclosure

i. The panels shall be accessible only from the front and made of Type 316 stainless steel and with a degree of protection to IP 65 in accordance with BS EN 60529.

ii. Each panel shall have the following conventional panel front controls and indications:

1) Emergency stop switch.

2) LOCAL (Field)/REMOTE (PLC) mode selection switch.

3) RUNNING indication light.

4) START pushbutton.

5) STOP pushbutton.

6) Common alarm indication light.

7) Power ON indication light.

iii. Each panel shall have a 10-inch coloured Human Machine Interface (HMI) touchscreen, interfaced to the Centrifuge PLC and providing a display of centrifuge unit operating parameters, trends, and alarms.

iv. The panel shall additionally be equipped with a rotating amber beacon light mounted on top of the panel activated by the Centrifuge controller in the presence of any significant alarm condition. The beacon shall not activate if the centrifuge is shut down.

b) Functions

i. LOCAL (Field): Provides for Manual START/STOP of the Centrifuge at the LCS. All interlocks and permissives are to be active.

c) START: Active only in LOCAL mode; initiates a request to the controller by momentarily depressing the START pushbutton. If all permissive and interlocks are satisfied, the centrifuge will start and run at a pre-set speed in the Differential Speed mode. This mode is intended primarily for maintenance purposes, but could be used for backup operations.

d) STOP: Active only in LOCAL mode; initiates a request to the controller by momentarily depressing the STOP pushbutton. This will begin the centrifuge stop sequence.

e) REMOTE (SCADA): Provides for monitoring and control of the centrifuge from the Plant Control System as part of the sitewide SCADA. This is the normal mode of operation.

f) Emergency Stop: Active for either LOCAL or REMOTE modes; initiates a systematic shutdown (as described in the relevant section of Process Control Narratives) of the centrifuge and activates alarms. This is a maintained position switch and must be reset locally before the centrifuge can be started by any means.

1.34.6 Programmable Logic Controller (PLC)

a) General

i. Each centrifuge shall have a dedicated programmable logic controller mounted in the CP located in the Centrifuge Switch Room at the Solids Dewatering Building. The PLC shall provide all control and monitoring functions as required for the operation and monitoring of the centrifuge.

ii. Provide all peer-to-peer communication required for the plant control system.

iii. Control functions described under this Section are typical for each centrifuge.

b) PLC Programming

i. General PLC programming requirements, such as file structure, generic PLC functions, memory allocation, and documentation, shall meet the requirements of PLC Hardware.

ii. Provide all PLC application software programming necessary for a fully functional and operable PLC system in accordance with the Specifications. PLC programming shall include:

1) I/O and register addressing assignments.

2) PLC application software development and installation.

3) PLC equipment configuration.

4) PLC interface to the Centrifuge Control System and vendor provided control panels.

5) System testing.

6) PLC application software debugging and troubleshooting.

7) System hardware and software documentation.

8) PLC system commissioning.

1.34.7 Uninterruptible Power Supply (UPS)

All components of the centrifuge control sub-system shall be powered by a feed from the Solids Facility central UPS System.

1.34.8 Screw Press

1. The screw press should be with a conical screw shaft and cylindrical sieve consisting of three treatment zones: inlet and drive zone, three-part thickening, and dewatering zone, and press zone with pneumatic counter-pressure cone.
2. The screw press must be fed with flocculated sludge of sufficient stability. The first part of the screw press should be provided with a large free screen surface so that the free supernatant liquor is quickly removed from the sludge.
3. The pressure probe should be provided in the inlet to protect the plant against excessive primary pressure and consequently excessive pollution of the filtrate liquor and excessive residual moisture in the sludge outlet.
4. The second part of the screen is to be designed in such a way that the volume of

material between the screw flights is reduced by the conical screw and the sludge is pressed against the inner screen surface so that the sludge is dewatered, with a continuous reduction of the filter cake thickness. The screen apertures should be much smaller in this screen section.

5. In the third part of the screen, the residual water will be pressed out of the sludge, at a minimum filter cake thickness, by the pneumatic counter pressure cone at the press discharge. Depending on the type and consistency of the sludge flocks the pressure applied on the sludge is to be varied infinitely.
6. The conveying screw should push the dewatered sludge past the pressure cone into the discharge chamber.
7. The sludge residence time in the screw press and thus the filtration time should be adjustable to individual requirements by adjusting the rotational speed of the screw shaft.
8. Brushes should be fitted on the flights to ensure permanent automatic sieve cleaning from the inside.
9. Intermittent cleaning of the sieves from the outside is to be accomplished by a spray bar. The spray bar should be stationary mounted whereas the screen basket is a rotating element.
10. For the purpose of cleaning, the feed into the screw press is to be temporarily stopped and the screw shaft should rotate in reverse. The flexibly supported screen drum should perform one complete rotation passing by the spray nozzle bar to clean the complete screen surface.
11. In pressing mode, sludge feeding should start again, and the screw shaft should rotate forward. The screen basket should rotate until arrested by ratchets anchored in the casing. Thus, the pressing process should continue.
    i. Electrical appliances on the machine:
    ii. Drive motor of screw
    iii. Solenoid valve in the wash water connection
    iv. Pressure sensor on the sludge inlet housing
    v. Pressure switch for compressed air supply (optional)

Material of construction:

The Screw Press should be made of stainless-steel material AISI 316 (or similar) and pickled in an acid bath.

Accessories for Screw Press:

i. Polymer injection and mixing device for continuous mixing of coagulants and sludge, comprising of polymer injection ring with integrated distribution channel and 4 injection nozzles. The double-sealed cover provides easy access to the distribution channel and nozzles.
ii. One-piece blockage-free design, self-adjusting mixing energy via lever and

adjustable weight. Weight-loaded mixing valve with inspection opening.

Nominal width	DN 65, DIN 2501
Fitting length	280 mm
Total length	660 mm incl. Lever and weight Polymer connection DN 25 sockets.
Housing	Cast iron, RAL 5015
Movable parts	AISI 420

1.34.8.1 Supercharge Reactor

For optimal floc formation, downstream the polymer injection and mixing unit. Horizontal reactor shaped to provide defined turbulence and pressurized feeding of the screw press.

Reactor length	4000 mm, Diameter 250 mm
Height adjustment range	180 — 200 mm Volume approx160 l
Inlet flange	DN 65
Outlet flange	DN125

Material of Construction:

i. Reactor completely made AIS 316, including height adjustable support legs. The pressure adjusting system to regulate the pneumatic pressure cone. The system allows a fine adjustment of the compressed air. A lack of air is electronically detected, and the cone can be moved backwards by a hand lever valve.

ii. Supply should include a pressure sensor and a hand lever valve wired ready for connection on a galvanized plate.

iii. L x H: 334 x 355 mm

iv. Air inlet (6-8 bar): 1 x 10 mm push-in fitting Air outlet: 2 x 10 mm push-in fitting

v. Electronic pressure switch with 2.5 m connector cable for voltage supply (24 V) and PNP switch output. Electrical control panel for Screw Press Control panel suitable for wall mounting in compliance with UVV and VDE standards.

vi. Complete with all components required for fully automatic plant operation, switch on/off of individual drives via function keys on the control unit, motor protection relay, overload protection, fuses, relays, lockable mains isolator, socket-power unit 24 V DC. Display on control unit of operating hours, operating and fault signals, and run times.

Control panel:

- Painted steel RAL 7035 Protection grade: IP55
- To control the following units:
- 1 Screw Press incl. Power element (frequency converter:)
- 1 flocculation reactor stirrer incl. Power element (frequency converter)
- 1 filling level probe in the flocculation reactor to prevent reactor overflow

- 1 washing system control
- 1 release/fault thin sludge pump
- 1 release/fault coagulant agent pump

Frequency Convertor:

- Designed in compliance with CE safety and EMV standards
- Convertor for integration in the main control panel of the electrical switchboard comprising:
- three-phase alternating voltage 3 x 380 / 460 V
- AC typical shaft power PM,
- N = 3.0 kW
- Frequency f = 50 Hz protection
- IP 20 integral class A EMI filter control display

Compressed-air plant:

Miniature compressor for compressed-air production and pneumatic regulation.

Type	Piston compressor.
Effective delivery:	Q = 200 l/min Max. Pressure: P = 10 bar
Reservoir volume:	V = 24 l Performance with 400 V AC: P = 1.1 kW
Protection grade:	IP 54

Including maintenance unit and pressure regulating valve

1.34.9 Solar Sludge Drying Bed

The basic principle of the solar sludge dryer system is the drying of sewage sludge in a glasshouse using incident solar radiation. The special sludge turning system performs spreading, granulation, turning and mixing of sludge. The sludge becomes open-porous, and new contact surfaces for evaporation are continuously created. The solution allows for continuous system operation. The sludge is transported through the thermos-shell construction from one end to the other: Dewatered sludge is continuously fed on one end, and dry granulate is produced at the other end.

Due to the special features of the sludge turning assembly, particularly its back mixing function, an open, porous and slightly wet sludge bed is maintained. The sludge is dry enough to prevent odour-generating biological processes but still wet enough to prevent the generation of dust under mechanical stress.

The sludge feeding options can be adjusted to suit customer-specific requirements. The dewatered sludge can be fed into the greenhouse either manually, i.e. with a wheel loader, or fully automatically by a distribution screw. The dried sludge is collected at other end of green house for manual collection or discharged either into a trough with screw conveyor for conveying into a container. Solar sewage sludge dryer system consists following components:

1.34.9.1 Mechanical Equipment

Fully automatic turning and transport system with integrated traction drive including driveway with pull chain and safety devices

1.34.9.2 Electro-technical Equipment

i. Electrical switchboard and control panel
ii. Climate Control
iii. Energy Chain
iv. Cable Package
v. Ventilation equipment

1.34.9.3 Green House

i. The Greenhouse construction with covers.
ii. Flaps, Window.

1.34.9.4 Sludge Turner

The sludge turner consists of a supporting frame which travels on driveway walls. The sludge is moved by a rotating double shovel installed in the frame. A movable plate which is mounted in front of the double shovel breaks up sludge lumps and regulates sludge transport.

The Sludge Turner provides the following features-

i. Sludge turning & transport over the entire width of the drying hall combined in one work step.
ii. Complete & intensive sludge aeration due to optimised sludge mixing & turning (minimized the risk of odour problems).
iii. High sludge aeration & mixing capacity of 15 m3/min (Volume of sludge moved)
iv. Intensive sludge turning- each sludge grain is moved over a distance of 1.5m during one sludge turnover cycle.
v. The end product is grainy & stable, and thus ideal for reuse.
vi. Grainy granulate, ideal for further reuse.
vii. Targeted back mixing- the return of dry granulate with floor contact.
viii. Back mixing of sludge over the entire hall width in one work step(1.5 m3/hr).
ix. Variable speed of the traction drive and double shovel drive, to optimally meet specific customer requirements.
x. Fully automatic operation.
xi. Low maintenance requirements.
xii. Optional automatic sludge removal from the drying hall.
xiii. The working velocity ensures intensive sludge processing.

1.34.9.5 Material of Construction

i. The complete machine including accessories is made of 304L (1.4307) stainless steel, acid treated in a pickling bath and passivated.

ii. The material of bearings, drives, chains, etc. is selected to suit specific stress levels.

iii. Corrosion protection of the drives: Synthetic resin primer, nitrocellulose combination lacquer, RAL 5015, 220 µm.

iv. Maximum permissible hydrogen sulphide content in the air: 6 ppm The following drives are provided for each sludge turner system:

a. Traction drive.

b. Double shovel drive.

c. Plate drive.

1.34.9.6 Traction Drive (Each Machine)

The traction drive consists of a frequency-converter-controlled gear motor and a shaft which distributes the power equally onto lateral chain wheels which engage with a pull-chain system. The pull-chain system ensures the safe travel of the sludge turner. The bridge is additionally guided by lateral rollers.

1.34.9.7 Double shovel drive (Each machine)

The double shovel drive consists of a frequency-converter controlled gear motor and a shaft which distributes the power equally onto lateral chain wheels which engage with a pull-chain system, with protected power transmission above the sludge field, i.e. without any sludge contact, via automatically tensioned chains.

The double shovel positions and traction drive positions are measured via the motor and the associated controls (Frequency converter/PLC)

1.34.9.8 Scraper Plate Drive

The scraper plate is mounted in front of the double shovel and vertically adjustable via a lift drive. The ultrasonic level probe is installed to measure sludge height & control the hoist motor of the scraper plate drive.

1.34.9.9 Other Process-Engineering Advantages of Sludge Turner System:

Continuously sludge feeding:

i. The sludge is mixed in and mixed back: No pasty phase problem, quick transfer into a stable condition due to the high drying degree.

ii. The sludge is granulated: The large surface of the produced sludge granulate accelerates the drying process.

iii. Even very difficult-to-treat sludge can be processed since the system ensures the immediate homogeneous distribution of sludge inside the greenhouse.

iv. The shovel runs very smoothly and evenly along the floor. This ensures, that the complete sludge is processed.

v. The low lateral walls (300 mm high) reduce shadows and consequential losses of solar energy.

vi. As the sludge is rolled in the shovels compact globular granules are produced.

1.34.9.10 Energy Chain System

An energy chain is used for energy and signal supply from the middle of the greenhouse (fixed point of feeding) up to the moving sludge turner. The use of an energy chain also allows for flexible positioning of the control panel. The energy chain consists of an open cable guide channel made of either galvanized steel or plastic elements. The chain is pulled and pushed by the SOLSTICE® sludge turner. The chain and cables are suitable for highly dynamic applications.

As the energy chain is installed on only one side of the sludge turner, it is very maintenance-friendly (accessible without auxiliary means) and leaves room for various sludge feeding and removal solutions. As the energy chain is installed at the side of the greenhouse, both the sludge feeding and removal areas are freely accessible.

1.34.9.11 Cable package without installation material

The cable package includes all cables required for control of the drying plant inside the greenhouse. The energy supply line, to the main control panel must be provided by the customer:

i. Supply lines to climate sensors, weather stations and ventilators.

ii. Supply line from the main control panel to the feed point of the energy chain, all lines in the energy chain and all lines on the sludge turner, including all intermediate terminal boxes and distributors inside the greenhouse.

The cable trays and ductwork required for laying the cables and lines are not included, and neither are in-house installations (lighting, power sockets) included as standard.

1.34.9.12 Climate Control Via Climate Sensors

The climate control system ensures optimal drying conditions taking into account safety aspects. Too high and too low temperatures in the greenhouse are avoided to protect the mechanical equipment. The measured climate data are used to calculate the drying potential of the air. The run times of the ventilators and greenhouse ventilation are controlled based on these settings. Condensate production is calculated and limited via greenhouse ventilation so that excessive sludge rewetting is prevented. The water evaporation is optimally controlled via the ventilators with a climate model. 6.

1.34.9.13 Ventilation Fan

Recirculation air ventilators are installed on the supply air side and in the middle of the greenhouse. Due to the turbulences generated on the sludge surface, the moisture in the sludge can pass into the air. The air is routed to the exhaust air side.

For discharge of the saturated air exhaust air ventilators are installed on the gable end of the greenhouse. A ridge flap can optionally be used in place of exhaust air ventilators. Ventilation control combined with climate sensors and ventilators generates an optimal drying climate inside the greenhouse. Protection against condensation prevents the remoistening of the

sludge.

1.34.9.14 Exhaust air ventilator (Each bed)

The highly efficient sturdy axial fan with EC technology, controlled by MODBUS, is balanced for ventilation.

1.34.9.15 Circulating air ventilator (Each bed)

The highly efficient sturdy axial fan with EC technology, controlled by MODBUS, is balanced, for ventilation.

1.34.9.16 Electrical control system

Complete with all components required for fully automatic plant operation, switch on/off individual drives via function keys on the control unit, motor protection relay, overload protection, fuses, relays, and lockable mains isolator. Display of operating & fault signals run times on the control unit.

The control plant is designed for the ambient conditions as per IEC 60204-1.

i. Air temperature: +5°C to +40°C

ii. Air moisture: 50% rel. air moisture at 40°C (Non-condensing)

iii. No contact with:

- aggressive or corrosive gases
- explosive atmosphere
- ionizing and non-ionizing radiation
- dusts
- acids, lye, salts

Control and Operation:

Program visualization and operation via a coloured touch screen. The group structure of the navigation menu with clear text and illustrations, provides for intuitive operation. All information relating to mechanical equipment and climate control is visualized in a structured form. Monitoring of the complete plant is provided on the start display, where updated measurements and the current program step of the machine and climate system are displayed. Various parameters can be freely programmed in the electrical system. The electro-technical components of the sludge turner are reduced to a minimum and integrated into one terminal box for easy installation and maintenance. All cables for control of the sludge turner are combined in an energy chain.

Basic controls:

- Sludge turning unit control
- Climate control
- Ventilator group control (potential-free contacts)
- Signals for the complete plant (“operation” / “fault”)

Additional components:

- Project-specific adjustment of the program of the solar drying unit
- Control panel ventilation for a floor-standing cabinet with a thermostat
- Remote control via the internet to be provided by the customer, via SIM card for UMTS or LTE
- Control of ventilator
- Additional electrical equipment/controls can be supplied on mutual agreement. Supply of additional or modified equipment will be charged extra on a time and material basis. If the power of the specified drives is changed, this will affect the electrical equipment required in the control panel and possibly also the control panel size.

1.34.9.17 Green House

Drying is achieved through direct sun radiation on the sludge and convection drying with hot air produced inside the greenhouse. The greenhouse is water-tight (rain), stable (snow) and weather-resistant (UV radiation, hail, dew) as provided by the material selected. The films and plates used are light transmissive. The greenhouse also protects the self-acting mechanical system.

Construction:

The greenhouse construction should allow for attachment of cable routes (cable tray, brackets, etc.), and ventilators. The construction should be of bending-resistant, galvanized steel profiles. If feeding is to be done by means of a screw or similar in the roof, the static construction for this system must be provided. The construction is designed to be drilled onto the customer's strip foundation.

Covering:

Air bubble film UV-coated (PE), Covering the gable front with Polycarbonate panels.

Ventilation:

The gable on the dry granulate side is to be equipped with a weather protection grating (of at least 6 m² per line). The weather protection grating is to be designed to prevent the ingress of rainwater into the greenhouse. The weather protection grating is not electrically controlled. Ventilators are to be installed in the outer shell of the greenhouse in the wet sludge section. They transport the saturated air out of the greenhouse into the open.

Gates/Doors/Windows:

Sliding doors should be provided in the gable (in case of feeding or unloading with wheel loader): The wings open from the middle and give free half the hall width each. All accesses to the greenhouse (doors/gates) should have locks. Each side of the greenhouse should have an inspection door to provide for control of the sludge bed and machine maintenance.

Feeding of dewatered sludge – Automatic or Manual

A wheel loader can be used for manual feeding, and an automatic conveyor can be used for fully automatic feeding. With proper feeding, the drying area is optimally utilized through even distribution of dewatered sludge.

1.35 Mechanical Mixers

1.35.1 Submersible Mixers

i) The submersible mixer shall be installed in the Anaerobic and anoxic zones, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec.

ii) The mixer shall have a self-cleaning propeller optimized for effective mixing and vibration-free running, and the required power shall be at least 10Watt/m3 of tank volume.

iii) The mixer shall be driven by a high-efficiency 3-phase motor IP68 Class F. The Motor shaft and rotor shall be dynamically balanced.

iv) Bearings shall be lubricated for life with a calculated life of more than 100,000 operating hours.

v) The mixers shall have the flexibility to be located at different depths, thereby avoiding dead zones.

   a. The mixer shall be provided with the following :

   b. Lifting frame with a winch which can be dismantled, free-standing with adjustable boom length.

   c. Mounting socket for free-standing hoist suitable for wall mounting.

   d. Guide for floor fixing components and support brackets for wall mounting.

   e. Stainless steel rope for raising and lowering the mixer.

vi) Rope block for holding the stainless steel rope where the lighting frame is used in different locations.

vii) Support rope for reliable support and guidance of the power supply cable.

viii) Support clamps and hooks to support the power supply cable in such a manner that it is not under strain. The propeller, propeller shaft and motor housing shall all be of SS 316

1.35.2 Mechanical Floating Mixer

1.35.2.1 General

Mechanical floating mixer and related equipment accessories shall consist of a motor, direct drive impeller driven at a constant speed, an integral flotation unit, and impeller volute.

1.35.2.2 Performance

Each mixer shall have a zone of complete mix and a direct pumping with a recirculation. Complete mix shall be defined as maintaining biological suspension of all mixed liquor suspended solids with design MLSS or less without the introduction of air.

1.35.2.3 Mixer Drive Motor

The motor shall be rated for 415-volt, 50 hertz, three-phase service. The motor shall be standard efficiency, vertical P base design, totally enclosed fan cooled TEFC, and generally rated for severe duty. The motor shall in all cases equal or exceed standard NEMA specifications. A minimum service factor of 1.15 shall be furnished.

The motor winding shall be non-hygroscopic, and insulation shall equal or exceed NEMA Class "F". A labyrinth seal shall be provided below the bottom bearing to prevent moisture from penetrating around the motor shaft. A condensate drain shall be located at the lowest point in the lower-end bell housing. Unit shall have a one- piece motor shaft continuous from the top motor bearing, through the lower bearing and down to and through the propeller. The shaft shall be manufactured from high-quality stainless steel. Motor bearings shall be releasable. Sealed bearings are not acceptable.

1.35.2.4 Motor Mounting Base

The motor shall be securely mounted onto a solid 316 stainless steel base which is integral to the motor base extension. All submersed wetted motor mounting base components shall be constructed of 316 stainless steel.

1.35.2.5 Floatation

Each unit shall be equipped with a modular float constructed of fibre-reinforced polyester skin FRP or equivalent with a central float passage of a size to allow installation and removal of the pump impeller. The float shall be foamed full of polyurethane foam of the closed-cell type and shall be totally sealed to prevent the foam from being in contact with the external environment.

1.35.2.6 Impeller

The impeller shall be designed to pump the liquid from near the surface and direct it down toward the vessel/basin bottom. The impeller shall be a two-blade marine-type precision casting of 316 stainless steel and shall be specifically designed for the application intended. It shall be dynamically and hydraulically balanced. The propeller must be attached to the motor shaft with a hardened stainless-steel pin and set screw. The impeller shall be capable of being reversed to cause back-flow liquid movement without causing damage to the mixer chassis and without causing up-flow liquid damage to the motor bearing and windings. No liquid

spray or other liquid leakage upward onto the surface of the motor support surface or flotation chassis will be allowed.

1.35.2.7 Intake Volute Assembly

The impeller shall operate in a volute made of a 316 stainless steel plate.

1.35.2.8 Vibrations

The entire rotating assembly, including the motor rotor, shaft, shaft accessories, and impeller, shall be dynamically balanced within 2.0 mils peak-to-peak horizontal displacement measured at the upper and lower motor bearings. Measurements shall be taken at a frequency equivalent to the motor RPM. Measurements shall be taken with the motor in a vertical, shaft-down position with the entire power section mounted on resilient pads.

1.35.2.9 Cable Mooring System

Each unit shall be provided with a maintenance cable mooring system complete with mooring cable, clips, thimbles, quick disconnects, anchors, and extension springs as shown on the drawings. Mooring cable, anchors, and hardware shall be 316 stainless steel. Field attachment of mooring points to the tank shall be the responsibility of the installing

contractor.

1.35.2.10 Cable Mooring Electrical Service Cable

Each unit shall include a conductor power cable wired into the motor conduit box and terminating at the basin wall. Electrical cable shall be supplied with Kellems grips at the motor and basin wall terminations. Electrical cable floats for the flotation of electrical service cable shall be provided. Attachment of cable and supply of junction box/disconnect at the basin wall shall be the responsibility of the installing contractor. 316 stainless steel adhesive anchors for attachment of mooring system components to the basin wall shall be provided.

1.35.3 Chemical Tank and Mixer

1.35.3.1 General

This tank shall be used to dissolve the alum or polymer to a constant concentration and feed the solution to the outlet channel of the aeration tank or the dewatering equipment. It shall be a vertical tank and shall be composed of the tank main body, mixer, manhole, electrical level gauges, direct reading level gauge, ladder, air exhaust pipe etc.

1.35.3.2 Fabrication

i) The tank shall be made of corrosion-resistant material.

ii) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.

iii) The tank shall be provided with necessary mounting seats for overflow pipe, etc.

iv) The motor-driven mixer shall be a vertical speed reducer, direct-coupled type of 2-stage propeller type, as a rule, and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the center or a position off the center according to the tank being angular or circular

v) The mixer shall be protected by electrical prevention of dry operation.

vi) The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.

vii) An alum feed cage of stainless steel shall be provided inside the alum solution tank.

1.35.3.3 Material of Construction

Main Tank body	GRP/HPDE or equivalent
Mixer frame	SS316
Mixer shaft	SS316
Blade	SS31

1.35.3.4 Accessories (per Unit)

Foundation bolt and nut	1 SET
Air vent pipe	1 SET
Mixer	1 UNIT
Direct reading level gauge	1UNIT

1.35.4 Alum Dispersion Rapid Mixer

1.35.4.1 General

The alum dispersion rapid mixer shall be an in-channel submersible chemical vacuum induction unit and consist of a chemical induction unit with mount bracket, guide rail assembly, floor mount base, boom hoist with manual brake winch and SS 316 cable, hose assembly, control panel and submersible power cable.

The unit shall be provided instantaneous diffusion/mixing and the highest level of durability and performance required for chemical feed application.

The hermetically sealed SS 316 motor shall provide the highest level of durability and performance required for chemical feed applications. All wetted materials shall be constructed from Grade 2 Titanium (unalloyed) and shall be designed for use with all common water and wastewater treatment chemicals. The mounting bracket shall be engineered for installation in open-channel applications.

The material of construction of chemical induction shall be as follows:

1.35.4.2 Material of Construction

Component	Material
Vacuum chamber	SS
Vacuum port	SS
Vacuum enhancer	Non-metallic
Propeller	SS
Propeller bolt	SS
Shaft	SS
Mechanical seals	Carbon / ceramic
Hardware	SS 316

1.36 Fans: General

Unless otherwise indicated, the requirements of this Section shall not apply to individual fans having a duty air flow rate of 0.7m³/s or less.

The make and type of fan shall be subject to approval.

Fans shall be type-tested in accordance with the requirements of BS 848 and shall be selected to give the air flow rate and sound power level specified.

ans shall be built to a fully developed design and shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty. Belt-driven fans shall be capable of running continuously at ten per cent over the selected duty speed.

Based on values of the resistance to airflow of items of equipment, ductwork, and the total distribution system. The Contractor shall verify these values based on the equipment offered and provide fans capable of delivering the required air volume when operating against the actual total system resistance.

Where fans are supplied with noise attenuators, full details shall be provided. Fan drives shall be as detailed elsewhere in this Specification.

Fans shall be installed using bolts, nuts, and washers with all ‘as-cast’ bearing surfaces for bolt heads and washers counter-faced. Holding-down bolts for fans and motors shall be

provided with means to prevent the bolts from turning when the nuts are tightened. Anti-vibration mountings shall be as detailed elsewhere in the Specification. Fans heavier than 20kg shall be provided with eyebolts or other purpose-made lifting facilities.

Where specified, or as necessary, fans shall be fitted with variable inlet vanes which shall be matched to fan performance to give stable control. Vanes shall be interlocked to ensure movement in unison. Operation shall be manual or automatic as specified. Where manual control is specified, the operating device shall facilitate positive locking in at least five different positions.

Vane blades shall not vibrate or flutter in any possible operating condition, and the construction of the linkage system shall minimize friction and lost motion.

Unless otherwise specified, the shaft and impeller assembly of all fans shall be statically and dynamically balanced. All propeller fans shall be statically and dynamically balanced where the impeller diameter is 750mm or greater. Where indicated, limits of vibration severity shall be in accordance with BS 4675: Part 1.

Fan bearings shall be suitable for the installed attitude of the fan. They shall be grease/oil ball and/or roller type or oil-lubricated sleeve type. All bearing housings shall be precision-located and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust and, where fitted with greasing points, they shall be designed to prevent damage from over-greasing. For grease-lubricated systems, the bearings shall be provided initially with grease recommended by the bearing manufacturer. For oil-lubricated systems, the housings shall provide an adequate reservoir of oil and shall include a filling plug and be oil-tight and dust-proof. Systems other than total-loss types shall include an accessible drain plug. All bearing lubricators shall be located to facilitate maintenance.

1.36.1 Ceiling Fans

Ceiling fans shall comply with IS 374 or BS 4934 for safety and BS 5060 for performance.

Fans shall be speed-controlled in at least five discrete steps, using a separate surface-mounted controller. The controller shall use a tapped autotransformer for speed control.

Motors shall be capacitor start/run type, with inner wound stator and rotating outer body and incorporating ball- type bearings.

Motors shall be suitable for use in a tropical environment.

1.36.2 Centrifugal Fans

Centrifugal fans for high-velocity high-pressure systems (defined within the HVCA Specification DW/141) shall be backward-bladed type.

Unless otherwise specified, centrifugal fans of more than 7.5kW at the fan shaft shall be of the backward- bladed type having a fan total efficiency not less than 75%.

Fan casings shall be built to permit withdrawal of the impeller after installation. Fans other than those in air-handling units shall be provided with flanged outlet connections and spigot inlet connections unless otherwise specified, except that, for negative pressures greater than 500Pa, inlet connections shall be flanged. A plugged drain point shall be fitted at the

lowest point in the fan casings. A permanent indication shall be provided showing the direction of rotation of the fan impeller. Fan casings shall be provided with removable access panels incorporating purpose-made air seals. The sizes of access panels shall facilitate cleaning and maintenance.

The impellers shall be of mild steel or aluminium alloy, of riveted, welded or other approved construction, with spiders or hubs of robust design.

1.36.3 Axial-Flow Fans

Axial-flow fan casings shall be rigidly constructed of mild steel or aluminium alloy, stiffened and braced where necessary. Mounting feet shall be provided where necessary for bolting to a base or supports. Inlet and outlet ducts shall terminate in flanges to facilitate removal. For in-duct mounting fans, the length of the fan casing shall be greater than the combined length of the impeller(s) and motor(s) and electrical connections to the motors shall be through an external terminal box secured to the casing.

Impellers shall be of steel, aluminium or plastics, and the blades shall be secured to the hub or the blades and the hub shall be formed in one piece. The hub shall be keyed to the shaft. Blades shall be aerofoil or laminar sections, capable of pitch adjustment where specified.

For axial-flow fans driven by motors external to the fan casing, the requirements for drives and guards mentioned elsewhere in this Specification shall be met. Unless otherwise indicated, a guard is not required for any part of a drive which is inside the fan casing. An access panel with purpose-made air seals shall be provided in the fan casing. The access panel shall be sized to facilitate maintenance.

Where axial-flow fans of the bifurcated type are specified, the motors shall be out of the air stream. Motors may be placed between the two halves of the casing in the external air or may be placed within the fan casing, provided that effective ventilation is given to the motors.

1.36.4 Propeller Fans

Propeller fans shall be ring-mounted or diaphragm-mounted as specified. Impellers shall be of steel, aluminium, or plastic. Blades shall be securely attached to the hub, or the blades and hub shall be formed in one piece.

1.36.5 In-line Centrifugal and Mixed-Flow Fans

Mixed-flow fan casings shall be rigidly constructed of mild steel, or aluminium alloy stiffened and braced where necessary. Mounting feet shall be provided where necessary for bolting to a base or supports. The inlet and outlet shall terminate in flanges to facilitate removal. Stator vanes shall be of mild steel or aluminium alloy. The design shall facilitate access to the impeller. Where motors are mounted external to the casing, the requirements for drives and guards given elsewhere in this Specification shall be met. An access panel with a purpose-made air seal shall be provided in the fan casing. The access panel shall facilitate maintenance.

1.36.6 Mechanical Roof-Extract Units

The fans used in roof extract units shall meet the appropriate requirements of the preceding clauses relating to fans generally and to particular types of fans. Cowls and bases shall be of materials which are resistant to the weather and solar radiations and are appropriate to the

location of the fan. Casings shall be formed to facilitate a weatherproof fitting to the building structure. Adequate access to electrical supply terminals and lubrication points shall be provided by means of hinged cowls or otherwise as appropriate. Back-draught dampers or fire-release dampers shall be provided where specified. Bird guards of not greater than 25mm mesh shall be provided as an integral part of the unit.

Protectively Coated Fans and Fans for Corrosive or Hazardous Applications:

Where fans are required to handle toxic, corrosive, flammable, explosive or high-temperature gases, the materials of construction shall be chosen appropriately, and all relevant safety regulations shall apply. Bearings and lubrication arrangements shall be suitable for the conditions. Protectively coated fans shall meet the appropriate requirements of the preceding clauses relating to fans generally and to particular types of fans, and the form of protection shall be as indicated. Where a protective coating is required for use with corrosive gases, the coating shall cover all parts of the complete fan, motor and casing assembly which will be affected. No fan shall be installed if the protective coating has been damaged. Impellers shall be of coated steel, stainless steel, aluminium or plastics as specified.

For fans installed in hazardous atmospheres, requirements shall be as specified.

1.37 Walkways, stairways and platforms

Walkways, stairways, and platforms shall comply with BS5395 Part 3.

Standard structural hot dip galvanized mild steel to BS EN ISO 1461: 1999 or marine grade aluminum sections shall be used.

Allowance shall be made for the fitting of equipotential bonding conductors with any lugs welded or holes drilled prior to galvanizing.

Walkways shall have an effective width of not less than that stated in BS 5395. Open mesh flooring shall comply with BS 4592. Toe plates of not less than 150mm height shall be provided on all walkways. Floor panels shall be sized to not exceed 25kg for a single-person lift or, where there is adequate space for movement around the panel (as detailed in the Manual Handling Operations Regulations 1992), 35kg for a two-person lift.

Stairway inclination shall be between 30deg and 42deg with the 'going' of stair treads not less than 250mm and landings situated after not more than 16 risers in any one flight.

Floor loading shall be as detailed in Table 3 of BS 5395 but not less than a general duty of5.0kN/m².

Plating Shall Be of The Non-Slip, Self-Draining Pattern Securely Fixed to The Supporting

1.38 Structure.

1.39 Outdoor Stairways Shall Have Open Mesh Treads.

1.40 Ladder and Stairs

For Sewage Pumping Stations, Sewage Treatment Plants, Sumps/chambers and all other Water Retaining Structures, Stairs, shall be in situ of RCC of 1.20 m wide, rise 150mm and tread 250 mm and also incorporated while designing the structure. Depending on the height of the structure, M. S. ladder of 450 mm wide, made up of 65mm x 65mm x 6 mm M.S. angle

iron and 20mm M.S. bars welded at 300mm c/c shall also be provided. M.S. ladder shall be epoxy coated.

1.41 Railing

Hand railing around the platforms, Balcony, stairs and landings shall consist of aluminium pipe of dia 40 mm of wall thickness with 5.08 mm thick (schedule-80) with anodizing in two rows (one at the top and the other at middle level) and 900 mm high vertical post, aluminium pipe of dia 40 mm of wall thickness with 5.08 mm thick (schedule-80) with anodizing and modular fittings @ 1500mm center to center (At least two vertical angles are to be provided wherever distance is less) and shall be built into the concrete or bolted to the SS plate embedded in concrete with all accessories like elbows, tees etc. including welding, threading and embedding in cement concrete floor. The pipe shall pass through a hole in the vertical angle. Railing shall be protected against corrosion after welding and shall be painted with three coats of approved paint. All Railing shall be SS railing (building works) and aluminium (balcony, landing, platforms) at SPS and CETP etc.

1.42 Access Steelwork

Ladders, step irons, platforms, covers and handrails to be supplied and fixed under this Contract are generally shown on the Drawings, but the Contractor shall ensure that the Works are designed for safe operation and maintenance by providing whatever safe access arrangements are needed.

Any small areas of chequer plating or similar coverings that are needed to cover gaps between items of Plant and the surrounding structure, and any access ladders, platforms and handrails that need to be attached to items of Plant to facilitate operation, inspection or maintenance, shall be supplied and erected by the Contractor.

The Contractor shall also supply and erect adequate access to all hand wheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance.

Chequer plating shall be of ‘Durbar’ or other non-slip pattern, not less than 4.5mm thick (exclusive of pattern) and hot dip galvanised after fabrication in accordance with BS 729.

Aluminium alloy flooring may be used instead of chequer plating. It shall comply with BS 1470 material H 30 TB.

1.42.1 General Technical Specifications for Handrails. (IS 4912, 1978)

1. A railing shall consist of a top rail, intermediate rail, and posts, and shall be not less than 90 cm vertical height from the upper surface of the top rail to the floor, platform, runway, or ramp level. The top rail shall be smooth-surfaced throughout the length of the railing. The ends of the rails shall not overhang the terminal posts except where such overhang does not constitute a projection hazard.
2. A stair railing shall be of construction similar to a railing, but the vertical height shall be not more than 85 cm nor less than 75 cm from the upper surface of the top rail to the surface of the tread in line with the face of the riser at the forward edge of the tread.
3. The ~anchoring of posts and framing members for railings of all types shall be of such

construction that the completed structure shall be capable of withstanding a point load of at least 90 kg applied in any direction at any point on the top rail.

4. Where railings are likely to receive heavy stresses from crowds, trucking or handling materials, additional strength should be provided by use of heavier stock, closer spacing of posts, bracing or by other means.

5. The maximum distance between any two horizontal or vertical members should not exceed 20 cm in one direction.

6. Overhangs shall be eliminated at the rail ends unless such overhangs do not constitute a hazard, such as baluster railings, scroll work railings and paneled railings.

1.43 Odour Control System

1. General

This specification covers the general requirement of the performance, design and construction of odour treatment units for the neutralization or absorption of odorous compounds by physical, chemical or biological action in used water (wastewater) application with all relevant statutory regulations and the latest edition of all relevant international, harmonized European and British Standards and Indian Standards and Code of Practices.

The specification covers the following type of treatment plant:

i. Dry Scrubber

ii. Bio Scrubbers (i.e. Bio-Trickling Filter) This specification shall also comply with: -

iii. The relevant Process Specification.

iv. All associated General Specifications.

v. The specific technical data schedules accompanying the Particular Specifications (if applicable).

vi. The relevant Electrical General and Particular Specifications.

The relevant Instrumentation and Control and Automation (ICA) General and Process Specification.

1. Submittal Requirements

i. The Contractor shall provide the following data and specifications for each equipment unit supplied, but not limited to, the information outlined in General Specifications Drawings, Documentation, and Recording of the Works, and Operation and Maintenance Manuals and also includes the following additional requirements:

ii. Proposed media bed depths and retention time.

iii. Any requirement for media re-generation (if applicable).

iv. The potable water demand and final effluent demand (flow and pressure requirement) (if applicable).

v. The estimated energy consumption and electrical drive loadings list

vi. Completed and final Technical Schedules attached in the Specifications:

vii. Process verifications to demonstrate that any scrubber media provided meets the required performance criteria.

viii. With respect to the above, where appropriate, the drawings shall include the minimum clearance distance required for the removal of plant and equipment and its associated components with the equipment in situ and termination points for the connection of external services.

1. Products:

General

i. This section covers the various possible technologies for odour control equipment which may be supplied by the Contractor, which includes:

ii. Dry Scrubbers – such as Activated Carbon media odour scrubbers

iii. Bio scrubbers – such as Bio-Trickling Filters

iv. Specific odour control technology requirements (if any) will be outlined in the Process Specifications for each site.

v. The Contractor shall only offer those proven technologies as listed above, with references as its primary offer. While new technology may be available and may be considered by the ENGINEER, primary offers which include unproven technologies will be rejected during the review process.

1. Dry Scrubber Units General

i. This section covers odour control equipment where foul air is passed through dry media and odorous compounds are adsorbed by the media. The performance may be enhanced using adsorption media impregnated with a chemical agent.

ii. Typical dry scrubbers used for the purposes of odour control are Activated Carbon (AC) based scrubbers.

iii. The Contractor shall provide pre-filters installed upstream of the Foul Air Fans and Activated Carbon vessels for removal of aerosols and particulates from the inlet air stream such that the inlet face of the Activated Carbon bed does not become blocked with aerosols or particulates.

iv. The complete odour treatment system based on dry adsorption such as AC as proposed by the Contractor shall fit within the designated areas as outlined in the process specifications.

v. The AC systems shall be a single pass system, (multiple beds installed in each vessel acceptable), and with all necessary internals and support structures to provide a complete functional system.

vi. The vessel dimensions (length x width and/or diameter) and media volume shall be calculated by the Contractor and properly designed to achieve the specified Performance Guarantees stipulated in the Specifications.

vii. The following minimum distances between adjacent AC vessels shall be satisfied to allow adequate access for maintenance and AC media replacement:

viii. All AC vessels shall be installed adjacent to a dedicated service road or grassed area capable of passing standard-sized vehicles and trucks.

ix. Quad-bed AC vessels mounted horizontally shall be provided with at least 3m between adjacent AC vessels.

x. Dual-bed AC vessels mounted vertically, and single-bed AC vessels shall be provided with at least 1.5 m between adjacent AC vessels.

xi. AC reactors shall be designed such that extra depth of AC media or addition of AC vessels may be added to meet performance requirements, should the initial odour performance testing results show failure to meet emission limits. The addition of extra AC media depth or AC vessels to meet performance requirements will be at the Contractor's cost.

xii. The AC systems shall incorporate the following ancillary systems as a minimum.

xiii. Inlet pre-filters.

xiv. Inlet heaters/dehumidifiers (specific to Contractor's proposed AC blend);

xv. For AC-based systems, the following instrumentation must be built into the Odour Treatment Plant and Control Systems, along with the local operator interface:

xvi. AC inlet common H2S analyser, measuring down to 1ppmv and with a minimum H2S analysis rate of 60 readings per hour.

xvii. AC exhaust common H2S analyser, measuring down to 0.01ppmv and with a minimum H2S analysis rate of 60 readings per hour.

xviii. Stack exhaust H2S analyser, measuring down to 0.01ppmv and with a minimum H2S analysis rate of 60 readings per hour.

xix. For AC-based systems, the following interlocks and alarms must be built into the Odour Treatment Plant Control System and local operator interface, in addition to the standard alarms required for the operation of the entire odour control system:

xx. For each AC bed:

xxi. High AC bed temperature alarm.

xxii. High AC bed differential pressure alarm.

xxiii. AC Media Requirements

xxiv. The type and composition of the AC media required/provided shall be subject to the Contractor's specifications as specified in the Specifications.

xxv. The Contractor shall be responsible for the appropriate carbon selection for the duty specified. This may include a dual-bed or quad-bed system if considered appropriate by the Contractor. The Contractor shall provide justification for the carbon selection including calculations to demonstrate that the minimum requirements will be achieved, and supported by case studies or references which must be submitted to validate claims.

xxvi. The AC media shall be of granular or pelletized form, and its composition shall match those specified in the Particular Specifications, with no more than 5% variation in

weight for each component making up the AC media.

xxvii. The AC media depth shall provide a minimum ventilation air contact time within the AC media bed as specified in the Particular Specifications, with no more than 5% compaction or shrinkage of media within the bed.

xxviii. The depth of media shall be such that the minimum contact time for the airstream in the OCS shall satisfy the requirements outlined in the Technical Data Schedules accompanying the Particular Specifications for each site, at the maximum design airflow, without exceeding the manufacturer recommended gas velocity through the AC media face (typically maximum 0.25m/s). The AC media shall be evenly distributed in the bed so that no bypassing or short circuiting of foul air occurs within the OCS.

xxix. The Contractor shall ensure that all AC media beds receive equal airflow and that no short circuiting occurs. Where multiple AC media beds or multiple AC cells are proposed, the contractor shall provide calculations and supporting documentation that demonstrate how equal airflow distribution will be achieved and how short circuiting will be eliminated or minimized.

xxx. For horizontal flow systems the Contractor shall install baffles to prevent short circuiting.

xxxi. For multiple AC cells in a single bed reactor, the Contractor shall install flow restricting orifices on each inlet plenum to prevent unequal airflow distribution.

xxxii. AC media adsorption H2S efficiencies (to break through, not saturation) based on the proposed media blend shall be supplied by the Contractor for reference. Recent extensive testing by the Australian Research Council (ARC) Sewer Corrosion and Odour Research (SCORe) project has identified that the typical H2S adsorption capacity to H2S breakthrough is much less than and can be as low as half of typical literature claims. Literature claims of AC media H2S adsorption are typically based on ASTM D6646-03 or equivalent, which quantifies the total H2S adsorption capacity of the media to saturation. This is impractical for field operation of OCSs as H2S and odour nuisance will be caused at H2S breakthrough, with AC media changeover required when this occurs. Contractors shall adopt AC media efficiencies outlined in the table below in their design of proposed AC systems. The ENGINEER reserves the right to test AC media efficiency to breakthrough and validate sizing claims.

Carbon Type	Adopted Values for H2S Adsorption Capacity (g/cm3 media)
Virgin Activated Carbon	0.03
Chemically Impregnated Activated Carbon or Alumina (Hydroxide or Permanganate impregnated)	0.14
Catalytic Activated Carbon	0.16

xxxiii. The Contractor is to ensure that each lot of AC media delivered to the project site for installation into the AC vessels complies with the requirements outlined in the Particular Specifications and is accompanied by an analysis sheet of the measured characteristics of the carbon in that lot.

xxxiv. The Contractor shall include information including details and price of the activated carbon media intended to be supplied in the tender documents. The ENGINEER may agree to proceed with this intended carbon; however, the ENGINEER reserves the right to request the Contractor to amend the specified carbon blend if deemed unsuitable for the contaminants in the foul air requiring treatment.

xxxv. The ENGINEER also reserves the right to source the proposed AC media blend independently from the Contractor, and not use the media offered by the Contractor. Should the ENGINEER agree to use the Contractor's carbon, it shall comply with the following requirements:

xxxvi. Details of the proposed AC media blend, and its performance characteristics, particularly moisture ingress shall be provided by the Contractor. Peat, coconut shell or high-grade coal are the preferred base materials for carbon manufacture.

xxxvii. The AC media shall also be required to absorb levels of hydrocarbons that may be present at times.

xxxviii. Unless otherwise specified in the Particular Specifications, a minimum of 30% virgin activated carbon (or similarly suitable AC media) shall be incorporated into the AC media blend, for removal of Reduced Sulphur Compounds (RSCs) and Volatile Organic Compounds (VOCs) which are typically resistant to adsorption onto impregnated activated carbon or catalytic activated carbon.

xxxix. Breakthrough and Media Replacement

xl. Breakthrough of H2S and odour is defined to occur when the H2S and odour reduction criteria in the Performance Guarantees stipulated in the Particular Specifications are exceeded, and consequently the AC media bed requires replacement.

xli. Unless otherwise specified in the Particular Specifications, the Contractor shall guarantee the AC media bed life shall exceed one (1) year to break through of H2S and odour based upon average inlet gas conditions as outlined in the Particular Specifications.

xlii. Unless otherwise specified in the Particular Specifications, the activated carbon shall have an odour removal efficiency of not less than 99% for all sewer-based odour and meet discharge H2S and odorous gas concentration limits as stipulated in the Schedule of Performance Guarantees in the Particular Specifications.

xliii. Specific Design Requirements.

xliv. The treatment unit shall be designed so that the volume of condensate accumulating within it is minimized. Facilities shall be provided with water traps for the collection and drainage of condensate to the point where it will prevent the escape of odorous air.

xlv. The volume and arrangement of the media shall be such that the rates of chemical and physical reaction between the media and odorants within each treatment state are optimized to achieve the specified performance.

xlvi. The configuration of the media bed shall be submitted with the Contractor's response

to this tender. Carriage trays/baskets where provided, shall satisfy the following requirements:

xlvii. Be composed of FRP or other proven corrosion-resistant material such as HDPE and be effectively seam-sealed to their support structure.

xlviii. Trays/baskets shall be designed so that they can be removed and replaced without damaging the treatment unit housing unit and without prolonged disruption to the odour treatment process.

xlix. The installed AC media shall have sufficient compressive strength to resist all operational loads without excessive deformation or bed settlement.

l. Utility

li. Plant service water of suitable quality shall be the primary source for fire-fighting sprinkler system sprays to the individual AC beds (provision of fire-fighting sprinkler systems is system-dependent and a requirement for systems treating high H2S loads).

lii. Dedicated safety showers with eye wash stations shall be provided in the vicinity of each AC vessel, with a maximum distance of 6m between safety showers. Potable water service water shall be the only source of water for the safety showers and eye wash stations at the individual AC beds.

liii. Dedicated hose reels shall also be provided in the vicinity of the pre-filters and at each AC vessel, which may be sourced by potable water or industrial water, if available on site.

liv. Adequate drainage facilities shall be provided and incorporate a water sampling point and water trap for containment of entrained moisture. Specific design requirements for AC odour scrubber vessels are listed below:

lv. The AC vessel shall be fitted with a suitable-sized drain line not less than DN 25 with a “U” bend water trap to drain leachate.

lvi. The “U” bend shall be made of clear plastic so that visual confirmation of the seal fluid can be undertaken. The drain line must contain a tapping on the “U” bend for inspection and wash-down if required.

lvii. The AC vessel shall also be fitted with an extra DN50 drain line with a manual isolation valve to drain leachate in case of blockages in the DN25 drain line;

lviii. The AC vessel shall be installed and mounted such that it is not necessary to disassemble the vessel for access to remove and replace the media in each AC bed.

lix. Vessel Access Manways

lx. Provide flanged and sealed manways for each AC at the following locations:

1. One manway at (or above) each AC media bed/cell
2. One manway at each AC media inlet plenum
3. One manway at each AC media outlet plenum

lxi. For AC vessels, each AC scrubber vessel and/or AC media bed shall be fitted with

the following additional sampling ports to collect air samples within the AC media bed at different bed depths (3 of). Each port shall take the form of a DN50 ball valve and be located at:

lxii. One port that allows sampling of air within the inlet plenum of the carbon vessel.

lxiii. One port that allows sampling of air at 25% of the depth of the activated carbon bed.

lxiv. One port that allows sampling of air at 50% of the depth of the activated carbon bed.

lxv. One port that allows sampling of air at 75% of the depth of the activated carbon bed.

lxvi. One port that allows sampling of air within the discharge plenum of the carbon vessel.

lxvii. All sampling ports along the AC vessel shall be fitted with devices which prevent aerosols or activated carbon media from exiting the port when opened.

lxviii. GAC Regeneration System.

lxix. Should, regenerable AC (GAC) be proposed by the Contractor, the following requirements must be satisfied:

lxx. Full details of the GAC re-generation system shall be provided with the tender response.

lxxi. The type of regenerating liquid required, frequency and duration of the re-generation cycle and volume of liquid waste produced during each cycle shall be provided with the tender response.

lxxii. Drainage facilities for the excessive/waste re-generating liquid shall be fitted with water traps and water seals to ensure no simultaneous escape of odorous air.

lxxiii. Spent Media Disposal

lxxiv. The method of removal, disposal, and waste classification of the spent media shall be stated in the tender submissions.

lxxv. The time required to completely remove all of the spent media from each treatment unit and replenish it with fresh media shall be stated in the tender documents.

Bio-Scrubber (Bio-Trickling Filter) General

i. This section covers odour control equipment where the treatment process utilizes the growth of a biofilm on an inert media irrigated with final effluent or potable water supplemented with nutrients, such as a Bio-Trickling Filter.

ii. The irrigating liquid, type, quality, pressure and flow shall be stated in the Contractor’s tender submissions.

iii. The target operating pH of the Bio-Trickling Filter (BTF) shall be stated in the Contractor’s tender submissions.

iv. Each BTF shall comprise the following as a minimum:

v. Mist eliminator.

vi. Irrigating liquid conditioning system, inclusive of nutrient storage tanks, transfer pumps, and nutrient flow monitoring devices (Contractor and system dependent).

vii. Irrigating liquid irrigation system, inclusive of irrigation water tanks, irrigation pumps, and irrigation flow monitoring devices.

viii. Irrigating liquid re-circulating system (Contractor and system dependent)

ix. Scrubbing blowdown system (Contractor and system dependent)

x. The complete BTF system as proposed by the Contractor shall fit within the designated areas as outlined in the Particular Specifications.

xi. The vessel dimensions (length x width and/or diameter) and media volume shall be calculated by the Contractor and properly designed to achieve the specified Performance Guarantees outlined in the Particular Specifications.

xii. The following minimum distances between adjacent BTF vessels shall be satisfied to allow adequate access for maintenance:

xiii. Minimum of 1m between adjacent Bio-Trickling Filters (BTFs),

xiv. All BTF vessels shall be installed adjacent to a dedicated service road or grassed area capable of passing standard-sized vehicles and trucks along one side of the vessel.

xv. Unless otherwise specified, the installation shall only incorporate bypass ductwork to allow odorous air to be removed from its source with all BTF units offline when the BTF system is combined with a dry scrubber polishing system such as an AC scrubber system.

xvi. Detail of the number, treatment stages and configuration of the BTFs and ancillary components/system provided shall be stated by the Contractor in the tender submissions and satisfy the minimum empty bed residence time (EBRT or contact time) as outlined in the Particular Specifications and accompanying Tender Schedules.

xvii. Each treatment stage shall comprise a random or structured bed of inert media and its associated support structure. The volume and arrangement of the media shall be such that the rates of mass transfer of odorants from the gas to the liquid phase within each treatment stage are optimised to achieve the required performance.

xviii. For BTF systems, the following interlocks and alarms must be built into the Odour Treatment Plant control system and local operator interface, in addition to the standard alarms required for operation of the entire odour control system:

xix. For each BTF vessel:

xx. Low flow alarm

xxi. High bed differential pressure alarm.

xxii. Leachate Low pH / High pH alarm.

xxiii. Media Requirements

xxiv. The proposed inert media shall not inhibit the growth of a biofilm nor have any leachable constituents, which could be detrimental to the operation of the treatment works or receiving waters.

xxv. The inert media shall be compatible with and/or resistant to the scrubbing liquid and have sufficient compressive strength to resist all operational loads without excessive deformation.

xxvi. The inert media shall be supported on a support grid, which will have sufficient free area to allow the free passage of air up through it with the simultaneous drainage of irrigation water and sloughed biomass down through it.

xxvii. The volume of inert media provided in the BTF shall be sufficient to achieve the reduction in H2S and odour as specified in the Particular Specification.

xxviii. The following media information shall be stated by the Contractors in the tender submissions as a minimum, and are outlined in the Particular Specifications:

xxix. The type and composition of media.

xxx. Specific surface area.

xxxi. Pressure drops across the media at given air speeds.

xxxii. The method of removal, disposal, and waste classification of the spent media shall be stated in the tender submissions.

xxxiii. The time required to completely remove all the spent media from each treatment unit and replenish it with fresh media shall be stated in the Contractor's tender submissions.

xxxiv. The BTF irrigation system shall incorporate the following as a minimum.

xxxv. Wire mesh strainer along the irrigation water line - to prevent solids carry over and blocking the irrigation system, such as spray nozzles. The strainer mesh size shall be selected based on the spray nozzle size and specifications proposed by the Contractor.

xxxvi. A flow monitoring device for the BTF irrigation flow.

xxxvii. A pressure relief device and irrigation liquid overflow from the BTF – in the event of excess pressure/flow of irrigation liquid.

xxxviii. An irrigation liquid sampling facility – to allow measurement of leachate pH for confirmation of BTF operation.

xxxix. The irrigating liquid requirement (i.e. type, quality, pressure and flow), and the frequency and duration of the irrigation cycle shall be stated in the tender submissions.

xl. The proposed irrigation system shall be arranged to ensure that the entire face of the media bed receives a uniform distribution of irrigating liquid.

xli. Should recirculation of the irrigation liquid be required for permanent long-term operation of the BTFs, associated recirculation pumps, piping, and valves shall be provided.

xlii. Specific Design Requirements

xliii. All materials that will come into contact with the irrigation liquid shall be compatible with and/or resistant to the irrigation liquid. The minimum pH value that the materials

are designed to withstand, without excessive corrosion, shall be stated in the Contractor's tender submissions.

xliv. An irrigation system shall be supplied to provide uniform distribution of the scrubber irrigation liquid over the surface of the media.

xlv. Full details of the scrubbing liquid conditioning system, scrubbing liquid irrigation system, scrubbing liquid recirculating system (if required for long-term permanent normal operation of the bio scrubber system) and scrubbing liquid blowdown (if provided), shall be provided with the Contractor's tender submissions.

xlvi. The blowdown system (if supplied) shall regulate the levels of dissolved oxidation products in the irrigating liquid and thereby maintain its target pH. If supplied, full details of the blowdown system shall be provided with the Contractor's tender submissions.

xlvii. The blowdown system (if supplied) shall incorporate facilities to visually confirm there is a flow of spent scrubbing liquid to drain.

xlviii. The excess/waste scrubbing liquid characteristics shall be stated on the Contractor's tender submissions.

xlix. A differential pressure indicator across the inlet and outlet of each BTF vessel shall be provided to monitor the pressure drop through the media in the vessels.

l. The housing shall be designed to contain the bed of media above a recycle liquor sump and air inlet plenum. An outlet air plenum and mist eliminator shall also be provided above the bed of media. External mist eliminators in the ductwork separate from the bio scrubber will not be allowed.

System Guarantee

i. The Contractor shall warrant that:

ii. All equipment provided by the Contractor as part of the OCS package shall be in accordance with this specification and shall perform as specified in the Process Specifications and accompanying Technical Data Schedules.

iii. All equipment provided as part of the OCS package shall be free from defects in workmanship and materials for a period of twenty-four (24) months from the date of final commissioning.

iv. The OCS shall operate automatically at an unattended facility, monitored remotely via a central SCADA system. All equipment supplied by the Contractor shall be suitable for unattended operation.

v. Based on the anticipated air flows through the OCS and the ambient conditions of the installation sites, all equipment items forming part of the OCS shall retain their structural and functional integrity for a period of twenty (20) years from the date of final commissioning.

vi. The Contractor shall repair or provide replacements for any defective components under the warranty provided that the defect is not the result of misuse by the owner. Replacements for any defective parts shall be provided by the Contractor

to restore equipment to its “as commissioned” working condition.

Performance Guarantee:

i. The Contractor shall guarantee that all equipment forming part of the OCS proposed shall achieve the following performance:

ii. The proposed odour control technology presented by the Contractor shall be in accordance with the requirements as outlined in the Process Specifications.

iii. The H2S and odour removal performance shall be in accordance with the specified removal efficiencies referenced in the Performance Guarantees outlined in the Particular Specifications, as measured between the OCS gas common inlet and the common discharge stack.

iv. The maximum outlet H2S and odour concentration at the exhaust stack must not exceed the guaranteed concentrations as specified in the Performance Guarantees outlined in the Process Specifications under all operating concentrations of H2S and odour at the inlet to the OCS.

v. If stipulated in the Process Specifications, the maximum H2S concentration at the site boundary as demonstrated by air dispersion modelling using an appropriate model (such as 3D Cal puff) by the Contractor must not exceed the guaranteed concentrations as specified in the Particular Specifications Performance Guarantees under all operating concentrations of H2S and odour at the inlet to the OCS.

vi. The maximum pressure differential across each OCS component shall not exceed that specified in the Process Specifications for all design conditions throughout the life of the installation, when measured between the OCS gas inlet and outlet.

vii. Media life

viii. Unless otherwise specified in the Process Specifications, the media life for AC systems shall be no less than twelve (12) months for each AC vessel, to H2S and/or Odour breakthrough, defined as when the outlet H2S and/or Odour concentrations exceeds the guaranteed concentration limits specified in the Particular Specifications Performance Guarantees and Technical Data Schedules

ix. Unless otherwise specified in the Particular Specifications, the media life period for Bio-Trickling Filter systems shall be no less than ten (10) years for each BTF vessel, to media breakdown and deterioration.

x. Process performance testing comprising of H2S and Odour removal performance testing, shall be the means of proving the performance criteria outlined in the Schedule of Performance Guarantees stipulated in the Particular Specifications have been met following installation and commissioning of the OCS.

xi. Performance testing shall be undertaken during the current dry season (i.e. between June to August) if the equipment is to be installed in the dry season, or the following dry season after installation if installation does not occur during the dry season, and not within ONE week of a significant rain event. A significant rain event is defined as a rain event that results in the sewage flow at the site being

greater than or equal to a wet weather event.

General Design Requirements

i. Details of the plant and equipment requirements shall refer to the Process Specifications.

ii. Unless otherwise specified in the Process Specifications, the odour treatment system will normally operate continuously and in a remote unmanned site, i.e. 24 hours per day, 365 days per year, reliably.

iii. Unless otherwise specified in the Process Specifications, adequate equipment redundancy shall be provided by the Contractor to allow a minimum of ONE (1) duty mechanical equipment item (e.g. foul air fans, irrigation pumps, etc.) and/or process vessel (e.g. AC scrubber vessel, BTF vessel, Bio filter cell, etc.) to be taken offline for maintenance and/or replacement without causing process upsets or critical failures.

iv. The plant layout drawings are provided for the information of the Contractor. It shows the general dimensions and locations of features that the Contractor shall incorporate into the final design. Any changes to these features that the Contractor may find necessary in his design or detail work must be approved by the engineer.

v. Preliminary Process and Instrumentation Diagrams (P&IDs) are also provided for the information of the Contractor. It shows the expected equipment which shall be supplied by the Contractor, and which will need to be incorporated into the final design.

vi. Minimum Equipment Items

vii. The odour treatment units shall include as a minimum, but is not limited to, the following equipment items:

viii. Odour covers to contain the odour air at its sources.

ix. An inlet manifold and associated ductwork to receive odorous air from the specified extraction points and stipulated ventilated sources, which direct it to the odour treatment units for treatment.

x. The odour treatment units along with its associated ancillaries, including but not limited to: containers, tanks, access stairways/ladders, walkways and hand railings, pumps, fans, nozzles, filters, cablings, turnings, control and instrumentation, pipework, flow control dampers, isolation dampers, valves, fittings and its supports etc. Access to the top of AC vessels will be required and adequate access staircases, platforms, and handrails must be provided for this purpose.

xi. If the odour treatment unit incorporates an Exhaust Stack, an outlet manifold and associated ductwork, to receive the treated air from the Odour Treatment Plant and direct it to the Exhaust Stack for discharge.

xii. Extraction fans to extract air from the specified extraction points and convey it through the various odour treatment equipment.

xiii. Associated electrical, instrumentation, and control equipment necessary to allow automatic operation of the odour control units. This includes local control panels, integration with the plant Programmable Logic Controller (PLC), plant SCADA, and associated monitoring facilities and equipment.

xiv. Any AC vessels proposed shall consist of a single pass system, and may consist of single, dual, or quad beds installed in each vessel, and supplied with all necessary internals to provide a complete functional system. Modular AC vessels in the form of rectangular AC vessels are also acceptable for this purpose.

xv. Materials of Construction

xvi. The materials of construction must be 100% compatible for corrosion resistance to compounds typically associated with sewerage foul air conditions and climatic. These compounds and expected climatic conditions are noted in the Process Specifications for each site. Unless otherwise specified or agreed with the engineer, the only acceptable materials of construction comprise of Fiberglass Reinforced Plastic (FRP).

xvii. Untreated foul air could contain hazardous levels of air contaminants. Consequently, electrical components or other equipment proposed by the Contractor which are to be located within 1 meter of potential air leakage sources shall be suitable for use in Class 1, Zone 2 hazardous areas and installed in accordance with the relevant Standards. Local control panels and controls shall all be located at least 1 meter from possible air leakage paths on separate mounts to avoid the need for a Class 1, Zone 2 classification.

xviii. Noise levels

xix. Unless otherwise specified in the Particular Specifications, noise levels from the components comprising the equipment (i.e. fans and ductwork) shall be less than 80 dB(A) at a distance of 1m from the component centre line (based on the components being mounted in free field conditions).

xx. Air balancing

xxi. General

xxii. Air handling systems, ductwork, and headers shall be air-balanced to give flow rates within 10% of designated air quantities, subject to the following:

xxiii. Air shall be distributed to minimise duct velocities; and

xxiv. Air resistance at fans shall be minimised, and the fans shall be adjusted to run at the lowest fan speeds and power consumption.

xxv. Balancing points shall be provided in ducts in sufficient numbers to facilitate the proper testing and commissioning of the air collection system but in any case, at least one for each branch duct and each main duct.

xxvi. All balancing points shall be located in readily accessible positions in straight ducts, at least seven 'hydraulic diameters' downstream from any bend or air control device. Where the required distance (seven 'hydraulic diameters') cannot be achieved, the Contractor shall design, supply and install straightening vanes or

diffusing grid to achieve stable flow conditions at the balancing point. All balancing points shall be easily accessible for measurement.

xxvii. Procedure

xxviii. Air balancing shall commence after the entire odour containment covers and odour control system installation have been completed.

xxix. Where there are inter-connecting ducting header systems, all interconnected systems shall be operated concurrently.

xxx. The final position of flow balancing dampers shall be marked upon completion of balancing and locked into position.

xxxi. Reporting

xxxii. The following shall be included on the air balance data sheets:

xxxiii. Static pressure differentials,

xxxiv. Air quantities through each sub-system or branch ducting after balancing, and

xxxv. Fan capacity and fan speed.

xxxvi. The final operating point shall be shown on the fan characteristic curve.

Mechanical Design Requirements Ductwork

i. All ducting which forms common air headers going into or out of the OCS shall comply with the following:

ii. All ductwork within the OCS compound shall be supported with galvanized mild steel brackets as necessary.

iii. Ductwork shall be designed and installed in accordance with Sheet Metal and Air Conditioning Contractor National Association (SMACNA) or equivalent standards subject to the engineer's approval.

iv. Ductwork shall be designed in accordance with duct pressure class B (medium pressure) with respect to static pressure and air leakage limits unless otherwise approved engineer.

v. Unless otherwise specified in the Process Specifications, the maximum ductwork air velocity shall satisfy the following requirements:

vi. 5m/s for ducting up to 150mm diameter.

vii. 8 m/s for ducting up to 750mm diameter.

viii. 10 m/s for ducting larger than 750mm diameter.

ix. The maximum pressure drop for the critical leg shall be 2 Pa/m. In the event that the pressure losses in the odour ducting are higher than the maximum specified pressure drop, or if negative pressure is expected, special design considerations for the ductwork will be required and shall be included in the submitted proposal to ENGINEER for approval with P.E. endorsement.

x. Unless otherwise approved, the ductwork installed shall be made from FRP, compatible with the corrosive conditions under which it must be operated. Any

deviations to the proposed ducting material shall be submitted to ENGINEER for prior approval.

xi. All joints in ductwork/manifolds shall be effectively sealed. Gaskets shall be full face and the material shall be compatible with humid and corrosive conditions of operation and submitted to ENGINEER for approval.

xii. Flexible connections shall be provided at the interface of all mechanical equipment items and along the ducting route to accommodate differential movement and prevent vibration transmission.

xiii. All ductwork shall be provided with flanged connections at their termination points.

xiv. Ductwork shall be securely fixed to rigid supports which are designed to allow ductwork expansion without damaging the gel coat. All clamps and brackets etc. shall be made of Grade 316 Stainless Steel unless otherwise specified.

xv. Ductwork shall be designed to prevent the accumulation of any condensate. Drain points for removal of condensate shall be provided, and shall satisfy the following:

xvi. All drain traps shall be fitted with S-bends and provided with visible water traps.

xvii. All drain points shall be rated for a minimum of 1.5 times the ductwork pressure at the point of installation and be made of materials resistant to corrosion by the condensate, which may be highly acidic.

xviii. All necessary access and sampling ports for the connection of pressure gauges, air velocity sensors etc. and sampling shall be provided. If practicable, access ports shall be positioned in straight lengths of ductwork, at least 3 ductwork diameters from dampers.

xix. All ductwork shall be UV resistant and shall be of a colour approved by PUB prior to installation.

xx. All ducting shall be smoke tested to ensure there are no leaks. Furthermore, an airflow balance test shall demonstrate that there is no more than 2.5% leakage through the system from the source to the point of discharge.

xxi. Ducting between the extraction points and the fan inlet shall be constructed to withstand the full suction pressure of the fan during blocked conditions (both duct and pre-filter).

Foul Air Fans

i. Where fitted, centrifugal, axial or mixed flow fans shall comply with the following:

ii. Fans shall be secured using anti-vibration mountings.

iii. Fans shall be provided with online vibration monitoring on the bearings which are connected to plant PLC and SCADA. Automatic interlocks on the PLC and SCADA shall be provided to automatically shut down fan operation upon detection of any imbalances during operation.

iv. Depending on the location of the fan installed, special acoustic enclosures may be required.

v. Terminal units' enclosed fans shall incorporate attenuation linings to reduce transmitted noise.

vi. A low airflow sensor shall be incorporated to provide an alarm in case of fan failure.

vii. To ensure that no hazardous gases are present in the housing, the control system shall ensure that on start-up, the fan runs for a sufficient period to purge the ductwork prior. This period shall not be less than 30 seconds.

viii. Positioning of the fans will be dependent on the type of odour treatment technology adopted. The following requirements should be observed unless otherwise specified in the Particular Specifications:

ix. For instances where only Bio-Trickling Filters are adopted, the fan(s) are typically positioned upstream of the odour treatment vessels and push air through the equipment.

x. For instances where a dry scrubber system such as an Activated Carbon system is implemented, fan(s)can be positioned both upstream and downstream of the odour treatment scrubbers and push/draw air through the equipment (pre-filter, heater, and scrubbers).

xi. For instances, where a combined Bio-Trickling Filter with Activated Carbon system is implemented, fans should be positioned between the BTF scrubbers and the AC scrubbers.

xii. Odorous air should not be drawn from a Zone 1 hazardous area through a Zone 2 hazardous area.

xiii. The impeller and shaft of the foul air fans shall be constructed of FRP or Grade 316 Stainless Steel unless otherwise specified in the Particular Specifications.

xiv. After fabrication the impellers shall be cleaned and Non-Destructive

xv. The fan housing and pedestal shall satisfy the following requirements:

xvi. Unless otherwise specified, in the Process Specifications, the fan housing, axial fan case, and pedestal shall be constructed from FRP or Grade 316 Stainless Steel and be fully welded. Any perforated sheeting used for sound attenuators (if required) shall be constructed of Grade 316 Stainless Steel.

xvii. For the Foul Air Fans integral access platform shall be attached to the fan pedestal to allow access to the fan-bearing vibration monitors.

xviii. The fan housing enclosure shall be fitted with a DN25 drain line and isolation ball valve for manual removal of condensate.

xix. The fan motor shall satisfy the following requirements.

xx. The selected fan motor shall be capable of continuous reliable operation when the fan is operating at a duty flowrate of 10% greater than that specified in the Particular Specifications.

xxi. The fan motor shall be wired to terminal boxes located external to the fan casing for ease of maintenance.

xxii. Fan gaskets and sealants shall satisfy the following requirements:

xxiii. All gaskets, regardless of where they are used, should conform to the following:

xxiv. Resistant to UV and other conditions that might reasonably be assumed to exist in the odour control facility, (e.g. high humidity conditions, bird droppings, cleaning chemicals, disinfectant, etc.).

xxv. If self-adhesive strips are applied, they should maintain their adhesive properties for the design life (25 years) without more than a 20% loss of adhesion compared with the new strip.

xxvi. The fans shall satisfy the following occupational health and safety requirements:

xxvii. Equipment shall be guarded in accordance with local regulations as outlined in the General Specifications for Workmanship Requirements (G1.3), Section G.1.3.37 Machine Guards.

xxviii. Guards shall be strong enough to withstand personnel and other loads during maintenance and inspection activities.

xxix. Appropriate workplace health and safety warning signs complying with local regulations, as outlined in the General Specifications for Workmanship Requirements (G1.3), Section G.1.3.37 Machine Guards shall be fastened to all equipment.

xxx. The fans shall satisfy the following requirements for noise:

xxxi. Tenders are to supply their tender noise emission data (overall at 1m free field and Octave band) to allow the ENGINEER to determine if dB (A) noise attenuation of the fans is required. Noise testing shall take place off-site.

xxxii. Tenderers are to comply with the noise requirements as outlined in the Particular Specifications.

xxxiii. Where acoustic enclosures are to be provided by the Tenderer, they shall be designed, constructed and installed to ensure:

xxxiv. Normal fan operation is possible without opening or removal of the enclosure.

xxxv. Quick and easy removal for inspection and maintenance is possible.

xxxvi. The enclosures do not impede the flow of cooling air over the fan motor when operating.

xxxvii. Be sufficiently robust to withstand a large number (not exceeding annual) of removal and replacement operations during the life of the fan, as well as be suitable for the installed environment.

xxxviii. Dedicated nameplates manufactured from appropriate corrosion resistant material shall be affixed to each fan casing and motor by means of Grade 316 Stainless Steel screws, engraved in accordance with the general specification.

xxxix. All items shall be individually labelled prior to packing and delivery. Labels shall include the following information as a minimum:

xl. Manufacturer name

xli. Contract number.

xlii. Manufacturer's item/part number

xliii. Final agreement on exact label contents shall be in consultation with the ENGINEER.

xliv. Where items are manufactured for specific mating parts, they shall all bear individual identification numbers and reference to the mating part identification numbers.

xlv. Liaison with the ENGINEER and timely provision of information is required to ensure installation can be completed in a timely and efficient manner.

xlvi. If Grade 316 Stainless Steel fan guards are provided, then no Protective Painting is required.

xlvii. The Foul Air Fan impeller shall be fabricated to withstand the stresses incurred during operation at the duty point as specified in the Particular Specifications for each site.

xlviii. The thickness of the casing and impeller material shall be as specified by the manufacturer.

xlix. Fan bearings shall satisfy the following requirements:

l. Bearings shall be mounted out of the air stream.

li. Bearings to have integral temperature monitoring instruments — Grade 316 Stainless Steel RTD probes with loop-powered 4-20mA signal converters and connection junction boxes. The instruments and signal converters shall be Intrinsically safe (e.g. ”IA”) and be certified to IEC standards.

lii. Fan bearing housings shall be supplied with a clearly marked vibration monitoring stub on each bearing.

liii. Fan bearings shall be of the type greased for life and designed for a rated fatigue life of 30,000 hours at the specified duty point.

liv. Fan vibration mounts shall satisfy the following requirements:

lv. Vibration mounts suitable for attachment to a concrete plinth shall be provided as part of the works by the Contractor. The concrete plinth for fan installation shall be excluded from the Contractor’s scope of supply.

lvi. The vibration isolators shall be rated to dampen the vibration frequencies that may occur during the fans' operating speed range.

lvii. The fan and motor shall be dynamically balanced and installed on bases designed to accommodate vibration isolators.

lviii. The fan and motor shall contain mountings selected to achieve 95% vibration isolation efficiency at the normal operating speeds of the equipment.

Exhaust Stack

i. The Contractor shall provide a self-supporting exhaust stack that will achieve the design requirements as follows as a minimum, and incorporates the requirements as outlined in the Particular Specifications:

ii. Suitable for operation under highly humid and corrosive conditions as expected for

sewer gas containing high levels of H2S, VOCs and other constituents typically found in sewer gas.

iii. Unless otherwise specified, the exhaust stack diameter shall be sized to accommodate an air velocity of approximately 15-20m/s and up to 25m/s.

iv. Unless otherwise specified, the exhaust stack shall terminate at a minimum height of 5m above adjacent buildings.

v. The Contractor shall supply the Exhaust Stack with a tundish and a drain line with U-bend water seal to allow for drainage of any accumulated water to the sump.

vi. The Contractor shall also supply the Exhaust Stack with appropriate sampling points to satisfy the local regulatory authority's requirements for air contaminant sampling.

vii. The Contractor shall provide the Exhaust Stack with appropriate bolts constructed of Grade 316 Stainless Steel for fastening onto a concrete footing.

viii. The Contractor shall design the Exhaust Stack for adequate stiffness and adequate footing size to limit deflections to a level that shall have no adverse impact on the foundation blots, or any equipment or ducting connected to the stack.

ix. To mitigate corrosion of a metal exhaust stack, if supplied, an internal lining of PVC can be used.

x. The external surface of the exhaust stack shall be painted with UV protection and a colour approved by PUB.

Valves and Dampers

i. The Contractor shall provide valves and dampers for the isolation and control of airflow. Valves and dampers shall be designed to withstand ambient and process conditions with the presence of water and condensate along with highly corrosive and acidic gasses.

ii. Valves and Dampers shall be constructed from FRP or Grade 316 Stainless Steel which can withstand corrosive operating conditions and be free of rattles, fluttering or slack movement and capable of adjustment over the necessary range without excessive self-generated noise or the need for special tools.

iii. All valves and dampers shall be of heavy-duty construction and designed to withstand up to 2-3 times the designed airflow and static pressure.

iv. Where isolation of a process unit, filter or fan is required, butterfly valves shall be used to ensure effective isolation. Dampers will not be acceptable when positive isolation is required.

v. The Contractor shall fit all extraction points with manually operated and lockable flow control dampers and isolation dampers and ensure the correct extraction flow rate is achieved during commissioning. All ducting going into or out of the odour scrubber vessels shall also be fitted with manually operated and lockable flow control and isolation dampers to ensure good flow distribution across all beds and

vessels.

vi. The position of the flow control dampers shall be set at commissioning and locked in position for normal operation.

vii. Isolation of the relevant extraction point, or section of ducting/equipment will be achieved by manual adjustment of the isolation valve.

viii. Blades shall be without sharp edges and sufficiently rigid to eliminate movement when locked. The blades minimum thickness shall be 1.6 mm.

ix. Damper bearings shall be oil-impregnated sintered bronze ball bearings or engineering plastic sleeve bearings. Where the operating temperature is expected to exceed 50°C, nylon shall not be used. Access for lubrication of bearings shall be provided.

x. Spindles shall be Grade 316 stainless steel, securely fixed to damper blades with minimum diameter as follows:

xi. Blade diameter < 600 mm = minimum diameter of 10 mm

xii. 1200 mm < Blade diameter > 600mm = minimum diameter of 12 mm

xiii. The damper shall be capable of being adjusted and locked in the following blade positions: "Open", "10° to open", "20° to open", "30° to open" and "Closed". The positions shall be clearly and permanently labelled.

xiv. All non-return dampers assemblies shall be counterweighted so that it:

xv. Offers minimum resistance to airflow, and

xvi. Closes by gravity.

xvii. For isolating duty and standby fans automated butterfly valves shall be provided in lieu of non-return dampers to ensure no backflow occurs through the standby fan.

Access Ports

i. Access ports shall be provided with facilities to prevent air ingress when not in use and shall be located such that monitoring instruments are easy accessible or visible from ground level.

ii. Unless specified otherwise, ductwork shall be earthed to prevent build-up of static electricity and have a maximum resistance to earth of 10 Ω, in accordance with PD CLC/TR 5040 (Electrostatics code of practices for the avoidance of hazards due to static electricity). Any equipment operating procedures or precautions required to prevent the build-up of static electricity shall be listed in the tender submission.

iii. Resilient seals shall be fitted between all joints in the housing and ductwork to prevent air leakage.

iv. All fixings and fasteners shall be manufactured from material which is resistant to corrosion and compatible for operation under corrosive conditions and the application environment, such as Grade 316 Stainless Steel.

v. Where non-return flaps are required to protect the unit from reverse flow, they shall be seated on resilient seals, thereby providing an effective seal against the

reverse flow of air. The flaps shall be designed to offer minimum resistance to normal flow.

Access Hatches

i. Unless otherwise specified, access panels shall have the following minimum clear opening:

ii. Personnel access: 900 x 900 mm.

iii. Hand access: 200 x 300 mm.

iv. The panels shall be double thick, deeply formed, constructed and insulated to match the duct. Cold bridging shall be minimized. Panel frames shall be rigid, and securely attached to the duct, with no part of the panel or frame protruding into the airstream.

v. The seals shall be silicone rubber mechanically fixed to either the panel or the frame to ensure an airtight seal when latched in the closed position. For fire-rated seals, use woven ceramic fiber material. Latches shall be Wedge type sash latches and there shall be a minimum of two.

Extra Tappings

The following extra tappings shall be provided by the Contractor for the Odour Control System:

i. Manometer tapings of minimum DN15 are to be positioned on the inlet air odour duct for the measurement of air pressure, as well as for H2S and odour sampling. The Contractor shall ensure the tapping points are accessible for measurement.

ii. Where ducting or drain lines contain U-bends where water and material may accumulate, tapings of minimum DN25 are to be positioned on each U bend, with a drain line from the tapping to the sump, to allow inspection and flushing of U-bends.

iii. Tapping on the exhaust stack for odour sampling purposes. This tapping shall be in accordance with the sampling requirements as in the specifications. The Contractor shall ensure the tapping points are accessible for measurement without the need for specialist or temporary access equipment.

iv. Tapping on ducting for odour sampling purposes and air testing. Such tapings shall be of minimum DN15 or shall be in accordance with the sampling requirements as in particular specifications.

v. All tappings shall be fitted with a removable seal/cap where required. Further details are provided in the P&ID and general arrangement drawings supplied with this document.

Flowmeters

i. An orifice plate-type flowmeter shall be provided for measurement of airflow through the odour treatment system.

ii. The flow meter shall be installed complete with all necessary accessories and ancillaries required to form a complete and functional system. In particular, the

flowmeter must satisfy the minimum straight lengths stated in the table below to ensure adequate accuracy of installation.

Parameter	Units	Value
Minimum Upstream Straight Length	-	5 x Pipe Diameter
Minimum Downstream Straight Length	-	3 x Pipe Diameter

1. Pre-Filter

i. A pre-filter shall be installed within the air intake duct for the removal of aerosols and particulates from the incoming airflow to prevent blockage of the media for the following conditions:

ii. Where the air is extracted from dusty areas; or

iii. Where the air is to be treated through a dry scrubber using adsorption technologies such as Activated Carbon.

iv. The pre-filter shall:

v. Be supplied with a self-contained sealed and lockable housing.

vi. Remove greater than 99% removal of water droplets of 4 µm or larger diameter at the design airflow.

vii. Have a maximum face velocity across the filter of less than 2.0m/s at the design flow rate with all duty units online.

viii. Be designed for continuous operation in odorous air which can be water-saturated and contain corrosive/acidic gasses.

ix. Be designed for the specified airflow rate as shown in the Particular Specifications.

x. Be designed for ease of removal, inspection, and replacement without requiring the use of specialised lifting equipment.

xi. Have pre-filter pads of standard replaceable size, the specific size requirements are outlined in the Particular Specifications for each site.

xii. Removable, disposable or washable panel filters are preferred. Each pre-filter pad shall be securely located within a non-corroding recessed tray/frame and held in position against a retaining mesh that is situated on the downstream side of the tray/frame.

xiii. Pre-filter pads shall be securely located within a non-corroding recessed tray/frame and held in position against a retaining mesh that is situated on the downstream side of the tray/frame.

xiv. The pre-filter tray/frame shall be designed for ease of removal, inspection and replacement.

xv. The pre-filter housing shall:

xvi. Have a hinged, air-tight lockable access door for inspection, cleaning and replacement of filter pads.

xvii. Have flanged inlet and outlet for ductwork connections.

xviii. Have an isolation damper on the inlet side of the housing so that the housing can be isolated from the foul air stream.

xix. Have a differential pressure gauge to measure the pressure drop across the pre-filter (i.e. the extent of blocking). The differential pressure gauge shall be clearly and permanently marked with the design values for “filters clean” and “filters dirty” conditions.

xx. Have a DN25, drain line to the sump fitted with a U-bend and water seal. The U-bend shall be made of clear plastic or glass so that visual confirmation of the seal fluid can be undertaken. The duct must contain a tapping on the U-bend for inspection and wash-down if necessary.

xxi. Have an extra drain line with a DN25 ball valve for maintenance purposes.

xxii. Have appropriate signage on access doors reminding them to keep doors closed.

xxiii. Be designed with the appropriate material for continuous operation on ventilation air which can be water-saturated and acidic/corrosive.

xxiv. Be constructed to withstand the full suction pressure of the fan (blocked duct conditions) so that permanent distortion of materials and breaking of seals do not occur.

xxv. Contractors shall provide details of the pre-filter and pre-filter housing in the returnable Technical Schedules accompanying the Particular Specifications.

De-humidifiers/Heaters

i. De-humidifiers/Heaters are typically required for odour treatment units utilising dry scrubbing adsorption mechanisms such as Activated Carbon (AC). However, the requirement for a dehumidifier will be dependent upon the type of AC media proposed by the Contractor and the tolerance of the proposed AC media towards relative humidity (RH %).

ii. The Contractor’s submission shall indicate if:

iii. A dehumidifier/heater will be required for the specified OCS, with characteristics as written in this section; or

iv. The reasoning behind why a dehumidifier/heater is not necessary for the specified OCS, with particular reference to the type of AC media blend proposed.

v. Supplied dehumidifiers/heaters shall have the following characteristics:

vi. The dehumidifiers/heaters shall be comprised of electric heater element(s) in a suitable housing integrated with the supplied pre-filters.

vii. Dehumidifiers/heaters shall maintain relative humidity at <90%RH at the design average air flowrate and preferably <75% RH.

viii. Be fitted with a thermostatically controlled heater element with a temperature indicator transmitter on the discharge stream and an integral over temperature protection.

ix. Low and high-temperature alarms shall be transmitted to the local control panel of

the plant at which it is installed, along with associated interlocks.

x. Be contained within an insulated self-contained sealed housing with lockable access hatches that are easily opened and closed for inspection and maintenance. The housing shall also have flanged inlet and outlet connections to ductwork and be insulated to minimize heat loss to the surroundings.

xi. The dehumidifiers/heaters shall be suitably protected in the following manner:

xii. Electrically to prevent the housing from becoming “live” in case of corrosion of the electric heating elements as well as protecting the elements from over-heating; and

xiii. Mechanically for OH&S considerations, to protect against personnel being exposed to hot surfaces.

xiv. The dehumidifiers/heaters shall be fitted with clearly labelled lockable electrical isolation switches mounted on an adjacent wall or purpose-supplied pedestal such that the heater elements can be independently isolated electrically for maintenance or repair purposes.

xv. If the dehumidifier/heater is not required, the Contractor shall allow space within the OCS and pre- filter housing to allow a future connection and installation of a dehumidifier/heater within the pre-filter housing upstream of the AC vessel.

xvi. Contractors are to provide details of the dehumidifier/heater and housing in the tender submissions for P.O. approval.

Electrical, Instrumentation and Controls General

i. Electrical equipment and instrumentation located within the odour control casing, or ductwork, shall be certified as suitable for use in a Zone 1 hazardous area (potentially explosive atmosphere), Gas Group Ibis, Temperature Class T3.

ii. Electrical equipment and instrumentation located outside the odour control casing or ductwork shall be certified as suitable for use according to the zonal rating of the surrounding area. Fan motors shall, as a minimum, be certified as suitable for use in a Zone 2 hazardous area.

iii. Control panels shall comply with the Electrical Specification requirements.

iv. Electric motors shall comply with the Electrical Specification requirements.

Control Narratives

i. The equipment supplied shall be controlled in its entirety by a PLC system provided by the Odour Treatment Plant Manufacturer. A detailed Functional Design Specification shall be prepared by the Odour Treatment Plant Manufacturer and submitted for approval by the engineer prior to the commencement of software programming.

ii. Interlocks between the Treatment Plant/Pump Station Main PLC and the Odour Treatment Plant PLC shall be provided to achieve any required special ventilation modes, e.g. for fire conditions.

iii. Control Narratives to allow automatic unmanned operation of the Odour Treatment

Plant shall be submitted by the Contractor as part of their tender submissions.

iv. The Contractor shall advise the alarm and interlock settings for the safe and reliable operation of the Odour Treatment Plant and included in the control narrative.

v. The Control Narrative shall include but not be limited to the following:

vi. Controlled starts and stops.

vii. Any signals required from upstream equipment.

viii. Any safety interlocks required for personnel or equipment protection.

ix. Interlocks and alarms required to meet EPA WAA conditions as outlined in the Particular Specifications and include the following as a minimum:

x. High concentrations of H2S in discharge air; and High flow alarm.

xi. Required equipment failsafe state in the event of power failure.

xii. Emergency stop requirements.

xiii. Alarm requirements, with the following as a minimum:

xiv. Low flow alarm from the foul air fans.

xv. High H2S concentrations in the treated air stream.

Scrubber Vessel Design Requirements General

i. The performance specifications provided below are for the information of the Contractor. They give general loadings, load combinations, and guidelines of features that the Contractor shall incorporate into the final design. Any changes to these features that the Contractor may find necessary in his design work must be approved by the engineer.

ii. If concrete scrubber vessels are proposed, all concrete structures in contact with corrosive odorous gasses and liquids must be provided with protective coatings or liners of suitable quality to prevent corrosion. As a minimum, protective plastic lining from Polyethylene (PE) or Polyuria (PU) shall be provided.

Design Inputs

i. The Contractor shall be required to complete the structural and mechanical design of each of the FRP vessels, internal support beams (or equivalent), internal media support plates, internal turning vanes and internal distribution pipework (as indicated on the drawings. The Contractor shall make allowance for additional ductwork loading supported by the vessels.

ii. The vessel diameter shall not exceed 3.6m.

iii. All spray nozzles shall be flanged with a minimum nozzle size of 50mm NB. They shall be located for easy access and to minimise the quantity of piping. Nozzle locations shall match those on the attached drawings. Nuts, bolts gaskets to be provided and materials of construction suitable for application.

iv. No exposed metal items shall come in contact with any process gas and liquid

streams.

v. Certified lifting lugs shall be designed, certified and provided on each vessel segment and any equipment requiring crane assembly/disassembly for maintenance or repair.

vi. All inlets and discharge ducting connections on each odour scrubber vessel shall be flanged.

vii. The inlet plenum shall be designed to ensure even airflow distribution through the odour scrubber media.

viii. Each vessel outlet shall have a design air exit velocity of less than 10m/s for the specified operating airflow as specified in the Technical Data Schedules appended to the Particular Specifications with all units in service (i.e. normal operating conditions).

ix. Each odour scrubber vessel shall be fitted with a differential pressure indicator transmitter fitted across each bed (or a maximum set of two (2) media beds for multiple beds installed within a single odour scrubber vessel) to assist in identifying blockages and determining if replacement of media is required due to media degradation.

x. Each odour scrubber vessel shall be installed and mounted such that it is not necessary to disassemble the vessel for access to remove and replace the media in each bed within the vessel.

Vessel Contents and Pressure Vessel Contents – Foul Air

i. The Contractor shall ensure corrosion resistance of the vessels and internals to the foul air.

ii. Vessel Contents – Liquid

iii. The Contractor shall ensure corrosion resistance of all FRP vessels and internals to the liquid products of reaction which are typically corrosive. This shall include entrained humidity contained within the vessel.

iv. Pressure

v. The design, operating, and test pressures of the vessels shall satisfy the requirements as outlined below or otherwise specified in the Specifications.

Mechanical Design Requirements Vessel Attachments:

i. Provide pipe supports integral to the tank for any down pipes or pipes supported from the vessel walls. Pipes shall be supported at a maximum of 1,500 mm intervals or more frequently as may be required by the relevant Standard.

ii. Media Support:

iii. Quantity: Sufficient to hold odour scrubber media plus entrained humidity and/or biomass/biofilm growth on the media.

iv. Specific media support requirements for odour scrubbers:

v. The media support directly underneath AC media shall where possible contain a

minimum of 200mm layer of inert large-diameter material (e.g. clay balls, pebbles, or plastic packing) for any potential leachate to be collected and drained.

vi. Opening size of media supports shall not allow passage of odour scrubber media or organisms suspended within the odour media but not allow the AC media or other media to fall through.

vii. Constructed of FRP or other approved corrosion-resistant material. Grade 316 Stainless Steel will not be acceptable for this application.

viii. Media support shall be structurally supported to limit the mid-span deflection to (L/125) where (L) is equal to the span length.

Sampling Ports

i. Each odour scrubber vessel shall be fitted with Odour and H2S logging and sampling points in the inlet and outlet plenums (i.e. areas of low air velocity of < 0.25m/s) with the following requirements:

ii. The sample points shall take the form of hinged lockable access hatches which allow access to the inlet and outlet plenums.

iii. The inlet and outlet plenums are to be fitted with hanging hooks for H2S data logging units which can be reached from outside the vessel without the need for personnel to insert their heads into the access hatches to observe or handle the H2S data logging units.

iv. The hinged access hatches are to have suitable sealing gaskets bonded to the access hatch and be able to be locked.

Vessel Access Manways:

i. All odour scrubber vessels shall be fitted with removable, lockable lid(s) or cover(s) for maintenance and/or media replacement without the need to physically dismantle the scrubber vessels.

ii. The number of sealed manways required is specified in the Particular Specifications and is specific to the proposed scrubber technology and arrangement.

iii. Manways physically located on any odour scrubber media beds shall be constructed of the same material as the vessel.

iv. Manways located in other locations shall be constructed with the same material as the vessel with a blank cover.

v. Means shall be provided for safely lifting the cover into place/removal. All manway covers shall be fitted with 2 Nos. of Grade 316 Stainless Steel lifting lugs and a davit shall be provided if the cover is greater than 16kg weight.

vi. Access manways shall be provided to all points in the vessel where maintenance or inspection will be required.

vii. Bolts shall be of Grade 316 stainless steel and installed using nickel anti-seize.

viii. Vessel Access Platforms

ix. The Contractor shall provide each odour scrubber vessels with access platforms and stairs to allow safe and convenient access for operations and maintenance activities (e.g. calibration, adjustment, media replacement, etc.) and for the inspection of internals (e.g. fire-fighting nozzles and Bio Trickling Filter irrigation spray pattern, instrumentation, media conditions, etc.) via the inspection ports.

1.44 Air Compressor

1.44.1 General requirements

i. Air supply plant shall be designed and configured according to the application(s) which are classified into the following groups:

ii. Motive power source for operating valve actuators, air motors, reverse jet filters, silo arch braking pads and pneumatically operated machines.

iii. Motive power source for starting diesel generating sets (if specified).

iv. Instrument air supply.

v. Air scour of membrane filters (if specified); and

vi. Air feed to operations such as dissolved air flotation and pumping surge suppression (if specified).

vii. Unless otherwise specified and with the exception of group (B) applications, air supply plant shall include at least one duty and one standby compressor set which shall be electrically driven by cage induction motors.

viii. Air shall be filtered to remove dust in order to protect the compressors from undue wear and to suit the needs of the application. Filtration shall take place on the intake side of the compressors and in the case of a group (C) at the point of use of the air.

ix. Oil-lubricated compressors may be used for group (A), (B) and (C) applications provided that oil- eliminating filters are installed on the delivery side of the compressors.

x. Where oil mist lubrication is recommended for certain types of valve actuators, the lubricators shall be installed at each point of use of the air. Oil-free compressors shall be used for group (D) and (E) applications.

xi. Air shall be cooled by means of after-coolers except generally in the case of group (D) applications.

xii. Air receivers shall be provided for group (A), (B), (C) and (E) applications to balance supply and demand or to provide a reserve to operate a prime mover.

xiii. Air dryers shall be provided for group (A) and (C) applications and when recommended for group (D) to suit the membrane filters.

xiv. Parts of the air supply plant other than the compressor sets and drivers where the surface temperature routinely exceeds 65°C shall be insulated and clad with aluminium.

xv. Water-cooled components subject to condensation shall also be insulated and clad in the same way.

1.44.2 Air intake

i. Air intakes shall be positioned in a manner, which avoids collection of contaminants such as engine exhaust fumes and excessive dust and always away from any extractor fan discharge points.

ii. Air may be admitted to the room, which houses the compressors either through an external wall or, where this is not possible, via an intake duct. Where air is delivered to processes on a continuous basis, the compressors may be connected to the intake duct in order to draw air from outside the building and not from the room itself.

iii. A louvered panel or panels shall be installed at the air inlet point together with filters. The filters shall comprise removable panels with convoluted elements mounted in frames. The elements shall be of the washable type and a spare set shall be provided to facilitate substitution for this purpose.

iv. Intake ducting shall be in galvanized steel and of adequate proportions to minimize pressure drop and vibration. Where necessary to suppress low frequency noise, a silencer of the multiple aero foil or `beam splitter' type shall be installed within the duct close to the inlet point.

v. Where air is drawn by the compressors directly from the room, appropriate provision shall be made to protect equipment and pipework from low ambient temperatures. Where air is drawn from outside the building, then heat from the machines must be dissipated effectively at times of high ambient temperatures.

vi. The room shall be properly ventilated.

1.44.3 Reciprocating Compressors

i. Reciprocating compressors of the oil-lubricated type shall be employed only for application groups (A), (B) and (C) as defined above.

ii. Oil-free reciprocating compressors may be employed for other low-capacity applications.

iii. Unless otherwise specified each compressor shall be rated for continuous operation at twice the maximum air demand or to recharge the receiver from empty in one hour whichever is greater.

iv. They shall be suitable for intermittent operation and shall maintain the associated air receiver pressure between pre-set limits irrespective of actual air demand up to the maximum demand.

v. Cylinder heads shall be readily removable for inspection.

vi. Each compressor shall be driven via a Vee-belt drive arrangement by a cage induction motor, which shall be rated to allow the compressor to operate at the safety valve setting without overloading.

vii. The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the baseplate.

viii. Where necessary, each compressor shall have an automatic solenoid operated unloading system to facilitate starting.

ix. This system shall be initiated by auxiliary contacts on the compressor motor starter and shall be subject to an adjustable time delay.

x. Oil-lubricated machines shall have an automatic oil lubricator fitted with indication of oil level and feed rate. The delivery side of each machine shall have an oil-eliminating filter with provision for draining into a portable container.

xi. Each compressor shall have an inlet air filter and silencer, a pressure safety valve, fusible plug, check valve and isolating valve.

xii. Compressors shall be tested in accordance with BS ISO 1217 and BS1571 Part 2.

xiii. Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS1123 Part 1.

1.44.4 Rotary compressors

Rotary compressors shall be selected from the following types unless otherwise specified:

1.44.5 Rotary lobe compressors

i. Generally, rotary lobe machines shall be sized to directly deliver the necessary flow rate of air at the pressure required by the process. Due allowance shall be made for operating a pressure safety valve set at a higher pressure without overloading the compressor or its driver.

ii. Under no circumstances shall a compressor be selected to operate at or above the continuous maximum temperature or discharge pressure specified by the compressor manufacturer.

iii. A clear safety margin shall be allowed, preferably of at least 0.2 bar.

iv. The sealing arrangement between the timing gearbox and compression chamber shall ensure that leakage of oil cannot take place during operation or shutdown.

v. Where necessary to facilitate starting of the compressor (e.g. at reduced voltage), an unloading arrangement shall be incorporated in the compressor delivery system and shall include a motorized valve operated via auxiliary contacts on the compressor motor starter.

vi. Each compressor shall be driven via a Vee-belt drive arrangement by a cage induction motor.

vii. The motor may be arranged for variable speed or two speed operation where this suit the requirements of the application. The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment.

viii. A sheet steel guard shall be bolted to the baseplate.

ix. Each compressor shall have an inlet air filter, inlet and discharge silencers, a pressure safety valve, pressure gauge, check valve and isolating valve. In process applications where the discharge pressure may approach the maximum permitted, the machine shall be arranged to shut down on high discharge temperature and a

suitable switch and thermometer shall be provided.

x. Where appropriate, the compressor and its accessories may be pre-assembled on a steel frame.

xi. Compressors shall be tested in accordance with BS ISO 1217 and BS 1571 Part 2.

xii. Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

1.44.6 Liquid ring compressors

i. Liquid ring compressors may be used for, in special circumstances only, for group (D) and if specified in process specification.

ii. Generally, liquid ring machines for process use shall be sized to deliver directly the flow rate of air at the pressure required by the process. Due allowance shall be made for operating a pressure safety valve set at a higher pressure without overloading the compressor or its driver.

iii. Each compressor shall have a seal water supply system, which shall include an isolating valve, in-line strainer, solenoid-operated valve, flow switches, regulating valve and check valve. The solenoid- operated valve shall be operated by auxiliary contacts on the compressor motor starter. The flow switches shall initiate a shutdown of the compressor if following start-up, the seal water flow goes outside high or low limits.

iv. The compressor materials shall be compatible with the seal water quality. Generally, a cast iron casing and grade 316 stainless steel rotor and shaft shall be used unless otherwise specified. Bearings shall be of the outboard type and shaft sealing shall be affected by packed glands.

v. Each compressor shall be driven via a V-belt drive arrangement by a cage induction motor normally arranged for fixed-speed operation.

vi. The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the baseplate.

vii. The delivery side of each compressor shall be connected to a dedicated water separation vessel. The vessel shall be of welded carbon steel construction to BS5500 and equipped with supporting feet, access manway, sight glass with safety enclosure, float-operated drain valve, manual drain valve, pressure gauge and pressure safety valve.

viii. The vessel shall be designed to maximize dis-entrainment of water and where necessary shall be fitted with suitable baffles.

ix. Level switches shall be provided to initiate the shutdown of the compressor if the water level in the separation vessel goes outside high or low limits.

x. The used seal water shall be piped to an approved discharge point.

xi. Each compressor shall have an inlet silencer, inlet check valve discharge check valve and isolating valve in addition to the features detailed above.

xii. Compressors shall be tested in accordance with BS ISO 1217 and BS 1571 Part 2.

xiii. Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

1.44.7 Screw Compressors

i. Screw compressors of the oil-free type may be used for application group (E) and if specified in process specification.

ii. Generally, screw compressors for intermittent duty shall be rated for continuous operation at twice the maximum air demand and shall be suitable for intermittent operation to maintain the associated air receiver pressure between pre-set limits irrespective of air demand up to the maximum value.

iii. Screw compressors for continuous duty shall be sized to deliver directly the flow rate of air at the pressure required by the process. Due allowance shall be made for operating a pressure safety valve set at a higher pressure without overloading the compressor or its driver.

iv. Under no circumstances shall a compressor be selected to operate at or above the continuous maximum temperature or discharge pressure specified by the compressor manufacturer. A clear safety margin shall be allowed.

v. The sealing arrangement between the timing gearbox and compression chamber shall ensure that leakage of oil cannot take place during operation or shutdown.

vi. Each compressor shall be driven via a V-belt drive arrangement by a cage induction motor.

vii. The motor may be arranged for variable speed operation where this suit the requirements of the application. The compressor and motor shall be mounted on a combination baseplate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the baseplate.

viii. Each compressor shall have an inlet air filter, inlet and discharge silencers, a pressure safety valve, pressure gauge, check valve and isolating valve. The machine shall be arranged to shut down on high discharge temperature and a suitable switch and thermometer shall be provided.

ix. Compressors shall be tested in accordance with BS ISO 1217 and BS 1571 Part 2.

x. Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

1.44.8 Centrifugal compressors

i. Centrifugal compressors shall be the single stage centrifugal type driven through speed increasing gear unit by an electric motor and shall be factory mounted on a common base plate with all accessories required for a complete system. Each system shall include a discharge check valve.

ii. Single stage compressors shall be horizontally split, single stage units with overhung shaft design or impellers mounted between bearings, integral suction and tangential discharge. Motor shall be 1500 rpm (fixed speed) totally enclosed

fan cooled (TEFC) squirrel cage induction type.

iii. Each compressor shall develop a discharge pressure at least 0.05 bar above the specified discharge pressure when the capacity is reduced to 70% of the capacity at the specified discharge pressure.

iv. Compressors shall operate satisfactory without surging at any point between 60 and 100% of the specified capacity.

v. Casings shall be cast iron made in sections with joints between sections accurately machined. Sections shall be held together by means of steel tie rods.

vi. Seals shall be provided where the shaft passes through the ends of the casing. Suitable seals shall also be provided to prevent bearing contamination and to prevent loss of bearing lubricant.

vii. Suction and discharge nozzles shall be flanged. Flanges shall be flat faced with diameter and drilling to BS EN 1092.

viii. Each section of the casing shall be equipped with a casing drain. Casing drains shall be piped together, and the common drain line piped to the edge of the baseplate. A drain valve shall be provided.

ix. Impellers may be of either fabricated or cast construction. Fabricated impellers shall be made of aluminium or grade 316 stainless steel and shall be riveted to cast hubs.

x. Cast impellers shall be accurately formed and machined on all exterior surfaces. Each impeller shall have uniform sections, smooth surfaces, shall be free from cracks and porosity and shall be dynamically balanced.

xi. Each shaft shall be of solid design and shall be fully machined or ground to size and polished. Each shaft shall be of ample size to transmit the maximum applied power and to carry all applied radial loads without excessive deflection.

xii. Each rotor assembly shall be supported at each end by one or more oil or grease lubricated antifriction bearings.

xiii. All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of air.

xiv. Bearings shall have a L10 life rating of 100,000 hours.

xv. Shaft speed shall not exceed the bearing manufacturer's recommendations. Bearings shall be mounted in housings outboard of the casing heads.

xvi. Bearing housings shall be arranged to permit inspection and replacement of the bearings without disconnecting the piping or disassembling the blower.

xvii. Each compressor shall be directly connected to the drive motor by means of a flexible coupling. Each coupling shall have a power rating of not less than 1.25 times the motor nameplate power when the misalignment is within the coupling manufacturer's tolerance limit. A suitable coupling guard shall be provided.

xviii. Each compressor shall be equipped with a dry-type air filter located upstream of

the suction inlet and silencers both in the suction and delivery.

1.44.9 Aftercoolers

i. All air supply plants other than group (D) applications and where liquid ring compressors are used shall incorporate after-cooling.

ii. Unless otherwise specified, a single aftercooler with isolating and bypass arrangement shall be provided for applications (A), (B) and (C) only as defined above. In other applications, standby capacity is required.

iii. Aftercoolers shall either be of the air-cooled type with finned tubes and electrically driven cooling fan or the water-cooled shell and tube heat exchanger type.

iv. Materials in contact with cooling water shall be resistant to corrosion. All heat exchange surfaces shall be accessible for cleaning.

v. Aftercoolers of the shell and tube heat exchanger type with air on the tube side and water on the shell shall be designed to BS 3274 and shall be type 2.

vi. The heat exchanger shell shall be in carbon steel 151 360 A to BS EN 10028 Parts 1 to 3 and BS EN 10029 and the corrosion allowance shall be not less than 2mm.

vii. The shell shall be blast cleaned and coated internally and externally as set out in Part 3 of the Specification. The epoxy system shall be used for internal parts of the shell and may be used for external surfaces also. The heat exchanger tubes shall be copper designation C106 to BS EN 12451 or, where specified, 70/30 cupronickel designation CN107 to BS EN 12451.

viii. The shell and tube side classifications shall be not less than Class 150.

ix. Pipe connection flanges shall be drilled to BS EN 1092 with the appropriate pressure designations but not less than PN10. Provision shall be made for the removal of condensate.

x. The heat exchanger shall be thermally insulated and clad with aluminium.

xi. The air outlet pipework shall be fitted with a thermometer and a temperature switch with voltage-free changeover contacts to initiate a high temperature alarm. The water supply pipework shall be fitted with a flow meter.

xii. Generally, the air outlet temperature shall approach the cooling medium temperature to within 10 deg. C at maximum air throughput or as otherwise specified.

1.44.10 Condensate separators

i. Condensate separators shall be installed downstream of air aftercoolers.

ii. The separators shall comprise pressure vessels and fabricated from carbon steel. The internal trim shall be designed to remove moisture from the air in droplet and mist form.

iii. The separator shall be equipped with an automatic drain valve with isolating valve and separate manual drain valve and voltage-free contact for high level alarm. The

drain connections shall discharge to an approved point.

iv. The air outlet from the separator shall be fitted with a thermometer and temperature switches with voltage free changeover contacts to initiate high and low temperature alarms.

1.44.11 Air receivers

i. Air receivers shall be installed wherever it is necessary to balance a variable rate of air consumption with a fixed rate of supply.

ii. The capacity shall be sufficient to limit the number of compressors starts to no more than 10 per hour. In group (B) applications, the capacity shall be sufficient for the specified number and duration of engine start attempts.

iii. Air receivers shall be of welded steel construction with a corrosion allowance of 2 mm and may be either vertically or horizontally mounted according to capacity. The vessels shall have suitable supporting feet or cradles as appropriate.

iv. Air receivers supplied under this contract shall comply with the requirements of local regulating authorities.

v. The fittings shall include a pressure gauge, pressure safety valve, automatic drain valve with isolating valve and separate manual drain valve. The drain connections shall discharge to an approved point.

vi. Safety valves shall comply with BS EN ISO 4126-1. The installation of safety valves, gauges and fusible plugs shall comply with BS 1123 Part 1.

vii. Pressure switches with voltage-free contacts shall be installed on the receiver to control the associated compressors and to initiate a low-pressure alarm. The control relays shall normally be mounted in the same panel as the compressor motor starters. Both the cut-in and cut-out pressure settings of the standby machine(s) shall be set lower than the corresponding settings of the duty machine(s).

viii. The Contractor shall be responsible for conducting all the required tests and meeting other requirements to achieve this.

1.44.12 Air dryers

i. Air dryers shall be of the automatic twin cell desiccant type designed to produce an outlet dew point better than -40 deg. C for applications in groups (A) and (C) and, when required, for group (B) as defined in Section General requirements.

ii. The dryer shall be of the floor mounting or wall-mounting type with twin carbon steel adsorbed vessels packed with silica gel beads.

iii. Dryers shall be designed and tested to BS ISO 7183 as applicable.

iv. The vessels shall each have an electric immersion heater designed for a 230 V AC supply unless otherwise specified, air inlet and outlet connections and drying media filling and emptying pads.

v. The dryer shall incorporate an automatic adsorbed changeover and reactivation

system comprising solenoid-operated valves and a control panel. The air for reactivation purposes shall be taken from the dry air outlet side and passed through the absorber to be reactivated at a rate controlled by an orifice plate.

vi. The dryer shall be thermally insulated and clad with aluminum sheet.

vii. Each adsorbed shall be sized for 8 hours of drying duty when operating at pressures between 4.5 and 7 bar g.

viii. The reactivation cycle shall include a period of air purge with the heater deactivated in order to cool the reactivated adsorbed to operating temperature prior to the changeover.

ix. The control panel shall incorporate the following features:

- Isolating switch for 230 V AC supply;
- Circuit protection for 230 V AC and 24 V DC circuits;
- Cycle timer;
- Heating timer;
- Heater contractors;
- Control relays;
- Control transformer;
- Indicator lamps for CELL No 1 DUTY, CELL No 2 DUTY, HEATER No 1 ON, HEATER No 2 ON;
- Indicator lamp for DRYER FAULT, voltage-free contacts for remote transmission of same shall be connected to the SCADA system.
- RESET push-button;
- LAMP TEST push-button.

1.44.13 Particle Filters

i. Particle filters on process gas streams shall be designed to remove dust with an efficiency of greater than 99.9 at a particle size of 1.0 micron, 99.5% at a particle size of 0.5 micron and 98% at a particle size of 0.1 micron.

ii. The pressure drop through the filter at the maximum gas flow rate shall not be greater than 0.03 bar when the filter is clean and not greater than 0.1 bar when the filter is dirty.

iii. The filters shall comprise carbon steel bodies with flanged inlet and outlet connections and removable top covers providing access to replaceable cartridge elements.

iv. Sufficient elements shall be installed so that replacement will be needed not more frequently than once every six months.

v. Where specified, a duplex arrangement of filters with inlet and outlet isolating valves shall be provided to permit element replacement without interruption to the

operating plant.

vi. The filters shall be equipped with a differential pressure indicator and switch with voltage-free changeover contacts, which shall be connected to the SCADA system to initiate a high-pressure drop alarm.

vii. A manual sampling and purge valve shall be provided downstream of the filter to permit testing with or without gas feed to the downstream process.

1.44.14 Air pipework

i. Pipework shall be arranged to minimize the transmission of vibration and where necessary, connections shall be made with anti-vibration couplings.

ii. Particular care shall be taken at points where condensation is likely to form or to accumulate such as following compression or cooling of ambient air or discharge of reactivation air from dryers.

iii. Appropriate traps and automatic drain valves discharging to approve points shall be installed.

iv. Thermal insulation and cladding where fitted shall be arranged in a manner which provides access to valves and other components for maintenance poses.

1.44.15 Air isolating valves

i. Air isolating valves shall be generally butterfly type to BS EN 593 and complying with the requirements of the General Specification of Valves, Penstocks and Stoplogs.

ii. Air isolating valves up to 50 mm N.B. may alternatively be in copper alloy to BS EN 12288 where compatible with the required temperature and pressure rating.

iii. All isolating valves shall be tested in accordance with BS EN 12266.

iv. Electric actuators for valves and solenoid-operated valves shall comply with the requirements of General Specification of Valves, Penstocks and Stoplogs.

1.44.16 Air flow control valves

Air flow regulating valves shall be globe type constructed of stainless steel 316C16 to BS EN 10213. Valve spindle shall be stainless steel type 316S16 to PD 970. Gland packing and seating ring shall be PTFE. Valves shall be sized in accordance with BS EN 60534 — 2. Flanged valves shall have integral flanges drilled to BS EN 1092 with pressure designation to match the pipework system. The flow control range of the valves shall be 10:1 or greater.

1.44.17 Air filters and silencers

Air filters on the inlet to compressors shall be of the dry element two-stage, high volume, and pleated type and shall have differential pressure gauge to determine when cleaning or element replacement is required. The efficiency of the filter shall be greater than 99% removal for particles 5 microns and larger. The intake silencer shall be located downstream of the filter, and it shall be acoustical absorption type with fiber glass packing.

1.44.18 Control of Instrument Air Compressors

i. The control system shall be designed so that either compressor may be selected as the duty unit and the other compressor as the stand-by unit. This selection shall be made locally and indicated on the SCADA system.

ii. The compressor shall be controlled automatically by the pressure-unloading valve associated with it to maintain the pressure in the air receivers within the limits necessary for the satisfactory operation of all associated plant.

iii. Compressors shall be fully controlled from a local panel with only monitoring provided on the SCADA system. An available signal shall be provided for each air compressor, and these shall be connected to the SCADA system for indication and alarming.

The stand-by compressor shall start automatically and deliver air to the air receivers if the pressure in the air receiver falls to a preset value, which shall be above the minimum value necessary for the satisfactory operation of all associated plants. The standby compressor delivery shall be controlled automatically by its pressure unloading valve.

1.45 BIOGAS generating sets & accessories

The gas generators, if proposed and installed by the Concessionaire, shall be designed with standby unit(s) to operate at maximum gas generation to give the optimum power output. The generators shall be connected to the plant's electrical power system in such a way that when they are in operation, they shall serve as the primary power source and the generated power shall be utilized to the fullest possible extent.

Power from the outside grid shall be used only when, and only to the extent that, the plant's total power demand exceeds the power being generated by the gas engines. Gas engines shall be suitable for operation with variable composition of Sewage Gas within prescribed limits.

The biogas will have a concentration of H2S@ 15% to 2.0%. This H2S which is highly corrosive in nature must be removed from the sewage gas before feeding the gas to the gas gen-sets. This H2S must be removed from this sewage gas by using chemical gas cleaning scrubbers.

The generator sets have to be designed to run on base load operation continuously during the peak gas generation: The H2S content in the sewage gas generated shall be removed by THE H2S scrubbing system.

The scrubber shall be capable of reducing the concentration below 200 ppm/required level.

The Biogas Engine Generator Sets shall be provided as a package system and shall include complete and comprehensive facilities for heat recovery from engine cooling as well as from generator fuel gases.

Recovered heat shall be used for heating of digesters. Biogas engine generator set, each with the necessary control panel and synchronization panel for parallel operation of engine generator set shall be provided.

as engines shall be designed for running on 100% sewage gas with a high level of fuel efficiency with lean burn combustion technology. There shall be provision of gas engines for power generation from the

gas produced by the proposed plant. The capacity of all gas engines shall be the same & the gas gen-sets shall not be overloaded more than 100% since gas gen-sets are meant for base load operation and cannot be overloaded.

The gas engine shall be hooked to the main LT panel. Gas engines shall be running in continuous operation. It will be preferred <2d that the gas gen -sets along with the H2S scrubber shall be provided as a package.

The electrical efficiency of the Gen sets at the alternator terminal under site conditions and 100 % load shall not be less than 40% (standard tolerance shall be applicable)

Biogas Engine design shall comply with reputed International standards including ISO, IEC, DIN, BS, VDE etc and shall be an automatic start and stop program process for safe operation. The Biogas Engine together with its control panel shall be tested at the engine manufacturer's factory. The biogas Engines shall have acoustic enclosures and be installed in completely closed soundproof rooms built in civil construction and shall be equipped with forced ventilation so as the maintain the controlled temperature and environment inside the room which is required for the operation.

Biogas Engine Generator set auxiliaries and accessories shall include a gas train, combustion air filters, electrical starting system, automatic lube oil replenishing system, sensor on engine, exhaust manifold, exhaust gas silencer, exhaust gas connection, exhaust gas chimney with ducting, jacket water preheating, radiator or cooling tower with circulation pump, flexible coupling, bell housing, engine generator set base frame, anti- vibration mounting, water and lube oil supply for engine and auxiliaries, Control and power cabling, engine control panel, PLC based Control system and remote data transfer facility, ventilation

system for engine generator room, etc., Engine shall have sensor and NOX, SOX control system to assess the performance of the Engine Genset. A suitable CH4 analyzer, H2S analyzer & a portable moisture analyzer shall be available to ensure that the biogas flowing to the engine is of appropriate quality. The Gas train or the

pipeline shall be supplied by the gas engine manufacturer, and it shall at least include a shut-off valve, a gas filter having fineness < 3 µm or lower, a valve leakage detector, a gas admission pressure regulator, pressure gauge, solenoid valves, gas pressure switch. Fuel gas, water, exhaust gas, and lube oil connections to each engine shall be stainless steel flexible type. Internals of silencer shall be of SS 430 to avoid corrosion on account of H2S present. The engine shall have connected forced feed lubrication and equipped with a minimum number of valves and be equipped with an electronically controlled air-gas mixture and electronic speed monitoring facility. The engine shall have exhaust gas temperature measurements for each cylinder.

1.45.1 Gas Holder

In Facilities where it is applicable, the gas holder shall have a holding capacity as per CPHEEO. The gas storage shall maintain a maximum gas pressure of 250 mm WC/wg. All gas holders shall be provided with the gas safety equipment {dual pressure relief/vacuum devices) as specified herein for protection of the storage unit.

1.45.2 Biogas Scrubbing System

The system shall include major equipment like Pre-Scrubber, Scrubber, wash tower,

regenerator, filter press and pumps. The system should have zero liquid discharge and no gas/ effluent emission in the process of scrubbing.

1.45.3 Gen-set components

Base frame, coupling, pre-lube pump, air filter, zero pressure gas control line with connection. Accessories, crankcase, driving gear, cylinder head, valve drive, ignition, carburetion, mixture charging, starter, lube oil system, sensor technology/actuator technology, and cabling etc.

1.45.4 Rotary current internal pole synchronous generator

Three-phase synchronous generator, brushless, self-induced, self-adjusting, with dampening cage for 30% inclined load and parallel operation, artificial star point, protection type IP 23, with tropical atmosphere and humidity protection insulation, degree of radio shielding "N", voltage target value setting ± 5%, Insulation Class H.

1.45.5 Gen-Set Components

Base Frame	:	Steel bend torsion-resistant construction
Coupling	:	High stretch, axial plug-in coupling for torsional elastic connection of the engine and generator
Pre - Lube Pump	:	Electric pump
Air Filter	:	Paper dry type air filter

1.45.6 Zero Pressure Gas Control Line with Connection Accessories

Crankcase	:	Alloyed special cast iron
Driving gear	:	Chrome molybdenum
Cylinder head	:	Special cast Iron.
Value drive	:	Toothed wheel-driven camp shaft.

1.45.7 Flare System

i. A Comprehensive auto flare philosophy shall be adopted along with the GAS engine power generation philosophy to complete the interlock of flaring with no power generation. Gas flow on the gas flare line shall have interlock with the flame detector to conclude the effective flaring.

ii. The flare unit shall be designed for biogas flow generated during average flow conditions. It shall be fabricated of suitable materials (carbon steel except for the top portion which shall be in SS 304). The design of the flare unit will be such that it shall be conveniently mounted on the steel supporting structure.

iii. The velocity of biogas through the flare unit should be minimal considering the 100-150 mm WC pressure of biogas at the flare inlet. Capacity of the Gas flare system shall be provided for the total gas generated from the proposed plant. Gas from the existing plant is not to be considered. The gas flare system shall be one working and one standby unit along with all accessories. Burner capacity shall be 150% of design gas generation.

iv. A suitable spark ignition system should be provided at a convenient location. Biogas shall be used as a pilot fuel. The pilot flame generated with the help of spark ignition systems shall propagate through the flare unit to ignite the main biogas. The control system involving the control panel, ignition transformer etc. shall be provided for the said purpose.

v. H.T. cable shall be provided from the secondary terminal of the ignition transformer up to the spark ignition system. Necessary ignition electrode OR 1 number 25 KVA generator set shall be provided. A diesel generator set can also be used to start the gas engine.

1.45.8 Moisture Trap

The moisture trap shall be designed to effectively separate moisture in the biogas such that, moisture-free biogas is made available at the outlet of a trap. It shall be of suitable materials for construction and be provided with a suitable drain connection.

1.45.9 Flame Trap

i. The flame trap shall be of suitable size for biogas application. It shall be used primarily in pipelines to prevent flashback during explosions.

ii. This device shall be installed in a horizontal or vertical pipeline and hence it should be bidirectional.

iii. The flame-arresting element shall be designed such that it results in minimal pressure loss under normal operating conditions but to ensure maximum security in the event of an explosion, the end connection shall be flanged.

1.46 Surface aerator

1.46.1 General

Surface aerator is used in a variety of wastewater treatment applications. Powerful pumping action transfers oxygen by breaking up the wastewater into a spray of particles, creating more surface area for atmospheric pressure to drive oxygen into the wastewater. At the same time, the oxygen-enriched water is dispersed and mixed. The result: Effective wastewater treatment. aerator represents over four decades of accumulated research and field testing in a broad range of municipal and industrial applications throughout the world. Mechanical aerator combines outstanding efficiency and versatility in a rugged design. It provides excellent oxygen transfer, low operating costs, trouble-free performance and outstanding resistance to environmental extremes to which aerators are continually exposed. The aerator shall be tested in accordance with IS 13166.

1.46.2 Motor

i. Totally enclosed, fan-cooled

ii. Heavy gauge cast iron fan shield

iii. Class F insulation

iv. Standard or premium efficiency available

v. Double-row bearings on the drive end

vi. Heavy-duty L-10, 100,000-hour bearings

vii. Dynamically balanced and vibration tested

viii. Designed to meet the most demanding operational requirements

ix. Moto Junction Box: The Opening in the motor housing for winding leads is completely potted with epoxy filler.

1.46.3 Motor shaft

i. One piece continuous from the upper bearings to the propeller

ii. 17-4 PH stainless steel in the 1150°F heat treated condition

iii. 135,000 PSI minimum yield strength

iv. Largest diameter shaft

v. Threaded and keyed on the drive end for simple propeller installation

1.46.4 Seal Guard

Positioned below the bottom motor bearing to prevent moisture from migrating up the shaft into the lower bearing.

1.46.5 Discharge Cone

i. Heavy-duty casting

ii. Large integral webs for rigid stability and increased lateral strength

iii. Designed for minimum head loss

iv. 304 stainless steel, or cast nickel-iron, epoxy-coated

v. Provides for lowest vibration levels

vi. Produces maximum diffusion of water particles

vii. 100% contact with the volute, which distributes both static and dynamic loads

1.46.6 Float

i. Large one-piece float for superior performance

ii. Engineered to provide stability and better buoyancy

iii. Fiberglass reinforced polyester (FRP), or 14-gauge, 304 stainless steel.

iv. Filled with closed-cell polyurethane foam that adds structural stability and prevents the possibility of sinking if damage occurs to the float exterior.

1.46.7 Deflector bearing

i. Shaft runs free under normal operating conditions

ii. Provides support only when under load

1.46.8 Debris deflector

i. Machined Delrin® for smooth fluid passage over the surface

ii. Attached with two recessed stainless steel set screws

iii. Double engagement provides an extra measure of preventing water migration up the shaft.

1.46.9 Propeller and Key

i. Precision investment casting

ii. 316 stainless steel.

iii. Dynamically balanced

iv. Keyed to mate to the motor shaft in the proper position

v. Secured to the shaft by a stainless-steel locking nut

vi. Simple installation or removal

vii. Anti-fouling, non-cavitating for greater operational efficiency

1.46.10 Locking Nut

i. Stainless steel

ii. Firmly and securely locks the propeller to the shaft

iii. Just two tools required to install or remove the propeller

1.46.11 Volute

i. 304 stainless steel.

ii. All sizes have a bottom flange for simple bolt-on attachment of the standard intake cone or optional anti- erosion assembly or draft tube

iii. Gussets at the top and bottom flanges add strength

1.46.12 Intake Cone

i. 304 stainless steel

ii. Hydraulically designed for proper loading on the propeller

iii. Sufficiently sturdy to support assembled aerator on a hard, flat surface

iv. (Optional) Anti-erosion assembly

v. (Optional) Draft Tube