

HOGENAKKAL WATER SUPPLY AND FLUOROSIS MITIGATION PROJECT

PACKAGE IV

Name of work: Operation and Maintenance of Transmission Main From Common Booster Pumping Station at Moongilpatti near Palacaode to Thinnur Master Balancing Reservoir (MBR), Feeder Mains, Break Pressure Tanks, Booster Pumping Stations, Internal Transmission Mains, Internal Networks, Re-chlorination stations, Union MBRs and Panchayat MBRs and Allied works for providing water supply to Hosur Municipality, 2 Town Panchayats (Kelamangalam TP and Denkanikottai TP) and 1823 Rural Habitations in Hosur Union, Shoolagiri Union, Veppanapalli Union, Thally Union, Kelamangalam Union in Krishnagiri District and 100 Rural habitations in Karimangalam Union (part) in Dharmapuri District under Package IV of Hogenakkal Water supply & FM Project for a period From 01.02.2020 to 31.03.2024.

VOLUME – 2/7

SPECIFICATIONS

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A1.0 DESCRIPTION OF THE WORKS

AI.1 Scope

Madam MBR is being located at the commanding level to feed the rural and urban areas with maximum services of drinking water supply to the public requirements of Package IV by collection of water for the beneficiary's demand at Moongilpatti sump by gravity. The entire Transmission Main is aligned from Moongilpatti Booster Station whose level is at + 494.105 m to Thinnur at Hosur which is at the level of 896.215 Package IV level. The total length of the main is about 67.170 Km of MS pipe ranging from 850mm to 600 mm and there are 5 boosters including Moongilpatti Booster to supply to the enroute Union areas of Karimangalam (part), Kelamangalam, Thally, & Hosur and with branch Internal Transmission Mains to Shoolagiri and Veppanapalli Unions. Kelamangalam, Denkanikottai Town Panchayats along with Hosur Municipality is provided with drinking water supplying by internal network and distribution system from OHTS. There are 5 tapping points namely Kaduchettipatti, Rayakottai, Jakkeri, Mathigiri and Thinnur along the pressure mains to feed all the areas above by pumping from sumps with pumping plants to negotiate the elevation to supply to the public.

The distribution of treated water is supplied to most of the sites by gravity arrangements. Where gravity feed will not be feasible due to their altitude, booster pumping stations provided for the necessary hydraulic lift. The treated water trunk mains from the MBR at MADAM to reach Common Booster Pumping Station for Packages IV and V near Palacode, where there are one storage reservoir (two separate compartments) and one pump well commonly be used by this Contract and the contract of Package V. The civil structure, the high voltage (33kV or 111(V) electrical works and the building services works of this Common Booster Pumping Station, which has been commonly used by both this Contract and Package V, shall be provided under this Contract. For the works in this Contract in this Common Booster Pumping Station, the Contractor has to maintain mechanical plants, electrical plants and instrumentation works, including the booster pumps (vertical turbine type), pipelines, valves, overhead cranes, LV switchboard, flow meters, level sensors/transmitters etc. Under the Contract, treated water from this Common Booster Pumping Station shall be discharged to Mahendramangalam sump water will be pumped to Kaduchettipatti Booster Station sump and water will be pumped to Rayakottai MBR and to some villages by gravity belonging to Karimangalam (part) Union separately from Kaduchettipatti sump water will be pumped to Ullukurukkai sump.

Ullukurukkai sump water is pumped to Kundumaranahalli and enroute tapping at Jakkeri has to maintain Kelamangalam Union and 2 Nos of town panchayats of Kelamangalam Union. Further the treated water has been pumped from Kundumaranahalli to Thinner in Hosur and for Mathigiri BPS to supply water to Mathigiri Tapping point, Hosur Municipality and to balance Union villages.

The alignment route is Near Palacode, Vellichandai, Rayakottai and Ullukurukkai, Kundumaranapalli and Thinnur in Hosur.

There are five booster stations at Moongilpatti, Mahendramangalam, Kaduchettipatti, Ullukurukkai and Kundumaranahalli with sumps and MBR and from the tapping points the water is supplied to Union MBRS and OHTS in habitations of Package IV of various capacities. The transmission pipeline from 850 mm size to 600 mm size is of MS for a total length of 67.170 Kms and the distribution network is for 3033.174 Kms of HDPE/DI pipes have to be maintained.

There are 645 Nos. Of RCC of MBRS, Sumps, Pump Houses, OHTS in the distribution area from Moongilpatti Booster Station to the habitation end to supply to all the beneficiaries up to agreement period.

The treated water trunk mains and the branch pipelines have to be maintained which are passing across the rivers, roads, railway and nalla by the Contractor. For the purpose of isolation, control and surge protection, the Contractor has to maintain all valves for Isolation, air valves for surge protection and valves for flow control.

Through the SCADA System, the signals of the levels in the union reservoirs, the flow/volume of water delivering from the tapping point branches to the union/panchayat reservoirs, the positions of all the major isolating/modulation valves, signals from the Re-Chlorination Stations and signals from the major or booster pumping stations displayed in the Human Machine Interface pages at the two Central Control Rooms (CCRs), that are located at the filter building of the Water Treatment Plant and the Tamil Nadu Water Supply and Drainage Board (TWAD) Project Office at Dharmapuri. Through the SCADA System, operators of the Employer shall be able to modulate the position of the flow control valves and open/close isolating valves at the CCR5. The SCADA System is operated by the Employer under Package I of the Hogenakkal Water Supply and Fluorosis Mitigation Project. The Contractor shall work closely with the contractor of Package I & V to enable all the control/status signals of all the devices that are to maintain at the sites of Package IV to function properly.

The Contractor shall be responsible for all insurances, where the cost of providing that entered into items in the Schedule of Prices. After the Contractor has satisfactorily complete the 60 months operation and maintenance works the Employer will take-over the whole Works

The Works contain a 3 months Defects Liability Period. Prior to handover the whole works to the employer the contractor has to conduct and satisfactorily complete the Test on Completion of O&M works. The scope of the tests to be done in this Test on Completion is detailed in Clause A15 of this General Specification.

AI.2 Works to be provided by the Contractor

Under this Contract, the Contractor has to maintain all the works in accordance with the Drawings, Specification and Bill of Quantities, which includes:

- (a) The works includes the supply of treated water trunk mains pipelines originate from the tapping-point branches pipelines from the trunk mains to the union reservoirs, main panchayat reservoirs and the distribution pipelines to other reservoirs, booster pumping stations and overhead tanks;
- (b) Maintaining all supports, piers and appurtenances for above ground river, nalla and culvert crossings.
- (c) Operation and Maintenance of valve chambers at the tapping-point branches (as shown in Table 3) of the trunk main pipelines, at the union reservoir sites, at panchayat reservoir sites, at overhead tank sites and at booster pumping station sites.
- (d) Operation and Maintenance of flowmeter chambers at the tapping-point branches (as shown in Table 3, all flowmeters are to be maintained by Package I) of the trunk main pipelines and at large booster pumping stations (as shown in Table 1, all

flow meters to be maintained by Package I, except Sl.Nos. 2 & 5). Maintain spool pieces flange adaptors and other associated pipes, which are to be maintained by the contractor of Package **I**, at the chambers at the tapping point branches of the trunk main pipelines.

- (e) Maintaining buildings for housing the on-line re-chlorination equipment and any associated works including roads, drainage, landscaping, fencing at each union reservoir.
- (f) Maintaining buildings and any associated works including roads, drainage, landscaping, compound walls, fencing, building services etc at the sites of booster pumping stations and booster pumpsets, (in large pumping stations except the Common Booster Pumping Station near Palacode where dual power supplies from TNEB obtained, electrical, mechanical, instrumentation and building services equipment in these buildings.
- (g) Maintaining union reservoirs, panchayat reservoirs, overhead tanks and any associated works including roads, drainage, landscaping, compound fencing walls and building services work at each site;
- (h) Maintaining all necessary cable ducts for SCADA instruments of Package I. These cable ducts include, but not limited to, the cable ducts for the cables connecting the ultrasonic level sensors at union reservoirs/large booster pumping stations and the full bore electromagnetic flow meter, primary head pipes at tapping point from trunk mains / Large Booster pumping stations to their transmitters, The cable ducts for the cables to connect the ultrasonic level transmitters the full bore electromagnetic flow meter transmitters the level electrodes controllers, the pressure transmitters (equipment of Package I contract) to the Local Control Panels (to be maintained by the contractor of Package I);

A 1.3 Pumpsets for Booster Stations

Vertical Turbine pumpset shall be installed at all the Booster Stations. Duties of Vertical Turbine pumps proposed to be installed at different Booster stations are detailed in the Table 1.

Table 1 (duties of Vertical turbine proposed to be installed at booster stations.)

S.No	Locations for 24hrs Lpm	Demand for 24hrs Lpm	Discharge at 23hrs pumping,	Total Head (m)	Power required (HP)	No of Units
1	Common Booster Station at Moongilpatti (near Palacode)	31773	33154	118	1430	2+1
2	Booster station II at Mahendramangalam	31773	33154	108	1310	2+1
3	Booster station III at Kaduchettipatti	26336	27481	95	950	2+1
4	Booster station III at Kaduchettipatti to Tapping point I	4731	4937	109	200	1+1
5	Booster station IV at Ullukutukkai	26336	27481	130	1300	2+1

6	Booster Station at Kundumarana halli	19402	20245	124	1020	2+1
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A 1.4 Pumping Main

The pumping Main from Common Booster Station at Moongilpatti near Palacode to Hosur carries the water requirement of Package IV. The details of pipes in the pumping main are furnished in Table 2.

Table 2 Details of pipes in pumping main.

Reference Chianage From - To (m)	Length of Main (m)	Pipe Material	Diameter of pipe (m)	Thickness of pipe shell-mm
Pumping main from Common booster Station to MBR at Thinnur				
0-6930	6930	MS	850	8
6930-17010	10080	MS	850	7
17010-18810	1800	MS	850	8
18810-23010	4200	MS	850	7
23010-37380	14370	MS	750	7
37380-43350	5970	MS	750	8
43350-502220	6870	MS	750	7

Reference Chianage From - To (m)	Length of Main (m)	Pipe Material	Diameter of pipe (m)	Thickness of pipe shell-mm
50220-55155	4935	MS	700	6
55155-57420	2265	MS	700	7
57420-65280	7860	MS	700	6
65280-67170	1670	MS	600	6
Branch pumping main to BPS at Mathigiri				
0-760	760	DI	350	K7
Kaduchettipatti BPS to Rayakottai MBR				
0-2730	2730	DI	350	K9
2730-6510	3780	DI	350	K7

A 1.5 Tapping point from Pumping Main

There are five tapping from the pumping main to feed Panchayats in different Unions as furnished in Table 3.

Table 3 Details of Tappings from the Pumping main and Master Service Reservoirs.

Tapping Point No.	Chainage	Location	Quantity Lpm	Size of Feeder	Feeding to	Name of Union	Type of chlorination Building	Size of flow control Valve (mm)	Electrum agneticmeter
I	23010	BPS II at Kaduchettipatti	4731 (4937)	350DI	Rayakottai Elevated MSR 6.00LLcapacity (by pumping)	Kelamangalam Union Panchayat	Type C	200	200
IA	23010	BPS II at Kaduchettipatti	705	200DI	Karimangalam Union Panchayat by Gravity	Karimangalam Union panchayat	Spot Chlorination	125	125

II	50220	Jakkeri	6935 (7236)		4 5 0 1 3 1 Jakkeri Elevated MSR (pumping) Elevated BPT 12.00LL Capacity	Kelamang alam U &ThaliU panchaya t To feed BSS by	Type C	300	300
III	65280	Hosur— Mathigiri Junction	3808 (3973)	350DI	GI MSR 6.00LL capacity at Mathigiri	Hosur U Panchayat & Thali U	Type C	250	250
IV	67170	Thinnur	1594 (16272)	600MS	Elevated MSR 20.00LL capacity at Thinnur	Shoolagiri U & Hosur U Panchayat	Type C	400	400

Table 4 Details of Tappings from the Pumping main and Master Service Reservoirs.

Reference Chainage From - To (m)	Length of Main (m)	Pipe Material	Diameter of pipe (mm)	Class of pipe
Feeder Main				
0- 5369	5369	DI	150	K9
5369-11464	28590	DI	100	K9
Branch feeder main				
0 —1250	1250	HDPE	90 OD	PN8
0 — 3600	3600	HDPE	90 OD	PN8

A2.0 GENERAL

REQUIREMENTS A2.1

Scope

This Part of the Specification covers certain duties of the Contractor in connection with the administration of the Contract; it includes also some of the general responsibilities of the Contractor in carrying out work under the Contract which are in addition to or in furtherance of the requirements of the Conditions of Contract.

The requirements of any clauses of this Specification herein or compliance with the requirements of the Engineer shall not limit any of the Contractor's obligations or liabilities under the Contract.

A2.2 Clause references

Except where stated to the contrary references herein to Clauses are reference to Clauses numbered in the Specification.

A2.3 Issue of documents

The Contractor will be supplied with one copy of the Contract Documents for his own use.

A2.4 Materials: general requirements

The term materials shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.

All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

The Contractor shall as far as possible use materials available in India for the completion of the Works, subject to compliance with the Specification.

Materials shall be transported, handled and stored so as to prevent deterioration, damage or contamination.

The products / pipes / material manufacturer should have BIS or relevant international standard specification certificates. The presence of certification mark on the

product is an assurance of conformity to the specification

A2.5 Substances and products

Substances and products used in the Works which may be applied to or introduced into water which is to be supplied for drinking, washing or cooking shall not contain any matter which could impart taste, odour, colour or toxicity to the water or otherwise be objectionable on health grounds. Only the substances and products which have been approved by a national or international regulatory body shall be used.

After award of Contract, from time to time the Contractor shall submit for the approval of the Engineer a schedule of substances and products he proposes to use in the Works giving the following information as applicable:

II Item of plant;

- Substance/product in contact with water;
- Manufacturer of plant/substance/product;
- Point of use in the Works;
- Name of the regulatory body, which has approved the substance/product;
- Date of approval (for use on water quality and on health grounds);
- Approval (with respect to water quality and health) reference number.

For all other products and substances to be used in the Works in such situations, the Contractor shall at his own expense obtain the necessary approval and follow the procedure set above and obtain the approval of the Engineer before use.

A2.6 Plant to be safe in use

The Contractor shall ensure that Plant is safe in use and any safety regulations imposed by law or by any authorised body empowered to make such regulations are complied with.

A2.7 Design life

"Design life" means the period for which an item is designed to operate at full design output without major overhaul involving extensive dismantling, serious corrosion or necessity for substantial renewal of any anti corrosion system, reduction of efficiency in excess of 5%, or replacement of major components essential to the functioning of the item etc except for consumables and for any limited-life components explicitly agreed at the time of the Contract award.

Minimum designed lives shall be as follows:-

- | | | |
|-----|--|-------------------|
| (a) | Roads, pipelines including associated pipework and valves and other buried or built-in pipework, structures of concrete, brick or blockwork | |
| (b) | Pipelines, structures of steel (including tanks) and valves | - 30 years |
| (c) | Machinery including pumps, valve actuators generating sets, transformers, switchgear, cabling, air blowers, compressors, process plant and electrical installations | - 20 years |
| (d) | Instrumentation, control and automation equipment | - 10 years |

All items and systems shall be designed to allow replacement or major overhaul at the end of the design life without requiring major work or dismantling of other items

and systems which interrupt operation of independent items and systems.

A2.8 Interfaces with other contracts A2.8.1 General

- (a) This Contract is the Operation and Maintenance of "Hogenakkal Water Supply and Fluorosis Mitigation Project —Treated water trunk mains from Booster Pumping Station near Palacode to Hosur, branch pipelines, union reservoirs, panchayat reservoirs, sumps, overhead tanks, chlorination stations, booster pumping stations, instrumentation, electrical and mechanical works.
The Employer will be maintaining the remaining works under Packages I, II, III and V. These packages are to maintained
- (b) Package I –Raw water Intake Works, raw water pumping station, treatment plant, treated water pumping station, booster pumping station, pumping mains, MADAM master balancing reservoir and allied works;
- (c) Package II –Supply of Treated Water through Trunk Mains from Master Balancing Reservoir at MADAM to Uthangarai, Branch Pipelines, Union Reservoirs, Panchayat Reservoirs, Sumps, Overhead Tanks, Chlorination Stations, Booster Pumping Stations, Instrumentation, Electrical and Mechanical Works;
- (d) Package III –Supply of Treated Water through Trunk Mains to Harur, Branch Pipelines, Union Reservoirs, Panchayat Reservoirs, Sumps, Overhead Tanks, Chlorination Stations, Booster Pumping Stations, Instrumentation, Electrical and Mechanical Works;
- (e) Package V –Supply of Treated Water through Trunk Mains from Main Balancing Reservoir at MADAM to Bargur, Branch Pipelines, Union Reservoirs, Panchayat Reservoirs, Sumps, Overhead Tanks, Chlorination Stations, Booster Pumping Stations, Instrumentation, Electrical and Mechanical Works".

The Operation and Maintenance of Works under this Contract will interface directly with all these Packages. The nature of these interfaces will be, as a minimum but not limited to, the scope entered in the table **below**:

Interface with	Nature of Interface
Package I	The contractor of Package I has to maintain all the instruments at sites of the tapping points from the trunk mains, the level transmitters at the sites of union reservoirs, the flowmeters/pressure transmitters/level sensors at the large booster pumping stations and all the required Local Control Panels for SCADA System at the sites of Packages IV. The Contractor has to coordinate with the contractor of Package I for all the interface works that are to incur and allow the contractor of Package I to access the sites under the Contract for maintenance work. The Contractor shall supply all other signals that are required by the SCADA System from their equipment, in accordance with the Particular Specification
Packages V	The Contractor has to maintain the civil structure, major electrical works and building services works for the Common Booster Pumping Station near Palacode and allowed the contractor of Package IV to access this site to carry out maintenance work.

Instrumentation , SCADA and Telemetry works

The Engineer will arrange meetings among himself, the Contractor Package IV and the contractors of Packages I, II, III and V to agree a programme for the instrumentation, SCADA system, and telemetry network, under the scope of supply of Package I, to be installed at the sites of Packages II to V.

Pressure transmitters and electromagnetic flowmeters has to maintained by the contractor of Package I at each of the tapping point from trunk mains sites and the large booster pumping stations.

The Contractor shall allow the contractor of Package I to access his sites to install the ultrasonic level sensor/transmitters at the union reservoirs/sumps of large booster pumping stations, the pressure sensors/transmitters, the electromagnetic flowmeter at the tapping point from the trunk mains/large booster pumping stations, and also the Local Control Panels (LCPs) for the SCADA System. The LCPs is to be used for the acquisition of signals and to activate the control command from/to the instruments, electrical and mechanical equipment at the sites of Package IV. The Contractor has to maintain all the fully open, fully close status signals for all isolation valves and the position status signals for the flow control valves. Also, the Contactor has to maintain the necessary control devices at the actuators of all these valves such that the SCADA Urtem shall be able to control them. For the isolation valves, the SCADA System shall be able to fully open, fully close and stop at intermediate positions of the valves. For the flow control valves the SCADA System shall be able to modulate their positions to control the flow passing through the tapping point branches from the trunk mains.

The instruments and valves signals is transmitted from these LCPs back to the Central Control Room (CCR) at the Water Treatment Plant of Package I. The Contractor shall attend all

meetings that are arranged by the contractor of Package I with the service providers when the discussion will be related to the SCADA work in Package IV.

At each site of Package IV, the Contractor shall provide a power supply of 100A, 230V, single phase to the Telemetry Rooms at Re-Chlorination Building and large booster pumping stations and directly to the LCP at the tapping points from the treated water trunk mains. The contractor of Package I will use this power supply for his UPS that in turn feed the LCP and other instruments.

After any part of the whole data transmission network be installed, the Contractor has to act in conjunction with the contractor of Package I to:

Test that all the signals from the primary devices (the contractor of Package I to be responsible for the instruments at the site of Package IV) shall be able to transmit to the SCADA system and be able to be displayed at the Human Machine Interface (HMI) display pages at the CCR of the Water Treatment Plant, the CCR at the TWAD Project Office at Dharmapuri and at each of the LCPs;

Test that the control commands being sent from the SCADA system through the HMI display pages any of the CCRs or at the respective LCP can control the relevant devices at each site of Package IV.

Cable ducts, drawpits and cable laying from local devices to the LCPs

The Contractor has to maintain the LCPs at each site of Package IV. The SCADA instrument of Package I and other cables LCP shall be maintained. For those instruments that are provided by the contractor of Package I, he shall be responsible to provide and install the cables to the LCPs, using the cable ducts, draw pits, cable trays and the like to be provided by the Contractor.

The contractor of Package I will maintain the requirements of the abovementioned facilities to the Contractor. For other devices being provided by the Contractor, he shall be responsible to provide, install and terminate the cables up to the cable terminals at the LCPs. The contractor of Package I will maintain and ascertain all the cables to the correct terminals.

A2.8.2 Interface with the contracts of Package V

Common Booster Pumping Station near Palacode

The Engineer will arrange meetings among himself, the Contractor and the contractor of Packages V to agree a programme to allow the contractor of Package N to access the Common Booster Pumping Station near Palacode, according to the construction programme of the Contractor at this site.

The contractor of Package IV has to maintain the civil requirements relating to their work at the Common Booster Pumping Station near Palacode, e.g. the pumpwell size for their pumps, the cable trench requirements inside their switchroom. The Contractor Package V has to maintain the civil works according to these requirements. All pipework and other associated mechanical equipment (e.g. valves) for the pumping works of Package IV has to maintain.

The contractor has to provide the electrical power rating requirement for their works at the common Booster Pumping Station near Palacode to the Contractor of Package V. Taking into account the power supply rating requirement for the work of this Contract at this pumping station, the Contractor Package V shall design the HV/LV Switchboard (depends on the actual power required). The Contractor Package V has to maintain the total power rating (Package V and Package IV total rating) to the Employer and to all liaison work with Tamil

Nadu Electricity Board. All road works, landscaping work, road lightings, cable ducts, earthing, lightning protection, site compound wall etc has to be maintained under Contract Package V.

A3.0 STANDARDS

A3.1 Reference standards (*For any works that are to be carried out in future as varied works*)

The Works shall be carried out in accordance with the relevant quality standards, test procedures or codes of practice, collectively referred to as Reference Standards, listed in the relevant part of the Specification. The Contractor shall familiarise himself fully with the requirements of such standards. During the submission of that works for the approval of the Engineer, the Contractor shall also provide one copy of such Standard that the works is conforming to for the use of the Engineer. If no standard is indicated then the relevant Indian Standard or, in the absence of such standard, internationally recognised standard shall apply.

Other national standards may be considered provided that they are, in the opinion of the Engineer, no less exacting than the corresponding standard quoted in the Specification. Equivalent or corresponding Indian Standards are acceptable. The Contractor shall demonstrate to the Engineer that the alternative standard is suitable and equivalent to the specified standard, and shall provide proof of previous successful use. The Engineer will decide whether or not the use of such alternative will be permitted as a Reference Standard. When an alternative standard is proposed, the Contractor shall supply the Engineer with a copy of that alternative standard that the equipment is complying to and also a copy of the standard as required to be complied by the equipment in the Specification, as part of the submission for the Engineer's approval.

A3.2 Applicable issue

The applicable issue of any Reference Standard shall, unless otherwise stated in the Specification, be the issue current at the date three months preceding the date for submission of the tenders for the Contract.

A3.3 Abbreviations for Reference Standards

The following abbreviations where used in the Specification refer to standards, codes of practice and other publications published by the organisations listed:

ACI	American Concrete Institute
ANSI	American National Standards Institute
API	American Petroleum Institute
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
BS	British Standards Institution
CP	British Standards Institution (Code of Practice)
DIN	German Industrial Standards
HMSO	Her Majesty's Stationery Office
IS	Indian Standards
ISO	International Organisation for Standardisation
JIS	Japanese Industrial Standards
SI	International System of Units
SIS	Swedish Standards Commission
WHO	World Health Organisation

A3.4 Reference Standards for Part A

Reference Standards are referred to in the text of the Specification in abbreviated form (e.g. BS 812). The full titles of some which are relevant to this Part are given below for convenience:

Standard Subject

ISO 216	Writing paper and certain classes of printed matter-trimmed sizes - A and B series.
BS 4884	Technical manuals. Specification for presentation of essential information
BS 1133	Packaging code. Introduction to packaging
BS EN ISO 5198	Centrifugal, mixed flow and axial pumps. Code for hydraulic performance tests. Precision class
BS EN ISO 9906	Rotodynamic pumps. Hydraulic performance acceptance tests. Grades 1 and 2
BS EN 1171	Industrial valves. Cast iron gate valves
BS 5163	Specification for predominantly key-operated cast iron gate valves for waterworks purposes
BS 6755	Testing of valves. Specification for fire type-testing requirements
BS EN 593	Industrial valves. Metallic butterfly valves
BS 1042	Measurement of fluid flow in closed conduits. Pressure differential devices. Guide to the use of devices specified in Sections 1.1 and 1.2
BS1041	Measurement of fluid flow in closed conduits. Pressure differential devices. Guide to the use of devices specified in Sections 1.1 and 1.2
BS EN 12334	Industrial valves. Cast iron check valves
BS 5158	Specification for cast iron plug valves
BS EN 13397	Industrial valves. Diaphragm valves made of metallic materials
BS 5159	Specification for cast iron and carbon steel ball valves for general purposes
BS EN 13789	Industrial valves. Cast iron globe valves
BS 7775	Specification for penstocks
BS 466	Specification for power driven overhead travelling cranes, semi-goliath and goliath cranes for general use
BS 6754	Specifications and testing of compressed air dryers
BS 6759	Safety valves. Specification for safety valves for steam and hot water
BS1123	Safety valves, gauges and fusible plugs for compressed air or inert gas installations. Code of practice for installation
BS 3274	Specification for tubular heat exchangers for general purposes
BS 5168	Glossary of rheological terms
BS 1571	Specification for testing of positive displacement compressors and exhausters. Methods for simplified acceptance testing for air compressors and exhausters
BS 5500	Specification for unfired fusion welded pressure vessels
BS 4871	Specification for approval testing of welders working to approved welding procedures. Arc welding of tube to tube-plate joints in metallic materials
BS 4999 Part 143	General requirements for rotating electrical machines. Specification for tests
BS 171	Specification for power transformers
BS 148	Specification for unused and reclaimed mineral insulating oils for transformers and switchgear

A4.0 CONTRACT ADMINISTRATION

A4.1 Contractor's organisation and administration of the Contract

For the purposes of this Contract the term 'Project Manager' shall mean the person appointed by the Contractor, and accepted by the Employer in the Tender, as his representative for administering the Contract on his behalf.

The Contractor shall submit to the Engineer a diagram showing the structure of the organisation for his administration of the Contract. This structure shall include a project managing organisation which may be part of the Contractor's organisation, or an outside body which shall be named by the Contractor.

The project management group shall include at least one permanent experienced project planner fully versed in the use of the planning software that the Contractor proposes to use. A Project Manager and an Assistant capable of deputising for the Project Manager both belonging to the project managing organisation shall be appointed (*Details to be enclosed in Schedule T2 of Price Bid of Agreement*). The duties of the Project Manager shall include responsibility for programming, progressing and co-ordinating the works, including:

- Obtaining all permissions from the relevant authorities to do the works;
- *Maintenance and* construction and testing of all civil works;
- *Operation and Maintenance of Mechanical, Electrical, Electromechanical plants and ICA accessories*
- *Modification* of Operation and Maintenance Manuals.

The Project Manager shall also be responsible for ensuring that all codes, standards and any other technical requirements of the Contract are complied with by all subcontractors.

All correspondence and communication between the Engineer and the Contractor shall be directed through the Project Manager.

The structure diagram shall state the names of the firms to be employed to carry out the following portions of the Works:-

- Pipe manufacture and supply
- Pipe *spares*
- Mechanical plant *spares*
- Electrical plant *spares*

Designs, drawings and documents that are required to be submitted to the Engineer for approval shall only be considered if they have been submitted by the Project Manager. The Project Manager shall ensure that all submissions are clearly identified as to their purpose. Each item shall be dated and stamped "checked by Project Manager".

A4.2 Progress reports and meetings

The Contractor shall submit three copies of a detailed progress report to the Engineer each month showing the *quantity of water supplied to the beneficiaries*. The report shall show progress to the end of the preceding month. The reports shall be accompanied by such additional information in approved form as may be required by the Engineer. The reports shall be forwarded promptly so that on receipt the content is not more than *three* days out of date.

The report format shall be agreed between the Project Manager and Engineer prior to issue of the first report.

Shortfall or excess qty supplied to the beneficiaries shall be detailed by the Contractor, with the proposed action to overcome it.

The Engineer may call meetings in his office, at the Contractor's office or at the Site, to review the progress of *Operation and Maintenance of works* of the Contract. The Contractor's Project Manager shall attend such meetings.

A4.3 Method statements

The Contractor shall prepare and submit to the Engineer detailed method statements *within 15 days from the date of work order* for all aspects of the *maintenance work such as attending to leaks, bursts, patrolling activities, maintenance of all valves in pipe line and in pump rooms, maintenance of pump sets and panel boards, sumps, MBRs, rechlorination stations etc.* In case of varied works, the method statements shall be submitted for review by the Engineer at least 28 days before the work covered by the method statement is programmed to *start*.

Each method statement shall comprise a step-by-step schedule of specific operations and activities with descriptions, dates, times and durations for each step. It shall highlight specific points in the programme and any permissions that are required before commencing operations. The statement shall clearly state who and what organisation will carry out work and precisely when and what support or provisions are to be made by others outside the Contract. The statement shall include all supportive detail to enable a clear understanding of the method and significance of each step of the operation. The statement shall provide details of the Health and Safety measures to be taken in carrying out the proposed activities.

No work which affects the operation of existing waterworks or the work of other contractors or which may be deemed by the Engineer as presenting a significant hazard, shall be carried out until the method statement has been agreed by the Engineer.

The Contractor shall revise the method statement as necessary if the Engineer requests it and the Contractor agrees with the Engineer's comments. If the Contractor disagrees and chooses not to amend a method statement he shall write to the Engineer clearly stating his reasons.

No agreement by the Engineer of the Contractor's method statement shall relieve the Contractor of his obligation to do the Works safely and in accordance with the Specification.

A4.4 Subcontract orders (For supply)

Where the Engineer has approved the supply of Plant or execution of work by manufacturers or subcontractors proposed by the Contractor when tendering, such manufacturers or subcontractors shall not be changed without the prior approval in writing of the Engineer. A copy of every sub-order shall be sent to the Engineer at the time the order is placed, each clearly marked with the title of the project and the Contract number.

A4.5 Delivery and storage of plant

A4.5.1 Packaging and marking

Upon the successful completion of prescribed off-Site testing and inspection and prior to despatch from the place of manufacture, items of plant shall be thoroughly protected against

corrosion and incidental damage from any cause.

Items intended to be painted shall receive the treatment specified and all unpainted parts liable to corrosion (with the exception of the electrical equipment) shall be thoroughly coated with an easily removable, high melting point grease or other approved protective substance.

Electrical equipment shall be suitably protected against corrosion and incidental damage to the satisfaction of the Engineer. Temporary leads shall be fitted to electrical equipment to enable anti-condensation heaters to be energised when the plant is in store. The heaters shall be energised by the Contractor when conditions require.

Items shall be packed to withstand transportation and rough handling in transit. Packages shall be suitable for exposure to the atmosphere and storage in the open. The Contractor shall be responsible for items being packed to reach the destination undamaged. The Contractor shall provide all necessary packing, cases and crates, properly strengthened. All packing shall be non-returnable. Packages containing dangerous or breakable goods shall be packed and marked in accordance with any statutory rules and orders applicable. Crates and packages shall be correctly and adequately marked as follows:-

- Employer's name;
- Title of scheme;
- Title of contract;
- Contractor's name;
- Designation site and item number matching approved schedules;
- Commercial markings.

The Contractor shall keep the Engineer informed of the state of deliveries. The Contractor shall send by air mail copies of all shipping documents to the Employer and to the Engineer, in accordance with instructions to be issued to him from time to time by the Engineer. Shipping documents shall be accompanied by copies of test certificates as required.

A4.5.2 Delivery

The Contractor shall be responsible for safe delivery of items to Site. Delivery shall include:

- Obtaining the necessary permits for all plant and equipment from relevant Authorities;
- Loading and transporting items by whatever means, including insurances;
- Taking charge of items at the port of entry or rail or air terminal in India, including payment of all handling charges, off-loading at terminal points, reloading and transporting to the Site;
- Taking delivery of items at the Site, off-loading and temporarily storing in store buildings or under cover until they are required for installation in the Works.

The Contractor shall examine items to the extent possible at the port or air or rail terminal, and more thoroughly whilst taking delivery at the Site. If the Contractor discovers that any item of Plant has been damaged in transit, he shall forthwith inform the Engineer who will inspect and may give instructions for its disposal.

Any item condemned by the Engineer shall be immediately removed and replaced by the Contractor.

Items with short shelf-life shall be delivered in the shortest possible time before use with the Plant.

A4.5.3 Storage

The Contractor shall provide all facilities for the safe storage of all Plant as recommended by the manufacturer.

Stored items shall be laid out by the Contractor to facilitate their retrieval as required.

Stacked items shall be protected from damage as required. No metalwork shall be stacked directly on the ground.

Small items shall be held in suitable storage and shall be clearly labelled.

Items shall be handled and stored so that they are not subjected to excessive stresses and their protective coatings are not damaged.

The Contractor shall comply with manufacturers' recommendation concerning the use of lifting arrangements.

A4.6 Erection of Plant

A4.6.1 General

The Contractor's site personnel referred to in the Conditions of Contract shall include at least one approved skilled working supervising erector to supervise the erection of the Plant and enough skilled, semi-skilled and unskilled labour to ensure completion of the Works in the time required. The Contractor shall not remove any supervisory staff or skilled labour from the Site without the Engineer's approval.

Plant shall be erected in a neat and workmanlike manner on the foundations shown on the approved drawings.

Where the Works are associated with or in physical contact with plant supplied under a separate contract, the Contractor shall satisfy himself that the work carried out by the other contractor is consistent with the correct operation of the plant. If the Contractor considers any work being done or any work completed, to be detrimental to the plant, he shall report the matter at once to the Engineer.

The Contractor shall make all holes and openings in building structures required for fixing small plant items and shall provide any associated supports.

A4.6.2 Foundations

Foundations shall comply with the details shown on the approved drawings. Where floors and plinths require be cutting away and preparing to accept foundation bolts or mounting frames and plates, the approval of the Engineer shall be obtained before any work begins.

A4.6.3 Foundation bolts and fixings

The Contractor shall supply all anchor bolts, holding down bolts, fixing bolts, washers, nuts, straps, supports, brackets, spacers and fixtures, which are needed for the satisfactory installation of the Plant. All fixing anchors, nuts and washer shall be of grade 316 stainless

steel.

A4.6.4 Fixing to structures

No holes in concrete, brick, timber or structural steelwork for fixing devices shall be drilled without the prior approval of the Engineer. Holes shall preferably be made with a rotary drill of the non-percussion type. A single-shot cartridge tool may be used only at the discretion of the Engineer.

Any damage caused by the Contractor to any surface during erection shall be made good by the Contractor at his own expense to the satisfaction of the Engineer.

The Contractor shall be responsible for the provision of any scaffolding required and the cost shall be deemed to be included in the Contract Price.

A4.6.5 Plant protection on Site

Plant shall be adequately protected during and after installation against damage to finished surfaces and fitted components and against ingress of dust, moisture and the effects of humidity. Structural finishing operations may have to be done near installed plant before it is taken-over and the Contractor shall take this into consideration in complying with the requirements of this Clause. The cost of all protection shall be included in the Contract Price.

A4.6.6 Cleaning and preparing surfaces at Site

On arrival at the Site all Plant shall be examined by the Contractor and the Engineer for damage to protective coatings. Damaged portions shall be cleaned down, all rust removed by grit blasting, if instructed by the Engineer, and the coating made good with a similar paint within four hours of surface preparation.

After erection and building-in, appropriate items of Plant shall be thoroughly cleaned to remove all debris and filled where necessary.

A4.6.7 Protective coatings applied at Site

The Contractor shall apply the protective coatings for the Plant at Site in accordance with the protective treatment system approved by the Engineer.

The first in-situ coat shall be applied immediately the items of Plant have been erected and built-in.

Painting of Plant shall be completed not later than one month after the Plant has been taken over.

Before the end of the Defects Liability Period all damaged paintwork shall be touched up, except where the damage is due to fair wear and tear, and the cost of this shall be deemed to be included in the Contract Price. Where touching up is done, the result shall be uniform in colour with the original paint. If uniformity of colour is not achieved after touching up, to the Engineer's satisfaction, then the entire item shall be re-painted so that uniformity of colour is achieved. The cost of this work shall be deemed to be included in the Contract Price.

A4.6.8 Connection of electrical power

The Contractor shall check all items of electrical plant for correct phasing and insulation resistance. Motors shall be dried out in accordance with the manufacturer's instructions and

checks on the insulation resistance shall be made at regular intervals. Drying out shall continue until the insulation resistance reaches a steady value as recommended by the manufacturer. After all drying out and checking of insulation resistance is complete the Contractor shall check that all electrical connections to the plant are correct and any errors shall be brought immediately to the notice of the Engineer.

Electric power shall only be applied to any plant item after the individual tests specified for the plant have been done to the satisfaction of the Engineer.

A5.0 HEALTH, SAFETY AND WELFARE

A5.1 Applicable regulations, acts etc.

The Contractor shall comply with the relevant requirements of all local and the national health, safety and welfare acts and regulations issued by the Ministry of Labour (MOL).

Compliance with the requirements of acts and regulations by the Contractor shall not relieve the Contractor from responsibility for the safety of his workers and employees and those of his subcontractors.

A5.2 Failure to comply

In the event that the Contractor fails to comply with the requirements of the regulations or with the Specification in respect of safe working conditions or practices on the Site, the Engineer will have the authority to instruct the Contractor to stop work in any particular location until the unsafe conditions or practices have been rectified to the satisfaction of the Engineer. The Engineer will issue safety violation notices to the Contractor, informing him that he is working unsafely and describing the nature of the unsafe working practice, the time and date and the location. In this event, the Contractor shall be responsible for all costs and delays resulting from complying with such instruction by the Engineer and for the actual costs incurred on rectification of the unsafe conditions or practices.

A5.3 Contractor's health, safety, welfare and security implementation plan

The Contractor shall prepare and submit to the Engineer for review a Site implementation plan specific to health, safety, welfare and security practices of the work to be carried out under the Contract. The Contractor shall carry out all work on the Site in accordance with the agreed Site implementation plan. The Contractor's plan shall reflect the requirement of the local and national requirements. It will include a methodology for carrying out risk assessments by the Contractor where these are deemed necessary. The plan will be updated from time to time to reflect any significant changes to laws and regulations or site activities.

A5.4 Contractor's health, safety, welfare and security (HSWS) officer

The Contractor shall appoint a qualified and experienced HSWS officer for the duration of the Contract. The full time duty of the officer will be to implement the site implementation plan, to prevent accidents and enforce the requirements of legislation in force. The name and qualifications of the officer so designated shall be submitted to the Engineer by the Contractor for approval within two weeks of the commencement of the Contract. The officer shall attend full time on site during normal working hours and whenever work is in progress during out of hours working, public and national holidays approved by the Engineer and available by phone and mobile during non-working hours.

The Contractor shall engage senior site engineers and foremen that are properly trained in the application of correct Health and Safety practices. These individuals shall liaise closely with the HSWS to maintain safety on site at all times. The Contractor shall submit the details of the

Health and Safety qualifications of all such site personnel.

The HSWS officer will be responsible for ensuring all relevant information and posters are displayed at locations throughout the site in accordance with the site implementation plan.

The HSWS officer will be responsible for keeping a site accident book to record all site incidents or any major site rescue events. The book will be available for inspection by the Engineer or any MOL authorised person. Record keeping must also be maintained to comply with any other legal or regulatory requirements.

The HSWS officer will be responsible for ensuring that every site worker and regular visitor is given site HSWS procedure training when they first enter the site and refresher training at an appropriate frequency agreed by the Engineer. All occasional visitors will be trained on arrival and be provided with the appropriate personal, protective equipment. Records of the training will be kept and available for inspection by the Engineer.

A5.5 Contractor's health, safety, welfare and security committee

The Contractor shall set up a safety committee comprising his full-time HSWS officer, project manager, site engineers and foremen for the Contract. The committee shall meet weekly and minutes shall be recorded and a copy shall be submitted to the Engineer. The Engineer shall be invited to be present at the meetings.

The purpose of the meetings will be to discuss and resolve health, safety, welfare and security aspects of various parts of the work, including possible areas of conflict or difficulty. Where different contractors are working in the same area or adjacent areas, or where the work of one may impinge upon the work of another, the meetings will consider what action needs to be taken to ensure that each contractor is aware of the safety requirements of others.

A5.6 Site health, safety, welfare and security coordinator

The Employer may appoint a HSWS Coordinator with a brief to oversee the health, safety, welfare and security arrangements of the various contractors working on the Site, to liaise with the Engineer and to draw his attention to any breaches of Contract requirements or the approved safety plans of the Contractor.

A5.7 First aid facilities

The Contractor shall provide a complete approved first aid kit in his site office. The kit shall be in the charge of either the Contractor's HSWS Officer or some other responsible person who will also be on the site during all working hours to ensure that the first aid kit is available without delay. The Contractor shall also provide a first aid kit in the office for the Engineer. Kits shall also be provided at all remote sites. The HSWS Officer and adequate numbers of other senior members of the Contractor's staff shall be trained in occupational site first aid duties including resuscitation to take account of numbers of site workers located on the permanent site and mobile site operations.

The Contractor will make arrangements with the emergency and rescue services to provide adequate support where on site first aid assistance is inadequate to meet the welfare requirements of all site workers.

The Contractor shall comply fully with all rules and regulations from time to time issued and

orders given by the Health Service of the Government or the local medical or sanitary authorities.

A5.8 Overhead hazards

Overhead protection shall be provided at any location where there is a hazard of falling objects. This shall particularly be observed around any scaffolding and in excavations.

'Goalposts' shall be erected beneath all overhead lines to prevent the arms or jibs of plant from approaching such lines. No plant shall be trafficked beneath overhead lines until the Engineer has inspected and approved the erected goalposts.

A5.9 Excavations or underground hazards

Every excavation or underground space into or through which a person may fall shall be covered by a temporary cover fixed securely in position or guarded by an effective barrier to prevent falls except where free access is required by work actually in progress. In such a case where work is in progress, the barrier shall be maintained in position to the extent possible, and suitable warning signs shall be erected.

A5.10 Drowning hazards

Where the work involves filling tanks with water leaving an open surface, the Contractor shall provide at all times and at suitable locations equipment for promptly rescuing persons from the water and resuscitating rescued persons. The Contractor shall take all necessary steps to prevent any such accidents occurring by providing adequate guarding.

A5.11 Slipping hazards

The Contractor shall not suffer or permit an employee to use a passageway, or a scaffold, platform or other elevated working surface which is in a slippery condition. Oil, grease, water and other substances causing slippery footing shall be removed, sanded or covered to provide safe footing.

A5.12 Tripping hazards

All passageways, platforms and other places of work shall be kept free from accumulations of dirt and debris and from other obstructions that may cause tripping. Sharp projections shall be removed or covered.

A5.13 Access to workplace

Temporary stairways, ramps or runways shall be provided as the means of access to working levels above or below ground except where the nature or progress of the work prevents their installation, in which case ladders or other safe means shall be provided. The Contractor shall not assume that access arrangements provided by the Employer will necessarily remain in place after the time that the Contractor commences work in a particular area.

A5.14 Dust and gases

Dust and gases shall be controlled by ventilation or otherwise so as to prevent concentrations tending to injure health or obstruct vision or from exceeding safe levels.

A5.15 Hazardous and corrosive substances

All alkalis, acids, gases and other hazardous and corrosive substances shall be so stored and used so as not to endanger employees in accordance with national and state regulations. Suitable protective equipment for the use of such substances shall be provided. Clean water supply shall be readily available for washing off any spillage of any corrosive substance on the

employees.

A5.16 Eye and ear protection

Suitable eye protection equipment shall be provided for and shall be used by employees while engaged in welding or cutting operations or in chipping, cutting or grinding any material from which particles may fly, or while engaged in any other operation which may endanger the eyes. The Contractor shall ensure that fully equipped eye washing facilities are available on permanent and mobile site locations. Ear protectors shall be made available for employees when operating noisy machinery.

A5.17 Respiratory and resuscitation equipment

Where required the Contractor shall provide sufficient numbers of respiratory equipment and the employee shall be trained to use respiratory equipment suitable for the type of operation for which it is to be used. The Contractor shall maintain such respiratory equipment in good condition and shall furnish the means for its continued efficient working condition. The Contractor shall provide regular inspection, cleansing and sterilisation of such equipment. Such equipment, when not in use, shall be stored in an accessible, closed container.

The respiratory equipment shall be either of the escape set type, where it is provided for possible emergency use, or working sets where work has to be carried out in conditions where toxic gases are present or where there may be a deficiency of oxygen identified by the HSWS officer or his appointed staff when a risk assessment is undertaken prior to a site operation commencing. Risk assessments will be available for inspection by the Engineer immediately on request.

All persons who may be required to use such equipment shall be adequately trained and shall have certificates to that effect. Individual certificates will be available for inspection from all authorised workers by the Engineer.

A5.18 Work in confined spaces

Where work is required to take place in a confined space, defined as an enclosed space or excavation with limited access and where there is no natural ventilation, the Contractor shall provide equipment for monitoring the quality of the atmosphere within the space. The equipment will be calibrated to occupational standards to measure the range of gases and atmospheres identified as part of the risk assessment undertake prior to entry. The equipment shall be used to check the atmosphere before personnel enter, and shall remain in place while work is in progress to ensure that the confined space is free of harmful or noxious gases. The Contractor shall not permit anyone to enter or work in a confined space, including personnel from other contractors, the Engineer staff or the Employer's staff if harmful or noxious gases are detected. Any personnel inside shall be evacuated immediately.

Prior to the commencement of the work, the Contractor will document a safe system of work which will be available for inspection by the Engineer.

All personnel working in such conditions shall be provided with escape sets. The Contractor shall provide a "top-man" who shall be stationed immediately outside the entrance to the confined space, and who shall maintain communication with personnel working inside the confined space. In the event of a transverse entry, this may require additional personnel to be used to facilitate a reliable line of communication if evacuation has to take place.. The top man shall have the means to raise the alarm in case of any emergency inside the confined space.

The Contractor shall provide adequate ventilation for workers carrying out work inside a confined space, pipeline or chamber or other enclosed areas by using blowers or other suitable means.

A5.19 Personal protective equipment (PPE)

Every site worker and visitor shall be provided with a full set of personal protective equipment for use at all times including a luminous vest, helmet of a type tested and approved by the MOL, steel toe-capped boots, gloves and other specific work related clothing offering ear and eye protection. All site workers and visitors shall be required to wear PPE while working on the Site, except in the Engineer's and Contractor's office. The Contractor shall display a notice on the access to the site stating that entry is for authorised personnel only, and that PPE is to be worn at all times.

Every employee required to work in water, wet concrete or other wet footing shall be provided with suitable safety, waterproof boots.

Every employee required to use or handle alkaline, acid or other corrosive substances shall be provided with appropriate PPE.

A5.20 Electrical hazards

Before work commences, the Contractor shall ascertain by inquiry or direct observation, or by instruments, where any part of an electric power circuit exposed or concealed is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact therewith. The Contractor shall post and maintain proper warning signs to his employees of the location of such lines, the hazards involved and the protective measures to be taken and shall, if practicable, de-energise the electric power circuit.

The Contractor shall not suffer or permit an employee to work in such proximity to any part of an electric power circuit that he may contact the same in the course of his work unless the employee is protected against electric shock by de-energising the circuit and earthing it or by guarding it, by effective insulation or other means acceptable to the Engineer. The location of underground powerlines that encroach on the Works shall be confirmed using cable detectors, the path of the cable shall be clearly marked. If such cables are adjacent to excavations, the cable location shall be confirmed by finding the cable using carefully controlled hand-dig methods under the supervision of a senior member of the Contractor's staff. No live cables shall be retained within working trenches or other excavations. Any such cables shall be diverted prior to excavation commencing. The Contractor shall at all times liaise with the local electricity supplier with regard to the locating and diverting of any supplies.

A5.21 Power driven saws, abrasive wheels and grinders

All portable power-driven hand operated saws, abrasive wheels and grinders shall be equipped with guards above the base plate which completely protects the operator from contact with the saw blade when in motion and with self-adjusting guards below the base plate which completely covers the saw to the depth of the teeth when the saw is removed from the cut.

A5.22 Public vehicular traffic

Whenever any work is being performed over, on, or in proximity to a highway or any other place where public vehicular traffic may cause danger to men at work, the working area shall be so barricaded as to direct traffic away from it or the traffic shall be specially controlled by persons designated for that purpose.

A5.23 Site traffic

All vehicles used at the worksite must be roadworthy and registered with the appropriate authority. No person shall drive a vehicle at the worksite unless they are a holder of the appropriate driving licence or certificate.

A site internal access management system including all appropriate road signs will be submitted by the Contractor to the Engineer for approval at the commencement of the Contract.

A5.24 Stability of structures

No section of the plant or other structure or part of a structure shall be left unguarded in such condition that it may fall, collapse or be weakened due to wind pressure or vibration.

A5.25 Storage of materials and equipment

All materials shall be stored or stacked in a safe and orderly manner so as not to obstruct any passageway or place of work. Material piles shall be stored or stacked in such a manner as to ensure stability. Hazardous materials shall be stored in secure areas and the HSWS shall maintain an up-to-date list of the persons with a key to those areas.

A5.26 Disposal of debris

Debris shall be handled and disposed of by a method which will not endanger persons. Debris shall not be allowed to accumulate so as to constitute a hazard.

A5.27 Excavations

No employee shall be permitted to enter any excavated area, including areas excavated by other contractors on the Site, unless sheet piling, shoring or other safeguard that may be necessary for his protection is provided. In most cases, excavations will be considered to be confined spaces and the appropriate procedures followed.

Where any employee in an excavation is exposed to the hazard of falling or sliding material from any bank or side more than 1.5 m high above his footing, adequate piling and bracing shall be provided against the bank or side to eliminate such hazard. The excavation and its vicinity shall be checked by a designated person after every rain, storm or other hazard-increasing occurrence and the protection against slides and cave-ins increased if necessary.

Shoring adequate to support the overhanging material shall be provided where banks are undercut.

Excavated material and other superimposed loads shall be placed at least 1 m back from the edge of open excavations and trenches and shall be so shored or retained that no part thereof can fall into the excavation, or cause the banks to slip or cause the upheaval of the excavation bed. Banks shall be stripped of loose rock or other materials which may slide, roll or fall upon persons below.

Open sides of excavations where a person may fall more than 1.5 m shall be guarded by adequate barricades, and suitable warning signs shall be put up at conspicuous positions. No employee shall be allowed to work where he may be struck or endangered by an excavating machine with which his activity is not directly related.

A5.28 Ladders, step ladders and access platforms

Every ladder, step-ladder and access platform shall be of good construction, sound material and adequate strength for the purpose of which it is used. Ladders, step-ladders and access

platforms shall not stand on loose bricks or other loose packing, but shall have a levelled and firm footing. Ladders of over 2m in height shall be securely tied to the structure it is propped against. Free-standing, portable ladders over 4m in height shall not be used.

A5.29 Working at height

All site workers who work at height shall be provided with appropriate PPE to prevent an accident by slipping or falling.

A5.30 Positioning of machinery

No person shall be permitted to position or operate machinery in a manner likely to endanger himself or others.

A5.31 Fixed and mobile cranes

Fixed and mobile cranes shall be so constructed, positioned and operated as to be stable. No crane shall be loaded beyond the safe working load except by an approved person or an inspector for the purpose of testing such machine.

Every crane including all blocks, shackles, sheaves, wire ropes and the various devices on the mast and jib shall be thoroughly inspected by an approved person at intervals not exceeding 12 months. Cranes shall be inspected before being first erected or operated on each job or after any major repair. Inspection and repair of crane jib shall be made only when the jib is lowered and adequately supported.

Outriggers and counter-weights shall be provided and used as specified by the manufacturer of the crane or by an approved person. Counter-weights shall be properly placed and secured. Levelling jacks or other suitable means shall be provided and used with outriggers of truck-mounted mobile cranes.

Firm and uniform footing shall be provided for cranes. When such a footing is not otherwise supplied it shall be provided by substantial timber, or other structural members sufficient to distribute the load so as not to exceed the safe bearing capacity of the underlying material.

Every power-operated crane shall be provided with efficient brake or brakes or other locking devices which will prevent the fall of the load when suspended and by which the load can be effectively controlled whilst being lowered. Hand or foot-operated brakes shall be provided with a substantial locking device to lock the brake in engagement.

No load-bearing part of any crane shall be replaced by another part, and no such machine shall be modified by the addition thereto or removal therefrom of any load bearing part, unless the replacement or modification shall be certified by either the manufacturer or the approved person who tested the crane.

A capacity chart shall be provided for every crane. Such chart shall be posted and maintained in a place clearly visible to the operator and shall set forth the safe loads for various lengths of jib at various jib angles and radial distances. Where outriggers are provided such loads shall be set forth with and without the use of outriggers.

Unless furnished by the manufacturer or builder of the crane, a capacity chart shall be prepared and certified by an approved person. Cranes shall have audible overload warning alarms.

A crane shall not lift any load that exceeds the corresponding safe working load specified by

its capacity chart.

Every crane having a jib shall be provided with an accurate indicator which shows, clearly to the operator, the radius of the jib and the safe working load corresponding to that radius at all times and gives warning signal when the radius is unsafe.

Before hoisting any load at a new job site, the jib shall be operated to its maximum height.

Crane cabs shall be locked when the operator is not present and no unauthorised person shall enter the cab or remain immediately adjacent to any crane in operation. If locking of a crane cab is impracticable, the operating mechanism shall be locked as to prevent the crane from being operated by an unauthorised person.

No crane shall be operated in such a location that any part of the crane or of its load in any position of jib or swing may come within 3 metres of live power line.

All the lifting equipment used at site shall be registered with the appropriate GOI Ministry and shall have a valid certificate at the time of usage.

All crane operatives should be authorised to operate the particular type of fixed or mobile crane. Valid certificates will be available for inspection by the Engineer. All banksmen will be formally trained to undertake their duties and refresher training will be given at an appropriate frequency agreed by the Engineer.

A5.32 Attachment of loads

Where a sling is employed to hoist long-length material, a lifting beam shall be used to space the sling legs for proper balance. When load is suspended at two or more points with slings, the eyes of the lifting legs of the slings shall be shackled together and this shackle or the eyes of the lifting legs may be shackled directly on the hoisting block or balance beam. The eyes may be placed on the lifting hook without shackles if the hook is of the safety type.

Each container or receptacle used for raising or lowering filter media or other loose material of any kind shall be so enclosed, constructed or designed as to prevent the accidental fall of such material.

Crane loads shall be raised vertically so as to avoid swinging during hoisting.

No crane shall travel with a suspended load except upon a safe runway. During travel without loads, crane's falls shall be secured or placed so as to prevent accident or damage by swinging.

A6.0 SITE WORKS

A6.1 The Site

The 'Site' include the Contractor's works areas, the Engineer's compound within the Contractor's works area and any temporary working areas described herein.

Possession of the Site, or parts thereof, to be given by the Employer shall be subject to any restrictions mentioned in the Contract. The Contractor's attention is drawn in particular to the way in which site areas for *maintenance of* pipeline will be made available. This is detailed in the Particular Specifications.

The Contractor shall undertake a survey of the condition and provide detailed digital record photographs of the Site prior to commencement of any site works.

A6.2 Site road and access

Except as may be otherwise provided in the Contract, the Contractor shall arrange for maintain and afterwards remove and reinstate all temporary site roads and accesses required for and in connection with the execution of the Works. Reinstatement shall include restoring the area of such roads and accesses to at least the degree of safety stability and drainage that existed before the Contractor commenced work.

A6.3 Data for setting out the Works

Unless otherwise stated any levels and co-ordinates shown on the Drawings or given in the Specification are related to 'GTS' survey of India. Stated levels are given to AMSL (Above Mean Sea Level) with regard to GTS. The Contractor shall be responsible for checking any temporary benchmarks and other levels given on the Drawings or given in the Specification and providing copies of the survey data to the Engineer.

The Contractor shall carry out all survey and levelling work to establish reference points in order to fulfil his obligations under the Contract.

The Contractor shall provide all survey and measuring instruments of every kind necessary for his own use in the execution of the Works.

A6.4 Geological, hydrological and meteorological information

Any geological or hydrological information given hereunder or elsewhere in the Specification or shown on the Drawings is to assist the Contractor at the time of tendering. Such information shall be deemed to be information provided by or on behalf of the Employer under the Contract. The information is not warranted by the Employer or the Engineer and the Contractor shall make use of and interpret the same on his own responsibility.

Meteorological information of Dharmapuri is given in Appendix A-2 of the Specification.

A6.5 Special hazards

The Contractors attention is drawn to the following special hazard.

- Intense monsoon season rainfall, lightning storms and consequent flooding.

The above is an example only and is not necessarily complete. The Contractor shall be deemed to have made, before tendering, his own examinations and inspections of the site and all interpretations of all relevant climatic and physical conditions and their impact on the works.

A6.6 Existing services

The Contractor shall be responsible for the security of all water, electricity, telephone and other services, drains, pipes and other apparatus belonging to or under the control of any public authority, company or person, which may be, or be liable to be, interfered with, by or in connection with the execution of the Works. The Contractor shall be responsible for organising or providing any temporary or permanent service diversions. The Contractor shall fully indemnify the Employer against any claim, action, expense, loss, damage or injury arising in this respect.

The Contractor shall ensure that the location of all existing electrical cables is identified using proprietary cable detection equipment by personnel qualified to carry out such work.

The Contractor shall obtain copies of all up-to-date services records for the Site prior to commencing the Works.

A6.7 Amenities to be preserved

The Contractor shall cause the least possible interference with existing amenities, whether natural or man-made. No trees shall be felled except as authorised by the Engineer and clearance of vegetation of any sort shall generally be kept to the minimum necessary for the Works.

A6.8 Security on the Site

The Contractor shall provide, maintain and remove secure temporary fences of 2m height around works areas, storage yards and compounds. The Contractor shall submit details of the proposed temporary fencing to the Engineer for approval prior to any works.

Access into the Site will normally be restricted to employees of the Employer, the Engineer and his staff and the Contractor for the Works. Where one party wishes to bring visitors on Site, he shall discuss and agree any relevant procedures before such a visit takes place.

The Contractor shall be responsible for the security and safety of all his operations, including storage of his own materials, tools and equipment, protection of completed work in place, site offices and the like.

The Contractor shall allow for providing security guards on a 24 hrs basis for the Site. At any time there should be at least one guard per part of Site occupied.

A6.9 Work in public highways

Where any work is to be carried out in or adjacent to a public highway (which for the purposes of the Specification shall be deemed to mean any street, road or footpath maintainable at public expense), the Contractor shall comply with, among other things, any requirements and recommendations of the police or other authority regarding traffic safety measures for road works. The Contractor shall provide all necessary equipment and trained staff to operate any traffic control systems required by the regulatory authority. In the event that there is no guidance from a regulatory body the Contractor shall in any case provide at least 2.5m clear road width for one-way traffic and provide traffic control using trained operatives with 'Stop-Go' signs.

The Contractor's attention is drawn in particular to the procedure for obtaining the Site required to lay pipeline in or adjacent to public highways, detailed in the Particular Specifications.

A6.10 Access and trespass to adjoining property

If the Contractor's work will cause unavoidable interference with access to adjoining property the Contractor shall first give seven days notice in writing to the occupier of such property and shall provide temporary means of access for vehicles, animals and pedestrians.

In carrying out the Works due regard shall be paid to the amenities of adjacent property and to the interests of owners, tenants and occupiers. The Contractor shall take adequate steps to prevent trespass by his employees and shall be wholly responsible for making good any loss or damage caused by such trespass.

The Contractor shall take all necessary steps to ensure that the activities of his employees (and those of his subcontractors) do not have any detrimental effect on the surrounding environment.

A6.11 Claims for damage to persons or property (procedure)

Any claim received by the Employer in respect of matters in which the Contractor is required under the Contract to indemnify the Employer will be passed to the Contractor who shall likewise inform the Employer of any such claim which is submitted directly to him by a claimant. The Contractor shall do everything necessary, including notifying the insurers of claims received, to ensure that all claims are settled properly and expeditiously and shall keep the Employer informed as to the progress made towards settlement, failing which the Employer shall be entitled to make direct payment to claimants of all outstanding amounts due to them in the Employer's opinion and without prejudice to any other method of recovery to deduct by way of set-off the amounts so paid from sums due or which become due from the Employer to the Contractor. If the Contractor receives a claim which he considers to be in respect of matters for which he is to be indemnified by the Employer under the Contract, he shall immediately pass such claim to the Employer. All information as aforesaid shall be given in writing and shall be copied to the Engineer's Representative.

A6.12 Advertisements

The Contractor shall not except with the written authority of the Engineer exhibit or permit to be exhibited on the Site any advertisement board. Any such advertisement may also be subject to the approval of the local planning authority before it is put up and it shall be removed if the Engineer so demands.

Site sign boards shall be erected, typically of 2m x 1m, to bear the logos and text as specified by the Engineer. Costs shall be deemed to be included in the site establishment items in the Price Schedules.

A6.13 Site Welfare

A6.13.1 Sanitation

The Contractor shall maintain the Site and all working areas in a hygienic condition and in all matters of health and sanitation shall comply with the regulations of the local authority.

The Contractor shall be responsible for providing all sanitary services necessary to keep all offices and stores in a clean, neat and hygienic condition.

The Contractor shall provide all proper temporary sanitary facilities for the Contractor's employees and sub-contractors. The sanitary facilities provided within the Site shall be of the portable type. The Contractor shall provide septic tanks as necessary for the disposal of sewage on sites occupied for a long term. Waste water and septic-tank effluent shall

discharge into properly designed French drains. Where the construction of septic tanks or water-borne sewerage is not feasible, the Contractor shall construct conservancy tanks and arrange for the removal and disposal of sewage. All such arrangements shall meet all the requirements as stipulated by the local health authority and the Contractor's proposals shall be submitted to and approved by the Engineer.

In particular, the Contractor shall ensure that his employees (and those of his subcontractors) only use the toilet facilities provided by him as part of his site establishment. Any person found urinating or defecating elsewhere on the Site shall be removed from the Site immediately, and shall not be re-employed on the Site.

The Contractor shall also provide for the removal and legal disposal off the Site of all rubbish and solid waste from offices and other areas of the Site, with collections being made at least twice weekly.

A6.13.2 General Hygiene and medical examination of Contractor's employees

Before commencing work on the Site, the Contractor shall ensure that all his employees are instructed about the necessity for the prevention of pollution. The Contractor shall immediately dismiss and remove from the Site any of his employees or representatives who have been polluting or fouling the Site or any of the water supply installations and shall take appropriate remedial measures to prevent a repetition of the occurrence and to disinfect the areas concerned all to the satisfaction of the Engineer.

During commissioning and subsequent operations the Contractor shall not employ upon the Site, or on periodic visits thereto, persons who are known to have any disease which could be water-borne or who is suffering from an illness associated with looseness of the bowels or who are carriers of typhoid bacillus or other potential pathogenic organisms or who are otherwise unsuited on medical grounds to be employed in or around water supply installations.

The Contractor shall if and when required to do so, arrange for his employees to be examined and tested in the manner approved by the local medical officer.

The Contractor shall immediately remove from the Site any such employees who as a result of such examination and testing may in the opinion of the medical officer or the Engineer constitute a danger to water supplies or who refuse to undergo an examination.

A6.13.3 Works to be kept clear of water

The Contractor shall keep the Works well drained until the Engineer certifies that the whole of the Works is substantially complete and shall ensure that so far as is practicable all work is carried out in the dry. Trenches shall be kept well drained and free from standing water. All other excavated areas shall be treated similarly except where this is impracticable having regard to methods of Temporary Works properly adopted by the Contractor.

The Contractor shall construct, operate and maintain all temporary dams, watercourses and other works of all kinds including pumping and well-point dewatering plant that may be necessary to exclude water from the Works while construction is in progress. Such temporary works and plant shall not be removed without the approval of the Engineer.

The Contractor shall be responsible for the arrangements to keep the Works free of water notwithstanding any approval given by the Engineer concerning those arrangements. The Contractor shall make good at his own expense any damage to the Works that may be

attributable to water or flooding resulting from the inadequacy of the arrangements required under this clause.

The Contractor shall ensure that no areas of standing stagnant water are present at any time on the site, as these may form a breeding ground for malarial mosquitos. The Contractor shall ensure that his health and safety plan includes adequate measures to avoid attracting mosquitos and to deal with any such hazards if they should occur.

Costs incurred by the Contractor in complying with the requirements of this clause shall be deemed to be included in the Contract Price.

A6.13.4 Discharge of water and waste products

The Contractor shall make provision for the discharge or disposal from the Works of all water and waste products and the methods of disposal shall be to the satisfaction of the Engineer and of any authority or person having an interest in any land or watercourse where water and waste products are discharged.

A6.13.5 Dust hazard and nuisance

The Contractor shall take necessary measures including the spraying of water in order to keep down dust, which would otherwise be raised by the carrying out of the Works.

A6.13.6 Fire hazard (naked lights)

No naked light shall be used by the Contractor on or about the Site without written permission from the Engineer. If in the Engineer's opinion the use of naked lights may cause a fire hazard the Contractor shall at no extra cost to the Employer take such additional precautions and provide such additional fire fighting equipment (including breathing apparatus) as the Engineer considers necessary.

The term "naked light" shall be deemed to include open fires, electric arcs and oxy-acetylene or other flames used in welding or cutting metals.

A6.13.7 Water supplies

All water for use in the Works shall be fresh and free from harmful impurities, to the satisfaction of the Engineer. The Contractor shall make adequate arrangements to deliver sufficient water to the Site for drinking, washing, sanitation and general cleaning down, in addition to any required for the construction, erection, testing, setting to work, testing for performance and guarantees at Site, commissioning and maintenance of the Works.

A6.13.8 Environmental Monitoring Plan

The Contractor shall enforce an Environmental Monitoring Plan during the *maintenance* period and at the Defects Liability Period. During the *maintenance* period, the air quality, noise level, plantation conditions, borrow area management at each site shall be monitored *and be kept at the safe levels and maintained at the standards prescribed by the CPCB*. During the Defects Liability Period, the noise level at the potential noise generation plant, e.g. the pumping stations, shall be monitored. The measurements stated above, both at the *maintenance* and the Defects Liability Periods, shall meet the minimum frequency and duration as stated by the standards by the CPCB.

The Contractor shall be responsible for environmental monitoring at the sites of Package III only, whilst those sites at Packages I, II, IV and V where the Contractor has interface work there, the environmental monitoring work will be responsible by the respective contractors of these Packages. Notwithstanding to that, the Contractor shall be responsible for all the necessary rectification work should any non-compliance of any parameter, and the causes of such non-

compliances are identified to be the responsibility of the Contractor.

A6.14 Work in the vicinity of electrical equipment

Any permanent fencing or other safeguards to be erected around electrical equipment shall be completed as far as practicable before connection is made to the electricity supply. In so far as this is not practicable the Engineer's Representative may permit the use of temporary fencing or other safeguards.

If further work adjacent to electrical equipment is necessary after connection has been made to the electricity supply the Contractor shall put into operation a "Permit to Work" system to the approval of the Engineer.

A6.15 Electricity supplies

The Contractor shall install, operate, maintain and subsequently remove temporary supplies of electricity for the heating, lighting and ventilation of all offices, stores and other temporary buildings used by the Contractor and by the Engineer's staff in addition to any supplies he may require in connection with the construction testing and maintenance of the Works. Such electricity supplies may be obtained either from Tamil Nadu Electricity Board and backed up with diesel generating plant provided by the Contractor.

The Contractor shall, at his own expense, supply, install, maintain and remove on completion, a temporary site electrical distribution system including wiring, cabling and distribution boards for power services, welding, lighting and all other electrical requirements in a safe and efficient manner. The Contractor shall submit details of the proposed temporary electrical distribution system to the Engineer. The Engineer may require the disconnection or alteration of any part of the electrical distribution system which, in his opinion, is dangerous or otherwise unacceptable. The Contractor shall not remove any of the installation without the approval of the Engineer.

A6.16 Compressed air

The Contractor shall supply any necessary compressed air plant and equipment required for erection, testing and commissioning of the Works.

Diesel engine driven compressors shall not be sited within buildings or in a location that may cause a health hazard to personnel due to exhaust fumes.

A6.17 Cleanliness of the Site

The Contractor shall maintain the area of his operations in a clean, tidy and safe condition. All disused materials, packages and other debris in connection with the Works shall be removed expeditiously from the Site by the Contractor at his expense.

If, in the Engineer's opinion, at any time the Site or part of it are not sufficiently clean and tidy, the Contractor shall take all necessary steps to rectify the situation as directed by the Engineer. This shall be done at the Contractor's own cost

A6.18 Contractor's offices etc

For the use of his own staff and work force the Contractor shall provide, erect, construct, maintain and subsequently remove all temporary offices, sanitary arrangements, stores, workshops, compounds, parking areas and the like necessary for the completion of the Works and maintenance of the Permanent Works and the siting and layout of these shall be to the approval of the Engineer. The Contractor may if he chooses, include a workers canteen within the Contractor's office and storage compound. The Contractor shall not erect labour lines and canteens elsewhere on site. Details and layout of such buildings and services shall be to the

general approval of the Engineer's Representative and the Contractor shall also obtain any necessary approval from any local or other authorities concerned.

The Contractor shall maintain all offices, buildings, tanks etc referred to in this and other clauses in good condition.

A6.19 Equipment for use by the Engineer and his staff

The contractor has to provide the equipment as entered in the table below for the use by the Engineer and the Engineer's Representatives. Should any of the equipment could not be used due to normal wear or failed to function as a result of equipment defect during the course of the Contract period, the Contractor shall replace the defective equipment for the Engineer and the Engineer's Representative.

All the equipments entered in *the table* shall be submitted to the Engineer for approval immediately after the award of the Contract and shall be available within 2 weeks after approval to the proposal is granted by the Engineer.

As a minimum the following equipment shall be provided.

Item	Quantity
Safety Helmets	10 Nos
Fluorescent safety vests	10
Plastic safety glasses	5 pairs
Disposable earplugs (replaces as used)	20 pairs
Automatic level and tripod	4
Plastic coated tapes 100m length	1
Plastic coated tapes 30m length	2
Steel tapes 5m length	3

A7.0 NOT USED

A8.0 PROGRAMME OF WORK

(For variation works to be carried out in future due to the infrastructure developmental activities by other Departments such as road widening and allied activities, programme shall be submitted by the Contractor as specified below)

In preparing the programme the Contractor shall take into account any restrictions on possession of the Site or of Temporary Working Areas imposed by the Contract.

The Contractor shall also take account of the availability dates for the different portions of the site.

The programme shall be presented as a Critical Path Network, together with Gantt charts. Particulars to be shown on the programme shall include:

- Submission of designs, drawings and documents.
- Engineer's approval procedures/review procedures
- Re-submission of drawings etc as necessary and review
- Civil construction of each major structure
- Placing of orders for Plant
- Plant manufacture
- Plant tests at place of manufacture
- Plant deliveries to Site
- Plant erection
- Plant tests at Site
- Tests on completion (commissioning tests)

The programme shall make reasonable allowance for any work to be carried out by other contractors employed by the Employer. The Time for Completion of the Works and Sections thereof shall correspond to the periods prescribed in the Contract.

Approval of the Contractor's programme by the Engineer shall not relieve the Contractor of his duties and responsibilities under the Contract.

The programme shall be updated and when requested by the Engineer to show actual progress and any revisions necessary to achieve completion.

A8.1 Times for Completion and damages for delay

Times for Completion and amounts of liquidated damages for delay for the Works are detailed in *Volume 1 Clause*.

A8.2 Taking over certificate

No taking over certificate shall relieve the contractor of any of his obligations in connection with other contractors whose work might be carried out subsequent to the issue of such a certificate.

A8.3 Measurement for payment

All work to be done and goods and services to be provided by the Contractor under the Contract and other general obligations of the Contractor shall be valued for payment by reference only to such items as are provided therefore in the Bill of Quantities/Schedule of Prices and (where permitted by the tendering procedure) to such further items as may have been added thereto by the Contractor when tendering. The cost of any work, goods, services and general obligations as aforesaid which are not so itemised shall be deemed to be included in the rates and prices for other items in the Bill of Quantities/Schedule of Prices.

A9.0 DRAWINGS AND DOCUMENTATION FOR PLANT

A9.1 Drawings furnished by the Employer

Drawings submitted as part of the Employer's Requirements are shown in *Volume 5*.

A9.2 The Contractor's Documents

A9.2.1 General

Clauses below describe the various engineering documents to be submitted by the Contractor to the Engineer and the procedures for submitting and obtaining approval of them (*if required for the works that may not be anticipated and has to be carried out during O&M*).

A9.2.2 Design

The Contractor is responsible for providing design

Such design shall include all necessary studies, surveys and investigation, temporary works designs and drawings, functional plans and general designs, diagrams, detailed designs and working drawings together with any and all other studies, investigations, computations, analyses and evaluations necessary to comply with the requirements of the Specification.

Functional plans and designs shall be based on the proposals submitted with the Contractor's Tender, subject to such modifications as the Employer and the Engineer may require under the terms of the Contract.

All designs, drawings and documents relating to design shall be submitted by the Contractor to the Engineer for review and approval in accordance with the Condition of Contract. Submissions shall be accompanied by corroborative information and computations as necessary to enable the Engineer to check the Contractor's designs.

All submissions shall be in English.

The Contractor shall be fully responsible for the content of all submissions to the Engineer irrespective of the source or origin of information contained in such submissions. All submissions irrespective of the source or origin of information shall be checked by the Contractor and endorsed as such before submission to the Engineer. The Engineer will not accept submissions for review unless these requirements have been met.

Approval by the Engineer of a submission by the Contractor shall mean that the Engineer has no objection in principle to the content of the submission, drawings, calculations, certificates samples and the like and that the Engineer finds the content of the submission good enough to allow the work relating to the submission to proceed. Approval by the Engineer shall not relieve the Contractor of his responsibility under the Contract. Approval will be given only on the basis of information available at the time to the Engineer on the understanding that subsequent events may require withdrawal or modification of such approval.

Review of designs, drawings and documents by the Engineer shall mean review in principle only and not verifying every dimension and detailed matter.

The Contractor shall carry out the Works only in accordance with designs, drawings and documents that have received the Engineer's approval.

A9.2.3 Documents in electronic format

All documents submitted for approval shall be provided in both electronic format as well as paper copies of sufficient number as specified elsewhere. Each electronic submission shall be provided on read/writable CD clearly marked with the project title, submission reference and a

description of the contents.

The Contractor shall provide the following electronic formats as a minimum:

Word-processing documents	- Microsoft Word
Spreadsheet documents	- Microsoft Excel
Databases	- Microsoft Access
Programme of works	- Suretrak
Drawings	- Autocad in dwg or dxf format

The Contractor shall submit details of the proposed software versions for the Engineers approval. As well as the above electronic documents, the Contractor shall submit a pdf/html copy version of all documents on the CD.

A9.2.4 Drawing standards

Drawings submitted by the Contractor shall be clearly printed with black lines on white paper, and shall be resistant to fading on exposure to light.

Prints shall be on durable paper of good quality and 80g/m² minimum weight.

Sheet sizes shall be in accordance with A series to ISO 216, and be A1 size unless otherwise stated in the Contract or agreed with the Engineer.

All drawings submitted by the Contractor shall use the English language and SI units.

All drawings shall be clearly and fully cross referenced to the Specification and the Engineer's Drawings as relevant.

Where drawings are revised, the revision letter or number shall be incorporated in the title block and the revision shall be clearly indicated on the drawing with the revision letter or number shown in an adjacent triangle.

All drawings shall also be submitted in electronic format and on CD-ROM in a format which is fully compatible with Autocad Release 2008 for Windows in a .dwg or .dxf format. When drawings are revised, this shall be done electronically and not manually, and CDs containing the revised files of all drawings, which have been supplied in electronic format, shall be submitted at the same time as the paper prints.

A9.3 Production, submission and approval

The production, submission and approval procedure for designs, drawings and documents shall comply with the following requirements:-

A9.3.1 Meanings

The following meanings shall apply:-

- "Preliminary drawings" means drawings which the Contractor submits to the Engineer for approval and any drawings returned by the Engineer marked "Preliminary" or not marked "Approved".
- "Approved" drawings means drawings which the Engineer so endorsed accordingly and returned to the Contractor. Approved in this context means that the work described thereon may proceed as long as it complies with the Contract.

- "Preliminary" and "Approved" as applied to designs and documents shall have the same meanings as applied above to drawings. A drawing which forms part of an "Approved" design or document shall not be an "Approved" drawing unless it has been so marked.

Approval to a design, drawing, or document may be partial or conditional. Such documents will, for example, be marked "Approved in respect of.....certain parts...." or "Approved subject to..... actions to be taken by the Contractor before the work described can proceed.....". In such instances the Contractor shall carry out the Works only in accordance with approved parts or after the conditional actions have been carried out and confirmed to the Engineer in writing.

A9.3.2 Form of drawings

Every drawing shall have a title box in the bottom right corner showing:-

- Employer's name;
- Title of scheme;
- Title of Contract;
- Contractor's name;
- Title of work location;
- Title of drawing;
- Drawing number;
- Date;
- Author;
- Signature of Contractor (to the effect that the drawing, whether his own or from any other source, has been checked by him before submission to the Engineer;

Each drawing shall also have a separate revision box with space for up to 10 revisions, and including revision number, revision date, revision description and revision check. It shall also include adequate clear space for the Engineer's markings.

Drawings submitted for approval shall bear the word 'PRELIMINARY' either as an electronic watermark or as an ink stamp. Drawings submitted as record drawings shall bear the word 'RECORD' in similar fashion.

Drawings shall be drawn to specified scales or to such scales as are appropriate for clearly detailing and conveying the Contractor's proposals. Scales shall generally be 1:2, 1:5, 1:10 or multiples of 10 thereof. The appropriate measuring scales used shall be shown on the drawings.

Drawings shall include cross references where appropriate and key information such as vital levels and dimensions. All plans shall show the "north" direction. All drawings shall clearly indicate the level datum used and its value.

The Engineer will not approve any unclear or ambiguous drawings.

A9.3.3 Form of designs and documents

Designs and documents submitted by the Contractor to the Engineer for approval shall generally include:-

- Contents list;
- Scope (description of the contents and purpose of the submission);
- Conclusions and recommendations;
- References, Specification requirements, codes, manuals and supporting documents used, drawing numbers, and titles of drawings which are based on the design;
- Description of design approach;

- Criteria, parameters and methods used;
- Test procedures, analyses and results;
- Calculations and schedules;
- Qualitative description and comments on results;
- Any other relevant information;
- Appendix.

Designs and documents shall be presented on A4 size paper with every page numbered and bound in order between covers formed of a transparent front and stiff back. The title of the submission shall be given on the front sheet beneath the transparent cover together with a reference number, Employer's name, title of scheme, title of Contract, Contractor's name, title of works location, author's reference, date, Contractor's signature, revision box and space for Engineer's markings as for drawings and any other relevant information. Drawings submitted as part of the design or document shall be folded into pockets at the back.

A9.3.4 Numbering and titling

The Contractor shall institute a reference numbering system for designs, drawings and documents so that each number used is unique. The numbering and title information on designs, drawings and documents shall be designed so that management, transmittal and communication in connection therewith can be carried out expeditiously. The Contractor shall submit to the Engineer for approval, a comprehensive register of the Contractor's Documents he intends to submit prior to the submission of any drawings for approval.

A9.3.5 Submission procedures

Every drawing submitted by the Contractor to the Engineer for review and approval shall be based on previously approved designs or documents. Interrelated drawings shall be submitted at the same time in a complete and self-sufficient set. Copies shall be collated into ordered bundles each with a list of contents and accompanied by a letter from the Contractor (not from subcontractors or suppliers). Revisions of previous submissions shall be highlighted and the reasons for these shall be stated in the covering letter.

All designs, drawings and documents submitted by the Contractor to the Engineer for approval shall be checked by the Contractor before submission. The Contractor shall likewise check submissions from his subcontractors or from any other source before passing on such submissions to the Engineer for approval.

On completion of checking, the Engineer will return the submission with one of the following comments:-

"Approved"	to allow work to proceed;
"Approved subject to"	to allow work to proceed subject to stated amendments and conditions;
"Not Approved"	revised submission required to include stated requirements.

Drawings with "Not Approved" and "Approved subject to" statuses shall be revised and re submitted within a maximum of 14 working days from the date of return.

Subject to any specific requirements in the Contract, all submissions shall be made sufficiently early to allow the Engineer time for review and approval, and for the Contractor to provide and submit revisions or alternatives.

Unless otherwise specified or agreed before submission, the Contractor shall allow not less

than 14 working days excluding week ends and public holidays for review by the Engineer of designs documents and samples which are required to be approved and 10 working days for review of re-submissions before manufacture or construction commences as part of the Works. The Contractor shall have demonstrated in his submissions that he has coordinated submissions by his subcontractor or suppliers to confirm that the Contractor is satisfied that they are acceptable for incorporation into the Works.

If the Engineer does not respond to any submission within the specified number of days, then the Contractor may proceed with the work but shall inform the Engineer in writing that he is proceeding with the work. Absence of response from the Engineer will not relieve the Contractor of his obligations to meet all the requirements of the Specification.

The Engineer will designate the address of his review office in respect of particular disciplines or work from time to time during the Contract. All submissions shall be made sufficiently early to allow the Engineer time for review and approval of drawings, documents and samples which are required to be approved before commencement of manufacture of plant or of installation or construction on site as the case may be and for the Contractor to provide and submit revisions or alternatives, or carry out further tests if, in the opinion of the Engineer, the initial submissions do not meet the requirements of the Contract.

Whichever status - "Approved", "Approved subject to" or "Not Approved" the Engineer assigns to any particular drawings designs or documents submitted for his review, will be based on the information provided in the submitted drawings designs or documents. It shall be the responsibility of the Contractor to ensure that all relevant information is provided to enable the Engineer to easily determine whether or not a submitted design complies with the specific requirements or intent of the Specification. Where the Engineer assigns an inappropriate status due to lack of clarity or incomplete or incorrect information submitted by the Contractor, this shall not relieve the Contractor of his obligations to provide the Works in compliance with the Contract. Any costs for abortive works or redundant equipment provided as a result of such situations shall be borne by the Contractor.

A9.3.6 Programme of submissions

In addition to showing the submission of designs, drawings and documents on his programme for the works, the Contractor shall submit a specific programme for submitting designs, drawings and documents to the Engineer for approval. The programme shall provide for the Engineer's review of the Contractor's submissions to be undertaken at a reasonably steady rate of working. The programme shall also make reasonable provision for re-submission of not approved designs, drawings and documents and for the time needed to transmit such designs, drawings and documents. No designs, drawings and documents will be accepted by the Engineer for review until the programme for their submission has been approved by him.

The Engineer may withdraw or modify his approval to an "Approved" design drawing or document as a result of subsequent submissions. In this circumstance, he will inform the Contractor in writing of the withdrawal or modification and, upon receipt of such information, the Contractor shall immediately take the necessary action in regard to the Works and confirm this to the Engineer in writing.

Where appropriate and as agreed between the Engineer and the Contractor drawings may be submitted in stages of development so as to allow certain milestones to be achieved or certain elements of the work to be started.

A9.3.7 Copies for Approval

The Contractor shall submit to the Engineer for approval five copies of all submissions. Only one copy generally will be returned to the Contractor.

A9.3.8 Copies of Approved Contractor's Documents

After approval, the Contractor shall submit to the Engineer three copies of all "Approved" drawings with the date of approval marked on the reproducible against a new revision/issue of the document. Three copies of all "Approved" designs and documents shall also be submitted.

A9.4 Definition of working days for approval of submissions

In the context of time for approval by the Engineer of submissions by the Contractor, and for no other, "working days" shall mean Monday to Friday in each week, and shall exclude any public holidays in Tamil Nadu. The number of working days shall be counted from the next working day following the day of delivery to the office of the Engineer until the day before the day of despatch from the office of the Engineer to the Contractor.

A9.5 Working drawings

A9.5.1 Plant working drawings

Drawings for all items of plant constituting an operating system shall be submitted to the Engineer concurrently and shall include diagrams showing circuit functioning and details for erection.

Plant working drawings prepared by subcontractors and manufacturers employed by the Contractor shall be checked by the Contractor for accuracy and compliance with the Contract as specified, before being forwarded to the Engineer. Working drawings, not so checked and noted, will be rejected and returned to the Contractor without further examination.

Working drawings for chemical, process, mechanical, electrical, instrumentation and similar plant shall include but not be limited to:-

- Single line diagram for electrical distribution system from point of supply to final plant connection;
- General arrangement drawings of the Works fully developed to show Plant layout and dimensions;
- General arrangement drawings for all items of Plant, drawn to scale, fully dimensioned and showing weights, foundation details and all clearances required for installation, operation and maintenance;
- Fascia layout drawings of switchboards and instrumentation and control panels showing controls, instrumentation, mimics and inscription details of all labels;
- Electrical block, circuit and wiring diagrams for switchboards and control boards;
- Supplementary block, circuit and wiring diagrams for integrated control, protection, metering and other schemes as required for a complete understanding of the Contractor's proposals;
- Instrument configuration loop drawings which shall identify each element and its location, all wiring and cable connections, and all inputs to and outputs from programmable devices. The drawings shall be prepared on A3 size sheets and presented in book format;
- Block diagrams to show power, control and instrumentation cabling systems with each cable, cable core and associated equipment terminals identified as in the cable schedules;
- Installation drawings showing cable routes and cable support system details. For cables installed in ducts and direct in the ground, the drawings shall include sections to show

- their disposition and the position of all marker posts, cable joints and drawpits;
- Cable schedules, which shall include the cable number, type, voltage, conductor size, number of cores and route length;
 - Cable termination schedules for all power, control, instrumentation and data cable showing all details of the cable schedule and also incorporate cable core ferrule and equipment terminal numbers and the diagram number(s) of connected equipment;
 - Single line diagram showing the electrical system neutral earthing, earth terminal(s) and electrode(s), and all circuit protective and equipotential bonding conductors;
 - Earthing installation layout showing conductor routes and the location of earth terminal(s), test links, earth electrodes and associated connecting chambers;
 - Earth terminal general arrangement;
 - Lightning protection system installation drawings showing air termination details, the location and route of down conductors, the location of bonds, test points and earth electrodes, and the location of bonding points in reinforced concrete structures;
 - Building services installation drawings showing the location of distribution boards, luminaries, socket outlets, heaters, ventilation fans and ductwork, air conditioning units, fire detectors and manual call points, intruder alarm switches and detectors, alarm sounders etc, and associated switches, thermostats, control panels and distribution board diagrams and/or schedules;
 - Fabrication and installation drawings for metalwork including platforms, floor plates and frames, hand railings etc;
 - Complete and detailed schedules listing all items of plant, instruments and ancillary equipment to be supplied by the Contractor;
 - List of safety signs and drawings;
 - Any additional drawings required to supplement those identified above and for other work not specifically identified;
 - Instrument Schedule shall list all instrumentation items (including actuated valves) area by area in loop number order. For each instrument item the Instrument Schedule shall as a minimum list the size, make, exact model, P&ID reference, range and calibration, loop diagram reference, service description, and location drawing reference;
 - PLC / Control System I/O (Input / Output) Address Schedules & Fieldbus / Modbus or other communication protocol segment assignment lists shall list all inputs and outputs to the PLC / control system. I/O shall be listed in address order, and grouped into cards or module blocks if applicable. For each address record, the tag number and service description of the connected device, the I/O type (4-20 mA analogue input, 24 V DC digital output, fieldbus / modbus or other communication protocol etc), the loop diagram/ fieldbus / modbus or other communication protocol segmentation drawing reference and the P&ID reference shall be listed. In the case of analogue parameters the corresponding range in engineering units shall also be listed. Eg 4-20 mA = 0 – 100 l/sec. Spare registers assigned for analogue and digital signals and fieldbus/modbus or other communication protocol data shall also be listed;
 - Instrument Datasheets shall be supplied for each instrument, identified by instrument tag number. The datasheet shall list all information required to replace and re-commission the instrument in the event of damage or failure. This shall include the final settings of all setup parameters stored in the instrument and process conditions (pressure, temperature, flow and other applicable variables);
 - ICA Panel Layout Drawings for each different panel or junction box a detailed drawing of both the internal and external layout shall be provided. Drawings showing the internal layout shall clearly show how segregation of 230 V AC and 24 V DC wiring has been achieved within the panel. Field connection boxes used solely to terminate flying leads to cables shall not require layout drawings. In the case of multiple identical junction boxes or field motor stop / start stations, a single typical panel layout drawings shall be

- acceptable provided such drawings are clearly labelled as to all the panels they describe;
- Panel Power Distribution Drawings shall clearly show the distribution of power at different voltage levels within each panel. Drawings should be specific including showing which items are supplied from each fuse or MCB. The drawing shall also show the instrument earth connection arrangements;
 - Instrument Location Drawings for all instruments (including control valves) shall show the location (identified by tag number) of every instrument. The location drawings shall also show the location of major equipment items and routing of main cable trays and ducts. In plant areas where a fieldbus/modbus or other communication protocol is being used, the instrument location drawings shall show the fieldbus/modbus or other communication protocol segmentation;
 - Instrument Loop Diagrams showing all connections, cables, terminals etc for all devices carrying the same loop number shall be provided for each loop connected using conventional wiring. The instrument loop diagram shall provide all information required to troubleshoot a loop ie. A technician shall be able to trace the electrical signal from field instrument through any junction boxes and signal isolators to the input terminals of a controller, any power supplies shall also be shown. The requirement for loop diagrams is not limited to closed-loop analogue control loops but applies to all instruments and fold devices. These shall be A3 size drawings;
 - Fieldbus/Modbus or other communication protocol Segment Drawings shall be provided for each fieldbus/modbus or other communication protocol segment. It shall show the general segment topology and details of devices on that segment. In addition it shall show design constraints such as segment and spur length, voltage drop and current draw, loop execution requirements, and placement of power supplies, power conditioners, and terminators;
 - Instrument installation, wiring and piping hook-up drawings, where applicable, shall be submitted. These shall be detailed in every respect;
 - I/O Connection Diagrams for control system I/O connected to non-field devices (eg to MCC's), connection diagrams meeting the same requirements as Instrument Loop Diagrams shall be provided.

A9.6 Record drawings

The Contractor shall provide record drawings to show the Plant as installed and incorporating any modifications made during erection and commissioning.

Information given on record drawings shall include tolerances, clearances, loadings, finishes, materials and ratings of plant. Record drawings shall comprise the approved drawings, marked up as necessary to show the Plant as installed. Submission to and approval by the Engineer of record drawings shall be a condition precedent to the issue of the Taking-Over Certificate.

Final approved Record drawings shall be submitted to the Engineer not later than three months after the issue of the Taking-Over Certificate. The number of copies to be submitted shall be as specified in the Schedule of Technical Particulars T3.

In addition to the bound sets specified in the Schedules, one copy of each record drawing at reduced scale (A3 folded) shall be included in each copy of the operation and maintenance manuals. The drawings, and particularly dimensions and notes, shall be prepared so that the drawings are still legible at this size.

Copies of the approved record drawings shall also be submitted on CD ROM disk.

The drawing files on CD ROM shall be in a .pdf and .dxf or .dwg (suitable for Autocad 2008 software) or advised to the Contractor at the appropriate time.

A9.6.1 Instrument Schedule

This shall list all instrumentation items (including actuated valves) in loop number order. For each instrument item the Instrument Schedule shall as a minimum list the size, make, exact model, P&ID reference, range and calibration, loop diagram reference, service description, and location drawing reference.

PLC/Control System I/O (Input/Output) Address Schedules & Fieldbus/Modbus or other equivalent communication protocol segment assignment lists

These shall list all inputs and outputs to the PLC/control system. I/O shall be listed in address order, and grouped into cards or module blocks if applicable. For each address record the tag number and service description of the connected device, the I/O type (4-20 mA analogue input, 24 Vdc digital output, fieldbus/modbus or other communication protocol etc), the loop diagram/fieldbus/modbus or other communication protocol segmentation drawing reference and the P&ID reference shall be listed. In the case of analogue parameters the corresponding range in engineering units shall also be listed. Eg 4-20 mA = 0 – 100 l/sec. Spare registers assigned for analogue and digital signals and fieldbus/modbus or other communication protocol data shall also be listed.

A9.6.2 Instrument Datasheets

A unique datasheet shall be supplied for each instrument, identified by instrument tag number. The datasheet shall list all information required to replace and re-commission the instrument in the event of damage or failure. This shall include the final settings of all setup parameters stored in the instrument and process conditions (pressure, temperature, flow and other applicable variables).

A9.6.3 Panel Power Distribution Drawings

These shall clearly show the distribution of power at different voltage levels within each panel. Drawings should be specific including showing which items are supplied from each fuse or MCB. The drawing shall also show the instrument earth connection arrangements.

A9.6.4 Instrument Location Drawings

The location of each instrument (including control valves) shall be shown (identified by tag number) on an instrument location drawing which shall also show the location of major equipment items and routing of main cable trays and ducts. In plant areas where a fieldbus/modbus or other communication protocol is being used, the instrument location drawings shall show the fieldbus/modbus or other communication protocol segmentation.

A9.6.5 Instrument Loop Diagrams

An instrument loop diagram showing all connections, cables, terminals etc for all devices carrying the same loop number shall be provided for each loop connected using conventional wiring. The instrument loop diagram shall provide all information required to troubleshoot a loop ie. A technician shall be able to trace the electrical signal from field instrument through any junction boxes and signal isolators to the input terminals of a controller, any power supplies shall also be shown. The requirement for loop diagrams is not limited to closed-loop analogue control loops but applies to all instruments and fold devices.

A9.6.6 Fieldbus/Modbus or other communication protocol Segment Drawings

A fieldbus/modbus or other communication protocol segment drawing shall be provided for

each fieldbus/modbus or other communication protocol segment. It shall show the general segment topology and details of devices on that segment. In addition it shall show design constraints such as segment and spur length, voltage drop and current draw, loop execution requirements, and placement of power supplies, power conditioners, and terminators.

A9.6.7 Instrument installation, wiring and piping hook-up drawings

Where applicable, installation, wiring and hook-up drawings shall be submitted. These shall be detailed in every respect.

A9.6.8 I/O Connection Diagrams

For control system I/O connected to non-field devices (eg to MCC's), connection diagrams meeting the same requirements as Instrument Loop Diagrams shall be provided.

A9.7 Operation and maintenance manuals

The Contractor shall submit the *modified and updated* operation and maintenance manuals for approval by the Engineer. Submission to, and approval, subject to comments, by the Engineer of the operation and maintenance manuals shall be a condition precedent to the issue of the Taking-Over Certificate.

Draft operation and maintenance manuals shall be available for the Engineer's use prior to the start of the Taking over Certificate.

The operation and maintenance manuals shall cover the setting to work, commissioning, testing, operation and maintenance of the Works. The greatest importance is attached to completeness and clarity of presentation. It shall be 'user friendly' bearing in mind the training and abilities of the Employer's personnel responsible for operating and maintaining the Works.

The preparation of the manuals shall be carried out by personnel who are trained and experienced in the operation and maintenance of the Plant described and are skilled as technical writers to the extent required to communicate essential data and are competent to prepare the required drawings and documentation.

A collection of standard pamphlets of a general nature unaccompanied by drawings and descriptive matter relating to items of plant as installed, will not be acceptable. In particular, information supplied by sub-contractors and manufacturers employed by the Contractor shall be co-ordinated into the comprehensive manual. Cross-referencing of descriptive matter, drawings and spare part lists must be complete.

The manuals shall be in English, shall be securely bound, and pages shall be of A4 size to ISO 216 or folded to that size in a loose-leaf hardcover binder, using not more than 70% of the binder capacity.

The format of the manuals shall be white paper for typed pages with neatly typewritten text except for manufacturers' printed data. Drawings shall be provided with a punched reinforced binder tab for binding into the text. Drawings shall be so sized that they may be folded to the size of the text pages.

All pages shall be clear, legible and permanent. Offset printing or multilith is preferable, but electrostatic or photocopies will be acceptable if clear and permanent.

Each volume of the manual shall be identified both on the front cover and on the spine, with the typed or printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", the title of the

project, including the Contract reference number, and the identity of the general subject matter covered in the manual. The text and drawings shall be placed in commercial 4-ring binders with durable and cleanable plastic covers. When multiple binders are used, the instructions shall be correlated into related consistent groupings.

The front cover and spine of each volume, shall also bear the Employer's logo, details of which will be provided by the Engineer. The background colour for the cover shall be proposed by the Contractor and agreed with the Engineer.

Each O&M manual volume shall contain a neatly typewritten table of contents arranged in a systematic order giving: name of Contractor, address and telephone number, a list of each item of Plant included, an index to the contents of the volume and a list of each plant item with the name, address and telephone number of any sub-contractor or installer. Only the manufacturer's printed data which is pertinent to the specific Plant shall be included. Each sheet of manufacturers' instructions shall be annotated to identify clearly the specific item or part installed and the instructions applicable to that item or part of the Plant. All inapplicable information shall be deleted. Plant data shall be supplemented with drawings as necessary to illustrate clearly component parts of equipment and systems, control diagrams, flow diagrams, and test procedures covered in the manual. Written text shall be as required to supplement the Plant data for that particular installation. Written text shall be organised into a consistent format under separate headings for different procedures and in a manner to provide a logical sequence of instructions for each procedure.

The operation and maintenance manuals shall describe the installation as a whole and shall give a step-by-step procedure with assembly drawings for any operation likely to be carried out during the life of each item of plant, including its erection, commissioning, testing, operation, maintenance, dismantling and repair. Manuals shall identify and cover aspects liable to affect other installations and shall include all health and safety precautions to be taken.

Maintenance instructions shall include charts showing lubrication, checking, testing and replacement procedures to be carried out daily, weekly, monthly and longer intervals to ensure trouble-free operation. Where applicable, fault location charts shall be included to facilitate tracing the cause of malfunction or breakdown.

A separate section of the manuals shall be devoted to each size and type of equipment and to each item of Plant. It shall contain a detailed description of its construction and operation and shall include all relevant pamphlets, and a list of parts with the procedure for ordering spares. The detailed sections of the manual, if necessary, shall contain further maintenance instructions and fault location charts. Subject to the foregoing, the manual shall generally comply with the recommendations of BS 4884 parts 1 and 2. (Technical Manuals - Content and Presentation).

Any additions, alterations or deletions which may be required by the Engineer following the experience gained during the periods of running and further maintenance shall be incorporated in these copies in the form of additional or complete replacement pages and the cost of these amendments shall be deemed to be included in the Contract Price.

The Contractor's attention is drawn to the need to ensure that the following items are included in the operation and maintenance manuals:-

- All health and safety instructions for chemicals and any precautionary measures necessary for ensuring health and safety and avoidance of misuse;

- General description of the scope, purpose and manner of working of each system or apparatus forming part of the Works, and the final functional design specification (FDS);
- Schedule of equipment supplied giving manufacturers' name and appropriate make, model/catalogue number, description of unit and component parts identified on drawings;
- Maintenance procedures for regular maintenance and preventative maintenance, including frequencies of routine operations, guide to fault diagnosis, fault finding charts, step-by-step procedures for dismantling, cleaning, servicing, part replacement and reassembling, including recommended clearances and tolerances;
- Maintenance procedures for the flushing of chemical tanks, pumps and dosing lines and procedures for dealing with leakages and spillages including neutralisation;
- Schedule of spare parts with ordering reference numbers and parts identified on equipment drawings;
- Schedule of tools;
- Schedule of changeover frequencies for duty/standby equipment;
- Sectional arrangement drawings of major items of plant with dismantling instructions;
- Plant layout drawings showing the "as erected" installation;
- P&I Drawings for "as installed" processes;
- Schedules for "as installed" instrumentation;
- Electrical system single line diagrams;
- Electrical system protection grading characteristics and setting data;
- General arrangement and circuit diagrams for switchboards and control panels "as installed";
- Diagrams of all "as installed" connections between electrical plant and instrumentation systems;
- Operating procedures including step by step instructions for pre-start, starting up, including start up following emergency shut down, normal operation and normal and emergency shutting down of the Plant;
- "Do's" and "Don'ts" in plant operation with attention drawn to all operations considered to be hazardous to personnel or likely to damage plant;
- Data on general setting of controls associated with controlling design conditions, monitoring instruments and switchgear, together with the details of initial settings of all adjustable items;
- Test certificates for works and site tests carried out on plant, for site tests carried out on pipework, electrical and instrumentation installations and other items where appropriate;
- Pump performance and calibration characteristics as tested and system characteristics;
- Manufacturers' printed operating and maintenance instructions;
- Lubrication instructions including frequency of application and schedule of recommended lubricants and their equivalents, which must be readily obtainable;
- Typical log sheets for recording plant operating information for each process and chemical plant with instructions for identifying departures for normal behaviour;
- Typical log sheets on which operating staff can record their service/maintenance checks on essential equipment and at periods recommended by the Contractor;
- Instrumentation, control and automation equipment operating instructions for normal procedures in a step by step format including flow charts, control operations, requests for display or printing of data, performance monitoring, response to alarms or failures, changing of operation parameters, and manual data entry;
- Description of the plant control philosophy (a layman's guide for operator assistants) including plant trips and interlocks;
- A schedule of alarms, giving cause and action to be taken;
- Procedures for calibration of instruments, dosing pumps etc;
- Data sheets for process and chemical plant giving design parameters;
- Data sheets for pumps, compressors etc giving capacities.

All drawings incorporated in the manuals shall be presented in such a way that they can be easily referred to whilst reading the associated description in the text.

The Contractor shall submit for the Engineer's approval, not less than one month in advance of the time at which any item of Plant is delivered to Site, two copies of instructions appropriate to the erecting, testing, operation and running maintenance of that item of Plant. These instructions shall form a draft of the relevant parts of the operation and maintenance manual.

Two complete draft copies of the manual for the Works shall be submitted to the Engineer at least one month before the commencement of the commissioning tests. These copies may be the same copies as those submitted in sections in accordance with the previous paragraph. In this case the Contractor shall check and certify that these two copies are complete before the commencement of the commissioning tests.

The commissioning tests shall not be started if the complete draft manual has not been submitted to the.

All copies of the manual shall be amended as necessary by the Contractor during the period of testing, commissioning and setting to work of the Plant. Following this updating, the Contractor shall check and certify that the copies of the amended manual are the final draft of the manual. The Engineer will review the final draft manual and advise the Contractor of any changes required. This review will be completed by the Engineer within 35 working days of the certification by the Contractor that the final draft manual is complete.

Final copies of the manual shall be submitted not later than three months after the issue of the Completion Certificate. The text of the manual shall also be submitted on IBM compatible CD ROM disc.

If any further revisions are necessary as a result of operational experience during the Defects Notification Period, all copies shall be revised by the Contractor within a period of thirty days of the need for revision becoming apparent.

A third copy of the draft manual shall also be provided by the Contractor for use by the operating staff during the period between the completion date and receipt of the final manual. The manual shall be clearly marked "draft". This copy shall also be amended as for the copies provided for the Engineer, and may, after checking and certification of its correctness by the Contractor, form one of the sets to be provided to the Board under the Contract.

Upon approval of the Draft O&M manuals, the Contractor shall submit six sets of the final O&M manuals, two sets of CD ROM discs and html format to be loaded onto the Works SCADA system.

A9.8 Other submissions

A9.8.1 Contractor responsible for testing

In addition to any specific obligations for sampling and testing, the Contractor shall be responsible for routine inspection sampling and testing of all materials, workmanship, plant and measuring devices, in order to control the quality of work and to ensure compliance with the Specification and with approved samples.

A9.8.2 Samples

Where the Contract requires the submission of samples, they shall be submitted by and at the expense of the Contractor not less than 20 working days excluding weekends and public holidays prior to the time that the materials represented by such samples are needed for incorporation into any work. Samples shall be subject to approval by the Engineer's Representative, and material represented by such samples shall not be manufactured, delivered to the site nor incorporated into any work without such approval.

Where samples, including samples of materials and workmanship constructed on the Site, are submitted as a reference for materials and workmanship to be provided as part of the Permanent Works, they shall, after being approved by the Engineer, be carefully preserved for this purpose on site by the Contractor to the satisfaction of the Engineer until permission is given by the Engineer for their disposal.

A9.8.3 Manufacturers' and Contractor's certificates

Where certificates are required by the Specification or relevant Reference Standard, the original and one copy of each such certificate shall be provided by the Contractor, unless otherwise specified. The original and copy certificates shall be submitted to the Engineer.

Certificates shall be clearly identified by serial or reference number where possible to the material being certified and shall include information required by the relevant Reference Standard or Specification clause.

Unless otherwise specified, the timing for submittal of certificates shall be as follows:

- (a) Manufacturer's and supplier's test certificates shall be submitted as soon as the tests have been completed and in any case not less than seven calendar days prior to the time that the materials represented by such certificates are needed for incorporation into the Permanent Works.
- (b) Certificates of tests carried out during the installation of plant and equipment or on completion of parts of the Permanent Works shall be submitted within 7 days of the completion of the test.

A9.8.4 Progress photographs

Operation and Maintenance works shall be recorded monthly in one copy of colour photographs of size not less than 175 mm by 125 mm. Each photograph shall be suitably mounted, captioned and bound into a set as directed and approved by the Engineer. In addition one further set of photographs shall be provided on CD ROM disc. The bound set of colour photographs shall be submitted to the Engineer with the Contractor's monthly progress report. The camera and photographic papers shall be of types to the approval of the Engineer

The photographs and discs shall be the property of the Employer and no prints from these may be supplied to any person or persons except with the authority of the Employer. The Contractor shall also ensure that no unauthorised photography is allowed on the Site.

A suitable typed caption shall be affixed to each photograph (prints and those on disc) describing the detail and date taken.

A10.0 INSPECTION AND TESTING OF PLANT FOR MAINTENANCE, VARIED/SHIFTING/REPLACEMENT (Due to the lethargic activities of the contractors operating personnel)

A10.1 Off-Site inspection and testing

A10.1.1 General

The Contractor shall offer all items of Plant for inspection by the Engineer at all stages of manufacture/*maintenance* and shall include for the testing of all Plant as required by the Specification. The Engineer / Employer / Third Party Inspection Agency may witness any test, at his sole discretion.

The Contract Price shall include for the costs of all inspection and off-Site tests including temporary assembly and subsequent dismantling, labour, materials, instrumentation, chemicals and consumable items, provision of test certificates, certified records and curves.

No Plant or materials for inclusion in the Works shall be despatched from any manufacturer's works without the written permission of the Engineer. Any Plant or materials despatched without permission shall be returned and tested in accordance with the Specification at the Contractor's expense.

The off-Site tests shall normally be carried out at the manufacturer's works but if the tests are beyond the resources of the manufacturer, the Contractor shall make arrangements for tests to be carried out elsewhere. The off-site testing may be witnessed by the Engineer or by inspectors appointed by the Employer. All travel and out of pocket expenses, eg. air tickets, accommodation, allowances, professional charges, etc. incurred by the inspectors in attending any test will be paid by the Contractor and be reimbursed under an item in the PROVISIONAL SUM. Details of Inspection Agency and the details of agreement between Third Party Inspection Agency and the Employer will be notified to the successful Contractor.

If during off-site testing, any Plant or materials fails to meet the requirements of the Specification, the defects shall be rectified forthwith. The rectified item shall be offered for re-inspection and witness testing, and all resulting additional costs incurred shall be borne by the Contractor.

The Contractor shall carry out all applicable tests required by the Specification and the Reference Standard, together with such tests as are necessary, in the opinion of the Engineer to demonstrate that the Plant or materials comply with the Specification.

When the Contractor is ready to carry out any off-Site test, he shall submit a detailed test procedure to the Engineer. The proposals shall give values, such as test parameters and make reference to Reference Standards, any other standards and manufacturer's literature. The proposed format for the test sheets shall be submitted at the same time. The testing shall not start until the Contractor's proposals and test sheets have been approved by the Engineer. After receiving approval, the Contractor shall notify the Engineer of the place and time of the proposed tests giving not less than fifteen working days notice.

The contractor shall carry out every off-site test at the time and place notified. If the Engineer does not attend any test, then the Contractor shall carry out the test in the absence of the Engineer and the certified copies of the test results shall be deemed to be a correct

record. The Contractor shall provide the Engineer with three certified copies of the test results within two weeks of completing the tests. Enough information, including the contract number and title shall be given on each test certificate to enable the Engineer to check for compliance with the specification.

No inspection or approval by the Engineer of the Plant or materials covered by the Contract shall release the Contractor from any of his obligations under the Contract.

Where items of Plant are of identical size and duty the Engineer may elect not to witness all tests, but the Contractor shall assume that the performance tests on all items will be done prior to offering any Plant for witnessed testing.

A10.1.2 Calibration of instruments

All instruments used for testing purposes shall have been calibrated by an independent accredited testing authority and shall have a valid calibration certificate.

The calibration validity period shall not be longer than 12 months. Instruments used for tests at site shall have been calibrated not more than 3 months before the start of testing.

The Contractor shall provide the Engineer with three copies of calibration certificates and correction graphs etc., at the time of testing.

Any test instruments shall be recalibrated if requested by the Engineer.

A10.1.3 Test procedure

The procedure and requirements for all tests off-Site on all Plant or materials shall be in accordance with the requirements of the Specification and shall in addition be in accordance with the requirements of the Reference Standards applicable to the item being tested.

A10.1.4 Guaranteed performance

The figures stated in the Contract for performance and efficiency shall be guaranteed by the Contractor in respect of the Plant offered at the duties specified. These figures will be binding and may not be varied except with the written approval of the Employer. No tolerances are permitted on these figures. Testing to the relevant standards and to prove guarantees given will be required for all Plant and materials and the complete Works.

A10.1.5 Test records

For any test required by the Contract; the Contractor shall produce a written record, in a form approved by the Engineer, certifying that the test has been completed. The Contractor's representative at the test shall sign the test record. The tests witnessed by the Engineer's Representative shall be certified by the Engineer's Representative on the same test record.

A10.1.6 Certificates

Certificates of test in triplicate shall be provided by the contractor for all off-site tests. These shall incorporate all test results, calculations, performance graphs and curves and shall be signed by the representatives of the manufacturer and the contractor. These certificates shall be provided within two weeks after completing the test. Copies of test certificates shall be included in the operating and maintenance manual.

A10.1.7 Notification

Following any inspection or testing of Plant or materials, the Engineer shall notify the contractor in writing either that:

- the item has passed the tests;
- the item on any part thereof is defective;
- the item is not in compliance with the Specification; or
- the item has not met guaranteed performance or efficiency requirements not compliance with the Specification.

The Engineer shall state the grounds on which the decision is based.

A10.2 Site inspection and testing**A10.2.1 Inspection**

During erection of the Plant the Engineer will inspect the installation from time to time in the presence of the Contractor to establish conformity with the Specification. Any deviations found shall be corrected forthwith to the satisfaction of the Engineer.

As soon as the Engineer is satisfied that the erection of the Plant in an installation has been completed and the Plant found to be in good working order and that the associated civil works have been substantially completed to an extent permitting the proper operation of the plant, the Contractor shall start testing at Site.

A10.2.2 Testing-general

Individual tests *of the plant shall be done* before any testing involving water entering supply, disinfection of all Plant items in contact with water to be supplied shall be undertaken by the contractor. The disinfection shall be subject to approval of the Engineer. When water is discharged to waste, the contractor may, subject to such conditions as the Engineer and Employer may lay down, operate and adjust the Plant as necessary in order to test the operation of the Plant. No water shall be put into supply except with the prior authorization of the Engineer and Employer and under such conditions as they may lay down.

No part of the Plant shall be set to work until it has been inspected and accepted by the Engineer.

A10.2.3 Testing programme

The contractor shall submit to the Engineer for his approval a programme for testing up to the issue of the Taking-Over certificate, at least 28 days in advance of the proposed start of testing and shall agree the timing with the Engineer and Employer not less than one week before the start of testing.

Details of the proposed test procedures shall be submitted by the Contractor, including the manner and order in which each item of Plant and process will be tested. Associated flow rates and durations shall be submitted, and log sheets shall be prepared for recording plant information and other operating, water quality parameters, and presentation and

interpretation of test data.

The programme shall be subject to approval by the Engineer and shall take into consideration the extent of progress on other contracts, the availability of water, chemicals and power, and the Employer's requirements for disinfection and discharges either to supply or to waste.

The Contractor and any specialist sub-contractor shall be available to attend meetings at the Site to discuss the testing programme, the test details and the test results.

A10.2.4 Labour, materials, water, electricity and chemicals for tests

For individual tests, the Contractor shall provide all necessary labour, materials, chemicals, water, electricity, fuel, stores, apparatus, instruments and indicators necessary to carry out the tests. If it is permitted by the Employer, the Contractor may be allowed to use the permanent electricity supply registered under the name of the Employer. The Employer has the final discretion to decide whether such permission will be given. If the Employer permits the Contractor to do so, all tariff fee that is to incur to the Employer has to be reimbursed by the Contractor. Electricity used for the tests shall be recorded on suitable meters provided by the Contractor, which shall be read by the Engineer in the presence of the Contractor at appropriate times. Electricity consumed as a result of testing activities shall be paid for by the Contractor. The Engineer will from time to time deduct the cost of supplying electricity to the Contractor from the Contractor's monthly progress claims. The Contractor has to make arrangement for water for carrying out all necessary tests.

During testing of the Plant, until the issue of the Taking-Over Certificate, the Contractor shall be responsible for all work, plant and costs in connection with the *O&M* of the Works.

The Contractor shall prepare test record sheets for recording of all test results for the approval of the Engineer at least one month before the programmed date for the tests. Three copies of each approved sheet shall be provided to the Engineer not less than one week before the start of testing.

A10.2.5 Individual tests

Individual tests shall be in the presence of the Engineer and shall include the following:-

- Hydraulic pressure/leakage tests for pipe work.

Hydraulic pressure/leakage tests shall be carried out on all new pipe work. Where pipe work is to be built in, these tests shall be carried out after erection and before concreting. The contractor shall ensure the pipe work is suitable anchored and supported to sustain the pressure in the not-built-in condition.

Pipe lines and valves shall be pressure tested to one and a half times working pressure unless otherwise specified.

Tests on all items of Plant and materials in accordance with the requirements of the Specification shall also be in accordance with the requirements of the Reference Standard applicable to the item being tested.

- Electrical tests to demonstrate compliance of the electrical installation with specified and statutory requirements;
- Operational test for all valves;
- Running test for all pumps, blowers, compressors, etc.;

- Noise and vibration levels measurements shall be carried out for all rotating equipment.

A10.2.6 Functional test of all protective devices.

All individual tests on items of plant or equipment making up a complete system shall be completed to the satisfaction of the Engineer, before *taking over of the components on completion of the contract.*

A10.3 Tests

The Contractor shall carry out such tests and re tests on complete systems as are required to demonstrate to the satisfaction of the Engineer that substantial portions of the Works are *in good operative condition* with a minimum of interruption in regular operation.

The tests shall demonstrate satisfactory performance of the items of Plant under normal operation and the irresponse to abnormal and emergency conditions.

Each process system shall be set to work under manual control and tests shall be carried out for such time as is agreed by the Engineer as appropriate. Subsequently the automatic control equipment shall be set to work and further tests done. For those equipments that are provided by other contractors but installed in the sites of this Contract, for instance the instruments and those items for the SCADA System being provided by contractor of Package I; the Contractor shall provide all the necessary assistance to the other contractors to ensure that these equipments *are in working condition*. For those equipments that are provided under this Contract but need to be controlled by devices of other contracts, for instance the flow control valves to be provided under this Contract but have to be controlled by the SCADA System, the Contractor shall work in conjunction with the other contractor to ensure that these equipments are *in working condition*.

The tests shall include simulation of the full ranges of alarm conditions over the full ranges of operation and include tests of emergency shutdown procedures including electricity power failure.

The period of tests shall finish after the plant has been satisfactorily operated by the contractor, as certified by the Engineer, for a continuous period of fourteen days or for such extended period in excess of 14 days as may be required by the Engineer to make up for interruption in operation. However, the contractor will not be required to run the plant under the provisions of this clause more than once for one continuous 14 day period.

A10.4 Testing operation

A10.4.1 General

The Contractor shall carry out certain tests to demonstrate compliance with specified performance of particular items of Plant or parts of the Works shall be carried out independently. These independent tests shall also be a condition precedent to the issue of the Taking-Over Certificate for *O&M* of the Works.

The *test*s shall demonstrate that the Works can fulfil all the mechanical, electrical, instrumentation, control and automation and process requirements of the Specification in the ambient conditions prevailing.

The *O&M* Works shall be tested for performance for a continuous period of 30 days, of which at least the last 15 days shall be uninterrupted by other tests. During the 30 days tests the Works shall be operated at the maximum output for at least 15 days as instructed by the

Engineer. The object of the tests shall be to obtain a comprehensive set of data to show that Plant performance meets the Specification within the design capacity limits.

Any deficiencies or deviations from the specified performance of plant disclosed by the tests shall be corrected by the Contractor and tests shall be repeated as necessary until acceptable results are achieved to the satisfaction of the Engineer.

These tests shall require provision of facilities and man-power, organisation and a high degree of co-operation between the Contractor and the Employer and it shall be deemed that this has been taken into account in the rates and sums entered in the Schedules.

The Contractor shall be responsible for collecting and collating all data and test results and shall carry out all necessary calculations to confirm compliance with the Specification. A report comprising test data, results, calculations and conclusions shall be submitted within one week of the date of completion of the tests, or set of tests.

Satisfactory completion of the Tests is a prerequisite for the issue of the Taking-Over Certificate for *O&M* of the Works.

A10.4.2 Testfailures

If the performance during the tests of O&M of the works (or any parts thereof) fails to comply with the Specification, the contractor, shall submit his proposals for meeting the requirement of the Specification and the guarantees to the Engineer for his approval and shall carry out at his own expenses whichever measures may be necessary to achieve the specified requirements. Such measures may include improvements, alterations or additions to the plant and or civil works and the contractor shall bear the whole cost of such modification including any changes to the civil, electrical, instrumentation or mechanical works.

The tests shall be completely repeated and shall be continued until the Engineer is satisfied that the requirements of the Specification and the guarantees have been met.

In case of repeated failure, the Contractor shall continue to make adjustments to the Plant and repeat the tests until full compliance is reached, or until the Employer, at his sole discretion, decides to accept the Plant, despite the failure of the tests. In this event the Contractor shall pay liquidated damages to the Employer as specified.

A11.0 PLANT TESTING FOR MAINTENANCE, VARIED/ SHIFTING /REPLACEMENT (Due to the lethargic activities of the contractor'S OPERATING PERSONNEL)

A11.1 General

The requirements for testing shall be as specified below.

A.11.2 Pumps, valves and pipework and general purpose machinery

A11.2.1 Off-site inspection and testing

(a) Pumps

Pumps shall be individually tested in accordance with BS EN ISO 5198 Part 2 (Class B) and the tests shall be with clean water. Site conditions shall be simulated as nearby as possible including the NPSH condition. Pumps shall be tested with their own prime movers. Where it is impracticable to include the full length of the connecting shaft, the Contractor shall state the allowances to be made for the losses incurred by its omission and shall demonstrate the accuracy of the allowances to the satisfaction of the Engineer.

Pumps shall be tested at the guaranteed duty point and over the full working range from the closed valve condition to 20 percent in excess of the quantity when a single pump runs alone at minimum head. The tests shall provide information for performance curves to be drawn for head/quantity, efficiency/quantity, power absorbed/quantity and net positive suction head/quantity. Readings shall be taken at a minimum of seven points in addition to shut-off condition. Each pump shall also be run at its duty point for at least 30 minutes.

Positive displacement pumps shall be tested in accordance with BS EN ISO 9906.

For eccentric helical rotor pumps the tests shall provide information for performance curves to be drawn for pump speed/flow, input power absorbed/flow differential pressure/flow and pump efficiency/flow.

Pump casings shall be subject to a pressure test at 1.5 times the pressure obtained with the delivery valve closed. The positive suction head when installed shall be taken into account in determining this pressure. During the test, the casing and joints shall show no signs of leakage, distortion or defect.

In addition to confirming the specified hydraulic performance of the pumpset, the test shall demonstrate that vibration is within the specified limits, the mechanical performance is satisfactory and the noise level is within the specified limit.

Additionally chemical dosing pumps shall be tested in accordance with API standard 675 and the specified flow linearity, steady state accuracy and flow rate shall be demonstrated.

(b) Valves and Penstocks – General

Valves and penstocks specified as operated by actuators shall be tested with their own actuator. For valves and penstocks fitted with power operated mechanisms, the test shall be carried out to demonstrate correct manual and power operation.

(c) Gate valves

Gate valves shall be tested in accordance with BS EN 1171 or BS 5163 and BS 6755 Part 1 as relevant. Whichever applies, valve seat tests shall be made under open-end conditions, the test pressure being applied to each face of the valve in turn.

(d) Butterfly valves

Butterfly valves shall be tested in accordance with BS EN 593 and BS 6755 Part 1. The seat test shall be for tight shut-off and low leakage. Valves shall be tested under maximum unbalanced water test pressure in either direction.

(e) Check valves

Check valves shall be tested in accordance with the requirements of BS EN 12334 and BS 6755 Part 1.

(f) Diaphragm valves

Diaphragm valves shall be tested in accordance with BS EN 13397 and BS 6755 Part 1.

(g) Ball valves

Ball valves shall be tested in accordance with BS 5159 and BS 6755 Part 1.

(h) Electric actuators

Electric actuators shall be tested in accordance with the Reference Standards. Compliance with the specified functional and performance criteria shall be demonstrated.

(i) Pneumatic actuators

Pneumatic actuators shall be tested in accordance with the Reference Standards. Compliance with the specified functional and performance criteria shall be demonstrated.

(j) Pipework

Pipework shall be tested in accordance with the appropriate Reference Standards.

(K) Castings

Castings shall be tested hydrostatically to 1.5 times the maximum working pressure for a minimum period of 1 hour.

(l) Surge vessels

Surge vessels shall be tested in accordance with the Reference Standards.

(m) Cranes

Cranes shall be completely assembled and tested for all operations in accordance with BS 466. All slings, ropes, shackles and other lifting equipment shall be tested at 1.25 x their Safe Working Load.

(n) Weighers

All weighing equipment shall be tested for accuracy with standard weights and shall be load tested at 1.25 times the safe working load.

A11.2.2 Individual tests

The following Site inspections and tests shall be carried out as appropriate:

- (a) Inspection to check the assembly of the Plant and conformity with the Specification and consented Drawings;
- (b) Rotational checking of all electric motors;
- (c) Hydrostatic testing of all pressurised pipework systems at 1.5 x maximum working

pressure for a period of at least one hour; during this time the pressure shall not change;

- (e) Functional testing of each pump, to prove correct operation, absence of fluid leaks, correct bearing temperatures and absence of undue vibration and noise for a period of not less than four hours;
- (f) Functional testing of auxiliary items including automatic in-line strainers and valve actuators;
- (g) Functional testing of valves to demonstrate correct orientation and operation;
- (h) Overhead cranes and slings, ropes, shackles and other lifting equipment shall be tested with a load of 1.25 x Safe Working Load and results recorded in accordance with the Reference Standards. Additionally each complete system shall be tested for all functions including overload safety device;
- (i) All weighers shall be tested with standard weights for accuracy and shall be load tested at 1.25 x the Safe Working Load;

A11.3 Chlorine Plant

A11.3.1 Off-site inspection and testing

Tests shall be carried out on all items of plant, pipework and valves to demonstrate compliance with the criteria specified, with relevant standards and tests specified.

Unless otherwise specified, the tests shall be in accordance with the Reference Standards, the manufacturers' own tests and those set out below:-

- (a) Welders of chlorine plant and pipework shall be tested and approved in accordance with the requirements of the appropriate part of BS 4871;
- (b) Non-destructive tests including radiography and/or other methods as specified shall be carried out on all welds in plant and pipework;
- (c) All gas isolating valves shall be tested in accordance with BS 6755 Part 1;
- (d) Changeover control panels shall be tested in accordance with tests specified for instrumentation;
- (f) Spray catcher shall be subjected to hydrostatic pressure hold test of 1.5 x design pressure for at least one hour;
- (g) All gas handling plant shall be subjected to the following tests:-
 - (i) Vacuum hold test for 1 hour where items normally operate under vacuum;
 - (ii) Pressure hold test at 1.5 times the design pressure for at least one hour using air or nitrogen. Where items normally operate under vacuum, a pressure hold test at a pressure of at least 1.5 bar g or the highest pressure that can occur under fault conditions whichever is greater shall be carried out.
- (h) Functional tests shall be carried out on all shut-off valves, vacuum regulators, pressure relief valves, gas control units, ejectors and related items which shall be temporarily rigged as systems to demonstrate correct operation and calibration. Water supply pressure and solution back-pressure for these tests shall be set to the limiting values anticipated at Site.

A11.3.2 Individual tests

The following Site inspections and tests shall be carried out as appropriate:-

- (a) Inspection to check assembly of the Plant and conformity with the Specification and approved Drawings;
- (b) The gas pressure pipework up to the vacuum regulator inlet connections shall be tested for at least one hour at 1.5 x maximum working pressure at 40°C using dry air or nitrogen; during this time the pressure shall not change. Where necessary, system pressure gauges may be removed prior to testing. On re-instatement of the gauges,

- the system shall be re-tested at the gauge maximum reading;
- (c) The gas pipework system from the vacuum regulators including gas control units up to the ejector inlet connections shall be subjected to the following tests each for a period of at least one hour:
 - (i) Vacuum hold test for one hour;
 - (ii) Pressure hold test at a pressure of 1.5 bar g using dry air or nitrogen;
 - (d) Relief valve operating pressure shall be demonstrated;
 - (e) The chlorine solution pipework including ejectors and all components up to the point of application shall be tested hydrostatically for at least one hour at 1.5 x maximum working pressure or 5 bar g whichever is greater. Manufacturers' recommended procedures shall be followed prior to execution of this test with particular reference to:
 - (i) Elimination of air on filling with cold water;
 - (ii) Temperature equilibration;
 - (iii) Stepwise application of test pressure starting at not more than 3 bar g for 10 minutes.
 - (f) The complete drum lifting system shall be tested with a load of 4.0 t and results recorded in accordance with the Reference Standards;
 - (g) Suspended weigher shall be tested for accuracy with standard weights and shall be load tested at 4 t;
 - (h) A functional test shall be carried out on the container changeover system using dry air or nitrogen at pressures up to the maximum working pressure of the system.

A11.3.3 Tests

Testing shall incorporate the following requirements:-

- (a) Functional tests shall be carried out using dry air or nitrogen on the vacuum regulators, pressure relief valves, gas control units, ejectors and related items as a system to demonstrate correct operation;
- (b) Following satisfactory completion of the foregoing tests, functional testing with chlorine shall be carried out to demonstrate correct operation and calibration of the Plant.
- (c) Chlorine shall be dosed into the water at the specified points of application over the dose range of 0.25 to 1.0 mg/l for a period of eight hours; 0.25 mg/l from 0 to 2 hours, 0.50 mg/l from 2 to 4 hours, 0.75 mg/l from 4 to 6 hours and 1.0 mg/l from 6 hours to 8 hours. After allowing one hour for residual stabilisation the free and total chlorine residual shall be tested upstream and downstream of the dosing point to verify the applied dose. The Contractor shall provide all necessary temporary tapings for taking samples and instruments to measure chlorine residual.

A11.4 Miscellaneous tests

A11.4.1 General

Miscellaneous tests shall include tests for chlorine cylinder trolleys, safety equipment, and chlorine contact tank and access equipment.

A11.4.2 Off-site inspection and testing

Tests shall be carried out on all items of plant to demonstrate compliance with the criteria specified, with relevant standards and tests specified.

Unless otherwise specified the tests shall be in accordance with the Reference Standards and the manufacturer's own procedures.

A11.4.3 Individual tests

The Site inspection and testing shall incorporate the following:-

- Cylinder trolleys shall be tested to 1.25 x Safe Working Load;
- Testing of access equipment for stability;
- Inspection of safety equipment to check sufficiency of supply and satisfactory installation.

A11.4.4 Commissioning tests

The testing shall incorporate the following requirements:-

- Chemical tracer tests using sodium chloride at a concentration of about 20 mg/l (with either conductivity or chloride concentration measurements) or fluoride at concentration less than 1.0 m/l as F (using specific ion electrode for concentration measurement) shall be carried out to demonstrate that the specified effective contact time in the chlorine contact tank has been satisfied at the maximum works throughput;
- Time to completely drain a clarifier from full.

A11.5 Switchgear and control gear

A11.5.1 Off-site inspection and testing

Tests shall be carried out to demonstrate compliance with the Reference Standards and the specified functional and performance criteria.

Unless otherwise specified, the tests shall be Routine Tests in accordance with the Reference Standards and the following additional tests as appropriate to demonstrate:-

- (a) 400V switchboards and MCCs
 - (i) Power frequency test of busbars with circuit breaker connected;
 - (ii) The interchangeability of withdrawable equipment;
 - (iii) The correct operation of electrical and mechanical interlocks;
 - (iv) The correct and accurate functioning of current and voltage operated protection relays by primary and secondary current injection and voltage application;
 - (v) The correct polarity between current and voltage elements of power operated protective devices, instruments and metering;
 - (vi) Meters do not creep with the removal of either the current or voltage supply.
 - (vii) The correct operation of control circuits, indications and alarms;
 - (viii) Where necessary a suitable test panel shall be provided for simulation of external controls and signals during such tests;
 - (ix) The calibration of ammeters Voltmeter, KW meter, PF meter, H₂ meter etc at 0.25, 0.5 and full scale deflection by secondary current injection;
 - (x) The calibration of transducers;
 - (xi) Type and special tests shall be carried out when specified.
- (b) 33/11/3.3kV switchboards (only applicable when these switchboards are used)

Power frequency voltage tests:-

 - (i) Power frequency high voltage pressure test with all breakers racked in and closed, between phases and from phase to earth;
 - (iii) Pressure test on secondary small wiring circuits;
 - (iv) Milli-volt drop tests - Milli-volt drop (Ductor) test across circuit breaker contacts and between extreme terminals on individual panels, (for comparison purposes, the manufacturer shall state design values for each size and rating of equipment);
 - (v) Operational closing tests - These tests are to ensure the operation of closing coil or spring release coil and satisfactory closing of the circuit-breaker with the voltage on the coil down to 80% of its rated voltage and to ensure that mal-operation does not occur, with a voltage at the coil of 120% of its rated

- voltage;
- (vi) Operational opening tests - These tests are to ensure the satisfactory operation of the shunt trip circuit, and the tripping of the circuit-breaker at no load conditions with the trip coil energised at 50% of its rated voltage;
 - (vii) Mechanical tests - All mechanical interlocks on the switchgear panels shall be thoroughly tested to ensure their correct operation, together with mechanical tripping, opening and isolating devices;
 - (viii) Interchangeability - Withdrawable circuit-breaker panels of identically equipped units shall be capable of inter-changing of circuit-breaker trucks. This facility shall be proved. A check shall also be carried out to ensure that the inter-changeability shall not be possible between incoming and outgoing feeder circuit-breaker trucks;
 - (ix) Heat run tests - Heat run tests will not be required on panels manufactured under this Contract provided type test figures for heat runs carried out on identical panel types are made available for inspection by the Engineer;
 - (x) General operation tests;
 - (xi) In addition to the tests given above, tests shall be conducted, where applicable, for the following purposes-
 - to ensure satisfactory tripping of the circuit-breakers with the closing coil energised;
 - to prove satisfactory mechanical behaviour of the circuit-breaker when the closing coil is energised with the tripping coil also energised;
 - to prove that the operation of the power closing device when the circuit-breaker is already closed causes neither damage to the circuit-breaker nor danger to the operator;
 - Protection and control circuits;
 - For all forms of current transformer protection, the following information shall be made available to the Engineer prior to the time of inspection:-
 - Current transformer magnetising curve;
 - Recommended relay setting;
 - Calculated primary operating current at this setting;
 - Calculated through fault stability values, where applicable;
 - Values of any stabilising and setting resistors employed in the scheme.
 - (xii) As far as possible, based on the completeness of the circuits in the final manufactured form within the manufacturer's premises, the satisfactory operation of associated control and protection circuits shall be proved by the following tests:-
 - to ensure the correct operation of all current operated protection relays and direct acting coils at the recommended setting by current injection;
 - to ensure the correct polarity between current and voltage elements of power relays, meters and instruments;
 - to ensure the correct operation of control circuits at normal operating voltage by operation of local control switches and simulation of operation from remote control positions.

Note: The checking of the operation of all protection relays and control circuits is to be carried out with all closing and tripping circuits energised at their normal rated voltage.

- (xiii) Instrument and metering equipment-
 - Indicating ammeters shall be checked for calibration at 0.25, 0.5, 0.75 and full scale deflection by primary current injection testing;

- Indicating voltmeters shall be checked for normal voltage readings by voltage application;
 - Frequency, power factor and kilowatt meters shall be tested for accuracy of indication;
 - Integrating kWh meters shall be tested for correct rotation. Creep tests shall be carried out to ensure that the meter is inoperative with voltage alone, if the secondaries of current transformers are left connected with the primary current interrupted;
 - All transducers shall be tested for at least 5 different points in the complete working range of each unit.
- (xiv) Current transformers;
 - (xv) Verification of terminal markings;
 - (xvi) High voltage power frequency withstand test on primary and secondary windings;
 - (xvii) Over-voltage inter-turn tests;
 - (xviii) Test for accuracy;
 - (xix) Voltage transformers ;
 - (xx) Verification of terminal markings;
 - (xxi) High voltage power frequency dry withstand test on primary windings;
 - (xxii) Test for accuracy;
 - (xxiii) Visual inspection;
 - (xxiv) Inspection of paintwork and measurement of paint thickness shall be carried out. Dimensional checks shall be also carried out.

A11.5.2 Individual Tests

The following Site inspections and tests shall be carried out as appropriate:-

- (a) 400V Switchboard and MCC
 - (i) Insulation resistance of main connections and secondary wiring using an approved insulation tester. The test shall be carried out between phases and phase to earth. All circuit-breakers, switches and contactors shall be in circuit and closed;
 - (ii) The correct operation of electrical and mechanical interlocks shall be demonstrated;
 - (iii) The correct and accurate operation of current and voltage operated protection relays shall be demonstrated by primary and secondary current injection and voltage application. At least two points shall be demonstrated for each relays. Simulation test on the operation of thermal overload relay for motor shall not be acceptable. Actual test on thermal overload relay for motor shall be carried out;
 - (iv) The stability of unit protection systems shall be demonstrated by primary current injection;
 - (v) The correct operation of control circuits, indications and alarms shall be demonstrated;
 - (vi) The continuity of all protective conductors shall be checked;
 - (vii) The correct operation of inter-tripping circuits shall be demonstrated;
 - (viii) Demonstration of accurate operation at 50% and 10% of working range on all measuring devices, meters and transducers;
 - (ix) Any tests required by the electricity supply company.
- (b) 33/11/3.3 kV Switchboard
 - (i) Pressure testing - Power frequency pressure test shall be carried out on equipment for use on systems above 1000 volts. For systems up to 1000 volts

- the insulation resistance of the equipment shall be tested with a 500 volt Megger hand generator. These tests shall be carried out with all circuit phases and phase to earth. All secondary small wiring circuits shall be similarly tested;
- (ii) Mechanical tests - All mechanical tests specified and carried out at Manufacturer's premises are to be re-checked to ensure satisfactory operation of the Works in the final erected state;
 - (iii) Inter changeability - On withdrawable circuit-breaker panels identically equipped units such as incoming and outgoing panels shall be capable of inter-changing of circuit-breaker trucks. This facility is to be proved;
 - (iv) Protection and control circuits - The satisfactory operation of all current operated protection circuits over their whole operating range and correct connection of CT wiring shall be tested by primary current injection;
 - (v) The checking of the operation of all protection relays and control circuits shall be carried out with all tripping circuits energised;
 - (vi) The satisfactory operation of all inter-tripping circuits shall be tested;
 - (vii) The satisfactory operation of control circuits shall be tested from local and from remote positions;
 - (viii) Indicating ammeters - Indicating ammeters shall be checked for calibration at 0.25, 0.5, 0.75 and full scale deflection by primary current injection testing;
 - (ix) Indicating voltmeters - Indicating voltmeters shall be checked for normal voltage reading by voltage application;
 - (x) Integrating kWh meters - Where possible kWh meters shall be tested for correct rotation. Creep tests shall be carried out to ensure that the meter is in-operative with voltage alone, if the secondaries of current transformers are left connected with the primary current interrupted;
 - (xi) Other indicating meters - Other indicating meters including frequency, power factor and kilowatt meters shall be tested for accuracy of indication;
 - (xii) Transducers - All transducers shall be tested for at least 5 different points in the complete working range for each unit;
 - (xiii) Current transformers - Current transformers shall be tested for the following:-
 - verification of terminal markings;
 - high voltage power frequency withstand test on primary windings;
 - test for accuracy;
 - (xiv) For all forms of current transformer protection the following information shall be made available to the Engineer prior to the time of testing:-
 - current transformer magnetising curve;
 - recommended relay testing;
 - calculated primary operating current at this setting;
 - calculated through fault stability values where applicable;
 - values of stabilising and setting resistors;
 - (xv) Voltage transformers - Voltage transformers shall be tested for the following:-
 - verification of terminal markings;
 - high voltage power frequency withstand test on primary windings;
 - test for accuracy;
 - (xvi) Operational sequence tests - Tests shall be carried out on all starter panels to test operational sequence and operation of protection devices. Sequential tests for pump- motor shall be able to carry out when putting the VCB at "Test" position without required to modify any control circuit;
 - (xvii) Continuity of earth conductors - Continuity tests shall be carried out on the earth conductor of the switchboard, such tests being by current injection;
 - (xviii) This does not include the earth resistance test of the station earthing system which shall be tested as detailed elsewhere in the Specification.

A11.6 Electric motors

A11.6.1 Off-site inspection and testing

Motors shall be inspected and tested to show that they are compliant with the Specification and approved drawings.

Tests shall be in accordance with BS 4999:Part 143. For low voltage standard production motors for general use, the tests shall be routine checks. For high voltage and low voltage motors for main drive application, the tests shall be duplicate.

If the test to determine the locked rotor current of cage induction motors is carried out at reduced voltage, allowance shall be made for the effect of saturation when adjusting for rated voltage. The estimated value of locked rotor current at rated voltage shall be stated on the test certificate.

A Polarisation Index test shall be carried out for high voltage motors.

The requirement for "basic" or "special" tests shall be as specified.

A11.6.2 Individual Tests

Each motor shall be inspected prior to site testing for:-

- Absence of damage during transportation and erection;
- Absence of moisture or other contamination;
- Ventilation openings and drain holes are free of debris;
- Cable glanding and core terminations for tightness and identification;
- Free rotor rotation;
- Free movement of brush gear;
- Remote start/stop/E.stop control box wirings and arrangement;
- Starting interlocks

Unless otherwise specified the following tests shall be carried out on each motor before energising:-

- Winding insulation resistance;
- Polarisation Index for high voltage motors;
- Insulation resistance between motor and heater windings and ancillary devices;
- Calibration of winding and bearing temperature monitoring devices and the operation of alarm and trip initiating contacts;
- Continuity and resistance of winding thermistors;
- Bearing insulation integrity;
- Brush pressure.

Any other tests recommended by the manufacturer or stipulated in the Reference Standards.

On the satisfactory completion of the inspection and tests listed above, motors shall be energised to check for correct direction of rotation, noise and the vibration levels are within the specified limits. The tests shall be carried out with the motor uncoupled from the driven plant.

A11.7 Transformers

A11.7.1 Off-site inspection and testing

Transformers shall be inspected and tested to show that they are fully compliant with the Specification and approved drawings and shall include the following tests as a minimum:-

- Routine tests;
- Measurement on winding resistance;
- Ratio, polarity and phase relationship;
- Impedance voltage;
- Load loss;
- No-load loss and current;
- Insulation resistance;
- Induced over voltage withstand;
- Separate source voltage withstand;
- Magnetic circuit voltage withstand
- Transformer tank oil leakage test (1 kg/cm² for 24 hours);
- Transformer noise level measured in accordance with methods and procedures detailed in IEC 551 -Noise level shall not exceed 65dBA;
- Tap changer switching, mechanical and electrical tests according to BS4571;
- Zero sequence impedance measurement;
- Type tests;
- Impulse voltage withstand test;
- Temperature rise test;
- On load tap changer panels;
- Operational tests;
- Sequence tests.

Unless otherwise stated by the Engineer at the time of placing the order, evidence of records of satisfactory type test carried out on identical transformers to those ordered will be accepted in lieu of actual tests on transformers manufactured under this Contract for impulse voltage withstand test. Temperature rise test shall be carried out on one transformer of each size and type. The guaranteed no-load and load losses of each transformer shall be verified at the manufacturer's works. The positive tolerances stipulated in BS 171 shall not be accepted. The Board reserves the right to reject any transformer which does not achieve its declared guaranteed values.

A11.7.2 Individual Tests

The Site inspections and tests to be carried out are as follows:-

- Ratio, polarity and phase relationship;
- Impedance voltage;
- Insulation resistance;
- Oil and winding temperature gauges shall be calibrated and tested;
- Pressure gauges and oil level indicator relays shall be tested with pilot cables connected by mechanical operation of contacts;
- Tap changer equipment including protective devices shall be tested to ensure correct operation;
- Oil tests;

Samples of insulating oil shall be taken and subjected to dielectric strength tests. If the insulating oil fails the site test, the Contractor shall carry out the drying of oil to remove the moisture content or replace the oil and then carry out the oil tests again to comply with BS 148.

A11.8 DC Supply Units

A11.8.1 Off-site inspection and testing

The correct operation of the charger in the float and boost modes and the alarm functions shall be checked.

The following tests shall also be carried out:-

- Insulation resistance test;
- Load stability test;
- Incoming supply line test;
- Ripple voltage measurement with battery disconnected;
- Noise level measurement;
- Dropper diodes functional test;
- Charger automatic changeover test;
- Charger manual changeover test;
- Battery discharge test;
- Burn-in test at 110% load for 8 hours;
- Visual inspection shall be carried out to check the dimensions, paintwork, paint thickness and components inside the enclosures.

A11.9 Instrumentation, Control & Automation

A11.9.1 Tests at manufacturers' works

Instrumentation shall be subjected to the manufacturers' own inspection and testing procedures together with a demonstration that an increase or decrease of the measured value at several points over the range of the instrument produces a corresponding increase or decrease in the instrument output signal or reading within the accuracy specified or otherwise required for the application.

Flow meters shall be factory calibrated and tested on a certified wet test rig. The calibration certificate shall be submitted to the Engineer.

Instrument and control panels, electrical interface cabinets inspection and testing shall be carried out to determine that:

- From visual inspection, design and construction are in accordance with the Specification. The engraving, position and fixing of all labels shall be shown to be satisfactory and in accordance with the approval of drawings;
- Power distribution circuits are correctly rated, coordinated and identified;
- Insulation resistance of circuits normally energized at potentials exceeding 50V to earth shall be not less than 10 MΩ between conductors and between conductors and earth using a 500V insulation tester. Any equipment liable to be damaged by the application of the test voltage shall be disconnected prior to testing;
- Each item of equipment within a particular loop and the complete loop function correctly. Each indicator, recorder and controller shall be checked over the whole scale range and there shall be no interaction with any other circuit. Controllers shall be checked for correct operation of control action, auto-manual circuits, cascade circuits, proportional, integral and derivative actions and any special features;
- Alarms function as required. Those initiated from remote contacts shall be tested by opening and closing the circuit at the panel outgoing terminals. Those operated from analogue signals shall be tested by use of a signal injector. Each test shall verify that the correct alarm circuit is operated, the alarm sequence is correct and that there is no interaction with any other circuit;

- Sequence programmes operate as required and that all input and output responses are correct.

A11.9.2 Individual Site tests

The following inspections and tests shall be carried out after installation at site:-

- All instrument piping shall be tested for continuity and freedom from leakage;
- All cables shall be tested for continuity and insulation resistance;
- Electrical supply voltages shall be checked;
- Instrument air supply pressure shall be checked;
- The common mode d.c. voltage at each signal input terminal shall be measured and recorded;
- The zero setting of each display instrument shall be checked;
- The correct calibration of each item in each loop shall be checked by introduction of appropriate signals at each source at five cardinal points of the range for increasing and decreasing signals;
- Every item shall be visually inspected and any damaged part or deficiency made good;
- All safety devices shall be tested for correct operation;
- Control sequences shall be checked with control inputs activated but outputs initially in a monitoring mode;
- The test methods to be used shall be as follows unless otherwise agreed with the Engineer;
- Pressure operated devices shall be tested with dead weight testers or portable calibrators;
- Level operated devices shall be tested by actual level variation or simulation thereof. Zero readings shall be checked against a benchmark where applicable;
- Flow devices of the pressure differential type shall be tested by application of differential pressures. Flow devices of the magnetic type shall be tested with a flow simulator. Where practicable, each flow device shall be checked by an actual displacement test;
- Water quality analysers shall be calibrated using prepared solutions;
- Each control valve shall be checked by operation of the manual output control on the associated controller. Automatic controllers shall be set to the appropriate estimated values of the control terms;
- All systems shall be checked for fail-safe operation as appropriate by simulated failure, open circuiting, disconnection and so forth;
- Instrument and control panels, electrical interface cabinets;
- These shall be tested as part of the tests on the process plant equipment.

A11.10 Cabling

A11.10.1 Tests at manufacturers' works

Unless otherwise specified cables shall be subject to Routine Tests in accordance with the Reference Standards.

A11.10.2 Individual Site tests

The following inspection and tests shall be carried out on the completed cable installation as appropriate:-

- Insulation resistance between cores and core to earth using an approved insulation tester compatible with the voltage grade of the cable under test. For high voltage cables, the test shall be carried out at the highest voltage compatible with the voltage grade of the cable under test. Where cables are jointed, the test shall be repeated after each joint has

- been completed;
- For multicore and multipair cables, continuity of each core and correct identification and ferruling;
- Supports and cleating arrangements are fitted;
- For power cables, correct phasing and phase colouring;
- Correct bonding and earthing of cable metallic sheaths, core screens and armouring;
- Sealing of cable entries against water and vermin ingress;
- Mechanical glands have been correctly fitted;
- For high voltage cables pressure tests shall be carried out in accordance with the Reference Standards using high voltage d.c. Wherever possible cables shall be energised after the satisfactory completion of the pressure test;
- For high voltage cables, additional checks and tests to the manufacturers' specific instructions shall be carried out;
- For low voltage cables, additional tests as required by the Reference Standard;
- Loop resistance test for each pair of conductors in multipair instrumentation and telephone distribution cables;
- Attenuation test for each pair of conductors in telephone distribution cables;
- Measurement of cross talk across pairs of conductors in telephone distribution cables over a minimum frequency band of 0.5 to 20 kHz. The conductors connected to a resistive load equal to that of their characteristic impedance. The injected signal shall have a sinusoidal waveform at a level equivalent to the intended operating level of the modems to be connected (-3dBm).

A11.11 Earthing

A11.11.1 Individual Site tests

On completion of the earthing installation tests shall be carried out in accordance with the Reference Standards and the following requirement:-

- Resistance of each earth point shall be measured;
- Resistance value of the overall earthing system after the connection of linking tapes;
- The earth contact resistance and the earth conductor continuity from each major piece of the Works, i.e. main switchboards, transformers etc., shall be measured by using an earth loop impedance tester and auxiliary return conductor.

A11.12 Building services

A11.12.1 Individual Site tests

The building services installations shall be inspected and tested in accordance with the Reference Standards.

A11.13 Lightning protection

A11.13.1 Individual Site tests

The lightning protection installation shall be inspected and tested in accordance with the Reference Standards and the following requirement:-

- Resistance of each earth point shall be measured;
- Resistance value of the overall earthing system after the connection of linking tapes.

A12.0 TRAINING

A12.1 Training requirements

Training shall be provided on site and at the Employer's premises as applicable, and shall commence at such time as directed by the Engineer/Employer.

Training of the *Contractor's* personnel shall aim at achieving optimum operation of the Works including maximum efficiency of plant, optimum use of chemicals, minimum loss of water, and minimum numbers of operating staff. The *Contractor's* personnel shall be trained in all aspects involved including management, operation of plant, water quality tests, laboratory procedures, control of chemicals, routine and periodic maintenance of every item of equipment and plant, health and safety at work, security and in all other subjects as may be required for satisfactory operation and maintenance of the Works.

The training shall be *in* Formal classroom and practical training in groups

During the period of class room and practical training, the Contractor *has* to train in the safe and efficient operation and maintenance of the installed plant. The Contractor shall allow for comprehensive training in at least two separate sessions for each of the following disciplines and designed to accommodate the Works shift (24hour,3shift) pattern.

- Staff discipline;
- Management staff;
- Operational staff including Works chemist and laboratory personnel;
- Electrical and ICA maintenance staff;
- Mechanical maintenance staff.

The exact number of personnel attending the training sessions will be finalised prior to the training.

During the training period, the Contractor shall remain fully responsible for the operation and maintenance of the Works,

The Contractor shall provide an experienced training manager (with a minimum of ten years training experience and five years experience in a similar capacity to organise and supervise the training programme. He shall be based on site and shall remain on site from the commencement of the training programme until the completion of the first 18 months *the O&M period*.

Training shall be performed by specialist personnel specifically allocated to the task. Such training shall be specific to the trainee's position and discipline and shall be appropriate to staff with the basic skills related to their grade.

The Contractor shall ensure that, training on individual items of plant, equipment or systems such as chemical facilities, instrumentation, control and automation systems (rCA) and similar shall be carried out by the manufacturer or specialist sub-contractor. The Contractor shall be responsible for ensuring that such training is properly co-ordinated into the overall programme, and that the quality of the training is of the type, quality and standard specified. The Contractor shall submit details of the number of training specialists he shall assign to each phase of training together with details of their duties, qualifications, capabilities and experience to the Engineer for approval.

The Contractor shall maintain a register of attendance at training sessions and the subjects covered and shall carry out assessments jointly with the Engineer and the Employer's representative to monitor the effectiveness of training.

Based on the assessments, the Contractor shall offer technical advice, organise and conduct special tutorial sessions for any personnel who have jointly been assessed and needing them and ensure that they carry out operations and procedures correctly.

Training shall be based on the relevant approved operating and maintenance manuals and record drawings including P&I Diagrams and flow sheets, which shall be available before training commences.

Training shall be provided for management, operating and maintenance staff and shall cover in detail the areas listed below. At least six months prior to the start of training the Contractor shall provide a draft syllabus of the proposed training and shall then develop in liaison with the Engineer and the Employer an approved syllabus, training programme and training methodology. The approved syllabus programme and methodology shall be submitted to the Engineer at least one month prior to the agreed start date for training. The syllabus to be provided by the Contractor shall be based upon, but not limited to, the following:

- (i) Health and safety procedures, with particular respect to toxic and hazardous gas areas, chemical handling, electrical plant use, maintenance, entry/working in confined spaces and similar;
- (ii) General plant description:
 - General process description and treatment objectives;
 - Process design parameters;
 - General description of electrical equipment;
 - General description of mechanical equipment;
 - General description of ICA system.
- (iii) Detailed description and demonstration on operation of individual process units, including process chemistry, sampling and laboratory procedures specific to the treatment processes adopted on the Works;
- (iv) Detailed description, including operation principles/mechanism and demonstration on operation and control of all electrical, mechanical and ICA equipment
- (v) Operating instructions, including normal operation, actions necessary under varying conditions and abnormal conditions, start-up and shut-down procedures for individual process units;
- (vi) Process optimisation
- (vii) Routine inspection and maintenance instructions;
- (viii) Fault finding and correction;
- (ix) Dismantling and re-assembly of plant and replacement of consumable parts;
- (x) Emergency procedures, including process aspects such as start up after power failure and gas leaks and chemical spillages;
- (xi) Set up and calibration of each control, protection, measuring and process equipment/system;
- (xii) Spares-strategic and consumables; (xiii) Special tools;
- (xiv) Trouble shooting and programme modifications to ICA systems, PLC and PC software and use of management systems provided under the Contract;
- (xv) Review of relevant drawings, P&IDs and O&M manuals.

A12.2 Training methodology

The method of delivery shall be structured to include theory, group discussion and part practical elements supported by audio-visual aids, hand outs, demonstrations and appropriate assessments. Hand outs shall include extracts from operating and maintenance manuals supplemented by specially prepared material and shall be prepared so as to be collated to form a set of course notes for use by attendees for future reference. Audio-visual aids shall include relevant video presentations prepared by plant and equipment manufacturers, as well as those prepared during plant installation and testing.

A12.3 Training duration

As a minimum requirement the following number of 8 hour, dayshifts shall be allowed for each course in the scope of training.

Subject	Days
Process chemistry	2
Operation of all plant including safety aspects of chemical and other plant	10
Electrical maintenance	4
Mechanical maintenance	4
ICA maintenance	5

The number of trainees per theory and group discussion class shall not exceed ten.

A12.4 Training assessment

The training shall be monitored continuously by the Contractor jointly with the Engineer and/or the Employer's representative and each trainee will be required to demonstrate their understanding of the instruction received. In order to achieve an acceptable standard of competence, the Contractor shall build into the training, a two-step assessment monitoring programme as set out below or a comparable assessment method approved by the Engineer:

- (a) Each session shall include small groups of trainees being given a task/scenario, which will require them to use the knowledge learnt during the session to feed back and demonstrate understanding in such a manner as to promote trainee participation without putting individuals under pressure. This type of assessment shall be adopted for both theoretical and practical sessions and time shall be built into the course programme for this purpose.
- (b) Each trainee shall be issued with a training task book which will include sections for recording attendance. Each section of the task book shall relate to a session undertaken during the training and will be signed off by the Contractor, Engineer and the Employer on completion of the training session.

A12.5 Training material

A comprehensive overall training manual shall be produced by the Contractor covering all disciplines and shall be submitted to the Engineer for approval six months before the commencement of the training programme. Three copies of the approved manual shall be submitted at least one month before the commencement of training. The presentation requirements of the manual shall be the same as those for the operating and maintenance manual. The manual shall also be submitted in CDROM with interactive webpage format. The manual shall be updated as necessary throughout the training programme.

In addition, each trainee shall receive one set of bound documents including the following:

- (a) Course notes;
- (b) Training information from the overall training manual appropriate to their Particular Skill areas (e.g. management, chemist, operator, electrical and mechanical maintenance);
- (c) Training task book for recording training and for individual assessment;
- (d) Functional task book, to be issued to each trainee shall include a comprehensive schedule of daily tasks to be carried out by the trainee staff member in their allotted position in maintaining satisfactory operation of the plant.

The training material shall be in a user-friendly style and shall cover in general terms the main technical procedures and activities associated with the Plant. The documents shall be in a format suitable for use in future training of Employer's personnel up to operating shift supervisor level.

Training documents shall be securely bound in such a manner that individual pages can be added or replaced so that the documents can be kept upto date.

On completion of the training programme, the training manual and other documentation, updated to take account of changes during the performance of the programme, shall be submitted to the Engineer in CD ROM format (IBM PC compatible)

A12.6 Training programme

The Contractor *has to* provide an outline training programme indicating target dates for the following associated activities:

- (a) Submission of draft training plan, draft training manual, training task book and draft functional task book;
- (b) Submission/agreement with the Engineer and the Employer of detailed training plan and syllabus. This shall include agreement of the assessment structure for trainees, training manual, training task books and functional task books;
- (c) Submission/agreement with the Engineer and the Employer of training development programme. This will include aspects such as duration of training courses, dates, training venue/arrangements, training content, training materials, confirmation of numbers involved;
- (d) Training review updates;
- (e) Two week "familiarisation" programme;
- (f) Number, dates and duration of courses/sessions within overall training programme;
- (g) Relative dates for start of plant tests;
- (h) Date for availability of draft operating and maintenance manuals.

A12.7 Training review update

The Contractor shall make available suitable personnel to carry out training updates and assessments at six months from the start of the Operation and Maintenance Period and at six months prior to the end of the Operation and Maintenance Period.

A12.8 Training support

Throughout the *O&M* of the Works, the Contractor shall advise the *O&M operating* personnel on the proper running of the Works, and provide technical support to overcome operating and maintenance difficulties.

The Contractor shall attend to all requests for advice and assistance, both oral and written, made by the *O&M operating* personnel and shall keep a written record of these requests with a copy submitted to the Engineer monthly.

Any advice or technical support given by the Contractor to the Employer's personnel, as a result of requests from them, and the action taken by them as a result of such technical support shall be recorded by the Contractor and copies shall be submitted to the Engineer monthly.

A12.9 Training record

The Contractor shall keep a complete record of Plant formal training carried out in the class room and on the plant on DVD (MPEG2 format) and at the end of the training period shall submit to the Engineer 4 copies of DVD disks (MPEG2 format)

A13.0 SPECIAL TOOLS, SPARE PARTS, TOOLS AND TEST EQUIPMENT

A13.1 Special Tools

As well as the workshop tools specified, the Contractor shall provide special tools or appliances which he considers necessary for *maintenance*, erection, dismantling or testing for any part of the Works during the life of the Works.

Special tools provided shall not be used for the erection of the Plant unless the Engineer instructs the Contractor to demonstrate the effectiveness of any special tool. The special tools shall be handed over to the Employer in a new and unused condition. Should the Contractor require any special tools at Site for erection, he shall provide his own.

Tools for each different type of equipment shall be contained in a suitable box clearly marked or labelled with its description. Each tool shall be identified and a list of tools shall be fixed to the inside of the box lid.

Each set of tools shall be supplied with the equipment it serves.

A13.2 Spare parts

The Contractor shall submit a complete list of spares recommended for continuous operation of all items of Plant and the Works for Operation and Maintenance Period, in Schedule of Technical Particulars T4. The list shall be based on average servicing requirements and prevention of breakdown for continuous operation of the Plant. The list shall contain a description of the spare parts, ordering reference numbers, with parts identified on equipment drawings, quantities, unit price and the total price. The prices entered in this list shall be the prices quoted. The list shall be re-submitted in a single submission for the approval of the Engineer before any items are ordered.

The sum included in the Contract for provision of those spare parts listed in the Price Schedules is provisional, and the Employer reserves the right to order spares in accordance with the recommendations of the Contractor, or to vary the list and quantity of items to be ordered, or not to order spare parts through the Contract. Should additional quantities be ordered from the Employer, the Contractor shall be obliged to supply based on the unit rates being entered in the Schedules of Technical Particulars. Any spares that are specified elsewhere as part of any plant item shall be provided and the cost shall be deemed to be included in the lump sum for the plant item.

The final approved spare parts schedule shall be submitted in hard copy and CD ROM format. It shall show part numbers, ordering references and equipment drawings showing the spare parts.

Spare parts shall be new original manufacturers' spares. They shall be packed separately from the main Plant in packages or containers designed to preserve the spares from the effects of long term storage under the ambient conditions at the Site. Any items which cannot be packed in this shall be protected from corrosion by applying temporary protective coatings and shielded from mechanical damage. All items shall be clearly labelled with brief descriptions and part numbers, and shall be cross-referenced to the approved spare parts list.

Spare parts being ordered additionally by the Employer for their use after they take over the operation and maintenance of the Works, shall be delivered to the Employer 6 months prior to the completion of the Contract. Whether the Contractor can achieve this requirement can be a prerequisite condition for the Employer to issue the Taking-Over Certificate on completion of the contract.

The Contractor shall not use any of the spare parts for rectification of defects (defects due to the lethargic activities of the contractor's operating personnel) without the written permission from the Engineer. Parts so used shall be replaced free of charge by the Contractor.

The Contractor shall not use any of the spare parts additional ordered by the Employer for them to carry out future operation and maintenance of the Works without written permission from the Employer or the Engineer. Parts so used shall be replaced free of charge by the Contractor prior to the issue of the Taking-Over Certificate of Section II of the Works.

All packages may be opened for such examination as the Engineer may require and packings shall be designed to facilitate opening and thereafter repacking.

A13.3 Tools and test equipment

The Contractor shall supply two sets of all the standard workshop hand tools necessary for the dismantling and repair of the Plant.

Tools and test equipment for each different type of equipment shall be contained in a suitable hardwood, floor mounted cabinet clearly marked or labelled with its description. Each item test equipment and tools shall be identified and a list shall be affixed to the inside of the cabinet door.

Each set of tools and items of test equipment shall be supplied with the equipment it serves.

A14.0 OPERATION AND MAINTENANCE PERIOD *OF THE WORKS*

A14.1 General

The Employer and the Engineer will arrange to handover *in a phased manner* of the whole Works *before 30 days* to the *successful* contractor, for them to commence the operation and maintenance of the whole Plant of the Works. The duration of *O&M of the works* will be 60 months. A test on completion for *O&M* has to be satisfactorily completed by the contractor to demonstrate to the Employer that the whole works is in good operative condition. The Engineer/Employer will issue a "minor outstanding works and defect list" that the Contractor has to accept to complete in the Defects Liability Period of O&M. The Employer and the Engineer will arrange to hand over in a phased manner (from the contractor now maintaining) of the whole of the works before 30 days to the successful contractor for them to commence the O&M of the whole of the works and to relieve the contractor now maintaining. The contractor now maintaining will be issued a minor and defects liability statement which has to be completed within 6 months. Under such scenario, the Employer will take-over the whole Works and will allow the existing maintenance Contractor to access all the Plants to rectify the defects identified and completes all the outstanding works in the Defects Liability Period.

A14.2 Contractors obligations during the first 12 months of *O&M* of the Works

During the first twelve months of *O&M* of the Works, which is also the defects liability period of previous maintenance contractor for six months, and the *Contractors* (the successful bidder and the previous maintenance contractor) shall be responsible for the following:-

- (a) *The successful bidder:*
Operation and routine maintenance for the whole of the Works, including the provision of all necessary skilled supervisory staff and unskilled workers necessary for full operation and maintenance of the works.
- (i) The supply of all spare parts required for maintenance of plant as specified elsewhere in the Contract;
- (b) Previous maintenance contractor:

Rectifying defects by the previous maintenance contractor in accordance with the requirements entered in the "minor outstanding works and defect list" issued by the Engineer shall be rectified by the *previous* Contractor in this Defects Liability Period and the *previous maintenance* Contractor shall prove to the Engineer or Employer of that;

A14.3 Contractor's obligations after the first twelve months and before the last twelve months of Operation and Maintenance Period

- (a) In this period, the Contractor shall provide *all* the operation and maintenance staff *for* operation and maintenance *of the work*;
- (b) Provision of all materials including chemicals, fuel and lubricants excluding electricity power charges for the operation of the Works.

A14.4 Contractor's obligations during the last twelve months of *O&M* of the Works

After satisfactory operation *and maintenance* of the Works during the first four years, the Contractor shall be responsible for the following *during the last one year*:

- (a) Operation and routine maintenance for the whole of the Works, including the provision of all necessary skilled supervisory staff and unskilled workers necessary for full operation and maintenance of the works.
- (b) Conducting studies as required by the Engineer on booster pump operation and controlling of flow from tapping point from trunk main to optimise operations;
- (c) The supply of all spare parts required for maintenance of plant as specified elsewhere in the Contract;
- (d) Carrying out amendments to the operating and maintenance manuals based on experience gained in the Employer operating the plant.
- (e) Provision of all materials including chemicals, fuel and lubricants excluding electricity power charges for the operation of the Works.
- (f) Handing over of all the works to the next successful bidder at the end of five years. Before handing over, the contractor has to perform all the tests as prescribed in clause A15 of this General specification.
- (g) The handing over period of one month by the present contractor to the Engineer and on the same instance handing over to the successful bidder will overlap at the last 60th month of the contract period.

A14.5 Employer's responsibilities in *O & M* of the Works

During the Operation and Maintenance Period, the Employer will provide and be responsible for the following in respect of the operation of the Works:-

- (a) Electric power;

A14.6 Periodic visits

The installation shall be visited during the eleventh month, twenty-third month, thirty-fifth month, forty-seventh month and fifty-ninth month of *O & M* of the Works by a competent engineer or other specialist representative and training manager of the Contractor. He shall inspect all Plant *being maintained* under the Contract, ensure that servicing, adjustments and recalibrations as necessary are being carried out on all those items requiring attention.

The Contractor shall obtain the Engineer's or the Employer's approval at 14 days prior to each visit and shall supply a full service report within 14 days after each visit.

A15.0 TEST ON COMPLETION FOR *O&M* OF THE WORKS

A15.1 General

Test on Completion at the end of *O & M* of the Works shall be carried out to show that the Works are in complete and satisfactory working order. The tests shall be agreed in detail with the Employer and be carried out to an agreed programme which shall be submitted to the

Employer at least 28 days prior to the start of the tests.

The tests will include functionality, leakage and any structural tests necessary to prove that the Works are in full and compliant order, and are fit for purpose.

The Test on Completion shall be similar to those set down for Trial Operation for Section I of the Works in Clause A10.4. The continuous period the Works, to be tested on handover, shall be 7 days. The tests shall be designed to prove that the Works and treatment performance meets the Specifications.

The procedures to be used for the Test on Completion during the specified period shall be as that stated in Clause A1 0.4, specified for *Testing* Operation of *maintenance* of the Works.

All Mechanical Plant and Pumping equipment shall be inspected during operation, and tested for functionality and performance. The Contractor shall prove to the Employer that plant as *taken over* and *maintained & operated* complies fully with specified performance.

The Contractor shall also assist the contractor of Package I to test the part of SCADA system with signals taking from the equipment of this Contract. The scope of work shall be determined among the Contractor, the Employer and the contractor of Package I.

All those defects and outstanding works identified in the Tests On Completion, that the Employer considers shall be completed prior to allowing the Defects Liability Period to commence, the Contractor shall carry out the rectifications works promptly. Repeated tests shall then be conducted.

After all the critical defects and outstanding works be completed and the necessary repeated tests be satisfactorily completed, the Employer will furnish to the Contractor a "defects and minor outstanding work list". The Contractor shall rectify all those defects and complete all the minor outstanding works in the list during the Defects Liability Period of *6 months from the completion date (after 5 years) of the O&M works*.

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CIVIL WORKS

B1.1 B1.1 Pipeline Works

B1.1.1 Scope

This section covers particular requirements applicable to the pipe laying works in the sites of the Contract *whenever shifting/replacement from the originally laid alignment arises.*

B1.1.2 Extent of the works

The civil works for the pipelines shall include supplying, excavation, laying, jointing, testing, backfilling and reinstatement of all pipes.

B1.1.3 Pipeline route

Package V comprises treated water trunk main originating from the master balancing reservoir at MADAM, the tapping-point branches from the trunk mains to the union reservoirs, main panchayat reservoirs and the distribution pipelines to other reservoirs, booster pumping stations and over head tanks, 70.216km of MS Pipes and 19.357 km of DI Pipes in Transmission main, 16.707km of DI pipes and 10.237km of HDPE pipes in Feeder main, 552.367km of DI pipes and 166.816 km of HDPE pipes in internal Transmission main, 58.759km of DI pipes 2198.005 km of HDPE pipes and 3.785 Km of GI pipes in Internal Networks. Also comprises of pipe carrying bridges / pillars at two locations, 4 nos of Union Master Balancing Reservoirs, 6+2 Nos of Union Sumps and Booster Pumping Stations, 153 nos of Panchayat Master Balancing Reservoir, 132 Nos of Panchayat Sumps, 2 Nos of Overhead Tanks with 16m staging height, 229 Nos Overhead Tanks of 6m staging height.

Treated water from the Common Booster Pumping Station to Kaveripatinam Break Pressure Tank (1+ 1 standby) pump, the Palacode Town Panchayat (1 duty + 1 standby) and the Palacode Union Reservoir (1 duty + 1 standby pump). From the Kaveripatinam Break Pressure Tank, treated water is delivered by gravity to reach Bargur.

The areas of coverage for the supply of treated water under Package V will include: Krishnagiri Municipality 3 Town panchayats (Kaveripattinam TP, Nagojanahalli TP & Bargur TP) and 1763 rural habitations in Kaveripattinam union, Krishnagiri union and Bargur union of Krishnagiri District and 4 Town panchayats (Pappalapatti TP, Palacode TP , Marandahalli TP and Karimangalam TP), and 887 rural habitations in Palacode uion, Pennagaram union (part), Karimangalam union (part) in Dharmapuri District . The locations of these tapping points are entered in Table 2 of this Specification and in the Drawings.

Pipes to be *maintained* include mild steel, ductile iron (DI) GI Pipes and High Density Polyethylene (HDPE). Details of the size of pipes, material of pipes used under the Contract are shown in the Drawings.

A preliminary estimation of the length, fittings and the like of the pipelines for each and every size and class of pipe to be shifted and re aligned is given in the statement of pipes and the cost has been arrived for each size of pipeline but the actual type, length and size of pipeline to be shifted and realigned (due to the development activities of the other service providers) cannot be forecasted. Hence a provisional lump sum amount towards the cost of civil works and supply of pipes has been given under Schedule P3 of price schedule in Volume 2 of Tender Schedule. This amount will be utilized as per ground reality as and when arises. The rate for the supply of pipes for realignment will be the rate quoted for the supply of pipes for attending to leaks and bursts. But, the contractor has to quote the unit rates for the civil works for all the type and size of pipes for every year for all the five years. For the work of shifting/realignment, the pipe rate and the civil works rate will be applicable for the respective pipe size and class for the respective year. The actual pipe length type and size shall be subject to be measured on site after the pipelines are installed, in accordance with the agreed pipeline route between the Contractor and the Engineer.

B1.1.4 The Site (For shifting and relaying of pipe line)

The Site provided shall be sufficient to lay the transmission pipeline and shall generally include the road shoulder and part width of the carriageway for two way roads. The Contractor shall carry out a detailed inspection of the pipeline route and draw up plans in consultation with officials of the relevant authority, indicating the working width available based on the above constraint. Plans shall be drawn at 1:1000 scale. If the Contractor considers that at any location there is insufficient working width using only part of the carriageway then he shall indicate this on the plans, and produce a schedule of the locations with proposals for achieving the working width whilst taking into consideration the requirements of the regulating authority regarding movement of public traffic etc.

The plans shall be submitted to the Engineer for use by the Employer in obtaining permissions from the authorities. The plans shall be submitted not less than *3days* in advance of the date scheduled for commencement of pipe laying. The site shall generally be made available such that the Contractor has up to 200m available at any one time. Further lengths of Site shall be made available as reinstatement work is completed. For example, once 50m of Site is reinstated, another 50m shall be made available. The precise details of this arrangement shall be agreed between the Employer, Engineer, Contractor and relevant authority whilst obtaining the permissions for the work.

The Contractor shall provide road reinstatement depending on the particular type of road, should open trench pipe laying method be adopted for that particular road. National and State highways and those maintained by the Public Works Department shall be permanently reinstated up to the top of the base course in accordance with the Drawings

and Specification. Depending on the requirements from the National highways, State highways and Public Works, the final reinstatement of the running surface shall be directly by these authorities. . Under this scenario, final reinstatement of the running surface shall be done by the authority and paid for by the Employer. If required for facilitating the work to be carried out, the Contractor shall be responsible for shifting permanently all service lines, cables, gas pipes, water pipes and drainage pipes, overhead or buried, and for gaining the permissions from the relevant authorities for canal and river crossings, highway/road crossings, railway crossings, nalla crossing etc. The role and involvement of the Employer at all these works will be to provide endorsement letters with the Contractor's letters to these authorities to make application for the aforesaid diversion works, that shall be done by these public services authorities, and the new works. . In case there is a delay of the Works, due to the Contractor not gaining permissions in time from these public services authorities to follow his programme, all time and economic impact shall be borne by the Contractor and not be reimbursed from the Employer. The Contractor shall assist these public services authorities to carry out their diversion work which shall include all other necessary work not within the scope of these public services authorities and its cost shall be deemed to be included in the price of the Contract.

The Contractor shall be responsible for felling or transplanting any trees it is necessary to remove after gaining permission from the relevant authority.

The Contractor shall make his own arrangements and pay all expenses for any additional area that he may require outside the site locations as shown in the Drawing, in order to have the pipeline work be done. The Contractor shall obtain the consent of the Engineer of such arrangement prior to proceeding with the work.

B1.1.5 Pipe laying

The pipeline shall be laid in accordance with the Drawings and include all fittings shown. The final pipeline route and exact locations of fittings and chambers shall be agreed on site between the Contractor and the Engineer following a preliminary survey to be done by the Contractor.

The pipeline shall be commissioned with a complete programme of flushing, pressure testing and disinfection.

B1.1.6 Mild steel pipes

Pipe shall be welded mild steel, factory coated with internal cement mortar coating and external coal tar enamel wrap for buried pipes. External coating for exposed pipe shall be factory applied sprayed polyurethane or fusion bonded epoxy. The pipe shall be supplied with spigot/sleeve joints for in-situ welding. Internal and external coatings shall be made good in-situ. External protection at joints on coal-tar coated pipe shall be made

good with either coal tar enamel or polyethylene heat shrink wrap. External protection at joints on all other coatings shall be made good with polyethylene heat shrink wrap.

Bedding shall generally be sand or graded granular material except for particular locations where mass concrete may be required.

Mild steel pipe is generally specified for river/canal crossings where the pipe is either on a pipe bridge or acting as a self supporting span. The pipe wall thickness on self supporting spans shall generally be greater than that for conventional buried pipes. In this case the pipes shall be supplied in accordance with the details given in the Bills of Quantities and the Drawings.

The Contractor may provide *Mild steel pipe of diameters equal to or less than 900 mm* with butt welded joints provided that he can demonstrate that the internal lining at the joints can be made good in-situ to the same standard as provided elsewhere. Alternatively he may provide these pipes with flanged joints, in which case he shall design the flanges to withstand all the structural loads, and submit his calculations to the Engineer for approval. The Contractor may propose an alternative form of joint, which shall be subject to the approval of the Engineer.

B1.1.7 Cathodic protection

In the pipeline of package 2, Cathodic protection of pipelines did not arise and hence not done. But if in the future, if situation arises for cathodic protection, this could be done by following the below specifications

B1.1.7.1 General

Cathodic protection of the pipelines shall be attained by Impressed Current Cathodic Protection (ICCP) and boosting the protection by the use of sacrificial anodes, whenever it is necessary. The cathodic protection system to provide shall conform to the requirements of the ICCP system entered in Clause K23 "Cathodic Protection of Steel Pipelines" in Volume 3 of the Specification and the sacrificial anode cathodic protection system requirements entered in Clause B1.1.7.3 below. Additional to the standards that are entered in Clause K23, the cathodic protection system shall also conform to the following standards, where it is applicable:

BS 7361 Part 1 1991 'Cathodic Protection Part 1 - Code of Practice for Land and Marine Applications' British Standards Institution, U.K;

BS EN 12473 General principles of cathodic protection in sea water;

BS EN 12474 Cathodic protection for submarine pipelines;

BS EN 12696 Cathodic protection of steel in concrete Part 1: Atmospherically exposed concrete;

BS EN 12954 Cathodic protection of buried or immersed metallic structures – General principles and application for pipelines;

BS EN 13173 Cathodic protection for steel offshore floating structures;

BS EN 13174 Cathodic protection for harbour installations;

NACE INTERNATIONAL (NACE) SP0169 (2007) Control of External Corrosion on Underground or Submerged Metallic Piping Systems;

NACE INTERNATIONAL (NACE) SP0572 (2007) Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds.

The Contractor shall employ and appoint a "Corrosion Engineer" to supervise, inspect, test and commission the installation of the cathodic protection system. The "Corrosion Engineer" shall be an engineer with certification or licensing that includes education and experience in cathodic protection of buried or submerged metal structures, or a person certified by relevant authority as a cathodic protection specialist. Such a person shall have not less than five years experience in the cathodic protection of underground buried pipelines. The Contractor shall submit evidence to justify the qualifications of "Corrosion Engineer" to the Engineer for review and approval.

The Corrosion Engineer shall design the cathodic protection system by taking into account of the followings:

1. Total surface area of the pipelines;
2. Type of coating and condition of coating at the pipelines;
3. Total bare surface area to be protected shall be assumed to be, as a minimum, 25% of the total surface area of the pipelines;
4. Minimum current density of 10 mA/m² to the protected surface area;
5. Chemical analysis of the treated water and the resistivity expressed in ohm-cm;
6. Minimum anode design life of twenty (25) years; and
7. Economic and maintenance convenience consideration.

The design for the cathodic protection system shall be submitted to the Engineer for approval and should be the pre-requisite condition for any pipe laying work to commence.

B1.1.7.2 Impressed Current Cathodic Protection (ICCP)

ICCP shall be used as the primary cathodic protection method for the pipelines under the Contract. Sacrificial anodes cathodic protection shall only be used either as a supplementary cathodic protection method to be installed in conjunction with the ICCP to boost the protection locally, when it is necessary; or under scenario where ICCP is unable to work effectively at a particular pipeline installation.

The ICCP system shall utilize an external direct current electrical source that forces the direction of the current, instead of the natural galvanic cell reaction when the pipelines are buried and in contact with soil. The positive terminal from the power source is connected to the ground bed anode and the negative terminal is connected to the cathode, which shall be the pipeline. The direct current electrical source shall be derived from an alternating current sources using a rectifier to perform the ac/dc conversion. The rectifier and its associated equipment shall confirm to the requirements entered in Clause K23.

Metal oxide coated titanium anodes, platinized titanium anodes, graphite anodes or silicon iron anodes shall be used. The Contractor shall submit their design of the anodes, with justification to show that the material chosen will provide the best performance at the installed sites, for the approval by the Engineer.

(a) Graphite anodes

Maximum allowable current density for the anode surface area, in application of pipelines buried in soil, shall be 10.76A/m². Chemical composition of the graphite anode shall be:

Impregnant	6.5 percent maximum
Ash	1.5 percent maximum
Moisture & Volatiles	0.5 percent maximum
Water Soluble Matter	1.0 percent maximum
Graphite	Remainder

(b) Mixed metal oxide coated titanium anode

Mixed metal oxide coated titanium anodes shall be provided by a firm that is regularly engaged in and has, as a minimum, 5 years experience in manufacturing and applying mixed metal oxide coatings to titanium anode substrates. The mixed metal oxide coated titanium anodes shall conform to the following requirements:

(i) Conductive Material

Titanium substrate coated with an inert, dimensionally stable, electrically conductive coating, with average composition of a 50/50 atomic percent, mixture of iridium and titanium oxides with a small amount of tantalum and ruthenium, 0.002 ohm-centimeter maximum resistivity, 50 MPa minimum adhesion or bond strength, and capable of sustaining a current density of 100 A/m² in an oxygen generating electrolyte at 66°C for 20 years. Sinter the mixed metal oxide coating to the titanium surface as to remain tightly bound to the surface when bent 180° onto itself;

(ii) Anode Life Test

An accelerated current capacity life test shall be performed on every lot of anode wire used to construct the anode as described. The anode wire material shall sustain current densities of 100 A/m² in an oxygen generating electrolyte for 20 years. The manufacturer shall certify that a representative sample taken from the same lot used to construct the anode, has been tested and meets the following criteria:

- The representative sample shall be 125 mm in length and be taken from the lot of wire that is to be used for the anode;
- The cell containing the anode shall be powered with a constant current power supply for the 30 day test period;
- The test cell sustains a current density of 10,000 A/m² in a 15 weight percent sulfuric acid electrolyte at 66° C without an increase in anode to cathode potential of more than 1 volt.

(iii) Adhesion or Bond Strength Test

Determine the adhesion or bond strength by epoxy bonding a 2.54 mm diameter stud to the ceramic coating and measuring the load to failure of either the epoxy or the interface between the coating and the substrate.

B1.1.7.3 Sacrificial anodes cathodic protection system

Sacrificial anodes cathodic protection (SACP) shall only be used as a supplementary cathodic protection method to be installed in conjunction with the ICCP to boost the protection locally, when it is necessary; or under scenario where ICCP is unable to work effectively at a particular pipeline installation.

The SACP shall be done by using sacrificial anodes in form of extruded magnesium ribbon anode laid in the pipe trench parallel to pipeline as shown in the drawing No: STD/PL/020/TA and STD/PL/021/TA. The length of ribbon at hot spot shall be length of hot spot pocket + 10.0 m on each side of pocket but not less than 100 m. The ribbon anode shall be connected the pipeline by means of tail cable with thermit welded joint.

Extruded magnesium ribbon anode shall be of the specifications that are stated in the following. Contractor shall furnish test certificate of chemical composition, dimensions and weight.

Material Composition:

	Element	% by Weight
	Zinc	0.01 max
	Aluminium	0.01 max
	Manganese	0.5 – 1.3
	Copper	0.02 max
	Iron	0.03 max
	Nickel	0.001 max
	Others (metal)	0.05 max each
		0.30 max total
	Magnesium	Balance
Open circuit Potential	:	-1.6 V with respect to saturated copper – copper sulphate reference cell
Consumption rate	:	kg per Amp – Year
Size	:	3/8" x 3/8" cross section
Insert	:	Continuous 1/8" iron wire core
Weight	:	0.24 lbs per foot or 0.357 kg per m
Anode tail cable	:	1C x 25 sq.mm PE insulated PVC sheathed high conductivity stranded unarmored copper conductor cable.
Heat shrinkable sleeve	:	Heat shrinkable sleeve of suitable size to shrink on anode and anode tail cable to seal the cable to anode core joint.
Job Description	:	The magnesium ribbon anodes wherever required shall

be installed prior to backfilling of trench as follows;

- The length of Magnesium ribbon anode equal to length of pipeline in soil resistivity $< 100 \text{ ohm} - \text{m} + 20 \text{ m}$ shall be cut from spool.
- The ribbon anode shall be laid in cable trench starting 10 m before and ending 10 m after chainage of pipeline to be provided with cathodic protection at each location as shown in tender Drawing.
- The core at extreme ends of the ribbon anode shall be exposed and cleaned thoroughly.
- 1 C x 6 sq.mm copper conductor each 5 m long shall be soldered to the core at both ends using silver solder (EUTEC ROD 157).
- The soldered cable to anode core shall be directly thermit welded to the pipeline. The procedure of thermit welding and encapsulation of pipe to cable joint is given in the tender Drawing.
- Soft soil shall be backfilled around anode before pipeline trench is backfilled.

(a) Initial Investigation

The Contractor shall carry out soil resistivity surveys at 1000 m intervals, on ROW (Right of Way) for buried pipeline under procedure given below to identify hot spots.

- Soil resistivity survey shall be carried out by 4 Pin Wenner technique at pin spacings of 1.5 m and 2 m.
- Additional readings shall be taken at following location or positions
 - At nalla, river, marshy areas etc i.e. where buried pipeline is close to water bodies.
 - Location/position where initial ERT survey show low value in proximity of $100 \text{ ohm} - \text{m}$ or drastic change in resistivity value from adjoining reading.
- If the ratios of two consecutive readings is greater than 2 and lower of the two readings is less than $200 \text{ ohm} - \text{m}$, additional reading shall be taken at mid point.
- If the ratio of additional reading to reading on either side is also greater than 2, another reading shall be taken between the mid point and the reading which is differing by ratio of 2. This procedure shall be followed, but minimum gap between readings shall be 100 m.
- Based on the soil resistivity readings, the length of pipeline [to the nearest 100 m] in soil resistivity less than $100 \text{ ohm} - \text{m}$ shall be identified.
- Based on the soil resistivity survey, the contractor shall prepare a detailed report with schematic drawing showing the soil resistivity on ROW clearly highlighting the locations where the soil resistivity is less than $<100 \text{ ohm} - \text{m}$.

(b) Final locations

The results of the survey shall be furnished to the Engineer, who shall determine the locations and extents of sacrificial anodes to be installed. The Contractor shall install all such anodes in the trenches of the pipeline.

B1.1.8 Ductile iron pipes

Ductile iron pipes shall be supplied with internal cement mortar coating and external coating of metallic zinc with a finishing coat of bituminous paint, as per the Specification. Pipes shall have spigot/socket joints. Pipes shall be Class K9 or K7, as specified on the Drawings.

Bedding shall generally be sand or graded granular material except for particular locations where mass concrete shall be required.

B1.1.9 High Density Polyethylene (HDPE) pipes

(a) Specification

HDPE pipes shall confirm to the following specifications:

- | | |
|----------------|---|
| ISO 12162 | Thermoplastics materials for pipes and fitting for pressure applications – Classification and designation – overall service (design) coefficient. |
| ISO 12176-1:98 | Plastics pipes and fittings – Equipment for fusion jointing polyethylene systems – Part 1 : Butt Fusion. |
| EN 712 | Thermoplastics piping system – End load – bearing mechanical joints between pressure pipes and fittings – Test method for resistance to pull – out under constant longitudinal force. |
| EN 713 | Plastics piping system – Mechanical joints between fittings and polyolefin pressure pipes – Test method for leak tightness under internal pressure whilst subjected to bending. |
| EN 715 | Thermoplastics piping systems – Mechanical and cemented joints between pressure pipes and fittings – Test method for leak tightness under internal pressure, including end thrust. |
| EN 921 | Thermoplastics pipes – Determination of resistance to internal pressure at constant temperature. |
| ISO 13953:1995 | Polyethylene pipes and fittings – Determination of tensile strength of test piece from butt fused joint. |
| ISO 13954:1997 | Plastics pipes and fittings – Peel de-cohesion test for polyethylene (PE) electro-fusion assemblies of nominal outside diameter greater than or equal to 90mm. |
| ISO 13955:1997 | Plastics pipes and fittings – Crushing de-cohesion test for polyethylene (PE) electro-fusion assemblies. |

ISO 13956:1995 Plastics pipes and fittings – Pull out de-cohesion test for polyethylene electro-fusion assemblies.

- | | |
|---------|---|
| IS 4984 | Specification for High Density Poly ethylene Pipes |
| IS 7328 | Specification for material of manufacturing |
| IS 7634 | Guidance on proper methods for laying and jointing of polyethylene pipe work system |

(b) Material

The HDPE pipe shall be made from base polymer and shall conform to the requirements as specified in MS 1058 Part 1:2002 and IS 4984. The base polymer shall be a single grade of polyethylene, PE 100. No rework material is allowable for the manufacture of the pipes. No additives that may contribute to toxic hazard, impair the fabrication of properties and chemical and physical properties in particular to long term mechanical and strength is allowed. The colour of the pipes shall be black with blue stripes. The material for stripes shall be of the same type of resin as used in the compound for the pipe.

(c) Pipe Classification and dimensions

All HDPE Pipes must be from Class PE 100 with nominal pressure rating be not smaller than the working pressure as shown in the Drawing.

Wall thickness and nominal diameter of PE 100 pipes are given below.

NOM. DIAMETER FOR OTHER PIPES (Outside diameter) (mm)	WALL THICKNESS (PN 5) (mm)	WALL THICKNESS (PN 8) (mm)	WALL THICKNESS (PN 12.5) (mm)
20	-		2.0
25	-		2.3
32	-	2.0	3.0
40	-	2.4	3.7
50	2.0	3.0	5.2
63	2.5	3.8	6.5
75	2.9	4.5	7.6
90	3.5	5.4	9.2
110	4.2	6.6	11.1
125	4.8	7.4	12.7
140	5.4	8.3	14.1
160	6.2	9.5	16.2
180	6.9	10.7	18.2
200	7.7	11.7	20.2
225	8.6	13.4	22.7
250	9.6	14.8	25.1
280	10.7	16.6	28.1
315	12.1	18.7	31.6
355	13.6	21.1	35.6
400	15.3	23.7	40.1
450	17.2	26.7	45.1
500	19.1	29.7	50.1
560	21.4	33.2	56

NOM. DIAMETER FOR OTHER PIPES (Outside diameter) (mm)	WALL THICKNESS (PN 5) (mm)	WALL THICKNESS (PN 8) (mm)	WALL THICKNESS (PN 12.5) (mm)
630	24.1	37.4	63.1

(d) Length and appearance

The required length of HDPE pipes in coil for nominal diameter 63 mm and below shall be 100 meter. The standard length of HDPE pipes for nominal diameter 125 mm and above shall be 9m or 12m. The internal and external surfaces of pipes must smooth, clean and free from scoring, cavities and other surface defects which may affect pipe performance. The ends of pipe shall cut cleanly and square to the axis of the pipe. Appearance shall be checked at the point of manufacture.

(e) Routine Test

The pipe suppliers shall furnish results of the routine tests carried out in accordance with the requirements as stipulated in MS 1058: Part 1: 2002. The minimum Oxidation Induction Time (OIT) for pipes fitting shall be 80 min.

(f) Pipe markings

All pipes must have the following markings:

- Manufacturer's name or trade mark
- Dimensions
- Material supplier and material class (PE 100)
- Pipe Class (PN)
- Year of manufacture (last two digits)
- Batch production number

(g) Pipe fittings and jointing method

Electro-fusion fittings comply to MS 1058 or EN 12201-3 shall be used. Electro-fusion fittings shall be injection moulded fittings made of PE but incorporating integral heating element(s) to enable fusion jointing with PE pipes. All PE100 fittings shall be jointed by couplers only. Electro-fusion socket fusion shall be used where an electrical resistance element is incorporated in the socket of the fitting which, when connected to appropriate power supply, melts and fuses the material of the pipe and fitting together. Contaminated surface of the pipe over the socket depth has to be removed prior to conducting the jointing work to ensure that a joint is completed effectively.

(h) Laying of pipe

HDPE pipes shall be joined to form a string above ground prior to snaking into the trench. To prevent scoring, pipe rollers should be used. Before lowering HDPE pipelines into the trench, a check should be made for cuts, deep scratches or other pipe damage and in

fusion jointed systems that the system has cooled sufficient before stress is imposed upon any pre-made joints. When lowering pipe into the trench, care should again be taken to avoid scoring of the pipe by contact with the sides and bottom of the trench. Use should be made of planks and ropes where appropriate but wire ropes or chains should not be used.

Gradual changes in direction of HDPE pipelines can be accommodated by pipe deflection but every effort should be made to keep the pipe as central as possible within the trench to enable adequate compaction of side-fill. The bending of HDPE pipelines is permissible and the properties of fusion jointed systems enable changes of direction without recourse to the provision of special bends or anchor blocks. However, the pipe should not normally be cold bent to a radius less than 25 times the outside diameter of the pipe. For push-fit or mechanical non end-load resistant jointing systems, anchor blocks to withstand the resultant thrusts must be provided. Under no circumstances should hot bending be attempted on site.

For installation of heavy flanged fittings, provision should be made for concrete support both for the weight and to resist the turning moments associated with valves and hydrants.

HDPE pipes and fitting may be partially or completely surrounded by concrete but they should be protected by 3mm rubber membrane to avoid possible damage during pouring or compaction to prevent high localized stresses.

After completion of an installation, pipe work and fittings should be inspected and made ready for testing to ensure the safety and efficiency of the systems. The trench may be backfilled prior to testing; but it is advisable to leave at least the joints exposed throughout the test.

Complete and accurate records should be taken of the installation. To assist the future location of the pipelines, a marker tape shall be laid along the line. The recommended position of the tape is 350mm below the surface directly above the crown of the pipe.

B1.1.10 Chambers and washouts

Chambers shall be provided in accordance with the Drawings. The exact location for each chamber shall be determined on site between the Engineer and Contractor. Unless indicated otherwise the access covers shall be of a uniform type and manufacture throughout the Works.

Access steps shall be of specially designed aluminium ladders in accordance with the Drawings and Specification. No improvised units shall be installed.

Where washouts have outfalls to ditches it will be necessary to install a headwall as indicated on the Drawings. The headwalls will need to be modified to account for local variations in the size and layout of the ditch. In certain cases the detail may be modified to

have the pipe discharging to an area of ditch lined with rubble pitching rather than providing a reinforced concrete headwall.

The Contractor shall review all the washout locations during the initial route inspection and shall agree with the Engineer the type of outfall to be used at each location. The location of each chamber shall be agreed in advance of the works in a similar way.

B1.1.11 Valves

The type and location of each valve is indicated on the Drawings.

Butterfly valves and gate valves, used for isolation purpose are of the resilient-seated type. Valves are fabricated of cast steel.

Air valves are exposed valves on above ground pipes. Air valves are fabricated of ductile iron.

Valves are in accordance with the Specification. The Contractor shall use uniform types and manufacture of each type of valve throughout the Works.

Flow Control Valves are sluice or butterfly valves according to the Drawings, specifically designed to reduce pressure across the valve and provide a maximum permissible flow downstream of the valve. Flow Control Valves are provided at the tapping points from the trunk mains and these valves are needle type valves. The tolerance in the flow value is $\pm 5\%$ of the design value. The manufacturer of the valve shall be subject to the approval of the Engineer. The valves shall be from PN16 to PN30 as that shown in the Drawings and rated and fabricated of cast steel. The flow setting shall be adjustable between fully unrestricted, to the full range at or below the design flow. Valves are located in chambers at sites *as* in the Drawings.

B1.1.12 Spares

The Contractor shall supply the spares to the *contractor's* storage yard, as directed by the Engineer. The price in the Bill of Quantity for spares shall include all transportation costs.

All spares shall be supplied properly packed and individually identified, as per the Specification. Consumables shall be clearly identified in terms of which size and type of valve they are for.

B1.1.13 Wide river crossings

At river where there is existing crossing bridge for vehicles or passengers, the span supports for the pipeline pipe bridge shall match the supports of the existing bridges. For other wide river crossings, 8m span supports shall be used and be constructed in accordance with the Drawings. The final detailed arrangements shall be agreed on site with the Engineer.

B1.1.14 Culvert, Small River and nalla crossings

At river where there is existing crossing bridge for vehicles or passengers, the span supports for the pipeline pipe bridge shall match the supports of the existing bridges. For other culvert, small river and nalla crossings where pipe bridges are used, 5 m span supports shall be used and be constructed in accordance with the Drawings. The final detailed arrangements shall be agreed on site with the Engineer.

B1.1.15 National highways, State highways, Railway and pipe culvert crossings

Initiating by the Contractor in accordance with their program of *the varied* work, the Employer will issue endorsement letters, with the application letters of the Contractors, to these authorities to obtain permission from them for the Contractor.

B1.1.16 Interface works with the contractors of Package I and Package IV

This Contract is the "Hogenakkal Water Supply and Fluorosis Mitigation Project - Package V - Treated Water Trunk Mains from Main Balancing Reservoir at MADAM to Bargur, Branch Pipelines, Union Reservoirs, Panchayat Reservoirs, Sumps, Overhead Tanks, Chlorination Stations, Booster Pumping Stations, Instrumentation, Electrical and Mechanical Works", The Employer will be procuring the remaining works under Packages I, II, III and IV. These packages are to maintain.

- (a) Package I - Intake Works, raw water pumping station, treatment plant, treated water pumping station, booster pumping station, pumping mains, MADAM master balancing reservoir and allied works;
- (b) Package II - Treated Water Trunk Mains from Master Balancing Reservoir at MADAM to Uthangarai, Branch Pipelines, Union Reservoirs, Panchayat Reservoirs, Sumps, Overhead Tanks, Chlorination Stations, Booster Pumping Stations, Instrumentation, Electrical and Mechanical Works;
- (c) Package III - Treated Water Trunk Mains to Harur, Branch Pipelines, Union Reservoirs, Panchayat Reservoirs, Sumps, Overhead Tanks, Chlorination Stations, Booster Pumping Stations, Instrumentation, Electrical and Mechanical Works;
- (d) Package IV - Treated water trunk mains from Booster Pumping Station near Palacode to Hosur, branch pipelines, union reservoirs, panchayat reservoirs, sumps, overhead tanks, chlorination stations, booster pumping stations, instrumentation, electrical and mechanical works,

The Works under this Contract will interface directly with all these Packages. The nature of these interfaces will be, as a minimum but not limited to, the scope entered in the table below:

Interface	Nature of Interface
Package I	<p>(1) The contractor of Package I has to commission all the instruments at sites of the tapping points from the trunk mains, the level transmitters at the sites of union reservoirs, the flowmeters/pressure transmitters/level sensors at the large booster pumping stations and all the Local Control Panels for SCADA System at the sites of Packages V. The Contractor has to coordinate with the contractor of Package I for all the interface works that are to incur and allow the contractor of Package I to access the sites under the Contract for carrying out his work, The Contractor shall supply all other signals that are required by the SCADA System from their equipment, in accordance with the Particular Specification.</p> <p>(2) The contractor has to make maintain for their trunk main pipelines to the treated water discharge pipe of the contractor package – I at outlet of the Master Balancing Reservoir at Madam. The contractor of package – I has to maintain his treated water discharge pipe to an interface point at about 1m outside the compound wall of the site of the Master Balancing Reservoir at MADAM and the Contractor has to maintained transmission main pipelines.</p>
Package V	<p>(1) The Contractor has to maintain the civil structure, major electrical works and building services works for the Common Booster Pumping Station near Palacode and allowed the contractor of Package IV to access this site to carry out maintenance work</p>

Interface with the contract of Package-I Pipeline Works

The Engineer will arrange meetings among himself, the Contractor and the contractor of Packages - I to agree a programmed for the maintenance of the treated water trunk mains of Package V to the treated water pipe end of Package I. The interface point will be outside the boundary wall of the Master Balancing Reservoir at Madam, at about 1m from the boundary wall. The treated water pipe end of Package - I is mild steel pipe of 1.5m in diameter with flange end.

Instrumentation, SCADA and telemetry Works

The Engineer will arrange meetings among himself, the Contractor and the contractors of Packages I, II, III and IV to agree a programmed for the instrumentation, SCADA system, and telemetry network, under the scope of Package I, to be maintained the sites of Packages II to V.

Pressure transmitters and electromagnetic flowmeters will be maintained by the contractor of Package - I at each of the tapping point from trunk mains sites and the large booster pumping stations.

The Contractor shall allow the contractor of Package I to access his sites to maintain the ultrasonic level sensor/transmitters at the union reservoirs/sumps of large

booster pumping stations, the pressure sensors/transmitters, the electromagnetic flowmeter at the tapping point from the trunk mains/large booster pumping stations, and also the Local Control Panels (LCPs) for the SCADA System. The LCPs is to be used for the acquisition of signals and to activate the control command from/to the instruments, electrical and mechanical equipment at the sites of Package V. The Contractor has to provide all the fully open, fully close status signals for all isolation valves and the position status signals for the flow control valves. Also, the Contractor has to provide the necessary control devices at the actuators of all these valves such that the SCADA System shall be able to control them. For the isolation valves, the SCADA System shall be able to fully open, fully close and stop at intermediate positions of the valves. For the flow control valves, the SCADA System shall be able to modulate their positions to control the flow passing through the tapping point branches from the trunk mains.

The instruments and valves signals will be transmitted from these LCPs back to the Central Control Room (CCR) at the Water Treatment Plant of Package I via GSM / CDMA mobile lines, satellite relay stations, The Contractor shall in conjunction with the contractor of Package I, and maintain the necessary cable ducts, draw pits and all other accessories at each site of Package - V, The Contractor shall attend all meetings that are arranged by the contractor of Package-I with the service providers when the discussion will be related to the work in Package - V.

At each site of Package - V, the Contractor shall provide a power supply of 100V, 230V, single phase to the Telemetry Rooms at Re-Chlorination Building and large booster pumping stations and directly to the LCP at the tapping points from the treated water trunk mains. The contractor of Package I will use this power supply for his UPS that in turn feed the LCP and other instruments.

The Contractor has to act in conjunction with the contractor of Package I to:

(a) Test that all the signals from the primary devices (the contractor of Package I to be responsible for the maintenance of instruments installed by Package-I at the site of Package V) shall be able to transmit to the SCADA system and be able to be displayed at the Human Machine Interface (HMI) display pages at the CCR of the Water Treatment Plant.

test that the control commands being sent from the SCADA system through the HMI display pages any of the CCRs or at the respective LCP can control the relevant devices at each site of Package V.

Cable ducts, drawpits and cable laying from local devices to the LCPs

The Contractor has to maintain all the cable ducts, draw pits, cable trays, supports and all other items of the cables from each of the devices, including instruments, electrical and mechanical equipment, to the LCPs at each site of Package V.

For those instruments that are provided under Package I, he shall be responsible to maintain installed cables to the LCPs, the cable ducts, draw pits, cable trays and the like provided by the Contractor.

Interface with the contracts of Package – IV

Common Booster Pumping Station at Palacode:

The Engineer will arrange meetings among himself, the Contractor and the contractor of Packages IV to agree a programme to allow the contractor of Package IV to access the Common Booster Pumping Station at Palacode, according to the maintenance programme of the Contractor at this site.

The contractor of Package IV will maintain the civil requirements relating to their work at the Common Booster Pumping Station near Palacode, e.g. the pumpwell, the cable trench inside their switchroom. All pipeworks and other associated mechanical equipment (e.g. valves) for the pumping works of Package IV will be maintained by the contractor of Package IV.

The contractor of Package - V will provide the electrical power rating requirement for their works at the Common Booster Pumping Station near Palacode to the Contractor of package – IV

The Common Booster Pumping Station at Palacode. All quarters building services work maintained by package- IV

B1.2 Reservoir, Booster Pumping Station Sump and Overhead Tank Sites

B1.2.1 Scope

This section covers the maintenance of civil, building aspects, electrical and mechanical systems of the works. The specifications for Plant, materials and workmanship appear elsewhere.

B1.2.2 Extent of the works

The activities include:

- (a) *Maintenance* of all new union reservoirs, panchayat reservoirs, inlet sumps to booster pumping stations (if applicable) and overhead tanks as shown in the Drawings. The locations and capacity of the reservoirs/tanks, boosters pumping stations and the

required operating duty for each of the booster pumps are shown in *the list and the Drawings*

- (a) *Maintenance of* union/panchayat reservoirs, chamber for inlet isolating valve, chamber for outlet isolating valve and chamber for washout valve;
- (b) *Maintenance of* inlet isolating valves at the inlet to the reservoirs, outlet isolating valves at the outlet of the reservoirs and washout valves into the corresponding chambers mentioned in item (b) above. *Maintenance of* all the necessary pipe works for connecting all these devices together, from these devices to the downstream reservoirs/overhead tanks and from these devices to the incoming branches from the trunk mains;
- (c) The Contractor has to maintain the re-chlorination station houses and all necessary building services and fire services equipment installed at the buildings. The Contractor has to maintain the power supply acquired from TNEB according to the loads that are connected Maintenance of all cable ducts, cable trenches, cable draw pits, cable trays, cable trunking and cable conduits for the electrical and instrument cables *and* has to liaise with the contractors of Package I
- (d) Maintenance of site roads for access to each of the sites; and
- (e) Maintenance of compound wall, landscaping and drainage at each of the sites. The access door, the main gate, for vehicles and the single leaf access door, the side gate at the compound wall, for entry/exit by the operation personnel provided shall be maintained properly.

Table - 2 - Re-Chlorinations Stations

S.No	Location	Quantity of Reservoirs	Union Reservoir(s) Or Panchayat Reservoir(S)	Type and size of branch pipeline (mm)	Chlorination Building Type
1	Kaduchettipatti	1	Karimangalam (Part)	200 DI	Type A
2	Rayakottai	1	TP 1 UR (Shoolagiri, Veppanapalli and Kelamangalam)	350 DI	Type A
3	Jakkeri	1	TP 2 UR (Kelamangalam and Thally)	500 DI	Type A
4	Mathagiri	1	TP 3 UR (Hosur and Thally)	350 DI	Type A
5	Dinnur	1	TP 4 UR (Hosur and Shoolagiri)	600 DI	Type A

B1.2.3 The site

Maintenance of all the union reservoirs and panchayat reservoirs specified in the *list and the Drawings*. The Contractor has to *maintain* all the items as described in Clause B1.2.2 above and all the necessary pipelines for interconnecting the treated water trunk mains, the union reservoirs, the panchayat reservoirs, the inlet sump to the booster pumping stations (if applicable) and the overhead tanks in a manner as specified in this Specification and the Drawings.

The Contractor shall take all necessary precautions to avoid damaging the existing overhead tank foundations, superstructures and other existing pipelines, when they are performing the *Maintenance* work of the chambers, pipelines, valves and other items as specified in the Clause B1.2.2 at these sites. The Contractor has to protect the existing overhead tanks and the existing pipeline connection when he is performing *Maintenance* work adjacently.

The Contractor *has to* store materials and equipment at places on the site agreed with the Engineer. No materials or equipment shall be left in a way that the reservoir structure is supporting it.

The Contractor has to submit a method statement to advise the work sequence of their work and to justify that they have taken into account all necessary protection provision to protect the existing plants, all necessary provision to prevent generating of excessive noise during construction etc. The method statement has to be submitted to the Engineer for approval.

B1.2.4 Work procedures at existing overhead tanks sites and other sites where there are existing plants (If additional OHTs are to be interlinked with Hogenakkal Water Supply and Fluorosis Mitigation Project)

The Contractor has to make application for a "Plant Modification Request" through the Engineer to the Employer, prior to carrying out any work at sites where existing plants are there. In the "Plant Modification Request" form, the Contractor has to state clearly the scope of work, the date/time to carry out the work, details of the equipment to use to carry out the work and the details of the persons responsible for the work. Together with the "Plant Modification Request" application form, the Contractor has to submit a "risk assessment report" to provide the details of the safety measures that have to be implemented when the work is carrying out and the "method statement" to advise the Engineer the sequence to conduct the work, as mentioned in Clause B1.2.3 above. The Contractor design and fabricate any specials required to fit the pipework into the existing overhead tanks. He may also make all necessary adjustments to the existing pipe layout in order to fit his required arrangement. Any such modifications shall be agreed with the Engineer prior to construction.

At the existing overhead tank sites, as the existing overhead tanks are used to feed water to the downstream villages, the work of the Contractor shall under no circumstances contaminate the treated water from the existing treated water source and the overhead tanks. The work of the Contractor shall not cause excessive long outage time to the existing treated water supply to the downstream consumers. The Contractor shall be responsible to clean the existing overhead tanks thoroughly should the work they carried out had been proven to contaminate them. The Contractor shall be responsible for any damage that is caused to the overhead tanks as a result of his work. Should the existing tank be unable to be repaired due to the damage that is caused, the Contractor shall be responsible to provide a new tank, conforming to the requirement of the Contract, to replace the damaged existing tank.

The Contractor shall only be allowed to connect his new pipelines to the existing overhead tanks during time when the disruption of the existing water supply to the downstream consumers could be kept to the minimum. For sites where the existing treated water supply to the overhead tank is not a continuous 24 hours schedule, the Contractor shall make "Plant Modification Request" application to carry out their work at the planned supply water outage time. For sites where the existing water supply to the overhead tank is continuous throughout the day, the Contractor shall carry out their work at agreed time by the Engineer, preferable at night when the water demand from the downstream consumers should be the least. Under such scenario, all existing water supply must be returned to normal after the agreed working hours.

The Employer and the Engineer will review the application and return the "Plant Modification Request" form to the Contractor within 7 working days. If the Contractor is disallowed to carry out the work, the Employer and the Engineer will advise the Contractor the reason for such decision.

B1.2.5 Buildings

The Contractor has to maintain the building housing the re-chlorination station at the union reservoirs. Also the Contractor has to maintain the telemetry room of the SCADA System for this union reservoir.

B1.2.6 Access roads and pathways

Access roads and pathways shall be maintained.

B1.2.7 Landscaping

The Contractor shall tend the landscaping, by watering and cutting as necessary *and* that the landscaping is properly maintained.

B1.3 The tapping point from the treated water trunk mains

B1.3.1 Scope

The tapping points are where the branch pipelines are connected to the treated water trunk mains to the downstream union and panchayat reservoirs. This section covers particular requirements applicable to the civil, building aspects, electrical and mechanical systems of the works. The specifications for Plant, materials and workmanship appear elsewhere.

B1.3.2 Extent of the works

The activities include:

- (a) At each tapping point from the treated water trunk main as shown in Table 2, chamber for flow control valve chambers for isolating valves, chamber for electromagnetic flow meters and chambers for washout valves *has to be maintained*;
- (b) *Maintain* flow controlling valves with electrical actuators, the outlet isolation valve for the flow meters and the washout valves to the chambers mentioned in item (a) above. *Maintain* all the pipe works connecting all these devices together and to the treated water trunk main
- (c) *Maintain* All ducting, cable draw pits, cable trays, cable tray supports, cable conduits etc for electrical and instrument cables; including those for all cables delivering to the Local Control Panel of the SCADA System.
- (d) *Maintain* roads for access to each of the sites;

B1.3.3 The sites

B1.4 The tapping points from the trunk mains are to be located in the following locations:

Table 1 - Tapping Points

Tapping point branch locations for sites under Package IV	Feeding to	Name of Union	Type and size of branch pipeline (mm)	Design Discharge (Lpm)	Size flow control valve (mm)	Size of electro-magnetic flowmeter (mm)
LS 0	Moongilpatty		850 MS	33154	600	600
LS 16805	Mahendramangalam		850 MS	33154	600	600
LS 22655	Kaduchettipatti	Ullukurukai, Rayakottai and Karimangalam	500 DI, 350 DI, 200 DI	27481, 5397, 705	500 , 350, 200	500 , 350, 200
LS 36955	Ullukurukai	Jakkeri	750 MS	27481	500	500
LS 50065	Jakkeri	Arasakuppam, Kelamangalam TP and	500 DI, 250 HDPE	20245, 6935	500 and 250	500 and 250

		Denkanikottai TP				
LS 54928	Kundhumaranahalli	Mathagiri	700 MS, 350 DI	20245, 4352	500	500
LS 66838	Dinnur	Badutheypalli and Hosur	600 MS	16272	500, 450,250, 200	500, 450,250, 200

B1.3.4 Access roads and pathways

Access roads and pathways shall be *maintained*

B1.3.5 Landscaping

The Contractor shall tend the landscaping, by watering and cutting as necessary *and* that the landscaping is properly maintained.

B1.4 Booster Pumping Stations

B1.4.1 Scope

This section covers particular requirements applicable to the civil, building aspects, electrical and mechanical systems of the works. The Contractor shall also refer to the requirements for Plant, materials and workmanship elsewhere in this Specification.

The activities shall include:

- (a) *Maintain* the inlet sumps and the booster pumping stations at sites as shown in the Drawings . *Maintenance* of the chambers, buildings, sumps etc *housing* the pumping plant, as that shown in the Drawings;
- (b) *Maintain* the booster pumps, isolation valves, air valves and all pipelines connecting these devices and to the incoming/outgoing treated water pipes;
- (c) *Maintain the* chambers in all the booster pumping stations as shown in Table 3 for inlet electromagnetic flow meter (if applicable), inlet and outlet valve chamber for this flow meter , chambers for discharge electromagnetic flow meter, inlet and outlet valve chambers for this flow meter and all the necessary pipelines between the equipment and the flow meters *are to be maintained* by the contractor of Package I;
- (d) The Contractor has to *maintain* the building *housing all the* building services and fire services equipment installed at the building.
- (e) The Contractor shall *maintain the* telemetry room inside the booster pumping station building, with all the building services facilities, *where* Package I SCADA System equipment *were installed*.

B1.4.2 The sites

The locations of the sumps and the booster pumping stations of the Contract are shown in the Drawing

B1.4.3 Buildings

The Contractor has to *maintain* the building housing the booster pumping station as detailed in the Drawings. The Contractor has to *maintain the* room inside the building for use by the contractor of Package I, as the telemetry house of the SCADA System. The Contractor shall *maintain* all the building services facilities and cable trenches at the telemetry house. One no. of 9,000 BTU air conditioner provided *shall be maintained* under the Contract (at the telemetry house). The door shall be painted in accordance to the requirements as entered in the Standard Specification with the finishing colour agreed by the Engineer.

B1.4.4 Access roads and pathways

Access roads and pathways shall be *maintained*.

B1.4.5 Landscaping

The Contractor shall tend the landscaping, by watering and cutting as necessary *and* that the landscaping is properly maintained.

B1.5 Re-chlorination stations

B1.5.1 Scope

This section covers particular requirements applicable to the civil, building aspects and the electrical system of the works. The Contractor shall also refer to the requirements for Plant, materials and workmanship elsewhere in this Specification.

B1.5.2 Extent of the works

At the union reservoirs, *the* re-chlorination station shall be *maintained* by the Contractor. The activities shall include:

- (a) *Maintenance of building housing the chlorination equipments and one No. of 9,000 BTU air conditioner at each telemetry room in the Union MBRs.*
- (b) *Maintain the Re-Chlorination Station;*
- (c) *Maintain the 400V distribution switchboard and motor control centre for each Re-Chlorination Station.*
- (d) *Maintenance of site roads for access to the sites;*
- (e) *Maintenance of pipelines for proper and efficient functioning of the system;*

B1.5.3 Pipework

The Contractor shall *maintain* all the pipe work, valves, fittings and appurtenances now functioning and replace if at all required as per the specification below.

Motive water pipe shall be Mild Steel or HDPE depending on pressure requirement. Steel pipe shall be seamless tubes with screw-thread joints and epoxy internal and external coating.

Chlorine solution pipe shall be HDPE rated for 16 bar working pressure. All dosing pipe shall be laid inside HDPE ducts to provide dual containment. Dosing pipe shall have solvent welded joints with additional polyethylene tape wrapping. Ductwork shall have sealed, watertight, solvent welded joints. The Contractor shall provide draw pits where necessary, e.g. at changes of direction, which shall be included in the rates at the Bill of Quantities for providing the pipe work. The locations and the quantity of the draw pits shall be proposed by the Contractor for the approval by the Engineer.

Valves outside the chlorine house shall be placed in buried chambers with vertical-ducts and top box for tee-key operation.

Chambers shall be of circular pre-cast or cast in-situ manhole rings, provided in accordance with the drawings. Marker posts shall be placed to clearly indicate the location of chambers.

The connection to the main pipe shall be flanged and wrapped to provide a tight containment seal.

B1.5.4 Buildings

The Contractor shall *maintain* the re-chlorination house, which houses the pipe work and equipment associated with the re-chlorination system.

B1.5.5 Access roads and pathways

Access roads and pathways shall be *maintained*.

B1.5.6 Landscaping

The Contractor shall tend the landscaping, by watering and cutting as necessary *and* that the landscaping is properly *maintained*.

B2.0 RE-CHLORINATION STATIONS (For Maintenance, varied or replacement work (due to lethargic activities of the contractor's operating personnel))

B2.1 General

B2.1.1 Scope

This section covers particular requirements applicable to the process and mechanical aspects of the works. The specifications for materials and workmanship appear elsewhere.

B2.1.2 Extent of the works

The Contractor shall *maintain* all the equipment and instrumentation *installed in* the re-chlorination system. This includes booster pumps, chlorinators, ejectors, all associated pipe work, alarms on chlorine cylinder pressure. The Contractor shall also *maintain* all the necessary connections to other pipes.

B2.1.3 Chlorination Building

The building *constructed as per* the Drawings shall be maintained properly . The type of Re-Chlorination Building at each union reservoir site is shown in Table 1.

B2.2 Chlorination Plant

B2.2.1 General

Chlorine is withdrawn as a gas from cylinders, metered under vacuum, mixed with water in ejectors and transferred to the point of application.

Plant for storage, metering and dosing of chlorine shall be *maintained*.

The following items of chlorination plant shall *also* be *maintained effectively*

- (a) Automatic chlorine cylinder changeover unit.
- (b) Chlorine vacuum regulators and pressure relief valves.
- (c) Chlorinators.
- (d) Injectors.
- (e) Chlorine leak detectors.

B2.2.2 Chlorine dose

The objective of chlorinating the water in the union reservoirs will be to boost the chlorine residual in the water which would have been depleted due to time and temperature to ensure a residual of at least 1.5 mg/l is maintained at the inlet to the reservoirs.

Chlorine doses shall be as specified below under 'Chlorinators'.

B2.2.3 Chlorine Cylinders

B2.2.3.1 Chlorine cylinders for the re-chlorination house

The cylinder store at the chlorination stations is sized to provide the following:

- (a) 2 spaces for duty and standby cylinders on line.
- (b) 2 spaces for reserve cylinders.
- (c) 2 space for empty cylinder.

The approximate dimensions and weights of the chlorine cylinders currently available for purchase are as follows:

50 kg cylinders:

Diameter:	240 mm
Height	1400 mm
Net weight of chlorine:	50 kg

80 kg cylinders:

Diameter:	270 mm
Height	1550 mm
Net weight of chlorine:	80 kg

100 kg cylinders

Diameter:	400 mm
Height	1050 to 1250 mm
Net weight of chlorine:	100 kg

The Contractor shall calculate the consumption rate of chlorine at each of the union reservoir and then choose the most appropriate size of the cylinders to use. Appropriate size and quantity of the chlorine cylinders shall be chosen such that the duty cylinders shall be able to provide the required chlorine for at least 28 days at average dosing rate and maximum, without the need for replenishment. Standby chlorine and reserve chlorine cylinders shall be of the same quantity and size as the duty chlorine cylinders. *At present 100 kg cylinders are in use.*

B2.2.3.2 General requirement for chlorine cylinders

The materials, design, manufacture, inspection and testing of chlorine cylinders shall be in accordance with BS EN 1964-1. The cylinders shall be of seamless construction. The steel used in the manufacture of the cylinders shall be in accordance with Clause 4 of BS EN 1964-1.

Fusible metal plug (either of filled or screwed type) *are* provided at the isolation valve of chlorine cylinder. The fusible metal plug shall serve as a pressure relief device for relieving excessive pressure in the event of overheating to prevent rupture. The melting temperature of the fusible plug shall withstand the chlorine pressure in the cylinder at that temperature.

The testing of the cylinders shall be to BS EN 1964-1, fulfilling the requirements entered in the following table:

Description of Test	Relevant Clause(s) in BS EN 1964-1
a. Heat treatment test	Cl. 4.1
b. Hardness test	Cl. 7.4.1
c. Mechanical tests including:	
(i) tensile test	Cl. 7.1.2.1
(ii) bend test	Cl. 7.1.2.2
d. Hydraulic tests	Cl. 7.4.2
e. Tightness test	Cl. 7.5
f. Hydraulic burst test	Cl. 7.2
g. Pressure cycling test (for new design only)	Cl. 7.3

The hydraulic test pressure of the cylinders shall meet the requirements as laid down in Clause 7.4.2 of BS EN 1964-1, which shall be not less than 3300 kPa.

One cylinder shall be randomly selected from every batch of new cylinders, except where the number in the batch exceeds 100 containers, in which case one cylinder shall be additionally taken in every 101 or part thereof, for subject to the hydraulic burst testing. The hydraulic burst pressure for cylinders shall be not less than the calculated value as stipulated in Clause 7.2 of BS EN 1964-1. The cylinder(s) shall remain in one piece without fragmentation after bursting.

An information tag for easy recognition of the particulars of each chlorine cylinder shall be provided, which shall include:

- (a) the serial number of the cylinder;
- (b) tare weight; and
- (c) date of last test/due date of next test.

Isolation valves for chlorine cylinders shall comply with the requirements of BS EN 849. The valve body shall be made of forged steel to BS970 Part 1 with monel metal valve spindle and PTFE gland packing. A suitably designed metal cap shall be fitted to protect the outlet valves of cylinders. The protection shall be in the form of stout metal cap which shall be standardised for the same type of cylinder.

B2.2.4 Chlorine draw-off system

Chlorine *are* drawn off as gas; adequate connections and cylinder isolating valves *are* provided to enable one duty and one standby cylinders of capacity 100 kg to be connected to gas headers.

One automatic cylinder changeover unit *is* provided. Automatic changeover of cylinders from duty to standby banks shall be initiated by low pressure in the chlorine gas pipe work.

The gas pressure pipelines shall be kept as short as possible and shall terminate immediately downstream of the electrically operated cylinder changeover valves at the remote chlorine vacuum regulator/pressure relief valves located in the chlorine cylinder store.

Two vacuum regulating/pressure relief valves (one duty, one standby) *are* provided.

The system *provided* with all necessary gas chlorine pipe work, including fixings and supports, electrically operated changeover valves, vacuum regulating/pressure relief valves, manual isolating valves, catchpots and pressure switches and gauges *shall be maintained*.

B2.2.5 Chlorinators

Sl. No	Location of Re-Chlorination Station	Designe d rate of Water supply (LPM)	Flow/ Pumpin g hours	Designe d MLD	Designed Chlorine dosage	Chlorin e Qty require d (Kg/ Day)	Chlorine Qty required (Kg/mont h)	Remarks
1	Kaduchettipatti	705	23	1.015	2	1.932	57.96	
2	Rayakottai	5397	18	5.828	2	12.034	361.02	
3	Jakkeri	6935	18	7.489	2	16.78	503.4	
4	Mathagiri	4352	18	4.7	2	11.652	349.56	
5	Dinnur	16272	18	17.573	2	28.486	854.58	
6	Total	33661		36.605		70.884	2126.52	

Two vacuum operated chlorinators of equal capacity (one duty, one standby) provided at each station *has to be maintained*.

The volume flows, proposed average and maximum chlorine doses, maximum chlorinator capacities and the maximum static head at the dosing point are tabulated below. It shall be possible to have the turndown required on the chlorinator output on manual control over the dose range of 0.25 to 1.0 mg/l for efficient dosing. The motive water pumps *has been* sized for the maximum chlorinator capacity.

Chlorinators functioning, are with remote wall mounted ejectors, one ejector per chlorinator, located in the chlorinator room and *with* necessary vent pipes discharging separately to a point outside. *At* the dosing point, the normal minimum flow is equal to 50% of the maximum flow.

B2.2.6 Ejector motive water supply

Ejector motive water supply *are* drawn from the pipe into which chlorine is dosed, at least 3 m upstream of the dosing point.

The pair of chlorinator ejectors *are* provided with two motive water pumps of the multi-stage vertical centrifugal type (one duty, one standby). Where necessary pump suction *are* provided with a strainer. Pump motors *are* provided *with* a power margin of not less than the following above the maximum power absorbed by the pump in any possible operating condition

Tenderer

Chief Engineer / Project Chief Engineer

Below 3.7 kW 30%

B2.2.7 Chlorine solution transfer system

The solution lines from the ejectors manifolded to a single header serving the point of application and provided with a solution transfer line terminating in a injection tube.

B1.5 B2.3 Chlorine leak detection

Chlorine leak detectors complete with leak sensors shall be provided in the cylinder store and chlorinator room as follows:

(a) Cylinder store - one detector with two sensors.

The leak detectors provided with low and high level alarm states.

B1.6 B2.4 Ventilation

The chlorine cylinder store and the chlorinator room *are* reasonably gas tight and provided with an extraction fan sized to ten air changes per hour.

The extraction fans *are* of the axial flow type and shall draw chlorine contaminated air from a low level by uPVC duct and discharge at high level. Fresh air shall be drawn from louvered openings fitted with safety bars, arranged to close under gravity when the ventilation system is not running. The discharge points *are* located remote from the air supply system intakes.

B1.7 B2.5 Safety equipment

At each re-chlorination station house, the following safety facilities are provided:

- (a) One safety shower complete with eye baths located at the entrance to the chlorine cylinder store;
- (b) Three sets of self contained air breathing apparatus and wall-mounted cabinets in the switch room;
- (c) Three sets of protective clothing including overalls, boots, goggles and helmets and storage lockers in the switch room;
- (d) One eye irrigator located in the switch room;
- (e) One first aid box located in the switch room; and
- (f) One emergency repair tool kit for use to take immediate action to stop temporarily minor leakage from a cylinder, and to be located in the switch room. The Contractor shall submit a list of recommended tool kit to the Engineer prior to place the order. Should the Engineer reckon that the tools in the recommended list are inadequate for future operators to carry out emergency repair, the Contractor shall provide the missing tools accordingly.

B3.0 ELECTRICAL & ICA SITE WORKS

B3.1 Scope of Works

This section covers the particular requirements for the *maintenance* of all electrical and ICA site works for the booster pumping stations, re-chlorination stations, tapping points from the trunk mains, the union reservoirs, the Panchayat reservoirs and the overhead tanks.

The Contract shall *maintain*

- (a) TNEB electricity supplies;
- (b) Low voltage switchboards and motor control centres, motor starters;
- (c) Switchgear battery units;
- (d) Power factor correction equipment;
- (e) Emergency stop push-buttons/local start/stop push-button stations;
- (f) Uninterruptible power supply units;
- (g) Power, control, instrumentation and telephone cabling installations;
- (h) Interface with electrical, ICA plant and SCADA System to be *maintained* by the contractor of Package I;
- (i) Earthing and lightning protection installations.

B3.2.7 Liaison with TNEB

The Contractor shall be responsible for:-

- (a) Confirming maximum short-circuit and maximum earth fault current data;
- (b) Confirming minimum short-circuit current data ;
- (b) *Maintaining* supply capacity;
- (c) Establishing any special TNEB requirements;
- (d) *Maintaining* protection of relay characteristics, settings and co-ordination. *Ensure* protection setting grading of the relays at the motor control centre under the Contract with the relay at TNEB switchgear ;
- (e) Agreeing procedures and responsibility for connection of 11kV or 400V LV feeder cables to the metering panel and pre-commissioning testing.
- (f) Responsibility of co-ordination with TNEB for overhead line work;
- (g) Liaison with the TNEB shall be by the Contractor through the Engineer.

B3.2.8 Liaison with Electrical Inspectorate

The Contractor shall be responsible for *ensuring power supply at all instant and to take all steps to restore in case of break downs by approaching the local TANGEDCO staff* as well as obtaining a sanction for energising the new supplies. All liaison with the TANGEDCO shall be by the Contractor through the Engineer.

B3.2.9 Utilisation voltages

- | | | | |
|-----|--------------|---|--|
| (a) | High voltage | : | 11000V |
| (b) | Low voltage | : | 400V |
| (c) | Control | : | a.c. - 230V |
| | | | d.c - 24V for SCADA and instrumentation. |
| | | | d.c.- 48V for other circuits. |

B3.2.10 400V system neutral earthing

The 400V transformer winding neutrals (if transformer is used) shall be solidly earthed.

B3.2.11 400V system voltage drop

(a) Steady state

Under normal service conditions, *it should be maintained that* the volt-drop at the terminals of the fixed current-using equipment shall not be greater than 4% of the nominal voltage of the supply except where a lower value is necessary for the:

- satisfactory operation of the equipment;
- compliance with the volt-drop criteria for motors during the starting period.

(b) Transient

During motor starting periods the following criteria shall apply and be maintained:-

- Under minimum supply voltage conditions specified earlier, the voltage at the motor terminals shall not be lower than 85% of the motor rated voltage;
- the voltage dip at the point of supply shall not be greater than limitation percentage of the rated voltage allowable by TNEB.

B3.2.13 Electrical Safety

The Contractor shall provide adequate safety labels for the safe operation and maintenance of all electrical equipment.

Each electrical switchboard shall be *maintained* with all necessary safety equipment including operating gloves, full length rubber safety mat, a minimum of 2 No CO₂ portable fire extinguishers, fire bucket and any other equipment deemed necessary by the Contractor.

An emergency first aid kit and safety procedures *are* provided in each switchroom *and shall be replaced after expiry*.

B3.3 Not Used**B3.4 400V switchboard and motor control centre****(c) Motor starters**

Motor starter control and protection facilities shall *be maintained and replaced at break downs*:

- Motor thermal overload and single phase protection;
- Start and Stop push buttons;
- Available, running, fault tripped lamps;
- Fault reset push-button;
- Hours Run meter;

- Indicating ammeter for motor above 5kW;
- Individual power factor correction capacitors above 15kW;

Motor starters above 22kW fitted with a microprocessor based comprehensive numerical type motor protection relay having thermal overload, phase unbalance/single phasing, reverse phase sequence and earth fault protection functions *shall be maintained*.

(d) Control and operation

All control and instrumentation equipment located within the ICA section of each switchboard/motor control centre *shall be maintained*.

(f) Feeder units

Feeder units of 63 Amp TPN MCCB provided on each switchboard and motor control centre *shall be maintained and replaced on breakdown*.

B3.5 Electrical ancillary equipment

B3.5.1 Power factor correction

The power factor at each load centre shall be corrected to no less than 0.95 lagging. The correction may be by means of capacitors connected to individual items of plant or by automatically controlled multistage capacitors connected to busbar sections.

B3.5.2 Uninterruptible power supplies

An uninterruptible power supply (UPS) unit or units provided to maintain a no-break supply to instrumentation, control and alarm systems shall, on loss of mains supply, be capable of supplying the connected loads for a minimum period of 60 minutes and will be maintained by the contractor of Package I.

B3.6 Site instrumentation

B3.6.1 General

. ---The instrumentation at the sites of the Contract provided *are to be maintained* by both the Contractor of *Package II* and the contractor of Package I. At each of the tapping point from the treated water trunk mains sites, an electromagnetic flow meter (each be completed with a flange adaptor, a spigot pipe) and a pressure transmitter installed *will be maintained* by the contractor of Package I. The Contractor shall allow the contractor of Package I to access their sites to do all the instrument *maintenance works*.

.At each of the sites of the union reservoirs, the contractor of Package I will *maintain the* two ultrasonic level sensors/transmitters. The Contractor shall allow the contractor of Package I to access their sites to do all the instrument maintenance *works*.

.At each of the tapping point from the treated water trunk mains sites, each of the union reservoir sites and the booster pumping station sites as stated in the Table 3, the contractor of Package I *has to maintain the* Local Control Panel for the SCADA System.

The SCADA System acquire signals from the equipments at the tapping point from trunk main sites, the union reservoir sites and those booster pumping station sites as mentioned in the Table 2 above. Also, the SCADA System perform control to some of the equipments at these sites. The minimum requirements for the signals to be connected to the SCADA System and the command to issue to control the equipments at these sites by the SCADA

System are as follows:

Union reservoirs sites

Digital Input to SCADA System

- Mains power healthy at LCP enclosures (signals to be provided under this Contract);
- Inlet and Outlet isolation valves available/fully open/fully close/failed (signals to be provided under this Contract);
- UPS failure (signals to be provided by contractors of each Package);
- LCP failure (signals to be provided by contractor of Package I);
- Reservoir low level (signals to be provided by contractor of Package I);
- Reservoir high level (signals to be provided by contractor of Package I);
- Mains power healthy at the incomers of the Re-Chlorination Station (signals to be provided under this Contract);
- Incomers and buscoupler circuit breakers on/off/tripped);

Analogue Input to SCADA System

- The sump level of each reservoir (duty/standby level sensors/transmitters at each reservoir) (signals to be provided by contractor of Package I);
- 400V switchboard busbar 1 voltage;
- 400V switchboard busbar 2 voltage;
- 400V switchboard incomer 1 power factor;
- 400V switchboard incomer 2 power factor;
- 400V switchboard incomer 1 power, apparent power and kWh;
- 400V switchboard incomer 2 power, apparent power and kWh.

Digital Output from SCADA System

- Open/close of the electrically actuated inlet valves at each reservoir (command signals to issue from the LCP to the electrical actuators at the inlet and outlet valves of the union reservoir. The Contractor shall make provision to accept these control signals)

Tapping point branches to the treated water trunk main pipeline

Digital Input to SCADA System

- Mains power healthy at LCP enclosures (signals to be provided by contractor of Package I);
- All flow control sluice valves available/fully open/fully close/failed (signals to be provided under this Contract);
- UPS failure (signals to be provided by contractor of Package I);
- LCP failure (signals to be provided by contractor of Package I)

Pulse Input to SCADA System

- Tapping point branch treated water flow quantity (signals to be provided by contractor of Package I);

Analogue Input to SCADA System

- Tapping point branch treated water flow rate (signals to be provided by contractor of Package I);
- Tapping point branch pressure (signals to be provided by contractor of Package I);
- Position of the flow control sluice valves (signals to be provided under this Contract)

Analogue Output or Digital Output from the SCADA System

- Position control of the flow control sluice valves (command signals to issue from the LCP to the electrical actuators at the flow control sluice valves. The Contractor shall make provision to accept these control signals).

Booster pumping stations (as shown in the Table 2 above)

Digital Input to SCADA System

- Mains power healthy of each incoming power supply (signals to be provided under this Contract);
- Booster pump available/running/stopped/failed (each pump) (signals to be provided under this Contract);
- All alarms and tripping signals for each booster pump and its associated motors (signals to be provided under this Contract);
- All valves available/fully open/fully close/failed (signals to be provided under this Contract)
- UPS failure (signals to be provided by contractor of Package I);
- LCP failure (signals to be provided by contractor of Package I);
- 400V switchboard busbar 1 voltage;
- 400V switchboard busbar 2 voltage;
- 400V switchboard incomer 1 power factor;
- 400V switchboard incomer 2 power factor;
- 400V switchboard incomer 1 power, apparent power and kWh;
- 400V switchboard incomer 2 power, apparent power and kWh.

Pulse Input to SCADA System

- Discharge treated water flow quantity (signals to be provided under this Contract)

Analogue Input to SCADA System

- The level of suction sump (if there is an intake sump in the booster pumping station) (signals to be provided under this Contract)
- Discharge treated water pressure and flow rate (signals to be provided under this Contract)
- Position of the flow control sluice valve (if available) (signals to be provided under this Contract)

Digital Output from SCADA System

- Open/close of all electrical actuated valves (command signals to issue from the LCP to the electrical actuators at the isolation valves. The Contractor shall make provision to accept these control signals);

- Start/stop/emergency stop of each booster pump (command signals to issue from the LCP to the electrical motor starters of the booster pumps. The Contractor shall make provision to accept these control signals)

Analogue Output from SCADA System

- Position control of any flow control sluice valve (command signals to issue from the LCP to the electrical actuators at the flow control sluice valves. The Contractor shall make provision to accept these control signals)..

Apart from those instrumentation and SCADA System equipment that are to be provided by the contractor of Package I, the Contractor shall *maintain* all other instrumentation as necessary to control and operate the proposed plant in a safe and efficient manner. As a minimum, the following instrumentation shall be *maintained* under the Contract:

- all instruments that are in the re-chlorination stations;
- Pressure switches at both the inlet and the discharge pipelines of all the booster pumping stations;

. --- Instrument power and signal cables protected against damage from electrical storms at the instrument and at the power source (for power cables) or signal terminus (for signal cables) *shall be maintained properly*. Each instrument has its own means of isolation and protected by an individual MCB.

B3.6.2 Instrument ranges and units of measurement

The ranges of display instruments and measuring systems under normal operating conditions correspond approximately to the following:-

- Levels 100% of Scale
- Flows 90% of Scale
- Pressures 70% of Scale
- Valve position 100% of Scale (fully closed to fully open)
- Temperature 60% of Scale
- Water quality Multiple range selection

All alarms and trips derived from an analogue instrument signal *are* adjustable over the full range of the instrument.

Units of measurement for use on measurement systems and displays and documentations *are* as follows:-

Parameter		Units		
Length	mm	m	km	
Mass	mg	g	kg	t(tonne)
Time	s	min	h	d
Area	m ²	ha		
Volume	ml	l	m ³	MI
Temperature	°C			
Velocity	mm/s	m/s	m/h	

Speed	rpm	spm				
Torque	N.m					
Volumetric flow:						
- liquids	ml/s	l/s	l/h	MI/d		
- gases	Nm ³ /min	Nm ³ /h				
Mass flow	mg/s	g/s	kg/h			
Pressure	mbar	bar	mH ₂ O			
Concentration						
- solids in liquids	g/m ³	mg/l	g/l	kg/m ³	%w/w	%w/v
- gases in gases	Vppm	mg/m ³				
Power	W	kW				
Current	mA	A				
Voltage	mV	V				
Noise	dB(A)					
Frequency	Hz					
Colour	°Hazen					
Conductivity	µS/cm (at 25°C)					
Turbidity	NTU					
spm-	Strokes per minute					
MI-	million litres					
MI/d-	million litres per day (one day = 86,400 seconds)					
Vppm-	parts per million by volume					
Nm ³ -	volume at 1.013bar, 0°C					

B3.6.3 Flow measurement

Flow meters *are* of the electromagnetic type provided with a separate transmitter with visual display unit. The transmitters *are* mounted in a visible location in an above ground building inside the enclosure of the LCP. The flow rate and the volume measured by each flow meter at the tapping point from the trunk main sites and the discharge rising main of the booster pumping stations as entered in Table 2 above *are* displayed on the relevant LCPs and transmitted to the CCR.

The flow meter *are* installed in accordance with the manufacturers' instructions and, as a minimum *are* installed in a straight section of pipework (i.e. no valves or bends) to allow five pipe diameters upstream and downstream of the flow meter. Where flow meters are installed below ground, they *are* housed in a suitably sized flow meter chamber with adequate space for all maintenance and operational activities.

B3.6.4 Level indicators and controllers

The transmitter display the level of the tanks/reservoirs and *are* calibrated to read 0.00m at tanks/reservoirs floor level.

— The level alarms and level signals from the above, at the union reservoir sites and the inlet sump of the booster pumping stations as entered in Table 2 above, *are* displayed on the relevant LCPs and transmitted to the CCR.

—

—

B3.6.5 Pressure instruments

The Contractor shall maintain as installed as per the below specifications and shall provide all pressure gauges and pressure transducers in case of replacements in accordance with the particular requirements of the site works specifications.

The Contractor shall *maintain* all pumps with suitably scaled and calibrated pressure gauges for local indication of both the suction and discharge pressures.

B3.7 Site control and monitoring

B3.7.1 Valve controls

The electrically operated valves *are* provided with local/remote switches, open/close push-buttons and emergency stop. For those flow control sluice valves and isolating valves at the tapping points from the trunk main sites, the valves shall be *are* capable of being operated via telemetry from the SCADA System at the Central Control Rooms in the Water Treatment Plant. The electrically operated valves *are* fitted with key lockable local/remote selector switches and open/close controls with spring-return to the non-operating position.

B3.7.2 Personnel and Plant Protection Devices

The Contractor shall maintain Personnel and plant protection devices such as chlorine gas leak detectors, pipeline surge protection system, pump suction and delivery pressure trip, etc

B3.8 Cabling

(a) General

The Contractor shall *maintain* cable installation comprising power, control, instrumentation, communications and all accessories including cable glands, terminations, cable markers, support systems, clips, fittings and fixtures :

- Interconnecting all Plant provided under the Contract;
 - Interconnecting Plant provided under the Contract to the TNEB point of supply;
 - Interconnecting ICA signals to the Local Control Panels of the contractor of Package I;
- and

The power, control and instrumentation cabling interconnect the entire Plant including

- Valves actuators, pumpsets, etc;
- Switchgear and distribution boards;
- Motor control centers;
- Local Control Panels;
- Local control units;

Measuring instruments and sensors;

(b) Cable grouping

The cables *are* grouped as follows:

- power cables - 230 Vac;
 - control cables - 24 Vdc;
 - Signal cables - process signals (e.g. 4-20 mA, 24 Vdc to 48 Vdc status signals);
- data cables - modulated signals (e.g. serial data communication signals);

(c) Cable types

High voltage power cables *are* of the XLPE/SWA/PVC type with a conductor size appropriate to the short-circuit current and short-time requirements. The cable *are* suitable for prolonged operation at plus 10% rated voltage.

400V power cables and control cables *are* 600/1000V grade PVC or XLPE/SWA/PVC .

All instrumentation cables carrying 4-20mA or 0-5V *are* of screened twisted pair cables with overall armour for mechanical protection. If multiple pairs cables are used, each pair of twisted cores shall be individual screened and an collective screen shall be available at the layer within the armour.

(d) Installation

External below ground all cables *are* installed in ducts and concrete trenches.

Duct systems *are* provided with draw chambers at the point of entry into buildings, at changes in direction and at suitable intervals in straight runs to permit the installation of cables without exceeding the manufacturers' recommended maximum tensile stress. Draw chambers are generously dimensioned to enable cables to be pulled without damage or excessive stress due to bending.

Cables in trenches are installed on tray and/or ladder systems.

External above ground Cables on structural surfaces *are* installed on tray and ladder systems or in trunking and conduit as appropriate. Cable tray on structural surfaces are fitted with covers. Internal Cables on structural surfaces are installed on tray and ladder systems or in trunking and conduit as appropriate. Cables in trenches shall be installed on tray and/or ladder systems.

- Cable tray, ladder and trunking systems
Cable tray, ladder and trunking systems *are* heavy duty hot dip galvanised steel with return flange at the upstand. Cable tray on external structural surfaces *are* fitted with covers.
Installations in the chemical and chlorine buildings shall be heavy duty GRP systems.
- Conduit systems
Conduit *is* heavy duty galvanised steel. Installations in the chemical and chlorine buildings *are* heavy duty GRP systems.

B3.9 Earthing

(a) General

A complete and fully interconnected low voltage earthing installation comprising earth

electrodes, earthing terminals and all earthing, protective and equipotential bonding conductors provided *shall be maintained* by the Contractor at each of the sites of reservoirs, sumps, tapping points from trunk mains, re-chlorination stations and booster pumping stations.

The earthing system provided conform to the requirements of TANGEDCO and the Specification.

(b) Earth electrode system

The Contractor shall *maintain* the earth electrode systems to provide an overall resistance to earth not greater than 1 ohm.

(c) Earthing terminals

A warning notice bearing the words 'SAFETY ELECTRICAL CONNECTION—DO NOT REMOVE' and in equivalent Indian language should be displayed in a conspicuous position at or near the main earthing terminal.

(f) Instrumentation earthing

The Contractor shall *maintain the* separate earthing terminal for the Local Control Panels and all the instrumentation in each telemetry housing/room. Each separate earthing terminal *are* connected to the station earth system through the earth terminal inside the same housing/room.

B3.10 Lightning Protection

A lightning protection system is provided on all main structures, complying to the requirements entered in BS6651.

B4.0 BUILDING SERVICES

B4.1 Scope

The Contractor shall *maintain* the complete building services installations at the sites of the Re-Chlorination Station House at the union reservoirs, at the sites of the booster pumping station house at the booster pumping stations and the sites of the tapping point from the trunk mains *such as*

- (a) Internal main and emergency lighting;
- (b) External walkways and floodlighting;
- (c) Small power;
- (d) Air conditioning;
- (e) Ventilation and ceiling fans;

B4.2 Lighting

B4.2.1 Internal main lighting

Internal lighting designed to provide the following minimum service illuminance, measured at floor level *have to be maintained and replaced as specified below:*

- (a) Pump hall areas : 200 lux

(b)	chlorinator/cylinder rooms	: 300 lux
(c)	Switchrooms	: 300 lux
(d)	Control room/Telemetry room	: 350 lux
(e)	Workshop areas	: 300 lux
(f)	Laboratory	: 500 lux
(g)	Offices	: 350 lux
(h)	Staff rooms and reception areas	: 150 lux
(i)	Toilets, washrooms, mess rooms, corridors and staircases	: 100 lux

To attain energy saving in operation, all fluorescent lightings shall be of T5 type with electronic ballast.

Pump halls and other high bay areas shall be provided with high or low bay energy efficient lighting. The Contractor shall provide all necessary equipment to ensure lighting maintenance can be performed in a safe and efficient manner. .

B4.2.4 External Walkway Area

Luminaires for the control room and offices shall be *maintained/replaced* to minimise glare and shall be suitable for VDUs.

B4.2.4 Floodlighting

Floodlighting *are* provided for the entrance to the site, pumping station wetwells, loading/unloading areas, the telemetry housing for the LCP at the tapping point from the trunk mains sites and reservoirs access/instrument locations.

Floodlighting provide a minimum service illuminance of 50 lux measured at the working plane.

B4.4 Ventilation

Mechanical ventilations are provided as follows:

Location:	Air changes/hour (ACH):
Pump room	5
Toilets and washrooms	4
Mess rooms and kitchen	6
Electrical switchrooms	10
Pump room for re-chlorination stations	10

For further details of ventilation requirements refer to the mechanical specification.

B4.5 Ceiling fans

All administrative areas such as the control rooms and offices *are* provided with 100W ceiling fans at a frequency of 1 per 15m² of floor area. The fans *are* provided with local speed controllers and switches adjacent to each individual unit.

B4.6 Air conditioning

The telemetry rooms in the Re-Chlorination House and the booster pumping stations *are* air conditioned. The air conditioning *are* designed to maintain a dry bulb temperature of 22 °C and relative humidity of 50% under the outside mean monthly maximum shade temperature and humidity specified elsewhere.

B5.0 BOOSTER PUMPING STATIONS**B1.8 B5.1 General**

The Contractor shall maintain the plant in the booster pumping stations of the Contract as shown in the Drawings.

The duties of the booster pumps are shown in the Drawings.

B5.2 Mechanical plant

Mechanical plant at the booster pumping stations *with the following has to be maintained*

- Inlet pipework connected to the inlet pipeline;
- Booster pumpsets as detailed below;
- Pump inlet and delivery valves, including delivery non-return valves;
- Delivery pipework connected to the delivery pipeline;
- Dismantling joints;
- Main inlet and outlet isolating valves;
- Ventilation fans;

B5.3 Booster pumps

Centrifugal pumps used at booster pumping stations with motor rating (each motor) in between 60kW (inclusive) and 10kW (inclusive). Submersible pumps used for all other booster pumping stations with motor rating not exceeding 10kW.

Pump motors *should be maintained with* a power margin of not less than the following above the maximum power absorbed by the pump in any possible operating condition

Above 60 kW	20%
Above 10 kW (inclusive) to below 60 kW (inclusive)	25%
Below 10 kW	30%

Centrifugal pumps to be used for booster pumping stations *are* of the horizontal-shaft, split-casing, double-suction type. All pumps *are* driven by horizontal directly-coupled induction motors at a speed not greater than 1,480 rpm.

B5.4 Overhead travelling hoist

A manually-operated overhead hoist travelling on a monorail shall be provided in each pumping station, designed to serve the pumpsets. The capacity shall be, as a minimum, sized at 1.25 times the heaviest component to be lifted.

The hoist shall be provided with all needed slings and other associated equipment to handle the plant installed.