



भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

**DESIGN, SUPPLY, INSTALLATION, TESTING
AND COMMISSIONING (DSITC) OF
ELECTRO-MECHANICAL, INSTRUMENTATION
COMPONENTS FOR 650 KLD CAPACITY STP
AT IIT HYDERABAD INCLUDING 3 YEARS OF
POST- COMMISSIONING OPERATION AND
MAINTENANCE OF THE PLANT**

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Notice Inviting Tender (NIT)

On behalf of the Director, Indian Institute of Technology Hyderabad invites lump sum bids from specialized agencies of repute in two bid system for the following work: ^{1 2}

1. **NIT No.:** IITH/SE/NIT/CPPP/2017-18/01
2. **Name of Work:** Design, Supply, Installation, testing and commissioning (DSITC) of electro-mechanical, instrumentation components pertaining to 650 KLD capacity Sewage Treatment Plant (STP) at IITH Permanent Campus with GE MBR technology and 3 years of post- commissioning operation and maintenance of the plant.
3. **Estimated Cost :** Rs 484,83,800.00
4. **Earnest Money Deposit (EMD):** Rs 9,69,700.00
5. **Period of Completion :** Part A: 9 Months, Part B: 3 years
6. **Last date and time of submission of bids:** 22 January 2018, 3 PM
7. **Time and date of opening of technical bid:** 22 Jan 2018 at 330 PM

0.1 Instructions to Bidders

- Components *The entire scope of this contract is split into two components, namely :*
Part A*: DSITC Works of electro-mechanical, instrumentation ,electrical, piping, automation including supply, installation, trial run, commissioning of 650 KLD capacity STP with tertiary treatment process

(* Civil construction work of the plant like RCC common collection sump, equalization tank, anoxic tank, aeration tank, membrane tank, treated water tanks, pump room ,control room building etc., is in progress which shall be handed over to the contractor for DSITC Works)

¹Contractor, Vendor, Bidder are used interchangeably in this document

²IITH, Institute, IIT Hyderabad are used interchangeably in this document and represent Director, IIT Hyderabad

- **Part B:** Operation & Maintenance of STP for a period of three years after completion of Part-A component.

- **Contract Period :**
 Part A: Nine Months for DSITC (Period of Original Agreement)
 Part B : Three Years (Period of Supplementary Agreement.)
 After completion of Part-A (Original Agreement) of the contract by the successful bidder, the contract will be provisionally closed and a Supplementary Agreement will be drawn up with successful bidder for Part-B component. The entire contract will be closed on completion of Supplementary Agreement.

- The defect-liability period for DSITC Works component is two years from the date of completion of Part-A.

- The proposed work is treated as a specialized work.

- The site for the work is available.

- The proposed STP shall be developed using Hollow Fibre Ultra Filtration (UF) MBR Technology of Suez Water Technologies & Solutions (I) Pvt. Ltd., formerly "GE India Industrial Pvt. Ltd.," . Henceforth, the phrase Technology Provider in this bid document shall mean and imply Suez Water Technologies & Solutions (I) Pvt. Ltd.,.

0.2 Initial criteria of qualification for bidding

Contractors who fulfil the following requirements shall be deemed to be qualified for bidding for the work.

1. Single Bidder on his own should meet the stipulated criterion and no consortium or Joint Venture shall be allowed.

2. The Bidder along with the bid must submit a Memorandum of Understanding (MoU) from the Technology Provider (Suez Water Technologies & Solutions (I) Pvt. Ltd.,formerly GE India Industrial Pvt. Ltd.,) for UF Membrane Bioreactor (MBR) technology for the proposed STP. Technology provider, i.e., **Suez Water Technologies & Solutions (I) Pvt. Ltd.,** the membrane manufacturer, shall additionally also provide the design and engineering guidelines for the MBR process. It is mandatory for the Contractor to submit guarantee bond for the performance of treatment system together with the Technology Provider.

The Draft MoU is enclosed at Section 7.15.

The draft Performance Guarantee bond is placed at Section 7.5

3. The bidder should have experience of similar works where he has successfully designed the process, supplied, installed and commissioned at least 3 STPs of 200 to 399 KLD or 2 STPs of 400 to 499 KLD or 1 STP of 500 KLD or above. The qualifying plant(s), should have been completed and commissioned by using GE Hollow Fibre Membrane in India in the last seven(7) years. The reference STPs needs to be successfully commissioned as on previous day of last date of submission of application for this bid.

4. **"Similar work" means :**

–construction of Sewage Treatment Plant including design, supply, installation, testing and commissioning of the Membrane Bio Reactor (MBR) type using GE Hollow fibre membranes(excluding Civil works).

– treatment plant of industrial waste water shall not be considered as similar work.

5. At the time of purchasing bid documents, the bidder shall furnish an affidavit in a proforma specified in Section 7.3 of bid document. In case , the bid documents are downloaded from the website of IITH, the affidavit specified in section 7.3 shall be submitted along with other bid documents.

6. The bidder should have had average annual financial turn over (gross) of Rs.5.00 Crore out of execution of similar works during the immediate last three consecutive financial years. This should be duly certified by a Chartered Accountant. Year in which no turnover is shown would also be considered for working out the average.

7. The bidder should not have incurred any loss in more than two years during the immediate last five consecutive financial years, duly certified by the Chartered Accountant.

8. The bidding capacity of the contractor should be equal to or more than the estimated cost of the work put to bid. The bidding capacity shall be worked out by the following formula:

Bidding Capacity =

$$AxNx2 - B$$

, where,

A = Maximum value of Similar works executed in any year during the last seven years taking into account the completed as well as works in progress.

N = Number of years prescribed for completion of work for which bids has been invited (0.75 years i.e., 9 months)

B = Value of existing commitments and ongoing works to be completed during the

period of completion of work for which bids have been invited.

9. The bidder should have a solvency of Rs.5.00 Crore certified by his Bankers.

0.3 Deadline of Submission

The last date of receipt of applications for issue of tender documents in prescribed format (Tender documents can also be downloaded from IITH website **www.iith.ac.in**) and date of issue of tender documents from IITH Office shall be as follows:

- i) Last date of receipt of application :**05 January 2018** up to 16.00 hours
- ii) Last date of issue of bid forms :**08 January 2018** up to 16.00 hours

0.4 Sale of Tender Documents

Bid documents consisting of the schedule of Contract Price (Price Bid and Payment Terms) of the work to be done and set of terms and conditions of the contract to be complied with by the Contractor whose bid may be accepted and other necessary documents, can either be downloaded from the IITH website www.iith.ac.in or be seen in the office of the Engineer-in-Charge, IIT Hyderabad between 11.00 hours & 16.00 hours from **28 December 2017 to 08 January 2018**, Monday through Friday except on Public Holidays. Bid documents shall be issued from his office, during the days and hours specified above on payment of the following amount towards cost of bid documents:-

(i) Rs 1500 + 18% GST=Total Rs 1770.00

(ii) Bid document cost is non-refundable and is accepted in form of Demand Draft drawn on any Scheduled Bank in favour of "**IIT Hyderabad**" payable at Hyderabad.

0.5 Submission of Bids

The bid shall be accompanied by Earnest Money along with cost of bid, if not paid earlier as in the case of downloaded bid from Website in the form as detailed below:

(i) Earnest money of as indicated in the Notice Inviting Tender (NIT) in the form of Bank Guarantee issued by any Scheduled Bank in prescribed format as given in Section 7.2 having validity up to 90 (Ninety) days from last date of submission of bids.

0.5.1 Methodology of Submission

Bid shall be submitted in following manner:

- **Envelope 1 marked Earnest Money Deposit:**

Earnest money plus cost of bid documents in case the bid document is downloaded from IITH website and the Earnest Money plus Proof /receipt of paying the cost of bid in case the tender documents are purchased from the Institute in hard copy form shall be placed in sealed envelope-1 marked **Earnest Money Deposit**.

- **Envelope 2: marked Technical Documents**

The eligibility documents are to be submitted as per the information / instructions/specimen forms given shall be kept in Envelope-2.

- **Envelope 3: marked Financial Bid** The Financial Bid shall be placed in sealed Envelope-3 and should be super scripted as Financial Bid.

- **Final Envelope: marked Tender Documents for STP at IIT Hyderabad** The sealed envelopes no. 1,2 & 3 as above shall be placed in another sealed envelope which shall be submitted before the deadline for submission of the bids.

- All the envelopes shall be super scripted with following data on it.

- (i) Name of work
- (ii) Name of bidder
- (iii) Last date of receipt of bid

0.5.2 Deadlines

Bids, which should always be placed in sealed envelope, in the manner detailed at para 0.5 above shall be received by the Executive Engineer, IIT Hyderabad up to 15.00 Hrs. on **22 January 2018** and shall be opened by him or his authorized representative in his office on the same day at 15.30 Hrs. After opening the main envelope 4, the envelope 1 containing the EMD shall be opened first. Bids without EMD or EMD not in the prescribed form shall be summarily rejected. Envelope 2 of those bids with valid EMD shall then be opened for technical evaluation. The envelope 3 containing financial bid shall be opened only for those bidders whose eligibility documents are found in order as per qualifying and experience criteria given in the bid document after technical evaluation. The date and time of opening the financial bids shall be communicated at a later date.

0.5.3 Bids to be Sealed

The bid in which rates are to be quoted should be properly bound and Sealed (Stapled/Stitched Taped / Wax sealed). Loose / spiral bound submission (in case the bid is

down loaded from website) shall be rejected out rightly. In case of any correction / addition / alteration / omission in bid document vis--vis bid document available on website shall be treated as non-responsive and shall be summarily rejected.

0.5.4 Unopened Bids

Un-opened financial bids shall be returned to the bidders after the final decision on the bid is reached.

0.6 Pre-bid Meeting

- (i) A pre bid meeting with the bidders shall be held on 10 January 2018 at 1030 Hrs. at Conference hall (Project Office, IIT Hyderabad). Bidders may seek clarifications in regards to the bid documents and methodology for submitting the bid document, in writing so as to reach The Engineer-in-Charge, IIT Hyderabad (the official nominated for this purpose) not later than 3 (three) days before the date fixed for the meeting. No request for clarification shall be considered thereafter. Pre-bid queries may also be sent through email to **secivil@iith.ac.in** before the deadline for sending the queries as stated above.
- (ii) The purpose of the meeting shall be to clarify the issues raised by the bidders. Minutes of the meeting including the text of the questions raised (without identifying the source of enquiry) and the responses given shall be uploaded on IITH website. Any modifications of the Bid Document which may become necessary as a result of the Pre-bid Meeting shall be made exclusively through the issue of an Addendum / Corrigendum and not through the Minutes of the Pre-Bid Meeting.
- (iii) Pre-bid clarifications shall not be sent to the bidders directly. Bidders shall check the website of the Institute regularly for the same. IITH shall not assume any responsibility over the failure of bidders to check Institute's website for clarifications.
- (iv) The Minutes of the Meeting as described above and the Addendum / Corrigendum, if any, shall be uploaded on IITH website only and it shall become part of the contract documents. Non-attendance at the Pre-bid Meeting shall not be a cause for disqualification of a bidder.
- (v) IITH reserves the right to reject any prospective application without assigning any reason and to restrict the list of qualified bidders to any number deemed suitable by it, if too many bids are received satisfying the laid down criterion.
- (vi) The bidder shall not be permitted to bid for works in IITH responsible for award and execution of contracts, in which his near relative is posted a Faculty or as an officer,

or engineer in any capacity between the grades of Engineer-in-Charge and Junior Engineer (both inclusive). He shall also intimate the names of persons who are working with him in any capacity or are subsequently employed by him and who are near relatives to any gazette officer in the IITH or in MHRD. Any breach of this condition by the contractor would render him liable to be removed from the approved list of contractors of this IITH. Near relative(s) for this purpose is/are defined as:-

(i) Member of Hindu Undivided family (HUF).

(ii) They are Husband and Wife.

(iii) The one is related to other in the manner as Father, Mother, Son(s), Sons wife (daughter-in-law), Daughter(s), Daughters husband (son-in-law) Brother(s), Brothers wife, Sister(s), Sisters husband(brother-in-law).

(vii) No Engineer of gazette rank or other Gazetted Officer employed in Engineering or Administrative duties in IITH is allowed to work as a contractor for a period of one year after his retirement from Government service, without the previous permission of the Institute in writing. All the intending bidders shall have to give a declaration, that none of his / her such near relative(s) as defined above is/are working in the IIT Hyderabad where he is going to apply for bid / work.

Such certificate in case of Proprietorship Firm shall be given by the proprietor, for Partnership Firm certificate shall be given by all partners and in case of Limited Company, by all Directors of the company. However, Government of India / Financial Institutions nominees and independent non-official part-time Directors appointed by Govt. of India or the Governor of the State are excluded from the purview of submission of this certificate while submitting bids by Limited Companies.

(viii) Any breach of these conditions by the Company or Firm or any other person, the Bid / work shall be cancelled and Earnest Money / Security Deposit shall be forfeited at any stage, whenever it is so noticed. IITH shall not pay any damages to the Company or Firm or the concerned person but damages arising on account of such cancellation to be borne by the contractor. The Company or Firm or the person shall also be debarred for further participation in the bid in IITH. Further, any breach of this condition by the bidder would also render him liable to be removed from the approved list of contractors of IITH.

(ix) The bidder shall furnish a declaration to the effect (In case of downloaded bid) that no addition / deletion / correction have been made in the bid document submitted and it is identical to the bid document appearing on website. Every page of downloaded

bid shall be signed by the bidder with stamp (seal) of his firm / organization.

- (x) Any information furnished by the bidder found to be incorrect either immediately or at a later date, would render him liable to be debarred from bidding/taking up of work in IITH. If such bidder happens to be enlisted contractor of any class in IITH, his name shall also be removed from the approved list of contractors.
- (xi) Agreement shall be drawn with the successful bidder. Bidder shall quote his rates as per various terms and conditions of the bid document which shall form part of the agreement.

0.7 Date of Commencement and Period of Completion

The time allowed for carrying out the work shall be Nine (9) months for execution plus Three (3) years of operation and maintenance. The date of commencement of work shall be reckoned from the 15th day after the date of issue of letter of award of work, or, from the first day of handing over of the site, whichever is later.

0.8 Validity of Bids

The tender for the work shall remain open for acceptance for a period of 60 (Sixty) days from the date of opening of the financial bids. If any tenderer withdraws his tender before the said period or issue of letter of acceptance/intent, whichever is earlier, or, makes any modifications in the terms and conditions of the tender which are not acceptable to the IITH, then the IITH shall, without prejudice to any other right or remedy, be at liberty to forfeit earnest money as aforesaid.

0.9 Performance Guarantee

The contractor whose tender is accepted shall submit an irrevocable Performance Guarantee of 5% (Five per cent) of the contract amount of Part A in addition to other deposits mentioned elsewhere in the contract for his proper performance of the contract agreement, (not withstanding and/or without prejudice to any other provisions in the contract) within 15 days of acceptance of tender by IITH. This period can be further extended by the Engineer-in-Charge up to a maximum period of 30 days on written request of the contractor stating the reason for delays in procuring the Performance Guarantee, to the satisfaction of the Engineer-in-Charge. This guarantee shall be in the form of Guarantee Bonds of any Scheduled Bank in accordance with the form given at Section 7.1

- (i) The Performance Guarantee shall be initially valid up to the stipulated date of completion of Part-A plus 60 days beyond that. In case the time for completion of work

for Part-A gets extended, the contractor shall get the validity of Performance Guarantee extended to cover such enlarged time for completion of work as may be specified by the Institute.

- (ii) The performance guarantee bond will be returned to the contractor after recording of the completion certificate for the Part A of the contract and upon submission of another Bank Guarantee equivalent to 5% of contract amount of Part B having validity of Three (3) years from date of start of Operation & Maintenance period.
- (iii) The Performance Guarantee bonds shall not carry any interest. The performance guarantee submitted against Part B of the contract will be released after handing over of the plant to IITH in good working condition after completion of the O&M period and after recording completion certificate for the entire contract comprising of Parts A and B.
- (iv) The Engineer-in-Charge shall not make a claim under the performance guarantee except for amounts to which the Institute is entitled to under the contract (not withstanding and/or without prejudice to any other provisions in the contract agreement) in the event of:
 - Failure by the contractor to extend the validity of the Performance Guarantee as described herein above, in which event the Engineer-in-Charge may claim the full amount of the Performance Guarantee.
 - Failure by the contractor to pay IITH any amount due, either as agreed by the contractor or determined under any of the Clauses/Conditions of the agreement, within 30 days of the service of notice to this effect by Engineer-in-Charge.
- (v) In the event of the contract being determined or rescinded under provision of any of the Clause/Condition of the agreement, the performance guarantee shall stand forfeited in full and shall be absolutely at the disposal of the Director, IITH.

0.10 Language

Language for the bids and communication through out the contract period shall be English.

0.11 Currency

The tendered amount shall be in Indian National Rupee INR

0.12 Security Deposit

The contractor whose tender is accepted will also be required to furnish by way of Security Deposit for the fulfilment of his contract, an amount equal to 2.5% of the Contract amount of the work for Part A. The contractor shall permit IITH at the time of making any payment to him for work done under the contract to deduct a sum at the rate of 5% of gross amount of each scheduled payment till the sum along- with the sum already deposited as earnest money, shall amount to security deposit of Part-A. Earnest money shall be adjusted first in the security deposit and further recovery of security deposit shall commence only when the up to date amount of security deposit starts exceeding the earnest money. Such deductions shall be made and withheld by IITH by way of Security Deposit unless he/they has/have deposited the amount of Security at the rate mentioned above in form of Guarantee Bond issued by any Scheduled Bank in the prescribed format.

0.13 Award of Work and Signing of the Agreement

The bidder, whose total bid amount for Part A plus Part B is the lowest shall be declared as the successful bidder. This Notice Inviting Tender shall form a part of the Contract Document. In accordance with conditions of the contract, the letter of acceptance shall be issued first in favour of the successful bidder. After submission of the performance guarantee, the letter of award shall be issued. The contract shall be deemed to have come into effect on issue of letter of acceptance of the tender. On issue of letter of award, the successful Tenderer/Contractor shall, within 10 days from such date, formally sign the agreement consisting of:

- The Notice Inviting Tender
- pre-bid clarifications
- all the documents including additional conditions
- special conditions of contract
- Technical Specifications and drawings, if any, forming part of the bid at the time of invitation of bid
- the rates quoted at the time of submission of bid and acceptance thereof together with any correspondence leading thereto.

0.14 Form of Agreement

INDIAN INSTITUTE OF TECHNOLOGY HYDERABAD
Kandi 502 285, Sangareddy (District), Telangana,
India Tel: +91 40 2301 7202 Fax: +91 40 23016032 / 23016003

Email: secivil@iith.ac.in

Lump Sum Tender Contract for Works

Tender for the work of:- *Design, Supply, Installation, testing and commissioning (DSITC) of electro-mechanical, instrumentation components pertaining to 650 KLD capacity Sewage Treatment Plant (STP) at IITH Permanent Campus with GE MBR technology and 3 years of post- commissioning operation and maintenance of the plant.*

- (i) To be submitted by **15.00 hours on 22/01/2018** to the Executive Engineer, IIT Hyderabad.
- (ii) technical bids to be opened in presence of tenderers who may be present at **15.30 hours on 22/01/2018** in the office of Executive Engineer, IIT Hyderabad.

Issued to:-.....**..... (Contractor) Signature of officer issuing the documents^{**3}.....
Designation Executive Engineer, IIT Hyderabad.
Date of Issue:**.....

TENDER

I/We have read and examined the notice inviting tender, Specifications applicable, Drawings Designs, General Rules and Directions, Conditions of Contract, clauses of contract, Special conditions, Schedule of Contract Price other documents and Rules referred to in the condition of contract and all other contents in the tender document for the work.

I/We hereby tender for the execution of the work specified for IIT Hyderabad within the time specified in bid document and in accordance in all respects with the specifications, designs, drawings and instructions in writing referred to in bid documents and with such materials as are provided for, by, and in respects in accordance with, such conditions so far as applicable.

We agree to keep the tender open for 60 (sixty) days from the due date of opening of financial bid thereof and not to make any modification in its terms and conditions.

A sum of Rs. _____^{*4}_____ has been deposited in the form of bank guarantee of a scheduled bank as earnest money. If I/We, fail to

³to be filled by EE

⁴to be filled by the bidder

furnish the prescribed performance guarantee within prescribed period, I/We agree that the said Director, IIT Hyderabad or his successors in office shall, without prejudice to any other right or remedy, be at liberty to forfeit the said earnest money absolutely. Further if I/We fail to commence work as specified, I/We agree that Director, IIT Hyderabad or his successors in office shall without prejudice to any other right or remedy available in law be at liberty to forfeit the said earnest money the performance guarantee absolutely, otherwise the said earnest money shall be retained by him towards security deposit to execute all the works referred to in the tender documents upon the terms and conditions contained or referred to therein and to carry out such deviations as may be ordered at the rates to be determined in accordance with the provision contained in the bid document.

I/We hereby declare that I/We shall treat the tender documents drawings and other records connected with the work as secret/confidential documents and shall not communicate information derived there from to any person other than a person to whom I/We am/are authorised to communicate the same or use the information in any manner prejudicial to the safety of the Institute.

Dated Signature of bidder

Postal Address

Witness:

Address:

Occupation:

ACCEPTANCE The above tender (as modified by you as provided in the letters mentioned hereunder) is accepted by me for and on behalf of the Director, IIT Hyderabad for a sum of Rs.**.....(Rupees.....**.....

The letters referred to below shall form part of this contract Agreement:-

i)

ii)**.....

iii) For on behalf of the Director, IIT Hyderabad

Signature.....

Dated

Designation.....

0.15 Integrity Pact

INTEGRITY PACT

IIT HYDERABAD is committed to follow the principle of transparency, equity and competitiveness in public procurement.

The subject Notice Inviting Tender (NIT) is an invitation to offer made on the condition that the Bidder will sign the integrity Agreement, which is an integral part of tender/bid documents, failing which the tenderer/bidder will stand disqualified from the tendering process and the bid of the bidder would be summarily rejected.

This declaration shall form part and parcel of the Integrity Agreement and signing of the same shall be deemed as acceptance and signing of the Integrity Agreement on behalf of the IIT HYDERABAD.

To be submitted by the bidder on his Letter Head

To

The Executive Engineer,

IIT Hyderabad

Sub: Submission of Tender

Dear Sir,

I/We acknowledge that IIT HYDERABAD is committed to follow the principles thereof as enumerated in the Integrity Agreement enclosed with the tender/bid document.

I/We agree that the Notice Inviting Tender (NIT) is an invitation to offer made on the condition that I/We will sign the enclosed integrity Agreement, which is an integral part of tender documents, failing which I/We will stand disqualified from the tendering process.

I/We acknowledge that THE MAKING OF THE BID SHALL BE REGARDED AS AN UNCONDITIONAL AND ABSOLUTE ACCEPTANCE of this condition of the NIT.

I/We confirm acceptance and compliance with the Integrity Agreement in letter and spirit and further agree that execution of the said Integrity Agreement shall be separate and distinct from the main contract, which will come into existence when tender/bid is finally accepted by IIT HYDERABAD. I/We acknowledge and accept the duration of the Integrity Agreement, which shall be in the line with Article 1 of the enclosed Integrity Agreement.

I/We acknowledge that in the event of my/our failure to sign and accept the Integrity Agreement, while submitting the tender/bid, IIT HYDERABAD shall have unqualified, absolute and unfettered right to disqualify the tenderer/bidder and reject the tender/bid in accordance with terms and conditions of the tender/bid.

Yours faithfully

(Duly authorized signatory of the Bidder)

To be signed by the bidder and same signatory competent / authorised to sign the relevant contract on behalf of IIT Hyderabad.

INTEGRITY AGREEMENT

This Integrity Agreement is made at on this day of 20.....

BETWEEN

Director, Indian Institute of Technology Hyderabad represented through Executive Engineer, IITH, *(Hereinafter referred as the 'Principal/Owner', which expression shall unless repugnant to the meaning or context hereof include its successors and permitted assigns)*

AND

..... Represented through
(Hereinafter referred to as the (Details of duly authorized signatory) Bidder/Contractor and which expression shall unless repugnant to the meaning or context hereof include its successors and permitted assigns)

Preamble

WHEREAS the Principal / Owner has floated the Tender No. *(hereinafter referred to as Tender/Bid)* and intends to award, under laid down organizational procedure, contract for hereinafter referred to as the Contract.

AND WHEREAS the Principal/Owner values full compliance with all relevant laws of the land, rules, regulations, economic use of resources and of fairness/ transparency in its relation with its Bidder(s) and Contractor(s). AND WHEREAS to meet the purpose aforesaid both the parties have agreed to enter into this Integrity Agreement (hereinafter referred to as Integrity Pact or Pact), the terms and conditions of which shall also be read as integral part and parcel of the Tender/Bid documents and Contract between the parties. NOW, THEREFORE, in consideration of mutual covenants contained in this Pact, the parties hereby agree as follows and this Pact witnesses as under:

Article 1: Commitment of the Principal/Owner

- 1) The Principal/Owner commits itself to take all measures necessary to prevent corruption and to observe the following principles:
 - (a) No employee of the Principal/Owner, personally or through any of his/her family members, will in connection with the Tender, or the execution of the Contract, demand, take

a promise for or accept, for self or third person, any material or immaterial benefit which the person is not legally entitled to.

(b) The Principal/Owner will, during the Tender process, treat all Bidder(s) with equity and reason. The Principal/Owner will, in particular, before and during the Tender process, provide to all Bidder(s) the same information and will not provide to any Bidder(s) confidential / additional information through which the Bidder(s) could obtain an advantage in relation to the Tender process or the Contract execution.

(c) The Principal/Owner shall endeavour to exclude from the Tender process any person, whose conduct in the past has been of biased nature.

2) If the Principal/Owner obtains information on the conduct of any of its employees which is a criminal offence under the Indian Penal code (IPC)/Prevention of Corruption Act, 1988 (PC Act) or is in violation of the principles herein mentioned or if there be a substantive suspicion in this regard, the Principal/Owner will inform the Chief Vigilance Officer and in addition can also initiate disciplinary actions as per its internal laid down policies and procedures.

Article 2: Commitment of the Bidder(s)/Contractor(s) 1) It is required that each Bidder/Contractor (including their respective officers, employees and agents) adhere to the highest ethical standards, and report to the Government / Department all suspected acts of fraud or corruption or Coercion or Collusion of which it has knowledge or becomes aware, during the tendering process and throughout the negotiation or award of a contract.

2) The Bidder(s)/Contractor(s) commits himself to take all measures necessary to prevent corruption. He commits himself to observe the following principles during his participation in the Tender process and during the Contract execution:

a) The Bidder(s)/Contractor(s) will not, directly or through any other person or firm, offer, promise or give to any of the Principal/Owners employees involved in the Tender process or execution of the Contract or to any third person any material or other benefit which he/she is not legally entitled to, in order to obtain in exchange any advantage of any kind whatsoever during the Tender process or during the execution of the Contract.

b) The Bidder(s)/Contractor(s) will not enter with other Bidder(s) into any undisclosed agreement or understanding, whether formal or informal. This applies in particular to prices, specifications, certifications, subsidiary contracts, submission or non-submission of bids or any other actions to restrict competitiveness or to cartelize in the bidding process.

c) The Bidder(s)/Contractor(s) will not commit any offence under the relevant IPC/PC Act. Further the Bidder(s)/Contract(s) will not use improperly, (for the purpose of competition

or personal gain), or pass on to others, any information or documents provided by the Principal/Owner as part of the business relationship, regarding plans, technical proposals and business details, including information contained or transmitted electronically.

d) The Bidder(s)/Contractor(s) of foreign origin shall disclose the names and addresses of agents/representatives in India, if any. Similarly Bidder(s)/Contractor(s) of Indian Nationality shall disclose names and addresses of foreign agents/representatives, if any. Either the Indian agent on behalf of the foreign principal or the foreign principal directly could bid in a tender but not both. Further, in cases where an agent participate in a tender on behalf of one manufacturer, he shall not be allowed to quote on behalf of another manufacturer along with the first manufacturer in a subsequent/parallel tender for the same item.

d) The Bidder(s)/Contractor(s) will, when presenting his bid, disclose (with each tender as per proforma enclosed) any and all payments he has made, is committed to or intends to make to agents, brokers or any other intermediaries in connection with the award of the Contract.

3) The Bidder(s)/Contractor(s) will not instigate third persons to commit offences outlined above or be an accessory to such offences.

4) The Bidder(s)/Contractor(s) will not, directly or through any other person or firm indulge in fraudulent practice means a willful misrepresentation or omission of facts or submission of fake/forged documents in order to induce public official to act in reliance thereof, with the purpose of obtaining unjust advantage by or causing damage to justified interest of others and/or to influence the procurement process to the detriment of the Government interests.

5) The Bidder(s)/Contractor(s) will not, directly or through any other person or firm use Coercive Practices (means the act of obtaining something, compelling an action or influencing a decision through intimidation, threat or the use of force directly or indirectly, where potential or actual injury may befall upon a person, his/ her reputation or property to influence their participation in the tendering process).

Article 3: Consequences of Breach

Without prejudice to any rights that may be available to the Principal/Owner under law or the Contract or its established policies and laid down procedures, the Principal/Owner shall have the following rights in case of breach of this Integrity Pact by the Bidder(s)/Contractor(s) and the Bidder/ Contractor accepts and undertakes to respect and uphold the Principal/Owners absolute right:

1) If the Bidder(s)/Contractor(s), either before award or during execution of Contract has committed a transgression through a violation of Article 2 above or in any other form,

such as to put his reliability or credibility in question, the Principal/Owner after giving 14 days notice to the contractor shall have powers to disqualify the Bidder(s)/Contractor(s) from the Tender process or terminate/determine the Contract, if already executed or exclude the Bidder/Contractor from future contract award processes. The imposition and duration of the exclusion will be determined by the severity of transgression and determined by the Principal/Owner. Such exclusion may be forever or for a limited period as decided by the Principal/Owner.

2) Forfeiture of EMD/Performance Guarantee/Security Deposit: If the Principal/Owner has disqualified the Bidder(s) from the Tender process prior to the award of the Contract or terminated/determined the Contract or has accrued the right to terminate/determine the Contract according to Article 3(1), the Principal/Owner apart from exercising any legal rights that may have accrued to the Principal/Owner, may in its considered opinion forfeit the entire amount of Earnest Money Deposit, Performance Guarantee and Security Deposit of the Bidder/Contractor.

3) Criminal Liability: If the Principal/Owner obtains knowledge of conduct of a Bidder or Contractor, or of an employee or a representative or an associate of a Bidder or Contractor which constitutes corruption within the meaning of IPC Act, or if the Principal/Owner has substantive suspicion in this regard, the Principal/Owner will inform the same to law enforcing agencies for further investigation.

Article 4: Previous Transgression

1) The Bidder declares that no previous transgressions occurred in the last 5 years with any other Company in any country confirming to the anticorruption approach or with Central Government or State Government or any other Central/State Public Sector Enterprises in India that could justify his exclusion from the Tender process.

2) If the Bidder makes incorrect statement on this subject, he can be disqualified from the Tender process or action can be taken for banning of business dealings/ holiday listing of the Bidder/Contractor as deemed fit by the Principal/ Owner.

3) If the Bidder/Contractor can prove that he has resorted / recouped the damage caused by him and has installed a suitable corruption prevention system, the Principal/Owner may, at its own discretion, revoke the exclusion prematurely.

Article 5: Equal Treatment of all Bidders/Contractors/Subcontractors

1) The Bidder(s)/Contractor(s) undertake(s) to demand from all subcontractors a commitment in conformity with this Integrity Pact. The Bidder/Contractor shall be responsible for any violation(s) of the principles laid down in this agreement/Pact by any of its Subcontractors/sub-vendors.

2) The Principal/Owner will enter into Pacts on identical terms as this one with all Bid-

ders and Contractors.

3) The Principal/Owner will disqualify Bidders, who do not submit, the duly signed Pact between the Principal/Owner and the bidder, along with the Tender or violate its provisions at any stage of the Tender process, from the Tender process.

Article 6- Duration of the Pact

This Pact begins when both the parties have legally signed it. It expires for the Contractor/Vendor 12 months after the completion of work under the contract or till the continuation of defect liability period, whichever is more and for all other bidders, till the Contract has been awarded.

If any claim is made/lodged during the time, the same shall be binding and continue to be valid despite the lapse of this Pacts as specified above, unless it is discharged/determined by the Competent Authority, IIT HYDERABAD.

Article 7- Other Provisions

1) This Pact is subject to Indian Law, place of performance and jurisdiction is the Head quarters of the IITH of the Principal/Owner, who has floated the Tender.

2) Changes and supplements need to be made in writing. Side agreements have not been made.

3) If the Contractor is a partnership or a consortium, this Pact must be signed by all the partners or by one or more partner holding power of attorney signed by all partners and consortium members. In case of a Company, the Pact must be signed by a representative duly authorized by board resolution.

4) Should one or several provisions of this Pact turn out to be invalid; the remainder of this Pact remains valid. In this case, the parties will strive to come to an agreement to their original intentions.

5) It is agreed term and condition that any dispute or difference arising between the parties with regard to the terms of this Integrity Agreement / Pact, any action taken by the Owner/Principal in accordance with this Integrity Agreement/ Pact or interpretation thereof shall not be subject to arbitration.

Article 8- LEGAL AND PRIOR RIGHTS

All rights and remedies of the parties hereto shall be in addition to all the other legal rights and remedies belonging to such parties under the Contract and/or law and the same shall be deemed to be cumulative and not alternative to such legal rights and remedies aforesaid. For the sake of brevity, both the Parties agree that this Integrity Pact will have precedence over the Tender/Contact documents with regard any of the provisions covered under this Integrity Pact.

IN WITNESS WHEREOF the parties have signed and executed this Integrity Pact at the

place and date first above mentioned in the presence of following witnesses:

..... (For and on behalf of Principal/Owner)

..... (For and on behalf of Bidder/Contractor)

WITNESSES:

1. (signature, name and address)

2. (signature, name and address)

Place:

Dated :

Chapter 1

Information and Instructions to Bidders

1.1 General

- (i) Model Letter of transmittal and other forms for deciding eligibility are given in Section 7
- (ii) All information called for in the model forms should be furnished against the relevant columns in the forms. If for any reason, information is furnished on a separate sheet, this fact should be mentioned against the relevant column. Even if no information is to be provided in a column, a nil or No such case entry should be made in that column. If any particulars/query is not applicable in case of the bidder, it should be stated as not applicable.
- (iii) The bidders are cautioned that not giving complete information called for in the NIT or not giving it in clear terms or marking any change in the prescribed forms or deliberately suppressing the information may result in the bid being summarily disqualified. Bids made by telegram or telex or through other electronic means and those received late shall not be accepted.
- (iv) The bidder should sign on each page of the bid document.
- (v) Overwriting should be avoided. Correction, if any, should be made by neatly crossing out, initialling, dating and rewriting. Pages of the eligibility criteria document are numbered.
- (vi) Additional sheets, if any, added by the contractor, should also be numbered by him. They should be submitted as a package with signed letter of transmittal.
- (vii) References, information and certificates from the respective clients certifying suitability, technical knowledge or capability of the bidder should be signed by an Officer not below the rank of Executive Engineer or equivalent. In case of certificates from

private organizations, such certificate shall be submitted in original issued by Project Manager of such organization.

(viii) The bidder may furnish any additional information which he thinks is necessary to establish his capabilities to successfully complete the envisaged work. He is, however, advised not to furnish superfluous information. No information shall be entertained after submission of eligibility criteria document unless it is called for by the IIT Hyderabad.

1.2 Definitions

In this document, the following words and expressions have the meaning hereby assigned to them.

- (i) Government or IITH or IIT Hyderabad or Institute or Department : Means the Indian Institute of Technology Hyderabad, Kandi-502285, Sangareddy District, Telangana State, India acting through the Engineer-in-Charge, IIT Hyderabad.
- (ii) Engineer-in-Charge means Engineer-in-Charge of the work, representing Director, IIT Hyderabad.
- (iii) Bidder or tenderer: Means the individual, sole proprietary firm, firm in partnership, limited company, private or public or corporation.
- (iv) Year: Means Financial year unless stated otherwise.
- (v) Technology Provider : Means Suez Water Technologies and Solutions (I) Pvt. Ltd., formerly GE India Industrial Pvt. Limited
- (vi) "GE" means Suez Water Technologies and Solutions (I) Pvt. Ltd., formerly GE India Industrial Pvt. Limited
- (vii) MoU means Memorandum of Understanding

1.3 Method of application:

- (i) If the bidder is an individual, the application shall be signed by him above his full type written name and current address.
- (ii) If the bidder is proprietary firm, the application shall be signed by the proprietor above his full typewritten name and full name of his firm with its current address.

(iii) If the bidder is a firm in partnership, the application shall be signed by all the partners of the firm above their full typewritten names and current addresses, or, alternatively, by a partner holding power of attorney for the firm. In the latter case, a certified copy of the power of attorney should accompany the application. In both cases, a certified copy of the partnership deed and current address of all the partners of the firm should accompany the application.

(iv) If the bidder is a limited company or a corporation, the application shall be signed by a duly authorized person holding power of attorney for signing the application accompanied by a copy of the power of attorney. The bidder should also furnish a copy of the Memorandum of Articles of Association duly attested by a Public Notary.

1.4 Final decision making authority:

IITH reserves the right to accept or reject any bid and to annul the process and reject all at any time, without assigning any reason or incurring any liability to the bidders bids .

1.5 Particulars provisional

The particulars of the work given in Chapter 4.1 are indicative. They are liable to change and must be considered only as advance information to assist the bidder.

1.6 Site visit

The bidders are advised to visit the site of work, at his own cost, and examine it and its surroundings to familiarize himself, collect all information that he considers necessary for proper assessment of the work and shall quote accordingly.

1.7 Criteria for eligibility

- (i) Contractors who fulfill all the initial criteria of qualification for bidding specified in NIT be eligible to apply.
- (ii) The bidder shall be registered with GST council of Govt. of India. A certified copy of Certificate of Registration for GST shall be enclosed with bid documents as a proof.
- (iii) The bidder should own construction equipment required for the proper and timely execution of the work.
- (iv) The bidder should have sufficient number of Technical and Administrative employees for the proper execution of the contract. The bidder should submit a list of the

personnel to be posted at site of work along with their credentials stating clearly how they would be involved in this work.

- (v) The bidders performance for each work completed in the immediately preceding seven years and works in hand should be certified by an Officer not below the rank of Executive Engineer or equivalent. In case of certificates from private organizations, such certificate shall be submitted in original issued by Project Manager of such organization.

1.8 Evaluation criteria

The details submitted by the bidders shall be evaluated in the following manner:

- (i) The initial criteria of qualification prescribed in Section 0.2 of NIT in respect of experience of similar works completed, bidding capacity and financial turn over etc., shall first be scrutinized and the bidders eligibility for the work be determined.
- (ii) The bidders qualifying the initial criteria of qualification as set out in Section 0.2 of NIT shall be evaluated for following criteria by scoring method on the basis of details furnished by them:

Table 1.1: Evaluation Break-up

Sl No.	Criterion	Maximum Marks
(a)	Financial strength (Form A & B)	20
(b)	Experience in similar works during last seven years (Form C)	50
(c)	Performance on works (Form E) time over run	10
(d)	Performance on works (Form E) quality	10
(e)	Personal and Establishment (Form F & G)	10
Total		100

- (iii) The scoring for evaluation shall be done as per Table 1.2. IITH reserves the right to restrict the list of such qualified contractors to any number deemed suitable by it.
- (iv) IIT Hyderabad will independently verify the credentials submitted by the bidder and may obtain the Client feedback directly. In case of adverse feedback of the clients, those bids will be disqualified. The bidders shall give complete contact information of clients of eligible projects while submitting their credentials. Bids with incomplete submissions in this context shall be rejected.

1.9 Disqualification

Even though any bidder may satisfy the above requirements, he would be liable to disqualification if he has:

- made misleading or false representation or deliberately suppressed the information in the forms, statements and enclosures required in the eligibility criteria document.
- record of poor performance such as abandoning work, not properly completing the contract, or financial failures / weaknesses etc.,

1.10 Financial information

Bidder should furnish the following financial information: Annual financial statement for the last five years in (Form A) & solvency certificate in (Form B) given at Chapter 7.

1.11 Experience in Similar Works

Bidder shall furnish the following attested credentials in the eligibility document :

- (i) List of all works of similar works successfully completed during the last seven years in (Form C) given at Chapter 7.
- (ii) List of the projects under execution or awarded in (Form D) given at Chapter 7.
- (iii) Particulars of completed works and performance of the bidder duly authenticated/certified by an Officer not below the rank of Executive Engineer or equivalent should be furnished separately for each work completed or in progress in (Form E) given at Chapter 7.

In case of projects pertaining to private sector, the bidder shall submit certificates in ORIGINAL issued by the Project Manager of the Client organization.

- (iv) Information in (Form D) should be complete and no work should be left out.

1.12 Organization information

Bidder shall furnish the following self attested documents:

- (i) Structure and organization in Form F given at Chapter 7.
- (ii) Details of Technical and administrative personnel to be employed for the work in Form-G given at Chapter 7.

1.13 Construction Plant and Machinery

Bidder shall furnish the following attested documents in the eligibility document:

- (i) List of P& M owned

(ii) List of construction plant and machinery likely to be used in carrying out the work in Form H given at Chapter 7.

1.14 EPF Registration

The Bidder should submit EPF registration Certificate valid as on date of opening of bid.

1.15 Goods and Services Tax (GST)

GST shall be applicable for Works contract as per GST Act amended from time to time. Quoted rates shall be inclusive of applicable GST. Nothing extra shall be payable.

1.16 Opening of price bid (financial bid) its validity

After evaluation of applications, a list of qualified bidders shall be prepared based on the minimum cut-off marks obtained. There-after the financial bids of only the qualified and technically acceptable bidders shall be opened at the notified time, date and place in the presence of the qualified bidders or their representatives. The bids shall remain valid for 60 days from the date of opening of financial bid.

1.17 Award criteria

IIT Hyderabad reserves the right, without being liable for any damages or obligation to inform the bidder, to:

- (i) Amend the scope and value of contract to the bidder.
- (ii) Reject any or all the applications without assigning any reason.
- (iii) Any effort on the part of the bidder or his agent to exercise influence or to pressurize the IIT Hyderabad would result in rejection of his bid. Canvassing of any kind is prohibited.

1.17.1 Award

The work shall be awarded to the successful bidder who has quoted lowest tendered amount. For the purpose of reckoning lowest tendered amount, the total of lump sum amount quoted for Part-A and amount quoted for three years of O&M of Part-B shall be considered.

1.18 Appendix-I

Criteria for evaluation of the performance of bidders for pre-eligibility

Table 1.2: Evaluation Criteria

Sl No	Attributes		Evaluation
1	Financial strength : 20 Marks		(i) 60% marks for minimum eligibility criteria (ii) 100% marks for twice the minimum eligibility or more, In between (i) & (ii) on pro-rata basis
	(i) Average annual turnover	16 Marks	
	(ii) Solvency Certificate	4 Marks	
2	Experience in similar Works– (a) 1 # 500 or above KLD or (b) 2# 400 to 499 KLD or (c) 3#200 to 399 KLD	50 Marks	(i) 60% marks for minimum eligibility criteria (ii) 100% marks for twice the minimum eligibility criteria or more, In between (i) & (ii) on pro-rata basis
3	Performance on works (time over run)	10 marks	(i) Without levy of compensation : 10 Marks (ii) With levy of compensation : 0 Marks (iii) Compensation not decided : 5 Marks
4	Performance of works (Quality) :	10 Marks	(i) Very Good :10, (ii) Good :8, (iii) Fair :5, (iv) Poor :0
5	Personnel and Establishment	10 Marks	(As per Form G): (i) Graduate Engineer :3 marks for each, (ii) Diploma Engineer : 2 marks for each up to max.4 marks, (iii) Supervisory/Foreman: 1 mark for each up to max. 3 marks

Chapter 2

Conditions of the Contract

2.1 General Conditions

1. As per the overall master plan of the IIT Hyderabad permanent campus project two sewage treatment plants are proposed to be constructed. These two sewage treatment plants are designated as STP-I and STP-II. This tender is for STP-I. The Civil works of STP-I are being constructed by IIT Hyderabad under separate contract. STP-I is planned to handle 1950 KLD sewage and accordingly civil construction work is being constructed in modules of 3 trains/streams of 650 KLD each with a common collection sump to cater to peak demand of 1950 KLD. The present contract is to bring into operation one 650 KLD (Module No.1) module by installation of electro-mechanical and instrumentation equipment required for one 650 KLD module and installation of all common equipment and instrumentation required for overall capacity of 1950 KLD (3 modules) like screens, centrifuge etc.,

The detailed working drawings of the civil construction works of proposed STP-I pertaining to Architectural plans, sections, elevations etc. indicating sizes of units, levels etc. and structural drawings are enclosed with the bid document in pdf format. Bidders are advised to thoroughly study these drawings specifically, the sizes of layout of different tanks, their sizes, levels etc. The design of electro-mechanical equipment of the proposed work shall be in tune with the Civil construction such that the treatment plant will meet the desired requirements in terms of quantity of treated sewage/day, quality of treated sewage etc. The following drawings shall form a part of the tender document:

Architectural Drawings:

- Drawing No.ES-STP-100:Excavation Plan.
- Drawing No. STP-AR-01: Site Plan.
- Drawing No. STP-AR-02: Plans and Sections.

- Drawing No. STP-AR-03: Plans and Sections.
- Drawing No. STP-AR-04: Elevation and other details.

Structural Drawings:

- Drawing No. ES-STP-01: STP foundation layout
 - Drawing No. ES-STP-01A: STP foundation details
 - Drawing No. ES-STP-02: STP framing plan and slab layout
 - Drawing No. ES-STP-03: STP beam details
2. Any clarification or doubt regarding these drawings may be raised by the bidders in the pre-bid meeting and get clarity before submission of bids. No claims shall be entertained thereafter.
 3. The power supply for the sewage treatment plant shall be made available at the control panel room. The distribution of power for various units/equipment, switch-gear/panels/starters/VFDs and cabling including design of cables and switch-gear shall be within the scope of the contractor.
 4. The total electrical load of the plant shall be worked out by the contractor and accordingly, IITH will arrange power supply cables up to the Control Room.
 5. All the equipment like motors, pumps, blowers etc. must be high energy efficient as per BEE Standards
 6. For Operation Maintenance Services, power supply will be arranged free of charge by IITH.
 7. The Institute has appointed Tata Consulting Engineers as Project Management Consultant (PMC) and Bharat Sanchar Nigam Limited as Project Certification Agency (PCA) for this work. The successful bidder shall execute the work in co-ordination with these two agencies. The role of PMC and PCA shall cease after closure of original Agreement. Representatives from both these agencies shall inspect all aspects of the work like conformance of material, processes, safety issues, attend factory inspections, if any, witness tests , scrutinize the Running Bill payment bills raised by the contractor and recommend the same to IITH for payment etc.
 8. The PMC and PCA shall satisfy themselves that the work has been done in each stage in conformity to the approved drawings and specifications contained in the tender documents and certify the same before recommending to the Engineer-in-Charge, IITH for the release of the scheduled payment.
 9. The work shall be carried out as per the drawings vetted by the Technology Provider and approved by the Engineer-in-Charge adhering to Technical Specification of con-

tract for Electro-Mechanical equipment, Membranes, Instrumentation, automation ,electrical works, piping etc. as per Chapter 4. All allied civil works required for equipment foundation, platforms etc., shall be executed as per CPWD Specification 2009 volume I and II.

10. The list of approved makes or brands are mentioned against each of the electro-mechanical, instrumentation, membranes and other items required for completion of work. The contractor shall procure any one of the approved makes conforming to the required specifications. The brand,make and model of equipment being procured shall be intimated in advance to Engineer-in-Charge before their procurement.
11. In case make/brand is not specified for any of the item required for the plant and not included in the list, contractor may propose any one of the reputed brands for such items for approval of Engineer-in-Charge. Procurement of such items shall be done only after obtaining written approval of Engineer-in-Charge.
12. The contractor shall make his own arrangements at site for proper storing of GE membranes as per the recommendations of the Technology Provider until installation of the membranes.
13. All electro-mechanical, instrumentation equipment shall be properly stored under protected environment at site until they are installed in their designated locations.
14. The testing charges for conducting the tests on influent sewage or treated water at third party laboratories as and when intended by the Engineer-in-Charge, shall be reimbursed. The reimbursement such third party test charges can be claimed along with the monthly O& M bills. Third party tests shall be done at the labs approved by the Institute.
15. The contractor shall arrange at site control room one desktop computer system loaded with required licensed software for monitoring the operations of the plant and for storing and retrieval of data along with one laser printer. The computer and printer shall be properly maintained at control room.
16. During the O& M period, the contractor shall maintain at site sufficient numbers of all equipment required for O& M like wheel borrows, spades, pans, safety equipment, all tools and tackles required for day to day operations and troubleshooting.
17. The contractor shall carry-out safety audit of the plant on quarterly basis and report there-of shall be furnished to Engineer-in-Charge. First safety audit shall be carried out after three months of commencement of O& M period.
18. All near misses, accidents in the premises of STP shall be reported to the Engineer-in-Charge as and when they occur. Process improvement to avoid such incidents in

future shall also be undertaken under intimation to the Engineer-in-Charge.

19. Housekeeping of the STP premises shall be the responsibility of the contractor until the end of O & M period. The entire external and internal premises of STP shall be maintained properly all the time including the janitorial services.
20. *Air conditioning Equipment:* Wall mounted split type air conditioners of 2 TR capacity shall be provided for the control room. Outdoor condensing unit shall be located on the roof of the building or grouted on the external side of the wall with suitable brackets.

One more set of 2 TR split ACs (2x2TR) shall be provided in the laboratory. Cost of these ACs is deemed to be included in the quoted lump sum amount.

The ACs shall be properly maintained during the O&M Period by the contractor.
21. IITH shall not ensure inflow of a 650 KLD sewage for treatment all along the contract period. There can be periods of low flow at regular intervals. The successful bidder shall design most appropriate design based on the GE MBR technology treatment process to ensure the treated sewage quality meets the standards specified in this document and shall simultaneously meet disposal standards as prescribed by the Central Pollution Control Board / Telangana State Pollution Control Board as may be applicable as per the law.
22. The contractor shall not assign or sublet any part or whole of the contract under any circumstances.
23. *Rights on treated water:* IITH shall have full rights on treated water including the softened water. Through a network of separate pipe lines , IITH will utilize the treated water for internal purposes like flushing, gardening and make-up water for HVAC systems on daily basis. Contractor shall not have any rights on the treated water.
24. *Running account bills and Final bills for the work:* The contractor shall submit all the running account bills in the proforma CPWA-27A and the final bill in proforma CPWA-27B. Payment under Schedule 6 of Payment Terms shall be treated as provisional final bill of Original Agreement(Part-A) for DSITC Works. The final bill of entire contract shall be payable on completion of Supplementary Agreement (Part-B) for O & M services and issue of completion certificate for entire work by Engineer-in-Charge.

2.2 Tender Rates

- (i) The tenderer shall study carefully, the drawings, specifications, schedule of contract price and all other conditions to fully understand the scope of work before quoting

his rates.

- (ii) The rates and amount for which the tender is approved shall be inclusive of all expenses for the proper and entire completion of the work and shall be inclusive of all taxes, duties and levies including GST, Import duties, labour cess, municipal taxes local taxes, all royalties, patent rights, other incidental charges etc. The Lump sum amount offered shall be final and no claim whatsoever on any account shall be entertained.
- (iii) Under Part-A of the contract, bidder shall quote lump sum amount for designing, supplying, installation, testing and commissioning of all electro-mechanical equipment, instrumentation, piping and allied civil works like equipment foundations, painting, electrical wiring, panels etc. The indicative list of electro-mechanical equipment, instrumentation, piping, automation etc., is given in Chapter 4. The bidder is required to quote a single lump sum amount including the GST (i.e., GST for all components as well as GST on works contract) for the total contract for Part-A. It may be noted that the list is indicative only and not exhaustive and hence quoted lump sum amount for Part-A shall include cost of all items required for supply, installation, trial run and successful commissioning of the plant as per approved design, drawings and specifications and nothing extra shall be paid over and above the quoted amount against Part-A of the contract.
- (iv) Under Part B of the Contract, contractor shall be responsible for operation and maintenance of the plant for three years. Bidder shall quote monthly charges inclusive of all taxes as per the Schedule of Contract price.

2.3 Specialized Work

Plant automation is considered to be specialized component of the Contract. The bidder shall propose such agency who fulfills the requirements specified in Section 5.50.

2.4 Taxes

(i) The Tendered amount for both Part-A and Part-B shall be inclusive of applicable Works Contract Tax under GST.

(ii) Other Taxes: Income tax/surcharge/cess or any other tax as applicable on the amounts paid by IIT Hyderabad shall be recovered at source at applicable rates as notified by Government of India and a certificate to this extent shall be issued to the contractor.

2.5 Mobilization Advance

- (i) Mobilization advance of 10% of contract amount for Part-A may be payable to the contractor after award of work against bank guarantee bond (BG) of any scheduled bank of 110% of the advance amount. The BG shall be submitted in the prescribed proforma as given in Section 7 and shall be valid for one year from the date of submission or as specified by the Institute. If the commissioning of the plant is delayed due to any reasons, the Contractor shall arrange for extension of validity of the BG to such period as specified by the Institute.
- (ii) Mobilization advance as stated above may be given, if requested by the contractor in writing within one month of the order to commence the work. Such advance shall be paid in one or more instalments to be determined by the Engineer-in-Charge at his sole discretion. The first instalment of such advance shall be released by the Engineer-in-Charge to the contractor on a request made by the contractor to the Engineer- in-Charge. The second and subsequent instalments shall be released by the Engineer- in- Charge only after the contractor furnishes a proof of the satisfactory utilization of the earlier instalment of the mobilization advance to the entire satisfaction of the Engineer-in-Charge.

If the circumstances are considered reasonable by the Engineer-in-Charge, the period mentioned above for request by the contractor in writing for grant of mobilization advance may be extended at the discretion of the Engineer-in-Charge.

2.5.1 Interest on Mobilization Advance

The mobilization advance shall bear a simple interest at the rate of 10 per cent per annum and shall be calculated from the date of payment to the date of recovery, both days inclusive, on the outstanding amount of advance.

2.5.2 Recovery of Mobilization Advance

Recovery of such sums advanced together with interest due on the entire outstanding amount up to the date of recovery of the instalment shall be made by the deduction from the contractors scheduled payments as follows:

- (a) 60% of mobilization advance from payments under Schedule 2 (on pro rata basis from each segment of schedule 2 payments.)
- (b) 80% of mobilization advance from payments under Schedule 3 less already recovered amount of mobilization advance.

- (c) 100% of mobilization advance from payments under Schedule 4 less already recovered amount of mobilization advance.
- (d) Above recoveries will be made along with applicable interest amount corresponding to that period.

2.6 Payment for additions and deductions for Omissions

- (i) Authorized variations shall not vitiate the contract but additions and omissions shall be measured up and paid. The rates for extra or reduction and deduction items shall be worked out as per prevailing market rates. The rates finalized by the Engineer-in-Charge shall be final and binding. The coefficients for materials and labour for analysing the rates shall be as specified in the latest Delhi Analysis of Rates published by CPWD. Where, such coefficients are not available, the actual observed values will be adopted.
- (ii) The execution of any items of work where any incidental work is actually required but not specifically stated in the tender, it is to be understood that the amount quoted by the contractor shall cover such charges also and nothing extra on account of such incidental charges, if any, shall be paid.

2.7 No Payment for Unsanctioned Extras

It shall be distinctly understood that no payment whatever will be made to the contractor for variations by way of extras in cases where such variations have been made without the written sanction of the Engineer-in-Charge.

2.8 Penalty for not fulfilling Effluent Characteristics

In case if the contractor fails to meet specified parameters of the quality of the treated sewage, the contractor shall pay to the IITH liquidated damages amounting to Rs 2,000.00 (Rupees two thousand only) per day of occurrence, over and above the costs and compensation that might be required by the IITH to pay to the affected people and parties ,if any.

2.9 Defect Liability Period

The defect liability period for this contract shall be for a period of two (2) years from the date of completion of Part-A.

The defects, if any, during the defect liability period shall be rectified free of charge by arranging free replacement wherever necessary as specified in the contract. All expenses

including statutory levies on account of such replacement shall be borne by the contractor.

2.10 Record of Completion

The Part-A of contract shall be deemed to be completed on issue of completion certificate by Engineer-in-Charge. The period of three years for Part-B of the contract shall commence only after the date of completion of Part-A. The whole contract shall be deemed to be completed on successful completion of both Part-A and Part-B components.

2.11 Warranty

All electro-mechanical equipment, instrumentation and ultra-filtration membranes shall have warranty till end of the total contract period for Part A and Part B. Even in case warranty of this period is not extended by any Original Equipment Manufacturer (OEM), it shall be the responsibility of the contractor to maintain the plant trouble free.

2.12 Disputes and Arbitration

(a) Unless otherwise specified, in all cases of disputes which cannot be settled by mutual negotiations, the disputes or differences shall be referred to a Dispute Redressal Committee (DRC) to be constituted by the Director, IIT Hyderabad at the request of the contractor. In case the decision of the DRC is not acceptable to the parties, those disputes shall finally be settled and binding on both parties by arbitration in conformity with the rules of Indian Arbitration and Conciliation Act 1996 as amended from time to time. All disputes or differences whatsoever arising between the parties out of relating to the construction, meaning and operation or effect of the general terms and conditions included in the agreement or the breach thereof shall be binding on the parties.

b) Performance of the Agreement conditions shall continue during arbitration and any subsequent proceedings.

c) The jurisdiction and seat of arbitration shall be Hyderabad. The Arbitrator shall be appointed by the Director, IITH.

d) All legal matters are subjected to within the jurisdiction of High Court (AP & Telangana), Hyderabad.

2.13 Force Majeure

In this Clause, Force Majeure means an exceptional event or circumstance:

(a) which is beyond a Partys control,

(b) which such Party could not reasonably have provided against before entering into the Contract,

(c) which, having arisen, such Party could not reasonably have avoided or overcome, and

(d) which is not substantially attributable to the other Party.

Force Majeure may include, but is not limited to, exceptional events or circumstances of the kind listed below, so long as conditions (a) to (d) above are satisfied:

(i) war, hostilities (whether war be declared or not), invasion, act of foreign enemies,

(ii) rebellion, terrorism, sabotage by persons other than the Contractors Personnel, revolution, insurrection, military or usurped power, or civil war,

(iii) riot, commotion, disorder, strike or lockout by persons other than the Contractors Personnel,

(iv) munitions of war, explosive materials, ionising radiation or contamination by radio-activity, except as may be attributable to the Contractors use of such munitions, explosives, radiation or radio-activity, and

(v) natural catastrophes such as earthquake, hurricane, typhoon or volcanic activity.

If a Party is or will be prevented from performing its substantial obligations under the Contract by Force Majeure, then it shall give notice to the other Party of the event or circumstances constituting the Force Majeure and shall specify the obligations, the performance of which is or will be prevented. The notice shall be given within 14 days after the Party became aware, or should have become aware, of the relevant event or circumstance constituting Force Majeure.

The Party shall, having given notice, be excused performance of its obligations for so long as such Force Majeure prevents it from performing them.

Notwithstanding any other provision of this Clause, Force Majeure shall not apply to obligations of either Party to make payments to the other Party under the Contract.

2.14 Price Escalation

The lump sum contract amount shall be final and Price Escalation shall not be applicable.

2.15 Time Extension of Contract Period

- (i) The time allowed for execution of the Part-A of contract as specified in NIT or the extended time in accordance with these conditions shall be the essence of the Contract. The execution of the works shall commence from such time period as mentioned in award letter or from the date of handing over of the site whichever is later. If the Contractor commits default in commencing the execution of the work as aforesaid, IITH

shall without prejudice to any other right or remedy available in law, be at liberty to forfeit the earnest money performance guarantee absolutely.

(ii) As soon as possible after the Contract is concluded, the Contractor shall submit a Time and Progress Chart for each mile stone of Part-A and get it approved by the Engineer-in-Charge. The Chart shall be prepared in direct relation to the time stated in the Contract documents for completion of components of the Part-A. It shall indicate the forecast of the dates of commencement and completion of various components of the work and may be amended as necessary by agreement between the Engineer-in-Charge and the Contractor within the limitations of time imposed in the Contract documents .

(iii) the work(s) be delayed by:

(a) force majeure, or

(b) abnormally bad weather, or

(c) serious loss or damage by fire, or

(d) civil commotion, local commotion of workmen, strike or lockout, affecting any of the trades employed on the work, or

(e) delay on the part of other contractors or tradesmen engaged by Engineer-in-Charge in executing work not forming part of the Contract, or

(f) non-availability of stores, which are the responsibility of IITH to supply if any or

(g) non- availability or break down of tools and plant to be supplied or supplied by IITH if any or

(h) any other cause which, in the absolute discretion of the Engineer-in-Charge is beyond the Contractors control,

then upon the happening of any such event causing delay, the Contractor shall immediately give notice thereof in writing to the Engineer-in-Charge IITH but shall nevertheless use constantly his best endeavours to prevent or make good the delay and shall do all that may be reasonably required to the satisfaction of the Engineer-in-Charge to proceed with the works.

(iv) Request for rescheduling of Mile stones and extension of time, to be eligible for consideration, shall be made by the Contractor in writing within fourteen days of the happening of the event causing delay on the prescribed form to the Engineer-in-Charge. The Contractor may also, if practicable, indicate in such a request the period for which extension is desired.

(v) In any such case the Engineer-in-Charge may give a fair and reasonable extension

of time and reschedule the mile stones for completion of Part-A of contract. Such extension shall be communicated to the Contractor by the Engineer-in-Charge in writing, within 3 months of the date of receipt of such request. Non application by the contractor for extension of time shall not be a bar for giving a fair and reasonable extension by the Authority and this shall be binding on the contractor.

2.16 Safety Requirements

(i) The contractor shall take all necessary measures for the safety of traffic and workers during construction and provide, erect and maintain such barricade including signs, markings, lights etc. necessary all around the construction site and offices, workshop, storage yards etc. The manner and the position of boundary where barricading is to be provided shall be decided by the Engineer-in-Charge whose decision shall be final and binding. Nothing Extra shall be paid for the same.

(ii) The painting of barricades in a suitable retro reflective paint shall be regularly done as decided by Engineer-in-Charge but not take more than the 3 months intervals. He should also deploy necessary watch and ward and signages to keep the public away from the construction site. During execution of work there may be requirement of dismantling and re-erecting of barricades at certain locations. The contractor shall have to do the same as per requirement of site and direction of Engineer-in-Charge. Nothing extra shall be payable due to this.

(iii) The contractor shall make arrangement for Helmets and leather shoes (meant of construction work at sites) for the labour and technical staff of the contractor during the entire period of construction for safety reasons.

(iv) Existing drains, pipes, cables, overhead wires, sewer lines, water lines and other services proposed to be retained, but encountered in the course of the execution of the work shall be protected against the damage by the contractor at his own expense. The contractor shall not store materials or otherwise occupy any part of the site in a manner likely to hinder the operation of such services.

(v) The contractor shall conduct his work, so as not to interfere with or hinder the progress or completion of the work being performed by other contractor (s) or by the Engineer-in-Charge and shall as far as possible arrange his work and shall place and dispose off the materials being used or removed, so as not to interfere with the operations of other contractors, or he shall arrange his work with that of the others in an acceptable and coordinated manner and shall perform it in proper sequence to the complete satisfaction of Engineer-in-Charge.

2.17 Foreign Exchange

No foreign exchange shall be made available by the department for the purchase of equipment, plants, machinery, materials of any kind or any other items required to be carried out in execution of work. Foreign exchange required for the work shall be arranged by the contractor at his own cost.

2.18 Compensation for Delay

If the contractor fails to maintain the required progress in terms of Section 2.19 or to complete the work on or before the contract or extended date of completion, he shall, without prejudice to any other right or remedy available under the law pay to the IITH on account of such breach, the amount calculated at the rates stipulated below as the Director, IITH (whose decision in writing shall be final and binding) may decide on the contract amount of Part-A of the work for every completed day/month (as applicable) that the progress remains below that specified in Table 2.1 or that the work remains incomplete.

(i) Compensation for delay of work : @ 1.00 % per month of delay to be computed on per day basis

Provided always that the total amount of compensation for delay to be paid under this Condition shall not exceed 5% Contract Amount of Part-A of the contract.

The amount of compensation may be adjusted or set-off against any sum payable to the Contractor under this or any other contract with the IITH.

2.19 Milestones of the Contract

The milestones of the contract are given in the table below. The Contractor shall achieve progress of the work in accordance with the set milestones. In case, the contractor does not achieve a particular milestone mentioned in the contract, and does not reach the last milestone within the specified period, the condition of penalty as stipulated under Section 2.18 will automatically be applied. Penalty in such case shall be automatic without any notice to the contractor.

Table 2.1: Table of Milestones

SI No	Milestone	Time Period
1	Submission of final design documents & drawings duly vetted by Technology Provider	One (1) Month
2	Supply of all electro-mechanical Instrumentation equipment to site	Four (4) Months
3	Supply of GE Membranes/ Cassette to site	Five(5) Months
4	Completion of Installation of electro-mechanical, electrical, piping,	Seven (7) Months
5	Supply, installation and commissioning of Plant Automation.	Eight (8) Months
5	Completion of Part-A (Trial run and Successful Commissioning of plant)	Nine (9) Months

**Time periods shown above table shall be reckoned from date of commencement.*

2.20 Documents to be submitted to IITH

The Contractor on completion of the work shall submit the documents as listed below: Documents related to equipment should be submitted to IITH as soon as they are available:

- Certificate of Origin 2 copies
- A set of shipping documents
- Import shipment/Airway bill/Bill of Lading copy at the time of delivery of the item at site
- Packing list original with 2 spare copies.
- Warranty Certificate with 2 spare copies.
- Manufacturers Test Certificate (MTC) of all equipment
- OEM manuals

Apart from the above, the Engineer-in-Charge is empowered to seek any documents, including priced invoices of materials and equipment related to execution of the works from the contractor.

2.21 Labour huts, watch and ward, storage of equipment

(i) IIT Hyderabad shall not allow the contractor to set up the labour camp inside its premises. The contractor shall make his own arrangements for labour camp outside the campus. (ii) The Contractor shall be responsible for watch and ward and for safe custody of his materials and equipment. IITH shall not assume any responsibility.

2.22 Transfer of Ownership

- (i) Ownership of the Plant and Equipment (including spare parts) to be imported or procured from within the country shall automatically deemed to be transferred to the Institute upon release of scheduled payment to the contractor.

- (ii) Notwithstanding the transfer of ownership of the Plant and Equipment, the responsibility for care and custody thereof together with the risk of loss or damage thereto shall remain with the Contractor until Completion of the stipulated O&M period, in which such Civil Construction, Plant and Equipment are incorporated.

- (iii) The Contractor shall be liable for any loss of or damage to any of the plant and equipment, or any other property used for purposes of the plant.

- (iv) The Contractor shall not be allowed to take back any items, equipment, loose furniture, computers & peripherals, tools and plants other than those issued by contractor to his workmen after the completion of OM period or at any point of time of operations. All the equipment installed and procured as a part of this contract shall remain the absolute property of IIT Hyderabad.

- (v) After completion of the O&M period, the contractor may take back tools and tackles, PPE issued to his workers, wheel borrows, spades, pans, unused chemicals, unused spare parts, unused registers/ stationary and other tools used for day to day operations.

2.23 Abbreviations

Table 2.2: Abbreviations

BIS/IS	Bureau of Indian Standards
BOD	Biological Oxygen Demand
BS	British Standards
CI	Cast Iron
COD	Chemical Oxygen Demand
DI	Ductile Iron
DSITC	Design, Supply, Installation, Testing and Commissioning
EIC	Engineer-in-Charge
GI	Galvanized Iron
GST	Goods and Services Tax
HMI	Human Machine Interface
HRT	Hydraulic Retention Time
I/O	Input/Output
IS/BIS	Indian Standards / Bureau of Indian Standard
KLD	Kilo Litres Per Day
LPH	Litre Per Hour
MBR	Membrane Bioreactors
MLSS	Mixed Liquor Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
MoC	Material of Construction
MS	Mild Steel
MWC	Meter Water Column
N m ³ /hr	Normal Meter Cube Per Hour
NaOCl	Sodium Hypochlorite
NB	Nominal Bore
O&M	Operation and Maintenance
P&ID	Process and Instrumentation Diagram
PLC	Programmable Logic Controllers
SCADA	Supervisory Control and Data Acquisition
SHT	Sludge Holding Tank
SI	System Integrator
SRT	Solid Retention Time
SS	Stainless Steel
SWD	Side Water Depth
TDH	Total Dynamic Head
TMP	Trans Membrane Pressure
TSS	Total Suspended Solids
UF	Ultra Filtration
UPVC	Un Plasticized Vinyl Chloride
VFD	Variable Frequency Drive CSS
Common Collection Sump	
SHT	Sludge Holding Tank

2.23.1 Abbreviations-Electrical

In this document, the following abbreviations of electrical terms have been used.

R - red phase

Y - yellow phase

B - blue phase ac - alternating current

dc - direct current

A - ampere
mA - milliampere
V - volt
kV - kilovolt
kW - kilowatt
kVA - kilovolt ampere
kWh - kilowatt hour
MVA - megavolt ampere
Hz - hertz (cycles per second)
HV - high voltage
IEC - International Electro Technical Commission
IS - Indian Standard
LV - low voltage
SP - single pole
SPN - single pole and neutral
DP - double pole
TP - triple pole
TPN - triple pole and neutral
HRC - high rupturing Capacity
MCB - miniature circuit breaker
MCC - Motor control centre
MCCB - moulded case circuit breaker
OEM - original equipment manufacturer
PCC - power control centre
PMCC - power and motor control centre
RCD - residual current device
ACB - air circuit breaker
VCB - vacuum circuit breaker

Chapter 3

Special Conditions of Contract

3.1 Special Conditions of Contract (SCC)-Part A

3.1.1 General

Description of DSITC¹ Works

(i) The Contractor shall carry out and be responsible for the design and installation of the 650 KLD capacity Sewage Treatment Plant. The Contractors work and services as part of the “DSITC Works“shall cover necessary design and installation of the STP and all allied works in accordance with and as contemplated by the Design-Build Documents and the Technical Standards including the design services in respect of the 650 KLD STP with tertiary treatment process and all allied works including treatment process, hydraulic, electro-mechanical ,electrical, instrumentation, piping, automation etc, Complete.

(ii) *Supplementing the General Conditions*

The provisions contained in this DSITC Works section are to be read in conjunction with the General Conditions of Contract and Special Conditions of Contract (SCC) as contained in this bid document for the purpose of providing greater specificity of the DSITC Works that the Contractor shall perform.

3.1.2 Design Services

(i) **Design and Engineering**

The Contractor shall execute the detailed design of 650 KLD STP and its execution in compliance with the technical specifications and requirements contained in the contract, codes of practices as published by the Bureau of Indian Standard (BIS) or its equivalent International Standards as well as “Manual on Sewerage and Sewage Treatment“ as published by the Central Public Health Engineering Organization (CPHEO) of the Ministry of Urban Development, Government of India, New

¹Design, Supply, Installation, Testing and Commissioning of 650 kLD STP1

Delhi. Wherever, the codes, standards and manual do not provide for the design and execution of some component i.e., required to be designed and executed, the Contractor shall follow the standard engineering practices. In case of any contradiction on a particular provision between various standards, the decision of IITH on that provision shall be final and binding.

- (ii) The designs and drawings as formulated by the Contractor shall be vetted by the Technology Provider and shall be approved by the Engineer in-Charge before commencement work at site.
- (iii) The Contractor shall be responsible for any discrepancies, errors or omissions in the specifications, drawings and other technical documents, desired output / performance of the STP, whether specifications, drawings and other documents have been approved by the Engineer-in-Charge or not, provided that such discrepancies, errors or omissions are not because of inaccurate information furnished in writing to the Contractor by Engineer-in-Charge.

(iv) **Codes and Standards**

Wherever references are made in the Contract to codes and standards, in accordance with which the Contract shall be executed, the edition or the latest version of such codes and standards shall apply unless otherwise specified. During Contract execution, any changes in such codes and standards shall be applied after approval by Engineer-in-Charge.

(v) **Design Responsibilities**

The Contractors design and design-related services shall include, but not limited to the following:

- (i) Acquisition of all data and information necessary to prepare the design and that are required to demonstrate that the 650 KLD STP meets or exceeds the required Effluent Quality Parameters specified in the bid document keeping in view the civil construction work already carried out by IITH
- (ii) Preparation of Hydraulic Flow Diagram (HFD)/schematic/preliminary design documents to illustrate the scale and character of the DSITC Works and how the units of the process-adopted functionally relate to each other.
- (iii) preparation of design development documents, based on the schematic design documents , consisting of drawings and other documents appropriate to the size of the 650 KLD STP to describe the units and character of the entire electro- mechanical

works, instrumentation ,control and electrical systems, materials, operations and such other elements as may be appropriate.

(v) Assisting IIT Hyderabad in obtaining all approvals, permits, including licences for the execution of this contract, and necessary compliance with occupational health and safety requirements, under the Applicable Laws of Central and or State Government Authorities, local Municipal Authorities etc., including all documentation for obtaining such approval, permits or licences.

(vi) the coordination required to integrate all parts of the DSITC Works;

(vii) Vetting of hydraulic design, P&ID drawings and other documents by Technology Provider.

3.1.3 Design-Build Documents

The Contractor shall prepare all of the basic and detail engineering Design-Build Documents including, but not limited to:

- (i) Documents shall include the designs, drawings, as-built documents, operations manuals, schematic design documents, design development documents, and all modifications thereto required in order to properly and fully design and build the STP and all allied works as contemplated as per the Technical Specification and the remaining provisions of the Contract.
- (ii) The Contractor shall prepare any other document, as may be requested by the Engineer-in-Charge, necessary to monitor the progress of the DSITC Works and assess the Contractors compliance with the Contract.
- (iii) The Contractor shall provide IITH with three sets of all of the Design-Build Documents duly vetted by the Technology Provider in reproducible form and shall modify them to keep them up-to-date as requested by IITH . The Design-Build Documents, with the exception of the as-built documents, shall be subject to the review and approval of the Engineer-in-Charge prior to performing any of the services set out in this Section in respect of any Design-Build Document.
- (iv) After completion of DSITC Works, the Contractor shall provide to IITH two sets of the as built Designs, Drawings/Documents in hard form one one set in soft form showing the exact as built locations, sizes and details of the STP and the DSITC Works as executed. The STP shall not be considered to have reached Completion until as built drawings have been submitted to IITH. The Contractor shall update the as built Designs, Build Drawings/Documents as necessary for the correction of defects or deficiencies contemplated by contract.

3.1.4 Design Considerations

In preparing the electro-mechanical design for the 650 KLD Capacity STP and all allied works and the Design-Build Documents, the Contractor shall,

- Protect public health and safety,
- Achieve required effluent quality parameters
- Ensure the STP and all allied works has the capacity to accommodate the anticipated sewage

3.1.5 Design Responsibilities On Site Issues

In preparing the electro-mechanical design for the STP and the Design-Build Documents, the Contractor shall ensure that the design of allied works like control valves chambers, anchor /thrust /pedestal blocks etc.,

3.1.6 Sewerage Treatment Plant Layout and operation sequence

The layout of the plant is shown in the architectural drawings provided with the bid document .Further,

- (a) The STP shall comprise treatment process leading to the minimum effluent quality parameters as specified in Contract. For achieving the desired treated sewage discharge quality standards and keeping in view the Civil construction work already carried out by IITH, the Contractor shall design most efficient system for primary, secondary and tertiary treatment systems using GE MBR Technology.
- (b) Plans for submission of process design and hydraulic design calculations, equipment lay out and hydraulic flow diagram (Process Instrumentation diagram), preparation submission of electrical & mechanical equipment drawings including equipment installation drawings, supporting calculations technical information, instrumentation control system and all allied /ancillary works of required capacity including, disinfection requirement, sludge disposal arrangements, as per approved designs, testing, commissioning. The testing shall be carried out by performing trial run of the plant for one month. Maintaining required MLSS during the trial run shall be the responsibility of the Contractor.
- (c) Scope of contractor also includes establishing office including store house for tools and spares, O& M manual and as-built drawings for all electrical mechanical works. The building construction is in progress and IITH will hand over the same to the contractor.

- (d) Supply and providing safety equipment namely gas mask, breathing apparatus, Air hose respirator, portable lighting equipment, non-sparking lighting equipment, portable air blowers, safety belts, inhalators and diver suit at the commencement of O & M and maintain them at plant for entire duration of O& M period.
- (e) Training IITH staff after commissioning of the plant.
- (f) Handing over of the Plant in good working condition with all relevant documents such as as-built drawings, physical operational condition of the assets, rights on proprietary technologies, software, systems, AMC documents, O& M manual, periodical reports along with soft copy to IITH.
- (g) Design shall be such that the plant requires minimum energy and less manpower requirement with full automation for its sustainable and efficient operation maintenance.

3.1.7 Influent Quality

The electro-mechanical design of the plant shall be based on the values of raw sewage as presented in Table: 3.1. The values indicated in the table are indicative and the system designed should be able to absorb variations by equalization of feed. All concentrations refer to maximum concentrations to be used for the systems design. Fluctuations in feed composition and hydraulics shall be appropriately equalized to allow for optimum biological treatment.

Table 3.1: Influent Parameters

Parameter	Unit	Design Criteria
pH	No Unit	6 to 8
Oil & Grease	mg/l	10-50
Chemical Oxygen Demand (COD)	mg/l	350 to 400
Biological Oxygen Demand 5-day (BOD5)	mg/l	200 to 250
Total Suspended Solids	mg/l	250-350
Total dissolved solids	mg/l	230-280
Ammonia, as NH ₃	mg/l	<35
TKN, as N	mg/l	<45
Total Alkalinity as CaCO ₃	mg/l	150
Total Nitrogen	mg/l	70
Hardness as CaCO ₃	mg/l	160-200
Phosphates	mg/l	2.1-2.3
Sulphates	mg/l	7.4-8.2

3.1.8 Influent Flow Data

Flow rate at the inlet to the proposed MBR as well as the resulting indicative bioreactor temperature is shown in Table 3.2

Table 3.2: Influent Flow Data

Parameter	Unit	Design
Max. Influent flow rate	KLD	650
Assumed Feed Temperature	°C	20-37
Peak Factor		2
Peak flow duration	Hour	3
Design Bioreactor Temperature	°C	30 (See Note 2)

Note (1): The feed flow to be properly equalized.

Note:(2): If flow is less than 50% of the designed flow then the number of hours of operation of the MBR permeate pump shall be reduced accordingly. System should be able to function at Minimum flow of 30% of the designed capacity.

Note (3): Biological and membrane process shall be designed for a Sewage Water temperature operating range of 25 to 35 °C. Higher temperatures >38°C have to be avoided as they exceed the tolerance for the biology and membranes; otherwise appropriate cooling arrangements shall be made by contractor.

3.1.9 Operation Basis

The STP shall be operational 24 hrs and 365 days of the year. Operations shall be so planned to consider Maintenance/Recovery Clean Time.

The permeate Pump shall operate for approximately 22 hours per day to treat the average daily flow of 650 KLD, remaining time shall be used for back wash cleaning purposes. This shall be pre-programmed in the PLC.

3.1.10 Required Effluent Quality

Table below shows the expected effluent quality upon equipment start-up and running of of the plant.

Table 3.3: Required Effluent Quality Parameters

Parameter	Unit	Required
Biological Oxygen Demand 5-day (BOD5)	mg/l	<5
Total Suspended Solids	mg/l	<5
Turbidity	NTU	<1
Hardness of softened water	mg/l	<50
Total coliform MPN/100 ml, max		<100
Oil and grease		Not detectable
Colour and Odour		Clear and Not objectionable
Chlorine	mg/l	>1 ppm as total Cl.

*Note : The test results of treated effluent shall conform to the above parameters within the permissible variation up to 5%. In case the results vary beyond the permissible limit,

the Contractor shall call the Technology Provider and take corrective action at his own cost.

3.1.11 Site Administrative Facility

The Contractor shall be responsible for the administration of the STP and all allied works during the Design-Build Period and the Contractor shall arrange at his own cost

- (i) temporary office facilities for use by the Contractor and his specialized agencies during the administration and execution of the DSITC Works;
- (ii) appropriate signage for the Site and the STP, including signs that:
 - identify the STP and its units;
 - provide warning and hazard notification in designated areas where warranted; and
 - identify areas of the STP that are restricted to visitors and are accessible to only designated employees of the Contractor;

3.1.12 Equipment Installation Services

- (i) The Contractor shall carry out all equipment installation in all units of STP designed pursuant to DSITC Works of the Contract.
- (ii) The Contractor shall have total control of the installation services and shall effectively direct and supervise the installation services so as to ensure conformity with the Design-Build Documents.
- (iii) The Contractor shall be solely responsible for installation means, methods, techniques, sequences, and procedures and for coordinating the various parts of the DSITC Works under the Contract.

3.1.13 Procurement and Transportation

- (i) The Contractors shall at his own risk and expense transport all equipment and materials to the site for execution of the contract.
- (ii) The Contractor shall be responsible for obtaining, if necessary, approvals from the authorities for transportation of Equipment and materials to the Site. The Contractor shall indemnify and hold harmless the IITH from and against any claim for damage to roads, bridges or any other traffic facilities or individuals that may be caused by the transport of the to the Site.

3.1.14 Temporary Supports, Structures and Utility Services

- (i) Contractor shall have the sole responsibility for the design, erection, operation, maintenance, and removal of temporary supports, structures and utility services and the design and execution of construction methods required in their use.
- (ii) The Contractor shall engage and pay for registered professional engineering personnel skilled in the appropriate disciplines to perform those functions required by law or by the Design- Build Documents and in all cases where such temporary supports, structures and utility services and their designs and method of construction are of such a nature that professional engineering skill is required to produce safe and satisfactory results

3.1.15 Document Review

The Contractor shall review the approved documents and shall report promptly to IITH any error, inconsistency or omission the Contractor may discover. If the Contractor does discover any error, inconsistency or omission in the documents, the Contractor shall not proceed with the work affected until the Contractor has corrected any such errors or inconsistency or supplied any missing information and these corrections have been approved in writing by IITH.

3.1.16 Plant and Equipment

- (i) The Contractor shall provide and pay for labour, Plant and Equipment, tools, construction machinery and equipment, materials and supplies, transportation, and all other facilities and services necessary for the performance of the DSITC Works in accordance with the Tender Documents.
- (ii) The Contractor shall ensure that all Plant and Equipment provided are in good working condition. Plant and Equipment which are not specified shall be of a quality consistent with those specified and their use shall be acceptable to IITH.

3.1.17 Documents at the Site

The Contractor shall keep one copy of all approved Documents as up-dated, submittals, reports and records of meetings at the Site, in good order and shall make them available to IITH upon request and at any reasonable time.

3.1.18 Use of the STP site

- (i) The Contractor shall confine construction machinery and equipment, storage of Plant and Equipment, Contractors Equipment (Design-Build) and Contractors Equipment (Op-

erations), and operations of Contractors Personnel to limits indicated and shall not unreasonably encumber the Site with Plant and Equipment, Contractors Equipment (Design-Build) or Contractors Equipment (Operations).

(ii) The Contractor shall not store Plant and Equipment, Contractors Equipment (Design-Build) or Contractors Equipment (Operations) at the Site which are not necessary for the construction of the STP.

3.1.19 Setting Out

If, at any time during the construction of the Plant, any error shall appear in the position, level or alignment of the plant, the Contractor shall forthwith notify IITH of such error and, at his own expense, immediately rectify such error to the reasonable satisfaction of IITH. Similar action shall be taken if any error, mistake, bad work is notified to the contractor by the Institute.

3.1.20 Quality Assurance

(i) The Contractor shall institute a quality assurance system to ensure compliance with the requirements of the Design-Build Documents. Compliance with the quality assurance system shall not relieve the Contractor of its duties, obligations or responsibilities.

(ii) The Contractor shall submit for approval details of all quality assurance procedures and documents relating to Contractors compliance with the quality assurance system to IITH before each stage of the DSITC Works is commenced as set out in the Time Schedule. When any document is issued to IITH , it shall be accompanied by the signed quality statements for such document, if any. IITH may audit any aspect of the quality assurance system and the Contractor shall take any corrective action as IITH may deem appropriate.

(iii) Contractor shall maintain at site all records of material brought to site, material tests conducted and test results there-of, in approved formats registers

3.1.21 Site Regulations and Safety

(i) The Contractor shall establish Site regulations setting out the rules to be observed in the execution of the Contract at the Site and shall comply therewith. He shall prepare and submit to IITH , proposed Site regulations for the IITH s approval, which approval shall not be unreasonably withheld. Such Site regulations shall include rules in respect of security, safety of Plant, gate control, sanitation, medical care,

emergency preparedness, emergency response, on-site safety training of employees and fire prevention.

- (ii) The Contractor shall comply with all applicable safety regulations in providing the DSITC Works and in occupying any part of the Site. Unless otherwise stated in the Design-Build Documents, the Contractor shall, during the Design- Build Period, carry out safety briefings of applicable site regulations to all employees, Specialized agencies, IITH representatives and visitors to the Site prior to permitting first access of the applicable person to the and at regular intervals thereafter.
- (iii) During the Design-Build Period, the Contractor shall develop and implement a comprehensive occupational health and safety program for the protection of the Contractors Personnel and all other persons who may attend at the STP site. The program shall include a description of how the Contractor shall,
 - (a) carry out all occupational health and safety responsibilities in respect of the STP site as required under the Applicable Law;
 - (b) develop and manage all required occupational health and safety reporting procedures; and
 - (c) manage all occupational health and safety claims.

3.1.22 Contractor's Equipment (Design-Build) and Site Clearance

- (i) All Contractors Equipment (Design-Build) brought by the Contractor onto the Site shall be deemed to be intended to be used exclusively for the execution of the Contract. The Contractor shall not remove the same from the Site without IITH's consent that such Contractors Equipment (Design-Build) is no longer required for the execution of the Contract.
- (ii) The Contractor shall maintain the STP site in a tidy condition and free from the accumulation of waste products and debris. The Contractor shall remove waste products and debris resulting from the Site and shall leave the Facility clean and suitable for occupancy and performance of the Operations and Maintenance Services before declaration of completion of Part-A of contract. The Contractor shall remove products, tools, construction machinery, and equipment, including the Contractor's Equipment, not required for the performance of the remaining ,if any,DSITC Works.
- (iii) Upon successful commissioning of plant, the Contractor shall remove products, tools, construction machinery and equipment, and waste products and debris, including the Contractor's Equipment (Design-Build).

- (iv) Upon the issue of Part-A Completion Certificate, the Contractor shall clear away and remove, from the STP site, all Contractor's Equipment (Design-Build), surplus material, wreckage, rubbish and temporary work or structures. The Contractor shall ensure that the STP site is in a clean and safe condition to the satisfaction of IITH .
- (v) If the Contractor fails to remove, no later than 30 days after the issue of the Completion Certificate, any remaining Contractor's Equipment (Design-Build), surplus material, wreckage, rubbish and temporary work or structures, IITH may sell or otherwise dispose of such items. IITH shall be entitled to retain, from the proceeds of such sale, a sum sufficient to meet the costs incurred in connection with the sale or disposal, and in restoring the STP site. Any balance of the proceeds shall be paid to the Contractor. If the proceeds of the sale are insufficient to meet IITH's costs, the outstanding balance shall be recoverable from the Contractor by IITH.

3.1.23 Protection of the Environment

- (i) The Contractor shall take all reasonable steps to protect the environment, both on and off the Site, and to limit damage and nuisance to people and property resulting from pollution, noise, dust and other results of its Services, including,
 - (a) adopting working practices that prevent or minimize the transfer of any pollutant off-site;
 - (b) maintaining the access roads in good repair;
 - (c) using appropriate dust suppressant methods;
 - (d) restricting trucking and loud machinery and equipment use to daylight hours;
 - (e) using mufflers, silencers and other appropriate methods to minimize the noise of the construction;
 - (f) maintaining a clean STP site, that are free of garbage.
- (ii) The Contractor shall, at all times during installation/ testing/ commissioning and O& M period ensure that the Environmental Management Plan is followed.

3.1.24 Security of the STP site

Unless otherwise stated in the Design-Build Documents:

- (a) the Contractor shall be responsible for keeping unauthorised persons off the Site from STP,
 - (b) the Contractor shall maintain detailed record of all persons that enter the STP site;
- and

(c) the Contractor shall ensure that authorised persons shall be limited to the Contractors Personnel, representatives of the Institute, employees of Specialized agencies and persons authorised by IITH.

3.1.25 Emergency Work

If, by reason of an emergency arising in connection with and during the execution of the DSITC Works, any protective or remedial work is necessary as a matter of urgency to prevent damage to the STP site, the Contractor shall immediately carry out such work.

If the Contractor is unable or unwilling to do such work immediately, IITH may do or cause such work to be done as IITH may determine is necessary in order to prevent damage to the Site of the STP. In such event IITH shall, as soon as practicable after the occurrence of any such emergency, notify the Contractor in writing of such emergency, the work done and the reasons therefore. by IITH is work that the Contractor was liable to do at its own expense under the Contract, the reasonable costs incurred by IITH in connection therewith shall be paid by the Contractor to IITH .

3.1.26 Tests and Inspection

- (i) The Contractor shall at its own expense carry out at the place of manufacture or on the Site all such tests and inspections of the Plant Equipment. The Contractor shall, in addition to those tests and inspections set out in the Contract, develop a plan for all testing and inspection of the equipment that is required in order to complete the STP in accordance with the Technical Specifications and as required by the Institute.
- (ii) The Engineer-in-Charge or his designated representatives shall be entitled to attend any test or inspection. The contractor shall make travel arrangements by approved mode of transport to the representatives of the IITH to attend inspection tests. Reimbursement of the expenses incurred on such travel arrangements shall be claimed in the running account bills of work.
- (iii) Whenever the Contractor is ready to carry out any test or inspection, the Contractor shall give a reasonable advance notice of such test or inspection and of the place and time thereof to IITH . The Contractor shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Engineer-in-Charge or his designated representatives to attend the test or inspection.
- (iv) The Contractor shall provide IITH with a certified report of the results of tests or inspection carried out on plant and equipment.

- (v) If IITH , or their designated representatives, fails to attend the test or inspection, or if it is agreed between the Parties that such persons shall not do so, then the Contractor may proceed with the test or inspection in the absence of such persons, and shall provide IITH with a certified report of the results thereof.
- (vi) If any Plant and Equipment or any part of the STP fails to pass any test or inspection, the Contractor shall either rectify or replace such Plant and Equipment or part of the STP and shall repeat the test or inspection upon giving a notice the Engineer-in-Charge.
- (vii) The Contractor shall give IITH access at any reasonable time to any part of the STP or any place where the Plant and Equipment are being manufactured or installed in the STP, in order to inspect the progress of the work and the manner of manufacture or installation.
- (viii) The Contractor agrees that neither the execution of a test or inspection of Plant and Equipment or any part of the Site and the STP , nor the attendance by IITH , nor the issue of any test certificate shall release the Contractor from any other responsibilities under the Contract.
- (ix) No part of the plant or foundations shall be covered up on the Site without the Contractor carrying out any test or inspection required under the Contract. The Contractor shall give a reasonable notice to IITH whenever any such part of the plant or foundations is ready or about to be ready for test or inspection; such test or inspection and notice thereof shall be subject to the requirements of the Contract.

3.1.27 Start-Up and Commissioning

- Flushing and disinfection of all piping and tanks (including process equipment tanks) and verification of removal of all residual debris from construction.
- Alignment required materials for rotating equipment
- MEG testing of all field motor power wiring (as required);
- Continuity checks for all electrical field wiring per Installation Checklist.
- Hydro-testing of all field installed piping
- Supply raw materials, oils/lubricants chemicals and utilities during start-up and operation.
- Operating and maintenance personnel during equipment checkout, start-up and operation.

- Process or biological start up and commissioning of the plant shall be completed by the contractor prior to membrane equipment start up.
- Commissioning plan shall include at least 10 hours of site safety training to all stakeholders.

3.1.28 Tests on Commissioning

- (i) The Performance Tests on Commissioning as set out in in the Contract and repeats thereof, shall be conducted by the Contractor during Commissioning of the STP and all allied works to ascertain whether the STP or the relevant part can attain the technical standards as required in the contract. The Contractors, Technology Providers and IITHs representatives shall attend the Tests on Commissioning, and shall advise and assist IITH . IITH shall promptly provide the Contractor with such information as the Contractor may reasonably require in relation to the conduct and results of the Tests on Commissioning, and any repeats thereof.
- (ii) Performance test is carried out for 72 hours / 3 days continuous operating run without intervention. During this period analysis of influent and effluent shall be performed by the Contractor. The field/laboratory tests carried out during the performance tests shall be witnessed by representatives of all stakeholders and documented within thirty (30) days of completion of commissioning of the system, the Contractor and Technology Provider shall start-up the Equipment. Thereafter, the Contractor shall maintain continuous and stable operation of the system until end of operation and maintenance services period of three years under this contract has been discharged.
- (iii) The Performance Test shall be conducted by the Contractor in accordance standard techniques and operating procedures specified in the Operating and Maintenance Manual approved by IITH. Compliance with the performance guarantee shall be demonstrated by successfully completing a three (3) day performance test. 24-h-composite samples of raw waste water and permeate shall be collected and analyzed each day during the performance test period. Compliance with the performance guarantee shall be determined by computing the arithmetic average of the effluent concentrations over the three (3) day period. If the calculated averages meet or surpass the guaranteed effluent parameters , the test is deemed successful.
- (iv) On-line instrumentation provided and grab sample testing performed is included as indications of the performance of the plant and to assist in the proper operation and control of the system. These results may include values beyond the stated

warranty values (during process upsets or if instrument poorly/not calibrated, etc.) and additional composite testing as above must be performed to establish that the plant is meeting performance requirements. All analytical work shall be carried out by the Contractor.

- (v) During the Performance Test, the MBR system operation should be according to the GE Operations Manual duly approved by IITH and the operating parameters specified in this section.
- (vi) In the event of an interruption during the Performance Test due to any of the following events, the test shall be extended by the period of the interruption plus the time required to re-attain operating conditions in effect at the time of the interruption and data recorded during that period shall not be included:
 - a. Power interruption in excess of sixty (60) minutes per day.
 - b. Mechanical failure of the system.
 - c. Any influent or operating parameter outside the accepted operating ranges defined in this section.
- (vii) If, after the system has been operated pursuant to the conditions herein above set forth, it becomes reasonably apparent, based on the results obtained at the completion of the Performance Test, that the system performance is short of the guaranteed performance, then additional Performance Tests of the system shall be conducted by the Contractor/Technology Provider. In such event, Contractor/Technology Provider shall be responsible to undertake all necessary reasonable corrective measures in an effort to bring the system up to the guaranteed performance levels.

3.1.29 Review of Works and Monthly Progress Report (Part-A)

- (i) The Contractor shall submit to IITH after the end of each month three copies, each signed by the Contractors Representative , a notice (the Monthly Progress Report) in such form as IITH may from time to time prescribe, showing the percentage of completion that the Contractor considers it has effected in the preceding month, in respect of the DSITC Works.
- (ii) The Contractor shall prepare monthly progress reports of the DSITC Works during the execution Period and submit hard and soft copies of the reports to IITH before 7th of succeeding calendar month.
- (iii) The DSITC Works monthly reports shall include the following information:

- photographs and detailed descriptions of progress, including each stage of design, procurement, manufacture, delivery to the STP site, erection, testing and commissioning;
- charts showing the status of DSITC Documents, purchase orders, manufacture and construction;
- for the manufacture of each main item, equipment, machinery, floor or component of the STP , the name of manufacturer, manufacture location, percentage progress, and the actual or expected dates of commencement of manufacture, Contractors inspections, tests and delivery relating thereto;
- detailed records of the Contractors Personnel and Contractors Equipment (Design-Build) on the STP site and the actual usage of the Contractors Equipment (Design- Build) during the reporting period and the tasks performed by the Contractors Personnel;
- copies of quality assurance documents, test results and certificates of the Plant and equipment;
- all monitoring results;
- safety statistics, including details of any hazardous incidents and activities relating to environmental aspects and public relations;
- percentage completion achieved compared with the planned percentage completion for each activity; and
- where any activity is behind in the scheduled completion, comments and likely consequences and a description of the corrective action being taken.

(iv) site co-ordination meeting of all stakeholders shall be held every fortnight to review the progress of the work and plan for future course of action. From contractors side, their Management Representative shall attend the such meetings.

3.1.30 Issue of Completion Certificate for Part-A of Contract

- (i) The Part-A component of the work is deemed to be completed only after issue of completion certificate by the Engineer-in-Charge upon successful completion of the commissioning of the plant .The commissioning is deemed to be successful only upon achieving the desired quality of effluent during the Performance Test.
- (ii) As soon as the commissioning of plant, in the opinion of the Contractor, been completed in accordance with the Specified Technical Standards, has satisfactorily passed all Tests on Completion , the Contractor shall so notify IITH in writing (the Notice of Completion of Part-A) and provide the as-built Design-Build Documents.

- (iii) Before notifying the IIT Hyderabad about the completion of Part-A, the Contractor shall complete all outstanding minor items so that the STP site are fully in accordance with the requirements of the Contract, failing which IITH shall undertake such completion and deduct the costs thereof from any monies owing to the Contractor
- (iv) IITH shall, no later than 30 days after receipt of the Contractors notice either issue a Completion Certificate stating that the STP has reached Completion as of the date of the Contractors notice of completion or notify the Contractor in writing of any defects or deficiencies or both.
- (v) If IITH is not satisfied that the DSITC Works are complete, IITH shall notify the Contractor in writing of any defects or deficiencies no later than 7 days after receipt of the Notice of Completion.
- (vi) If IITH notifies the Contractor of any defects or deficiencies or both, the Contractor shall then correct such defects or deficiencies, and shall repeat the procedure (5) If IITH is satisfied that the DSITC Works have reached Completion, IITH shall, no later than 7 days after receipt of the Contractors repeated Notice of Completion, issue a Completion Certificate stating that the DSITC Works have reached Completion as of the date of the Contractors repeated Notice of Completion.

3.1.31 Key Staff to be deployed at site

Minimum Staff to be deployed at site by the Contractor during the DSITC execution period.

Table 3.4: Key Technical Staff

S.No	Staff	No	Minimum Qualifications
1	Project Engineer	1	Graduate in Electrical/ Mechanical Engineering with not less than 10 years experience in construction of Sewage Treatment Plant.
2	E & M Engineer	1	Graduate Engineer (Electrical or Mechanical engineering) with not less than ten years experience in construction of similar engineering works

CVs of key staff shall be submitted along with the bid and shall be subject to approval of IITH . During execution period, if any staff is to be replaced by the Contractor, suitable CV shall be submitted against the Key persons and to be got approved by IITH.

3.2 Special Conditions of Contract(SCC)-Part:B

3.2.1 Introduction

The contractor shall ensure the Operation and Maintenance of the Sewage Treatment Plant (STP) in compliance to the guidelines contained in the latest edition of of the Manual on Sewerage Sewage Treatment Systems Part-B, Operations and Maintenance, published by the Central Public Health Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, Government of India, New Delhi. Notwithstanding anything contained in the said manual, conditions laid down here under in the foregoing sections shall also apply.

3.3 Effective date of commencement of Part B

The effective date of commencement of Part B of the contract shall be reckoned from the next day of declaration of completion of Part A of the contract by the Engineer-in-Charge. The Contractor shall be prepared to take up the maintenance activities from this day onwards.

3.4 Scope of Operation and Maintenance Services

After the trial run and commissioning of the plant, the Contractor shall operate and maintain the Sewage Treatment Plant under this contract for a total period of three (3) years .The break-up of this three year period is given here-under:

- A) For first two (2) years w.e.f commencement of the defect liability period of STP
- B) For next one (1) year w.e.f completion of defect liability period of STP

Part-B component of contract shall be executed complying the following conditions :

1. After Commissioning of STP, during the first Two(2) years of the O M period running concurrently with defects liability period (DLP), the Contractor shall operate and maintain the plant as per approved OM Manual and maintain the quality of the treated effluent as prescribed in the contract document.
2. After completion of DLP of STP, the Contractor shall Operate and maintain the sewage treatment plant, all instruments and mechanical, electrical equipment in accordance with the quantity and quality parameters specified in DSITC Works for a further period of One year as stated above. At the discretion of the Institute, the contractor shall provide the O&M services for further three months period beyond the three years at the same quoted rates applicable for the third year.The plant equipment covered under the above contract shall be totally attended to, by the Contractor

including any Troubleshooting to ensure smooth and trouble free operation.

3. The Equipment is operated and maintained at all times in accordance with the Operations and Maintenance manual duly approved by IITH issued to the contractor after plant commissioning.
4. The plant is operated within the mixed liquor characteristics defined in the contract
5. The Contractor shall monitor the performance of the sewage treatment plant; conduct the analysis of the inlet sewage and effluent quality after treatment. Contractor shall initiate and take adequate actions to ensure smooth and satisfactory performance / running of the plant.
6. The Contractor shall prepare and implement an effective plant maintenance programme in consultation with IITH. It is an absolutely Contractors responsibility to look after all sorts of maintenance whether preventive, Minor, Major, or break-down.
7. The Contractor shall determine operating parameters, select settling (Chemical doses etc.) and generally optimize the process, and working of the treatment plant meeting the required quality parameters.
8. The Contractor should plan & procure all spares, Polyelectrolyte and all consumables including chemicals, grease, lubricating oil, cleaning agents, laboratory reagents etc.
9. The Contractor shall be responsible for keeping up-to-date record of documents including History Card for equipment and maintaining every day log book relating to various analyses performed.
10. The Contractor shall maintain and update logbook, in which details of operational parameters are recorded every day and at regular interval say hourly or as decided mutually.
11. The Contractor shall prepare and submit a weekly report of plant performance records.
12. The Contractor shall be responsible to carry out day to day periodic maintenance, necessary to ensure to smooth and efficient performance / running of all equipment / instruments comprising the sewage treatment plant and maintaining the record of the same.
13. The Contractor shall have to issue identity cards with photographs to all the staff employed for Operation and Maintenance. The list of the same shall be submitted to IITH mentioning qualification & experience.

14. The Contractor shall employ staff for operation and maintenance of the Plant as per the minimum specified here-in for entire duration of O& M Services period of Three (3) years.
15. The above staff shall be distributed in three shifts and at no point of time the plant shall remain unattended. As per agreement the number of staff in each shift should always remain present otherwise penalty towards absence of any staff shall be recovered from the Contractor. The Contractor shall make the arrangement of reliever for weekly-off/holiday etc. Absence on any ground like weekly off or holiday shall not be considered. The presence of staff in each shift should be marked in muster (muster shall be in electronic form by use of biometric machines logged to the computer system installed in the plant) to be maintained at office of shift-in-charge at Sewage Treatment Plant that shall be considered as final. The Contractors staff must mark their presence in this muster. The Contractor may maintain a separate register for his own purpose. Copy of muster shall be enclosed with every monthly bill.
16. The staff of Contractor shall always remain in contact with the Engineer-in-Charge or his authorized representative deployed by IITH and follow their instruction.
17. Unsatisfactory and inefficient running of the plant and unnecessary and excessive usage of spare, consumable, etc. supported by the reasons which are under control of Contractor shall be highly objected. In such cases IITH s decision shall be final and binding to the Contractor.
18. It is required that at least once in every one month a technical expert of contractor other than the Staff of the Contractor shall visit and audit the functionality of the plant and systems and shall suggest, if required, to improve the efficiency and working of the plant etc. No separate payment shall be made for such visits. The visit must be recorded and outcome of the visit/minutes of the meeting should be got signed by IITH authorities without which the visit shall not be considered.
19. In addition to the contractors technical expert visit, the contractor shall arrange a visit to the plant by representative of Technology Provider (GE) once in every six months. The Technology Provider shall study the functioning of the plant, conduct tests on in-coming sewage and treated sewage, compare the results with the specified parameters of effluent. The Technology Provider shall submit the inspection report commenting on the state of affairs of the plant, maintenance and up-keep of equipment, house-keeping, safety and environmental issues including the test

results. The report shall also include suggestions for the reasons and corrective actions needed if the test results are not satisfactory and improvement of systems, in general.

20. Compliance on the issues mentioned in the inspection report of Technology Provider shall invariably be furnished by the contractor to the Engineer-in-Charge within one month of date of issue of inspection report. Documentary evidence shall be furnished along with compliance report substantiating the corrective action taken and the subsequent test results meeting the requirements of contract.
21. The first inspection of plant by Technology provider shall be carried out within the first six months (preferably at the end of first three months) of O& M period and subsequent visits shall be planned once in every three months until completion of total three years O& M period.
22. All expenses for arranging visits of Technology Provider shall be borne by the Contractor and hence the contract price for O& M Services are deemed to be inclusive of the same. Nothing extra shall be paid by IITH on this account. In case, the visit of Technology Provider is not arranged by the contractor within fifteen(15) days from the due date of visit, IITH shall arrange such visit by the Technology Provider at the risk and cost of the Contractor. All expenses incurred by IITH towards arranging the visit of Technology Provider for inspection of plant will be recovered from the ensuing bill of the contractor in addition to a penalty amount of Rs 10,000.00 for every such default on part of contractor.
23. Contractor shall comply with all safety rules and regulations mentioned in O& M manual. IITH shall not be responsible for any accident /injury to the staff of the Contractor. Further the IITH shall not provide any insurance or medical facility to the staff of Contractor. The responsibility lies with the Contractor.
24. All Central/State Government / Semi-Government / Local Bodies Rules and Regulations pertaining to this contract shall be followed and observed by the Contractor without any extra cost to IITH.
25. No accommodation / guesthouse / transportation facility shall be provided by IITH to the Contractor or his representatives. Operation & maintenance staff shall not be given any accommodation facility inside the plant (IITH) premises.
26. The Contractor should employ all the staff within seven days of successful commissioning of plant.

27. The Contractor shall provide the necessary tools and tackles required for day-to-day maintenance during O& M period.
28. The scope of work also includes up-keep of complete plant area premises, including floor, toilet block, railing, door, windows, light fixtures and ceiling etc. The entire premises of the plant area shall also be cleaned and maintain by the Contractor regularly.
29. The work shall be done as per specified standard practices and by following labour, factory, electrical, TSPCB and all statutory rules and regulations as applied of Local, State and Central Government of India etc. .
30. Right is reserved by IITH for suspension, dismissal, termination of any staff employed by Contractor who are found to be indulging in unlawful, unethical activities.
31. Monitoring of proper functioning of plant shall be done as per approved O& M manual. Contractor has to maintain all quality parameters of effluent within stipulated limit or he shall be penalized for not maintaining the parameters specified in the contract. All expenditure incurred for the same like, suit fee, court fee, case fee, or the penalty as decided by Engineer-in-Charge and penalty charged by TSPCB or any other statutory body shall be charged to Contractor and deducted from his security deposit, bills, etc.
32. Contractor shall have to test the effluent / influent at his own cost at the plant laboratory on daily basis. The same will be verified by and checked by IITH whenever required.
33. No equipment shall remain ideal or un-attended or damaged for the period of 3 days. If any equipment is not repaired, rectified and or replaced within 3 days, the Contractor shall be penalized with no limit at the rate of Rs. 2000/- per day delay per each individual equipment of the plant. In case, the contractors fails to attend the faults within 3 days, the same shall be attended by IITH at the risk and cost of the contractor
34. During Operation & Maintenance period, Contractor has to supply all the spares, at his cost during preventive, major-minor breakdown, replacement and maintenance work. No extra payment shall be made for such maintenance on any ground. No separate payment for the same shall be made by the IITH irrespective of the number of such break down / minor, major repairs replacements. **After completion of DLP of two years, the Contractor may enter into annual maintenance agreement**

(AMC) with concerned original equipment manufacturers (OEM) for equipment of plant so that the plant is operated trouble free.

35. Copies of such AMC agreements may be submitted to IITH for record. The AMC may be renewed every year before due date. At the time of handing over of the plant to IITH after the end of O& M period, all equipment of plant shall be in good working condition.
36. Operation and maintenance of PLC based automation system and all instruments installed in the STP shall be the responsibility of the Contractor. All repairs, replacements towards the entire instrumentation works during the O& M period shall be in the scope of Contractor.
37. The Contractor shall also dispose off the sludge, screenings, grit and any other material to the satisfaction of IITH at his own cost .However, IITH shall have full rights on the dried sludge for using for its internal purposes.
38. At the time of handing over of the plant on completion of O&M period, the contractor shall handover all records pertaining to the plant like Operating Manuals, Warranty Certificates, AMC copies, registers of Tests/flow particulars, charts, third party reports etc. to IITH.
39. **output and Operational Guarantees:** The Contractor is fully responsible for treating all the Sewage reaching at the Common Collection Sump. The performance of the Contractor shall be treated as unsatisfactory if he fails to treat the complete sewage or does not maintain the guarantees mentioned in the contract excepting in force majeure condition or fails to fulfill other conditions of the contract.
40. **Treated Effluent Quality:** The Contractor shall operate the Sewage Treatment Plant in such a way that the treated effluent quality attains parameters as prescribed in this contract document.
41. The scope of O&M Services includes softening of the treated sewage water after the process of Ultra filtration of MBR. The quantity of effluent to be softened per day shall be a minimum of 2,50,000 litres. The hardness of the softened water shall be less than 50 mg/l. The softened water shall be made available in the soft water tank. All equipment, consumables required for softening of the effluent shall be borne by the contractor and nothing extra shall be payable on this count. IITH will utilize this soft water for make-up water of HVAC system.

42. **Chemical Requirements:** All chemicals and other consumables consumed to operate the Sewage Treatment Plant and other facilities under this contract shall be borne by the Contractor.
43. **Adverse Operating Condition:** During which the raw sewage quality deteriorates beyond the Specifications contained in contract, the following provisions shall be applicable:
- a) If the raw sewage can still be treated to meet the Output Standards, the Contractor shall comply with such specifications.
 - b) In the event it is not possible to meet the Output Standards, the Contractor shall immediately inform IITH and take all corrective measures at his own cost and risk to ensure that the prescribed output standards are achieved.
44. **Test to be carried during O & M period:** Sampling and testing to be carried out for the parameters given below: This schedule shall also be maintained during the O&M period. Sampling shall be done in accordance with BIS 3025.
- (i) Inlet chamber at sewage treatment plant for flow, BOD, pH, suspended solids(SS), temperature, COD , oil & grease, TDS ; Outlet of the sedimentation units for BOD, suspended solids, pH, COD and oil grease, TDS.
 - (ii) Inlet of the reactor unit for MLSS, Dissolved Oxygen pH.
 - (iii) Outlet of the reactor unit for Dissolved Oxygen, Sludge volume Index pH.
 - (iv) Outlet of the secondary treatment units for BOD, Suspended solids, pH, COD and oil grease
 - (v) Outlet of the chlorination units for BOD, Suspended solids, pH
 - (vi) Excess sludge for Volatile suspended solids, total solids, specific gravity
 - (vii) Various parameters to be tested by online monitoring system at these locations as per specific requirements of Instrumentation.
 - (viii) Residual Free Chlorine after Chlorination.
 - (ix) Hardness of softened water
 - (x) Total Coliform
45. The Contractor shall get analysed the untreated as well as treated sewage samples once in every three months from TSPCB or any other lab approved by the Engineer-in-Charge for all parameters mentioned in Table 3.1 and Table 3.3 specifying the characteristics of treated sewage. The necessary lab testing charges will be reimbursed by the Institute on actuals. The TSPCB Vigilance testing charges for samples

directly collected by TSPCB are also reimbursable to the Contractor. The Contractor shall ensure adherence to standard protocols of collection and storage of samples.

3.4.1 Calibration of Instruments

All the measuring instruments and other devices shall be calibrated regularly as mentioned below:

- (i) The instruments and devices shall be calibrated by the plant Manager or any authorized specialized staff of the Contractor once in every two months.
- (ii) All such instruments shall be calibrated once in every twelve months by approved third party specialized agency.
- (iii) Immediately after calibration, the results/ reports shall be submitted to IITH. (iv) First calibration by approved third party specialized agency shall be done after twelve months of commencement of O& M period.

3.4.2 Contractors staff during OM period

(i) **Key Staff:**

The minimum key staff required for O & M Services shall be as given below. Non-deployment of the personnel during O&M as per the contract shall lead to imposition of penalty as mentioned in Contract.

(a) One Electro-Mechanical Engineer (Plant Engineer)

Degree in Mechanical or Electrical Engineering from a recognized university/ Institute with minimum 10 years experience in Operating /Maintaining any STP.

(b) Plant Operator: One per each shift

with minimum 7 years experience in managing STP

CVs of key staff shall be submitted at the commencement of of O & M period and shall be subject to approval of IITH.

- (ii) **Non Key Staff :** The contractor must deploy adequate number of non -key staff comprising of operators, skilled technicians, semiskilled and unskilled labourers to discharge the contractual liabilities of operation and maintenance and other essential activities of upkeep of the plant.
- (iii) Institute shall monitor the presence and availability of such key and non-key staff. As specified elsewhere in the contract document, the contractor shall maintain the attendance in biometric form for all the staff so deployed.
- (iv) No labour below the age to 18 years shall be employed on the work. List of staff is to be given by the contractor to IITH and advance intimation to be given before

deputing/removing any staff from site during the period of contract. Not more than one of the Contractor's key staff shall be absent from the Plant premises at any given time. In case it is necessary for more than one of the key personnel to be absent at a given time, the Contractor shall provide replacement of equivalent or better qualifications. The CVs of such key staff replacements shall be got approved from IITH in advance.

- (v) Engineer-in-Charge shall be empowered to direct the Contractor to remove any or all staff employed on OM of the plant if in his opinion continued presence of such staff is detrimental to safety or proper OM of the plant. Whenever the Engineer-in-Charge informs the Contractor in writing that any person on the work is in his opinion unsatisfactory or/incompetent or unfaithful or dishonest, untruthful or disorderly or to be otherwise unsuitable, such person shall be discharged by the Contractor from the work and shall not be employed again on it. The Contractor shall comply with such directions and immediately deploy suitable substitute(s) thereof.

3.4.3 Safety and Security

The Contractor shall take all safety precautions under various Acts/Rules under central/State Govt. from time to time and he shall be responsible for safety of its staff and the consequences thereof. IITH shall deploy round the clock security personnel at entrance of plants premises. The Contractor shall be responsible for the safety of the plant, equipment and personnel during O&M period.

3.4.4 Responsibility for damages

(a) Safety of the whole of the plant shall remain with the Contractor who shall be responsible for all accidents or damages from whatever cause arising and chargeable for anything that may be stolen, removed, destroyed or damaged to whomsoever belonging and also for making good all defects and damages to the said works or to any property adjoining or any cause whatever, whether such damage or defects were occasioned by the negligence of the Contractor or not or may be or might have been discovered during the progress to be known after the completion whereof or whether payment may wholly or partially have been made or the works approved as supposed to have been properly done and no certificate of approval of any works by any statutory bodies shall affect or prejudice the right of IITH against the Contractor or be considered or held as at all conclusive as to the sufficiency of any work materials.

(b) Adequate safety precautions against fire, flooding, lightening, electrical shocks, accident due to moving/non-moving heavy/light equipment shall be strictly taken up by the

Contractor at his own cost. Suitable safety measures like gumboots, gloves, safety belts, ladders, safety lamps, gas masks, Oxygen apparatus, insulated tools, alarms etc. shall be provided by the Contractor. Necessary medical first aid kit shall be made available all the time. In absence of observance of above safety precautions, the Contractor shall be responsible for any unforeseen loss of the equipment or persons dealing with it. Special care shall be taken by the Contractor while carrying out the work in sewage gas zone. Any incidence of human life or accident shall be totally Contractor's responsibility.

(c) The Contractor shall ensure that the staff employed are adequately skilled and trained and takes all necessary precautions while carrying out the work as per Indian Electricity Rules/Factory Act/CPHEEO Manual/Approved Operation Manual or manufacturer's special instruction for safety / gas handling. The staff should use all protective and safety equipment which should be provided by the contractor during operations.

(d) In the event of any accident on or off site, in which the Contractor or his personnel are involved, in which an injury occurs to any person whether directly concerned with the project or a third party, the Contractor shall inform IITH within 24 hours of the occurrence of the event. The plant shall be open to local/state/central agencies for verification of safety/emission/acts compliance.

(e) During night hours, the main gate should be locked. However, shift duty staff should be alert and open the gate during surprise checking of IITH staff or any other Government Authorities or his nominee without any wait. Only bona-fide persons shall be allowed in the plant premises being a prohibited area. Smoking and drinking liquor are prohibited in the plant. The staff engaged shall wear common uniform with name plate indicating name and designation during duty hours.

(f) All staff of the contractor deployed on the plant for OM shall carry valid identity cards issued by Contractor and duly counter-signed by Engineer-in-Charge.

3.4.5 Reporting

The Contractor shall prepare daily and monthly reports (in approved formats) of pumping/treatment and project performance and submit to IITH and shall assist IITH in preparing the necessary documents for their purpose and record as per Performa given from time to time. The reports shall contain the following:

- Raw Sewage quantity, quality and effluent quality as per the on-line monitoring programme and other tests as specified in this section and print outs of online monitoring shall be submitted to Engineer-in-Charge.
- A description of the maintenance work carried out in the reporting period. A report on major failures, if any, their causes and remedial actions taken.

- Sludge quality and quantity (daily basis) in the reporting period.
- Power and chemicals consumed in the reporting period.
- An inventory of the chemicals and spare parts available at the end of the reporting period.
- O&M staff deployed by the Contractor during the reporting period.
- Major repair works carried out, if any
- . Near misses and other accidents happened during period under report.

3.4.6 Record Keeping

Contractor is required to maintain separate register as well as computerized records at STP of following information:

- Pumping register
- Quantity of sewage treatment and performance register
- Working hours register
- Electricity break down register
- Maintenance register
- Staff attendance register in the form of computer generated log sheets of biometric attendance.
- Monthly Electricity consumption register
- AMC with OEM register
- Equipment breakdown, repair record and extent of repair
- Chlorination equipment and chlorine toner operating and using register
- Soft water quantity register
- Any other registers/ records as may be required by the Engineer-in-Charge.
- In addition to the above, the contractor shall also submit two sets of asset registers containing details of:

all major electro-mechanical equipment ,instrumentation like various operating machines such as Manual and Mechanical Screens, Mechanical Grit Removers, Pumps,

Motors, Scrapers, Air Blowers, Centrifuge , all equipment related to PLC and Automation, etc. . The information shall include the make, model number, serial number, book value, warranty, particulars of OEM etc.,

One set of the assets register shall be kept in the control room and maintained by the Plant Engineer.

- Records of effluent quality and other laboratory tests are kept in the laboratory as per testing schedules.
- The record with respect to flow shall be maintained by Contractors as per Table below. The concerned staff passes the daily log sheet to the plant Manager on the subsequent day duly signed. The plant Manager shall verify the daily record as well as the calculations and shall be responsible to generate further data using these.

Table 3.5: Hourly Record of Flow

Date/Time	Head Over Notch /Weir / Meter	Rate of Flow	Average Rate of Flow in past Hour	Flow Quantity
0600				
0700				
0800				
0900				
-				
-				
1400				
1500				
1600				
-				
-				
0000				
0100				
-				
-				

3.4.7 Site Order Book

A Site order Book shall be kept by the Engineer -in-charge at the plant site. Orders entered in this Book by the Engineer-in-Charge or his authorized representative shall be held to have been formally communicated to the Contractor. The Engineer-in- Charge or his authorized representative shall sign each order as it is entered and shall hand over the duplicate to the Contractor or his staff, who shall sign the original in acknowledgment of having received the order.

3.4.8 Operations

(a) In case, the motor or any other equipment is burnt or damaged due to negligence of the Contractor or due to faulty operation it shall be sole responsibility of the Contractor

to rewind/replace/repair it as per standards of the equipment free of cost. In case of any fault in operation and performance of the plant, Contractor or his staff at duty shall immediately report to IITH about it.

(b) The Contractor shall run the plant after ensuring proper voltage. He shall also record all the power failures and voltage, current, power, KWH in daily log sheet. He shall bring it to the notice of Engineer-in-Charge about the breakdown/power failure. He shall also get the electricity restored simultaneously.

(c) Any dispute with the workmen shall be Contractors responsibility as per Labour Laws/Govt. Rules and Regulations. In no way IITH shall be responsible for the disputes between them. The Contractor shall follow the rules and regulations as per rules of the Government and applicable laws.

(d) The Contractor shall arrange all necessary required tools, tackles and instruments in advance for proper operation and maintenance of the entire plant. The Contractor shall operate and maintain all (E&M) equipment as per the recommendations of the respective equipment manufacturer. He shall further maintain and operate the plant, as per CPHEEO manual to obtain the treated effluent results as per approved norms specified in this document elsewhere.

(e) The floating material/scum,if any, should be collected in bins and dispose the same in open pits away from the plant & machinery which should be dried and disposed off regularly at a location outside the plant and approved by statutory authority. During rainy season, this should be buried after using lime.

(f) The screened material, grit and the dried sludge cake from the centrifuge should be collected in tractor or by appropriate means and the same shall be disposed off at site /yard within the battery limits ,away from the plant.The screened material, grit and any other non-useful material so collected and accumulated over a period of time shall be removed at regular intervals from the STP and IITH premises by transporting the same using mechanical means to approved municipal dumping ground.

3.4.9 Maintenance

1. The work shall be carried out and completed under the exclusive control direction and supervision and to the satisfaction of Engineer-in-Charge. Engineer-in-Charge shall likewise have full power to reject or condemn any work or material that he may deem unsuitable. In case of any work or material being rejected by the Engineer in-charge, the Contractor shall immediately remove and replace the same to the satisfaction of Engineer-in-Charge or Engineer-in-Charge shall have full powers to get the same removed and replaced and deduct the expenditure incurred in the

process from any amount due or that may become due to the Contractor.

2. The Contractor shall use only the original and genuine spares of the original equipment as per recommendations given in the maintenance booklet of the manufactures/as per directions of Engineer-in-Charge . Adequate stock of such spares is to be maintained by the Contractor. Test certificate of manufacturer is required for bearings along with supplies. Test certificate of all major equipment shall be submitted from the manufacturer.
3. If any material brought to the site , be in the judgment of the Engineer-in-Charge, found inferior or improper & not as per described standards, the said materials or workmanship shall, where required by Engineer-in-Charge, shall be removed or amended by the Contractor forthwith.
4. The Engineer-in-Charge is authorized to remove or cause to be removed the materials and workmanship so objected to or any part thereof and replace the same with such other materials and workmanship as shall be satisfactory to him and there upon the Contractor shall on demand repay to IITH the expenses incurred there by or to which the IITH may be put or be liable in connection therewith, the amount thereof to be certified by the Engineer-in-Charge whose certificate shall be final.
5. The Contractor shall also be responsible to maintain cleanliness in around the plant including electro-mechanical equipment, disposal of floating amterial removed from the bar screens etc., Grit and other unwanted material and keep the premises in a tidy condition. The terraces of the STP building shall be always kept free of debris, junk, waste material, vegetation etc.
6. All leakages should be attended promptly to avoid unhygienic conditions, deterioration of plant and building. Chokages of Electro-Mechanical equipment, sewer lines of STP building, rain water pipes, storm water drains should be removed at once. All the valves/gates which are not used regularly should be operated at least once a week and make sure that they are properly lubricated /greased.
7. All safety valves should be checked daily and ensure that they are working properly. In case of any fault the same should be attended immediately without any wait. The maintenance of the plant shall be as per maintenance manuals of the manufacturer for all equipments. Contractor shall keep all the safety devices in working order.
8. The Contractor should make sure that no unwanted material should float/grow in and around different units. In case it is found the same shall be removed /cleaned

immediately. He shall also be responsible for cleaning/sweeping the plant buildings inside and outside, roads, foot path etc.

9. Weirs of reactors etc shall be maintained clean round the clock. During preventive/ breakdown maintenance, the Contractor shall visit the unit/units as and when needed. The pumping units or any other machinery required ,if any, shall be arranged by the Contractor at his own cost for completing the preventive maintenance work. In case of battery operated auto system panels, system alarm etc., batteries are required to be maintained and replaced as and when needed by the Contractor.
10. The Contractor shall provide necessary protection systems wherever necessary including alarms. Cautionary Sign boards shall be placed at appropriate locations
11. The Contractor shall maintain the Supervision Control and Data Acquisition System (SCADA) in working condition for the 3 years of O & M period. The Contractor shall not remove/shift any equipment/machinery even temporarily without written permission of Engineer-in-Charge.
12. POL (Petrol/Diesel Oil & Lubricants) has to be arranged by the Contractor as and when needed as per manufactures recommendations for periodical maintenance of entire plant. IITH shall not provide such items.
13. The Contractor shall have to carry out periodical testing of the installations/equipment as per CPHEEO manual and Indian Electricity Rules as amended up to date and shall have to maintain complete record in the maintenance register.
14. IITH shall be at liberty to post its staff for surveillance/ inspection at the plant with access to all units, control room and records, log books, MIS (Management Information system), data etc. round the clock as required. The logbooks will be attested by the authorized IITH Officials and this record shall be open for further inspection/checking by IITH and all other Government Agencies CPCB/TSPCB etc. for further action/improvements/rectifications.
15. In case of major repair due to normal wear and tear/break down, the Contractor should bring the same to the notice of IITH immediately and necessary measures for its repair/replacement should be taken simultaneously. Breakdown, all repairs of any kind are to be attended by the Contractor. Any unit/equipment being irreparable in the opinion of IITH shall be replaced by the Contractor at no cost to IITH .
16. The Contractor shall give his telephone no., contact addresses, etc. to Engineer-in-Charge as well as shift duty shift staff to contact him/them during emergency/odd

hours etc. The mobile number of the authorized representative of the contractor and that of plant manager shall be displayed on notice board placed at a prominent location in the STP building.

17. The contractor shall arrange a white notice board in the control room of STP and all details like sewage volume handled/treated , treated water volume, test results etc, shall be displayed on daily basis.
18. The contractor shall display in the control room a schematic flow diagram and the layout of the plant and equipment.

3.4.10 Routine, Preventive, Minor & Major maintenance

Routine, Preventive, Minor & Major maintenance of all Electrical, Mechanical, hydraulic machines & Equipment of the plant as listed below shall be the responsibility of the contractor.

- (i) Routine & preventive maintenance of electrical /Mechanical/ hydraulic/ machines equipment is to be carried out as per the approved operation & maintenance manual. Minimum oil & grease requirement for one year Operation & maintenance of the Plant to be procured by the Contractor well in advance.
- (ii) The Contractor should prepare schedule of daily maintenance preventive maintenance of all the equipment & machinery operated & run by him in the premises of the plant. The schedule should be as per the guidelines mentioned in the contract & as per the approved O & M manual. The scope covers Routine, Preventive, Minor & Major maintenance of all major minor equipments, and machines in the Plant like Submersible pumps, blowers, Coarse & Fine screens, Grit Removal Mechanism, Channel gates, Decanters, Sludge pumps, Centrifuge feed pumps, Centrifuges, hollow fibre membranes etc. All dosing systems including Chlorine Dosing equipment, etc.
- (iii) The scope also covers Routine, Preventive, Minor & Major maintenance of all the instrumentation system installed like PLC, Actuators, Flow meters level indicators etc. The Contractor should also carry out Routine, Preventive, Minor & Major maintenance of all major minor electrical equipment like Electrical Panels, Switch Gears, Power Cables, Control cables, Changeover switches etc. so as to ensure uninterrupted round the clock operation of the Plant.
- (iv) The Contractor should maintain all civil structures including office/ Store room, Storm water drains, fencing etc in a neat manner. He should maintain all civil structures of the plant sturdy to complete the natural/designed lifetime. The Contractor

should carry out the safety audit of the plant & necessary certificate from the competent authorities must be obtained .

- (v) The Contractor should procure and keep stock all the spares required for all types of maintenance in advance in sufficient quantity. The brand/make of the part/equipment/machine to be repaired /replaced should be as per IITH approved list & as per the approved O & M manual or as per the existing manufacturers brand.

3.4.11 Release of Hazardous Substances or waste, if any

(a) The Contractor, after first notifying the IITH/TSPCB shall be responsible for fulfilling all requirements associated with any release of any substance into the environment as required by Applicable law or by any Legal Entitlement including but not limit to the notification or reporting of releases / Hazardous substances or Hazardous Waste. The Contractor shall prepare a memorandum evidence such notification or reporting and provide copies thereof to IITH , along with any documents provided to the relevant regulatory agency regarding such release.

(b) The Contractor shall assist IITH in the process of obtaining clearances of all such agencies as required for the purpose, including all clearances during O&M period. He shall be fully responsible to comply with all requirements of Laws including hazardous substances, emission standards for air, discharge standards for effluent oil, sub-soil pollution. The Contractor shall not release any hazardous/toxic materials inside the premises.

3.4.12 Technical Audit

Engineer-in-Charge has the right to conduct a technical audit of the plant and to perform any analysis or inspection he deems necessary. The Contractor shall at his cost provide all assistance IITH requires to complete these inspections. Such audits may cover all or any of the obligations of the Contractor, including without limitation:

(a) Verification of the system capacity with due allowance for normal wear and tear during the O&M Period.

(b) Verification of the performance standards and useful life of the individual assets of the Facility, with due allowance for normal wear and tear during the O&M Period.

(c) Verification of the capacity of the Facility to meet Output Standards during the residual life of the Facility with due allowance for normal deterioration expected during such residual life.

(d) Sampling, testing and verification of the Output Standards for treated sewage, sewage losses.

3.4.13 Inspection

(a) At any time or at the end of each twelve month period, or at the initiative of the TSPCB, a visit shall be organized so that both parties can check the condition of the installations at the facility.

(b) A report shall be drawn up to record the opinions of the both parties. IITH/TSPCB reserves the right to call the Technology Provider, equipment manufacturers or specialized technicians for these visits.

3.4.14 Taking Over of Plant after Completion of O & M Period

The plant shall be taken over by IITH on satisfactory completion of the Operation & Maintenance of the plant provided:

- (i) The plant /equipment are in good, smooth running condition. The results of the treated waste water quality for the preceding three months of operation of the plant are within the limits specified.
- (ii) In case of major repairs /replacement of equipment, the performance guarantee for such unit/equipment shall be extended by six months from the date of putting back in to satisfactory operation of such unit/equipment ,in case such putting back is within last three months of the end of completion of operation & maintenance period.
- (iii) All records of operation & maintenance are handed over to IITH in proper condition.
- (iv) In case taking over of the STP is delayed on account of Contractor's failure, the operation & maintenance period shall be extended further till he meets the requirement without any extra cost to IITH .

Chapter 4

Scope of Work and Services

4.1 Scope of Part-A of the Contract

- (i) Unless otherwise expressly limited in the Contract the Contractors obligations cover the provision of all Plant and Equipment , Installation Services required for the design, procurement, quality assurance, installation, associated civil works which are not explicitly excluded, trial run, commissioning and delivery of the Plant and Equipment and completion of the facilities in accordance with the plans, procedures, specifications, drawings, codes and any other documents as specified in the Contract including ,but are not limited to, the provision of supervision and engineering services, the supply of labour, materials, equipment, spare parts and accessories, Contractors tools & plants and other machinery; construction utilities and supplies, temporary materials, structures and facilities, transportation (including, without limitation, unloading and hauling to, from and at the Site) and storage.
- (ii) The Contractor shall, unless specifically excluded in the Contract, perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract as being required for fulfilling the contractual requirements as if such work and/or items and materials were expressly mentioned in the Contract.
- (iii) Indicative details of scope of the work for which bids are invited are as under :
- Civil Construction by IITH: IITH shall make available the following Civil structures required for execution of contract:
- Common collection sump
 - Equalization Tank
 - Anoxic Tank
 - Aeration Tank
 - Membrane Tank

- Treated water storage sump
- Pump room
- MCC and Panel room
- Store Room
- Through a network of sewer pipes already laid or by other means, the raw sewage will be made available by IITH in the common collection sump of the STP.

(iv) The DSITC Services under the Part-A of contract includes the following components of the work :

(a) Design of electro-mechanical, instrumentation, piping, automation components of the plant to meet the specified performance requirements (b) Supply, installation, testing and commissioning of electro-mechanical equipment/components including GE MBR membranes Supply, installation and commissioning of all instrumentation, piping ,automation and electrical works of plant (the scope of IITH is confined to construction of all tanks, office building with basic electrical services)

(c) Complete allied works like valve chambers, thrust blocks, anchor blocks, etc.,

(v) The OM services under the Part-B of contract includes Operation and Maintenance of the plant for 3 years from the date of commissioning.

4.1.1 Contractor's Responsibilities

The Contractor shall design, supply, install, test, commission and run the STP with due care and diligence in accordance with the Contract.

The Contractor confirms that he has entered into this Contract on the basis of a proper examination of the data relating to the site and facilities provided by the IITH, and on the basis of information that the Contractor could have obtained from a visual inspection of the Site and of other data readily available to him relating to the Facilities .The Contractor acknowledges that any failure to acquaint himself with all such data and information shall not relieve his responsibility for properly estimating the difficulty or cost of successful performance of the plant.

4.2 Details of Equipment

Indicative details of equipment which will be a part of Scope of Part-A of Contract: The table 4.1 shows the list of equipment for the proposed UF MBR System and the contractors scope of supply. The indicative quantity and capacity of these equipment shall be as mentioned in the Schedule of Contract Price of the bid document. The symbol "Y" in the

table indicates with whom (Contractor or IITH) the scope of the equipment/item lies. The list is only indicative. The Contractor shall provide any other equipment not mentioned in the table below, required for commissioning of the plant.

Table 4.1: Indicative details of equipment which will be a part of Scope of Part-A of Contract

Common Collection Sump and associated equipment	Scope of Contractor	Scope of IITH
RCC Common Collection Sump		Y
Coarse screen, 16 mm	Y	
C I Sluice Gates	Y	
Manual Fine screen, 6mm	Y	
Mechanical Fine screen, 6mm	Y	
Grit removal system	Y	
Oil and grease removal system	Y	
Drain valve for oil and grease	Y	
Level Switch	Y	
Coarse bubble diffusers (10 Nos, approx)	Y	

Equalization Tank and associated equipment	Scope of Contractor	Scope of IITH
RCC Equalization Tank		Y
Bioreactor Feed Pump	Y	
Discharge Check Valve	Y	
Pressure Gauge Isolation Valve	Y	
Pressure Gauge	Y	
Discharge Isolation Valve	Y	
Pump discharge to tank return Isolation Valve	Y	
Mechanical screen (2 mm punched hole Type)	Y	
Mechanical screen Isolation Valve	Y	
Flow Transmitter	Y	
Coarse bubble diffusers in equalization tank	Y	
Other piping, valves & other items as denoted in P&ID	Y	

Mixing Blowers and associated equipment for CCS, Equalization Tank and SH Tank

Mixing Blowers and associated equipment	Scope of Contractor	Scope of IITH
Inlet/Discharge, Filter-Silencers	Y	
Mixing, Blower with Acoustic hood	Y	
Pressure, Safety Valves (integral to blower package)	Y	
Discharge, Pressure Gauge c/w Isolation Valve	Y	
Discharge, Check Valves	Y	
Discharge, Isolation Valves	Y	
Other, piping, valves & other items as denoted in P&ID	Y	

Membrane Aeration Blowers and Associated Equipment

Membrane Aeration Blowers and associated equipment	Scope of Contractor	Scope of IITH
Inlet/Discharge Filter-Silencers	Y	
Mixing Blower with Acoustic hood	Y	
Pressure Safety Valves (integral to blower package)	Y	
Discharge Pressure Gauge c/w Isolation Valve	Y	
Discharge Check Valves	Y	
Discharge Isolation Valves	Y	
Blower Discharge Low Flow Switch	Y	
Other,piping, valves & other items as denoted in P&ID	Y	

Process Aeration Blowers and Associated Equipment

Process Aeration Blowers and Associated Equipment	Scope of Contractor	Scope of IITH
Inlet/Discharge Filter-Silencers	Y	
Process Air Blower with acoustic hood and VFD	Y	
Pressure Safety Valves (integral to blower package)	Y	
Discharge Pressure Gauge c/w Isolation Valve	Y	
Discharge Check Valves	Y	
Discharge Isolation Valves	Y	
Blower Discharge Low Flow Switch	Y	
Other,piping, valves & other items as denoted in P&ID	Y	

Anoxic tank and Associated Equipment

Anoxic tank and Associated Equipment	Scope of Contractor	Scope of IITH
RCC Bio Reactor Splitter Channel (applicable for multiple trains)		Y
RCC Anoxic Tank		Y
Anoxic Tank Mixer (Submersible type) 1set	Y	
Inlet Sluice Gate/ isolation valve (applicable for multiple trains)	Y	
Outlet Sluice Gate/isolation valve (applicable for multiple trains)	Y	
Other Piping, valves and other items as denoted in P&ID	Y	

Membrane Bio-reactor and Associated Equipment

Membrane Bio-reactor and Associated Equipment	Scope of Contractor	Scope of IITH
RCC Aerobic Tank		Y
RCC Membrane tank distribution channel (applicable for multiple trains)		Y
Aerobic Tank Fine Bubble Diffuser	Y	
Dissolved Oxygen Transmitter	Y	
Outlet Sluice Gate/isolation valve (applicable for multiple trains)	Y	
Aerobic Tank Level Switch	Y	
Air Inlet Isolation Valves	Y	
Air Drop Pipe from Tank top to bottom	Y	
Other Piping, valves and other items as denoted in P&ID	Y	

Membrane Tank and Associated Equipment

Membrane Tank and Associated Equipment	Scope of Contractor	Scope of IITH
Feed Water Sluice Gate/ Isolation valve (applicable for multiple trains)	Y	
RCC Membrane Tank		Y
ZeeWeed, Membrane Cassette SS 304	Y	
ZeeWeed 500D, 370 sqft Membrane, 30 no. of modules fixed in one cassette of 48 module capacity	Y	
Permeate Collection Headers SS304L	Y	
Membrane Air Scour Header Pipes SS304L/PVC	Y	
Straub couplings- Air header	Y	
Air Header Cassette Isolation Valve	Y	
Permeate header cassette isolation valve	Y	
Cassettes pins, brackets, hangers, beams	Y	
SS304L Fasteners for SUEZ/GE supplied header piping	Y	
Deflector Plate for Membrane Tanks	Y	
Cyclic Air Valve (if applicable as per P&ID)	Y	
Membrane Tank Level Transmitter	Y	
Isolation Flow Valve Automatic/manual as shown in P&ID (Drain)	Y	
Isolation, Flow Valve Automatic/manual as shown in P&ID (RAS inlet header)	Y	
Other Piping, valves and other items as denoted in P&ID	Y	

Permeate Pump and Associated Equipment

Permeate Pump and Associated Equipment	Scope of Contractor	Scope of IITH
TMP Pressure Transmitter	Y	
Pressure Switch	Y	
Permeate Isolation Valve (Automatic)	Y	
Pump Suction Pressure Gauges	Y	
Pump Suction Drain Valve	Y	
Permeate /Back-pulse Pump	Y	
Permeate /Back-pulse Pump VFDs	Y	
Pump Discharge Pressure Gauges & Gauge Cock	Y	
Pump Discharge Drain Valve	Y	
Pump Discharge Check Valve	Y	
Permeate Discharge Isolation Valve Automatic	Y	
Permeate Flow Meter	Y	
Back-pulse Water Isolation Valves Automatic	Y	
Back-pulse recirculation valves- Automatic	Y	
Online Turbidity meter	Y	
Other Piping, valves and items generally as denoted in P&ID	Y	

Back pulse tank and Associated Equipment

Back pulse tank and Associated Equipment	Scope of Contractor	Scope of IITH
FRP Back Pulse Tank	Y	
Back Pulse Tank Header inlet valve- Automatic	Y	
Sodium Hypochlorite Solution Injection Valves (Ball check and ball valve) for Recovery/ Maintenance cleans	Y	
Citric Acid Solution Injection Valves for Recovery cleans (Ball check and ball valve)	Y	
Level switch	Y	
LIT Isolation Valve	Y	
Back Pulse Tank Drain Valve	Y	
Other Piping, valves & items generally as denoted in P&ID	Y	

Permeate pump priming system and Associated Equipment

Permeate pump priming system and Associated Equipment	Scope of Contractor	Scope of IITH
Pump Suction Ejector Inlet Isolation Valve	Y	
Pump Suction Ejector Angle Seat Valve	Y	
Pump Suction Ejector Pressure Gauge	Y	
Permeate Pump Ejector	Y	
Solenoid Valve	Y	
Filter	Y	
Isolation Valve	Y	
Other Piping, valves & items generally as denoted in P&ID	Y	

RAS pump priming system and Associated Equipment

RAS pump priming system and Associated Equipment	Scope of Contractor	Scope of IITH
Pump Suction Isolation Valves	Y	
Pump Suction Pressure Gauges/Valves	Y	
Pump Suction Piping Drain Valves	Y	
RAS Pump	Y	
Pump Discharge Pressure Gauges/Valves	Y	
Pump Discharge Check Valves	Y	
Pump Discharge Piping Drain Valves	Y	
Pump Discharge Isolation Valves	Y	
Other Piping, valves & items generally as denoted in P&ID	Y	

Chemical cleaning system NaOCl dosing system (M)

Chemical cleaning system NaOCl dosing system for maintenance clean	Scope of Contractor	Scope of IITH
Pump Inlet Isolation Valves	Y	
Pump Discharge Valve	Y	
Sodium Hypochlorite Pump	Y	
Tank Level Switch	Y	
Pump Pressure Safety Valves	Y	
Discharge flow indicator	Y	
Pump discharge Isolation Valve	Y	
Pump Suction Foot Valve/Check Valve	Y	
Other piping, valves, chemical and items generally as denoted in P&ID	Y	

Chemical cleaning system NaOCl dosing system (R)

Chemical cleaning system NaOCl dosing system for Recovery clean	Scope of Contractor	Scope of IITH
Pump Inlet Isolation Valves	Y	
Tank	Y	
Pump Discharge Valve	Y	
Sodium Hypochlorite Pump	Y	
Tank Level Switch	Y	
Pump Pressure Safety Valves	Y	
Discharge flow indicator	Y	
Pump discharge Isolation Valve	Y	
Pump Suction Foot Valve/Check Valve	Y	
Other piping, valves, chemical and items generally as denoted in P&ID	Y	

Chemical cleaning system

Chemical cleaning system Citric dosing system for recovery and maintenance clean	Scope of Contractor	Scope of IITH
Pump Inlet Isolation Valves	Y	
Tank	Y	
Pump Discharge Valve	Y	
Citric Acid dosing Pump	Y	
Tank Level Switch	Y	
Pump Pressure Safety Valves	Y	
Discharge flow indicator	Y	
Pump discharge Isolation Valve	Y	
Pump Suction Foot Valve/Check Valve	Y	
Other valves and items piping, chemical, controls generally as denoted in P&ID	Y	

Air Compressor system

Air Compressor system	Scope of Contractor	Scope of IITH
Air Compressor with Vertical Receiver Tank	Y	
Receiver Tank Pressure Gauge	Y	
Receiver Tank Pressure Switch	Y	
Receiver Tank Pressure Relief Valve	Y	
Receiver Tank Drain Valve	Y	
Receiver Tank Isolation Valve	Y	
Refrigerated Air Dryer	Y	
Refrigerated Isolation Valves	Y	
Inlet Filter	Y	
Primary Coalescing Filter Isolation Valves	Y	
Primary Coalescing Filter Bypass Valve	Y	
Pressure Regulator Valve	Y	
Discharge Pressure Indicator	Y	
Other Piping, valves & items generally as denoted in P&ID	Y	

Plant Automation*

Plant Automation Component	Scope of Contractor	Scope of IITH
PLC panel with required I/O, 16 HMI interface :HMI Panel to comprise standard PC with CPU, 22 LED monitor, Laser printer, SCADA software. The automation shall include designing automation, system integration job and all hardware/software/instruments/sensors/ transducers/ equipment/ panels/electrical components etc. Complete, as per scope mentioned in Technical Specifications of the contract.	Y	

* For detailed information and scope of work, Specifications under sections 5.48 and 5.49 shall be referred to.

Mono Rail Arrangement

Monorail and hoist	Scope of Contractor	Scope of IITH
Hot dipped galvanized mild steel Monorail and hoist for membrane installation & maintenance across all three trains and membrane lay down area		Y

Sludge de-watering & Softening Systems

Sludge de-watering and Softening systems	Scope of Contractor	Scope of IITH
Coarse Bubble diffuser for Sludge holding tank (3 Nos, approx)	Y	
RCC Sludge Holding tank		Y
Feed Pump isolation Valve	Y	
Sludge transfer pump	Y	
Pressure Indicator	Y	
Check Valve	Y	
Discharge Isolation Valve	Y	
Centrifuge	Y	
Polymer Dosing Pump	Y	
Polymer Dosing Pump Isolation Valves	Y	
Polymer Check Valves	Y	
Level Switch	Y	
Polymer Dosing Tank	Y	
Softener System	Y	
Softener feed pump	Y	
Softener vessel with Resin	Y	
Softener internal piping with valves	Y	
*Instruments set	Y	
Other Piping, valves & items generally as denoted in P&ID	Y	

* Contractor shall install all required instruments and equipment to fulfill the specified effluent characteristics in terms of quantity and quality.

Instrumentation in treated water tank & Soft water tank

Sludge de-watering and Softening systems	Scope of Contractor	Scope of IITH
Complete Instrumentation in these tanks	Y	

4.3 Works in the scope of IITH

In addition to the information provided in 4.2, the following works are within the scope of the institute.

Civil Works

- Civil works for Pre-treatment system such as screen chamber, grit chamber.
- Civil tanks such as Equalization tank, Bioreactor, Membrane tank etc.
- Treated water storage and Sludge holding tank as shown in relevant drawings.
- Water proofing treatment of all RCC tanks
- All access platforms on tanks
- Pavement around the treatment plant
- Internal pathways
- Walkways over treatment tanks including railing
- Fencing with gate all-round the plant
- Membrane tank coating as required

Electrical Works

- Incoming three phase power supply cable
- * general lighting, fans and general power wiring
- * Extending of Body earthing GI strips near the incoming power cable
- *Street lighting

Table 4.2: Other Equipment

Other Equipment		
Description	Scope of Contractor	Scope of IITH
All Civil Works listed below:		
Civil works for Pre-treatment system such as screen chamber, grit chamber		Y
Civil tanks such as Equalization tank, Bioreactor, , Membrane tank & etc.		Y

Treated water storage and Sludge holding tank as shown in Civil drawings		Y
Water proofing treatment of all RCC tanks		Y
All access platforms on tanks		Y
Pavement around the treatment plant		Y
Internal pathways		Y
Walkways over treatment tanks including railing		Y
Fencing with gate all-round the plant		Y
All Electrical Works listed below:		Y
Incoming three phase power supply cable		Y
*. general lighting, fans and general power wiring		Y
*. Extending of Body earthing GI strips near the incoming power cable		Y
*Street lighting		Y
– Equipment Foundation civil work, full floor coverage equipment contact pads, etc.	Y	
– Process and utilities piping, pipe supports, hangers, valves, etc. including but not limited to:	Y	
Piping, painting to pipes ,pipe supports and valves between plant process equipment	Y	
– All other equipment as required for completion of MBR System as per P&ID	Y	
– All Electrical wiring, conduit and other appurtenances required to provide power connections as required from the control panel to all electrical equipment, pump motors and instruments, sensors.	Y	
– All weather protection as required for process equipment skids and control equipment. Skids and electrical panels are designed for indoor operation and shall need shelter from the natural elements.	Y	
–Raw materials, chemicals, and utilities during equipment start-up and operation	Y	
– Equipment lifting davit arm with lifting cables	Y	
– Motor Control Centre	Y	
– Membrane tank coating as required		Y

- Laboratory Assistance during trial run and commissioning of STP plant as required.	Y	
- Disposal of Initial Start-up wastewater and associated chemicals	Y	
- Receiving, unloading and safe storage of equipment at site until ready for installation;	Y	
- Erection and Installation (equipment, instrumentation & piping) & commissioning	Y	
- Erection installation of electrical panel and cabling works , required earthing, non-skid type electric insulated rubber mats	Y	
- Fire Fighting Systems and fire extinguishers		Y
- Any other equipment/ item/work not included above and is required for completion of the STP	Y	
- Working platforms in the laboratory		Y

4.4 Contractors Scope of supply for Design and Detail Engineering

The scope of the contractor includes design of the treatment process adopting hollow fibre UF MBR technology of Suez Water Technologies & Solutions (I) Pvt. Ltd., with due consideration to the layout and hydraulic volumes of various treatment tanks already constructed by IITH. The Contractor shall submit detailed design calculations with references to Codes, Manuals etc.,. The design calculations and drawings shall be vetted by the Technology Provider. Tentative list of drawings/documents which shall be submitted to IITH for approval of design shall include the all the drawings listed herein under Table 4.3:

Table 4.3: Drawings and Submittals

Sl.No	DRAWING / DOCUMENT NO	DRAWING / DOCUMENT TITLE	PURPOSE I For information; A- For approval
BASIC ENGINEERING PACKAGE			
1	XXXXXX-AM-01	Process Flow Diagram	A
2	XXXXXX-AP-01	P & I Diagram	A
3	XXXXXX-AG-01	Equipment Layout	A

Table 4.3: Drawings and Submittals

Sl.No	DRAWING / DOCUMENT NO	DRAWING / DOCUMENT TITLE	PURPOSE I For information; A- For approval
4	XXXXXXX-AE-01	Equipment List	A
CIVIL DESIGN INPUT DRAWINGS			
5	XXXXXXX-PG-02	GA for Bioreactor tank	A
6	XXXXXXX-PG-03	GA for Membrane tank	A
7	XXXXXXX-CA-01	Equipment Foundation Layout	A
8	XXXXXXX-PG-05	GA of MCC/Control Building	A
9	XXXXXXX-PG-08	GA for Diffuser Arrangement Bioreactor tank	A
10	XXXXXXX-SA-07	Fabrication drawing for Baffle Plate	A
11	XXXXXXX-SA-011	Puddle Pipe Drawings (if applicable)	A
DETAIL ENGINEERING PACKAGE (Mechanical)			
1	XXXXXXX-KG-01	Data sheet for Screens	I
2	XXXXXXX-KG-02	Data sheet for Process Air Blowers	I
3	XXXXXXX-KG-03	Data sheet for Membrane Air Blowers	I
4	XXXXXXX-KG-04	Data sheet for UF Membrane	I
5	XXXXXXX-KG-05	Data sheet for Bioreactor feed pumps	I
6	XXXXXXX-KG-06	Data sheet for RAS pumps	I
7	XXXXXXX-KG-07	Data sheet for Permeate cum Back-pulse Pumps	I
8	XXXXXXX-KG-08	Data sheet for NaOCL Dosing Pump	I
9	XXXXXXX-KG-09	Data sheet for nutrient dosing pump	I
10	XXXXXXX-KG-10	Data sheet for Citric Acid Dosing Pump & agitator	I
11	XXXXXXX-KG-11	Data sheet for NaOCL Dosing Pump	I
12	XXXXXXX-KG-12	Data sheet for Manual butterfly valves	I
13	XXXXXXX-KG-13	Data sheet for actuated butterfly valves	I
14	XXXXXXX-KG-14	Data sheet for ball valves	I
15	XXXXXXX-KG-15	Data sheet for wafer check valves	I
16	XXXXXXX-PC-03	Piping Routing drawing	A
17	XXXXXXX-PG-05	GA for Nutrient dosing tank	I
18	XXXXXXX-PG-06	GA for Citric acid Dosing tank	I
19	XXXXXXX-PG-07	GA for NaOCl dosing tank	I

Table 4.3: Drawings and Submittals

Sl.No	DRAWING / DOCUMENT NO	DRAWING / DOCUMENT TITLE	PURPOSE I For information; A- For approval
20	XXXXXXX-PG-08	GA of Back-pulse Tank	I
21	XXXXXXX-PK-01	Valve schedule	A
DETAIL ENGINEERING PACKAGE (E&I)			
1	XXXXXXX-EO-01	Electrical Load list	A
2	XXXXXXX-IK-01	Instrument Schedule	A
3	XXXXXXX-JH-01	PLC I/O List	A
4	XXXXXXX-IE-01	PLC Panel GA & Wiring Drawing	A
5	XXXXXXX-JA-01	Control Narrative	A
6	XXXXXXX-JB-01	Operating Sequence Chart	A
7	XXXXXXX-JC-01	Control Logic Summary Chart	A
8	XXXXXXX-ID-01	Data sheet for Pressure Gauges	I
9	XXXXXXX-ID-02	Data sheet for Pressure Switch	I
10	XXXXXXX-ID-03	Data sheet for Level Switch	I
11	XXXXXXX-ID-04	Data sheet for Pressure Transmitter	I
12	XXXXXXX-ID-05	Data sheet for Level Transmitter	I
13	XXXXXXX-ID-06	Data sheet for Flow Transmitter	I
14	XXXXXXX-ID-07	Data sheet for Temperature Transmitter	I
15	XXXXXXX-ID-08	Data sheet for pH Transmitter	I
16	XXXXXXX-ID-09	Data sheet for Turbidity Analysers	I
17	XXXXXXX-ID-10	Data sheet for DO Analysers	I
18	XXXXXXX-ID-11	Data sheet for FLOW Switch	I
19	XXXXXXX-ID-12	Data sheet for Junction boxes	I
20		Cable Termination details	I
GENERAL			
1	XXXXXXX-UA-01	Operation and Maintenance Manual	A
2	XXXXXXX-WF-01	Master Construction Schedule conforming to Milestones of contract	A
3	XXXXXXX-YC-01	Inspection Test Plan	A
4	XXXXXXX-TB-01	Pre-commissioning Procedures	A
5	XXXXXXX-TB-03	Drawing Document List	A

4.5 Scope of Technology Provider

The Contractor shall arrange required technical services by the Technology Provider as specified in the MoU document between the Contractor and Technology Provider Suez Water Technologies & Solutions (I) Pvt. Ltd.,. The costs incurred by the contractor for arranging the technical services by the Technology Provider are deemed to be included in the Contract Price for Part-A and Part-B of the Schedule of Contract Price for DSITC Services and O&M Services. Nothing extra shall be payable on this account. All incidental expenses like travelling, lodging and boarding arrangements for the representative(s) of Technology Provider shall be borne by Contractor during entire period of this Contract. The following are the technical services to be rendered by the Technology Provider:

4.5.1 Technical Advisory Services during Pre-Construction

The Contractor shall undertake the design of the proposed sewage treatment plant in consultation with the Technology Provider. Technology provider shall scrutinize the design calculations of all electro-mechanical, instrumentation, piping, electrical and automation of control systems and vet the same. Similarly, all deliverable drawings/documents including Maintenance Manual shall be vetted by the Technology Provider duly affixing the signature of authorized signatory along with seal of Suez Water Technologies & Solutions (I) Pvt. Ltd., .

4.5.2 Technical Advisory Services during Equipment Installation

In support of unloading the equipment, rigging the equipment into place, installing interconnecting piping, installing interconnecting wiring, installing power wiring, installing pneumatic lines, verifying adequate drainage, testing for adequate water and air pressure, testing power supply and testing interconnecting wire circuitry.

4.5.3 Technical Advisory Services during Post-Installation

Inspection of installation work, address questions, develop punch list of completion items necessary prior to next visit including technical advisory services in support of loading membrane elements / cassettes (if not loaded in factory)

4.5.4 Technical Advisory Services during Equipment trial run

Includes technical advisory services in preparing the equipment to operate I/O verification, support for flushing & back washing system, operating the equipment manually, I/O verification, operating the equipment automatically, testing control system, technical advisory services in support of membrane loading, flushing preservative, and system

sanitization

4.5.5 Technical Advisory Services during Commissioning of plant (Performance Test)

Includes technical advisory services in support of set-up of and witness performance test of 72 hours / 3 days continuous operating run without intervention beyond normal operational activities.

4.5.6 Formal Training

This shall include formal on-site training to staff of Contractor and IITH that typically takes place after the commissioning of the plant. This does not include informal training that takes place with an operator being present and assisting the technicians performing start-up. The on-site training program shall also include site safety training. The training program shall be properly documented and a report shall be submitted to IITH.

4.5.7 Other Services

The technical services listed above shall include at least 4 trips to site with total 20 working days on-site availability for above mentioned services. Travel time to and from the job site for Technology Provider's Field Service personnel is not included in the 20 days period.

In addition to above technical services, the contractor shall arrange representative of Technology Provider at kick-off meeting to be held at site after award of work.

As specified in the Conditions for O&M Services, the contractor shall arrange visits of the Technology provider to the plant once in every three months for complete performance audit of the plant and submit such audit report to the Institute.

4.5.8 Performance Guarantee

As specified in the bid document the Technology Provider shall submit performance guarantee bond for the quality of treated sewage by furnishing to IITH a joint undertaking with Contractor to this effect.

4.6 Scope of Part-B of the Contract

Scope of work under Part B of the contract i.e, Operation and Maintenance services is given in the Special Conditions of the Contract.

4.7 Schematic P&ID

For understanding of the bidder, a schematic of the plant is given in this section. The P&I diagram is only indicative. On award of the work, the Contractor shall prepare schematics, detailed processes, P&ID and good for construction drawings incorporating all working details for approval of the institute after due vetting by the Technology Provider.

INDICATIVE P&ID FOR PROPOSED SEWAGE TREATMENT PLANT AT IIT HYDERABAD

REV	DESCRIPTION	ECO	DNN	APVD	DATE	CHKD	TOLERANCES UNLESS NOTED DECIMALS X 1/8 XXX 1/8	FRAC A	DRAWN BY MK	DATE 08NOV17	SCALE	CUSTOMER/JOB	DWG DESCRIPTION	SIZE	DRAWING NO.	REV
									CHECKED BY CS	DATE 08NOV17		IIT HYDERABAD STP I - 1x650KLD	PIPING & INSTRUMENTATION DIAGRAM COVER SHEET	A1	896582-AA-01	A
									APPROVED BY DNN	DATE 08NOV17						
									APPROVED BY	DATE						
A	INITIAL RELEASE		MK	DNN	08NOV17	CS										

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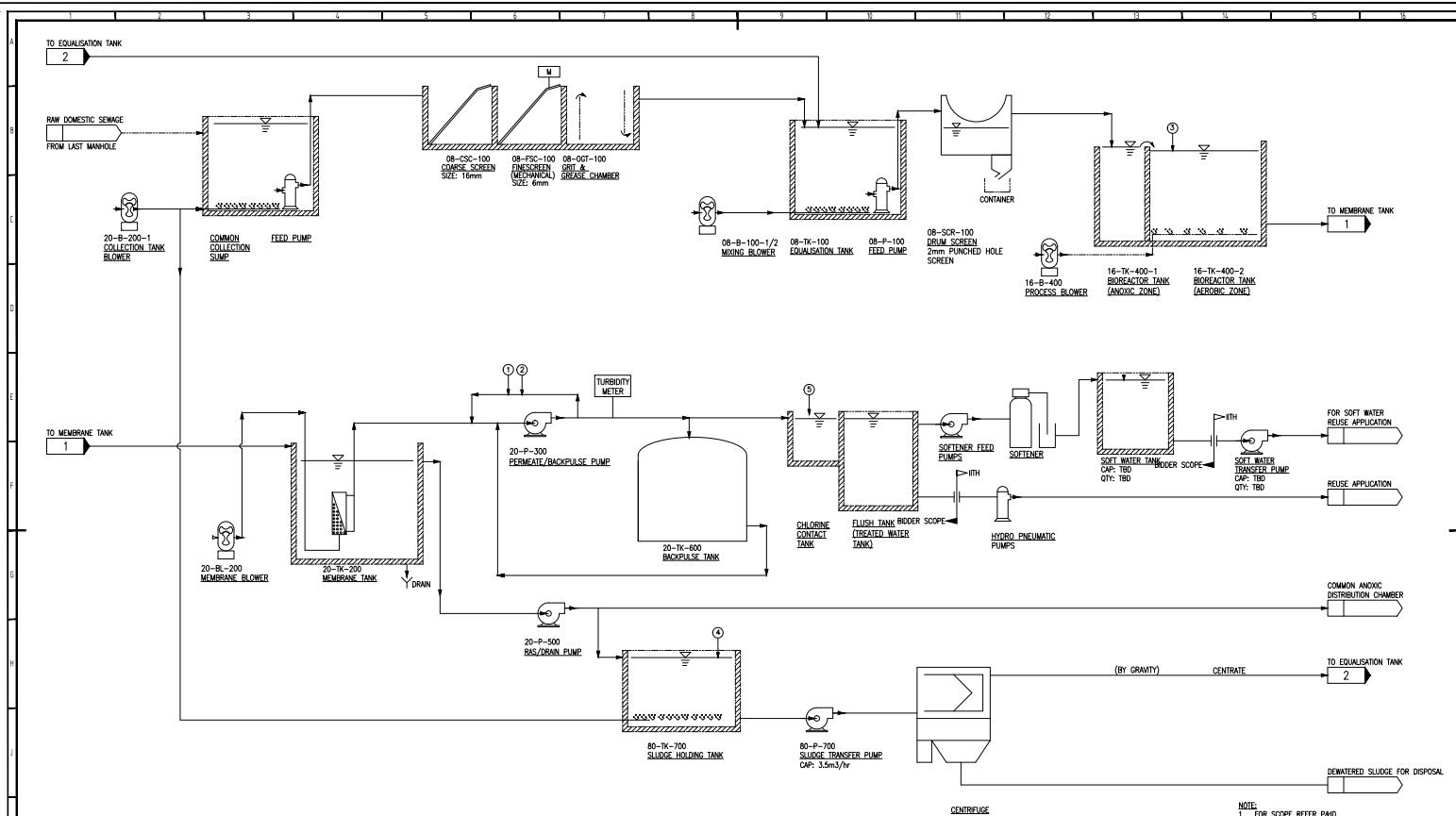
SCALE: N.T.S SHEET 1 OF 3

CONTROL VALVE ACTUATORS	VALVE SYMBOLS	RELIEF	PUMPS, BLOWERS, & COMPRESSORS	FLOW ELEMENT	CONNECTIONS	FILTERS	VESSELS/TRIM	MISCELLANEOUS	SCOPE BREAK
PISTON DOUBLE ACTING PISTON SPRING TO OPEN PISTON SPRING TO CLOSE DIAPHRAGM DOUBLE ACTING DIAPHRAGM SPRING TO OPEN DIAPHRAGM SPRING TO CLOSE DIAPHRAGM DOUBLE BALANCING BACK PRESSURE CONTROL (EXTERNAL REGULATING) BACK PRESSURE CONTROL (INTERNAL REGULATING) PRESSURE REDUCING (EXTERNAL REGULATING) PRESSURE REDUCING (INTERNAL REGULATING) ROTARY MOTOR ANALOG ROTARY MOTOR DIGITAL I/P CONVERTER POSITIONER TRAVEL STOP GEAR MANUAL GEAR WHEEL CHAIN MANUAL CHAIN WHEEL SOLENOID SOLENOID 3 WAY SOLENOID 4 WAY	(PLEASE REFER TO THE P&ID FOR THE SYMBOLS) GATE (OR GENERIC) BALL BUTTERFLY NEEDLE GLOBE DIAPHRAGM ANGLE PLUG PINCH Y-BALL KNIFE GATE UPWARD SLIDING GATE DOWNWARD SLIDING GATE MANUAL BLAST GATE BACKFLOW PREVENTER CHECK INJECTION QUILL FOOT FLOAT 3 WAY 4 WAY 5 WAY 6 WAY 2 VALVE MANFOLD 3 VALVE MANFOLD 5 VALVE MANFOLD SAMPLE	PRESSURE SAFETY VACUUM SAFETY MULTIFUNCTION PRESSURE RUPTURE DIBG VACUUM RUPTURE DIBG AIR RELEASE VACUUM BREAKER VENT GROUND DRAIN	CENTRIFUGAL PUMP CENTRIFUGAL/REGENERATIVE BLOWER PROPELLER PUMP ROTARY LOBE COMPRESSOR BLOWER METERING PUMP VACUUM PUMP (DRY) AIR OPERATED DOUBLE DIAPHRAGM PUMP VACUUM PUMP LIQUID RING POSITIVE DISPLACEMENT PUMP AIR COMPRESSOR PISTON AIR COMPRESSOR ROTARY SCREW CAN PUMP REFRIGERATED AIR DRYER WELL PUMP FAN DRUM PUMP ERI PRESSURE EXCHANGER SIGMABLE SLUMP PUMP MOTOR HYDRAULIC PRESSURE BOOSTER MOTOR VFD MOTOR	PADDLE WHEEL ANNUBAR FLOW NOZZLE FLUME MAGNETIC PITOT SONIC/ULTRASONIC TURBINE VENTURI TUBE VORTEX MASS FLOW/CORIOLIS ROTAMETER IN-LINE FLOW CLASS FLOW STRAIGHTENER FIXED ORIFICE ADJUSTABLE ORIFICE RESTRICTED ORIFICE RESTRICTED ORIFICE ANGLE ORIFICE PLATE QUICK-CHANGE	FLANGE FLANGE BLIND MECHANICAL COUPLING OR VICTAULIC MECHANICAL COUPLING OR VICTAULIC PLUG SANITARY SANITARY PLUG THREADED THREADED PLUG SOCKET UNION CAMLOCK CAMLOCK PLUG HOSE BARB WELDED PIPE CAP PLAIN END PIPE COUPLING REDUCER COMPRESSION FITTING COMPRESSION FITTING PLUG SPECTACLE BLIND OPEN SPECTACLE BLIND CLOSED HEATING TANK HEATER FIXED ORIFICE ADJUSTABLE ORIFICE RESTRICTED ORIFICE RESTRICTED ORIFICE ANGLE DESUPERHEATER	FIXED SCREEN TOP HAT STRAINER BAR SCREEN HEPA FILTER Y STRAINER CONICAL STRAINER FILTER PUMP SCREEN STEAM TRAP RESIN TRAP RO/UF FOUR PORT HOUSING TWO PORT HOUSING END PORT HOUSING MEMBRANE MODULE	CONICAL BOTTOM TANK PROPELLER AGITATOR VORTEX BREAKER VESSEL INSULATION TANK (CLOSED TOP) TANK (OPEN TOP) DOMED TANK PRESSURE VESSEL HORIZONTAL/VERTICAL OR RECEIVER MANHOLE MANHOLE W/ SWAY ARM VESSEL SIGHT GLASS WATER LEVEL LADDER/PLATFORM	MUFFLER EDUCTOR STATIC MIXER EXPANSION JOINT SILENCER VIBRATION ISOLATOR HIGH PRESSURE FLEXIBLE CONNECTOR INJECTION SPARGER DIAPHRAGM SEAL/GAGE GUARD PULSATION DAMPENER SPRAYER NOZZLE DESICCANT AIR DRYER HYDROMETER POT COARSE BUBBLE DIFFUSER ELEVATION VIEW FINE BUBBLE DIFFUSER ELEVATION VIEW THERMOWELL TOP MOUNT LEVEL SWITCH ULTRASONIC LEVEL CALIBRATION COLUMN ION EXCHANGE BOTTLE	BODDER SCOPE MATERIAL BREAK MATERIAL A MATERIAL B PIPE INSULATION/DOUBLE CONTAINMENT PP 2" (*PP INDICATES PERSONNEL PROTECTION - OPTIONAL) LINE TYPES PRIMARY PROCESS SECONDARY PROCESS SAMPLE/DRAINS/VENTS/ETC PRIMARY PROCESS (BY OTHERS) SECONDARY PROCESS (BY OTHERS) FUTURE EQUIPMENT LIMIT OR BOUNDARY LINE EQUIPMENT EQUIPMENT (BY OTHERS) FLEX HOSE/TUBING SOFTWARE-LINK ELECTRICAL ELECTROMAGNETIC OR SONIC SIGNAL (WIRELESS) PNEUMATIC HYDRAULIC SIGNAL CAPILLARY TUBING HEAT-TRACING STEAM-TRACE ELECTRICAL-TRACE MISCELLANEOUS LINE OBJECTS SLOPE CONTINUATION SYMBOL CONTINUATION SYMBOL CROSSOVER LINE REVISION CLOUD REVISION TRIANGLE

REV	DESCRIPTION	ECO	DWN	APVD	DATE	CHKD	TOLERANCES UNLESS NOTED OTHERWISE DECIMALS X .1 XXX .1	DESIGNED BY MK DATE 08NOV17	SCALE AS SHOWN	CLIENT/CORP IIT HYDERABAD STP 1 - 1x650KLD	DWG DESCRIPTION PIPING & INSTRUMENTATION DIAGRAM LEGEND & SYMBOLS	SIZE A1	DRAWING NO. 896582-AA-01	REV A
APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17	APPROVED BY DNN DATE 08NOV17
INITIAL RELEASE		MK	DNN	DNN	08NOV17	CS								

INSTRUMENT FUNCTIONS		INSTRUMENT SYMBOLS		EQUIPMENT / INSTRUMENT TAGGING SCHEME		EQUIPMENT ABBREVIATIONS												
SUCCESSING LETTER	A	C	E	G	I	L	Q	R	S	T	Y	VZ	SYMBOL	DESCRIPTION	LINE IDENTIFIER	MATERIAL CODE	MATERIAL	CLASSIFICATION
ALARM	AH	AL	AL	AL	AL	AL	AL	AL	AL	AL	AL	AL	Panel Mount Instrument	11-XXX-222A-3	11-XXX-222A-3	CONCRETE	CC	ASORBER
HIGH-HIGH ALARM	AHH												Field Mount or Primary Instrument			METALLIC	AS	AIR COMPRESSOR
HIGH ALARM	AH												Behind Panel Instrument			ALLOY 20	AC	ACTIVATED CARBON FILTER
LOW ALARM	AL												Pilot Light			CAST IRON	AE	ACTOR
LOW-LOW ALARM	ALL												PLC Function with Display			CARBON STEEL	ARV	AIR RELEASE VALVE
SENSOR FAULT ALARM	AFA												PLC Function, Blind			COPPER	B	BLOWER
BAND CONTROLLER	AC												PLC Input/Output			DUPLIX IRON	BF	BAG FILTER
INDICATING CONTROLLER	AI												Undefined Interlock Logic			304, 304L STAINLESS STEEL	C	CENTRIFUGE, CYCLONE
SENSOR (PRIMARY ELEMENT)	AE												Summing			AL-IRON	CD	CONDENSER
GLASS	AI												Continuation Arrows			254-SMO	CDM	CATALYTIC DESTRUCT MODULE
INDICATOR	AL												Service			2205	CF	CARTRIDGE FILTER
PILOT LIGHT	AL												Flow - Single Direction			307	CH	CHILLER
TOTALIZER	AR												Flow - Both Directions			307	CHL	CHROMATOR
RECORD	AS												Transfer Arrow to Same Sheet			307	CL	CLEAN-IN-PLACE
SWITCH	ASH												Transfer Arrow to Different PID Document			307	CLS	CLARIFIER
HIGH-HIGH SWITCH	ASHH												Service			307	COMV	COMBUSTOR
HIGH SWITCH	ASH												Flow			307	CP	CATALYTIC OXYGEN REMOVAL SYSTEM
LOW SWITCH	ASL												Pressure			307	CP	CONTROL PANEL
LOW-LOW SWITCH	ASLL												Temp			307	CR	CRYSTALLIZER
BLIND TRANSMITTER	AT												Temp			307	CS	CHEMICAL SYSTEM
INDICATING TRANSMITTER	AS												Flow			307	CT	CHECK VALVE
SELECTED VALVE (TRD)	AS												Flow			307	DMF	DISSOLVED OXYGEN
RELAY, COMPUTATION, COMPARTER	AT												Flow			307	DO	DISSOLVED OXYGEN
CONTROL VALVE	AV												Flow			307	DR	AIR DRYER
VALVE	AV												Flow			307	E	EXHAUSTOR
FINAL CONTROL ELEMENT	AZ												Flow			307	EAF	ENTRAPPED AIR FLOTATION

DESCRIPTION	ECO	DNN	APVD	DATE	CHKD	TOLERANCES UNLESS NOTED OTHERWISE	DESIGNED BY	DATE	SIZE	DRWN NO.	REV
INITIAL RELEASE	MK	DNN		08NOV17	CS		CS	08NOV17	A	896582-AA-01	A
DESCRIPTION	PIPING & INSTRUMENTATION DIAGRAM										
CLIENT/JOB	IIT HYDERABAD STP 1 - 1x650KLD										
DATE	08NOV17										
MATERIAL/FORM NO.	LEGEND & SYMBOLS										
SCALE	N.T.S.										
SHEET	3 OF 3										



1	2	3	4	5
SODIUM HYPOCHLORITE MAINT./RECOVERY CLEAN	CITRIC ACID MAINT./RECOVERY CLEAN	COAGULANT	POLYMER	SODIUM HYDRO FOR DISINFECTION

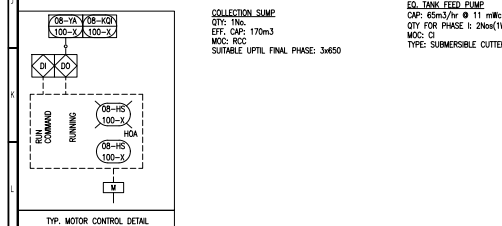
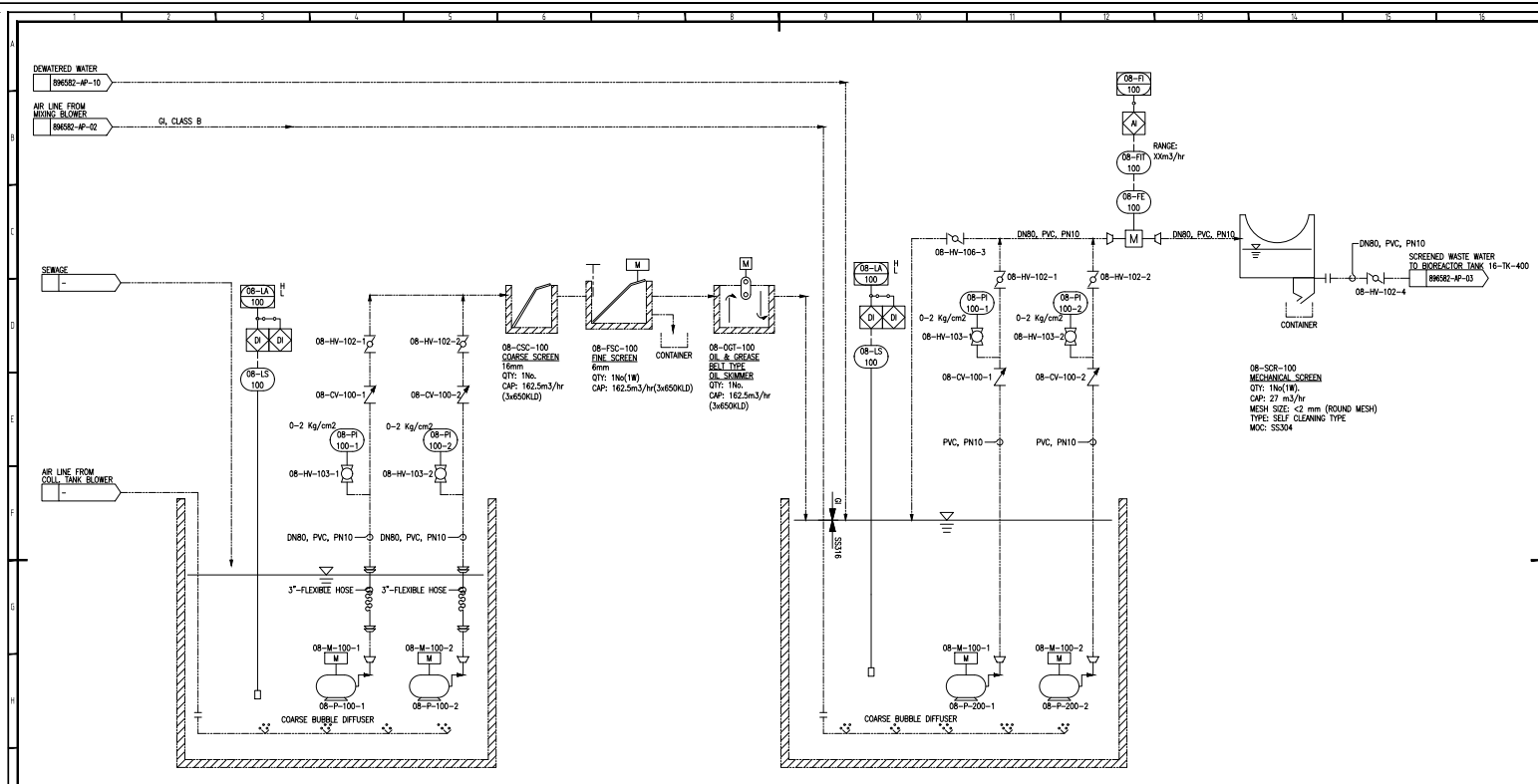
NOTE:
1. FOR SCOPE REFER PAID

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APPROVED BY DNN	DATE 08NOV17	APPROVED BY DNN	DATE 08NOV17	APPROVED BY DNN	DATE 08NOV17	APPROVED BY DNN	DATE 08NOV17	APPROVED BY DNN	DATE 08NOV17	APPROVED BY DNN	DATE 08NOV17	APPROVED BY DNN	DATE 08NOV17	APPROVED BY DNN	DATE 08NOV17
INITIAL RELEASE		MK	DNN	08NOV17	CS										

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MATERIAL/FORM NO. SCALE N.T.S SHEET 1 OF 1



COLLECTION SUMP
 QTY: 1No.
 EFF. CAP: 170m³
 MOC: RCC
 SUITABLE UP TO FINAL PHASE: 3x650

EQ. TANK FEED PUMP
 CAP: 65m³/hr @ 11 mH₂O
 QTY FOR PHASE 1: 2Nos(1W+1S)
 MOC: CI
 TYPE: SUBMERSIBLE CUTTER PUMPS

08-TK-100
EQUALISATION TANK
 CAP: 300 m³
 MOC: RCC

08-P-100-1/2
BIOREACTOR FEED PUMP
 CAP: 27 m³/hr @ 9 mH₂O
 QTY FOR PHASE 1: 2 Nos(1W+1S)
 MOC: CI

08-SCS-100
MECHANICAL SCREEN
 QTY: 1No(1W)
 CAP: 27 m³/hr
 MESH SIZE: < 2 mm (ROUND MESH)
 TYPE: SELF CLEANING TYPE
 MOC: SS304

- NOTES:**
- 1 TRAN+ 1x650 KLD
 - THIS P&ID DOES NOT INDICATE SCOPE OF SUPPLY, FOR SCOPE OF SUPPLY PLEASE REFER BID DOCUMENT.

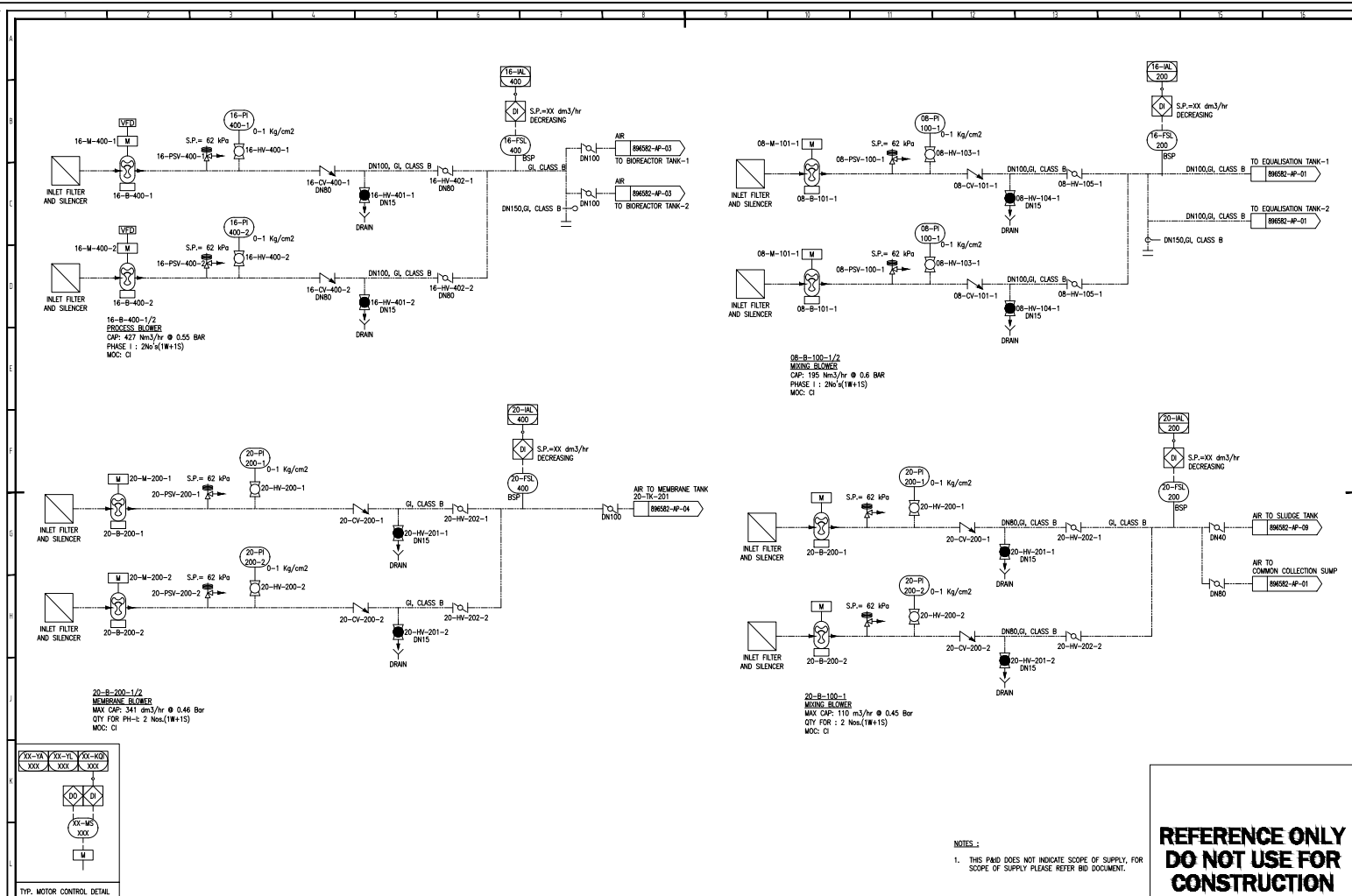
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A	INITIAL RELEASE	MK	DNN	DNN	08NOV17	CS			08NOV17		08NOV17	IIT HYDERABAD STP 1 - 1x650KLD	PIPING & INSTRUMENTATION DIAGRAM EQUALISATION TANK		A1 896582-AP-01	A

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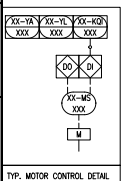
MATERIAL/ROOM NO.

SCALE: N.T.S. SHEET 1 OF 1



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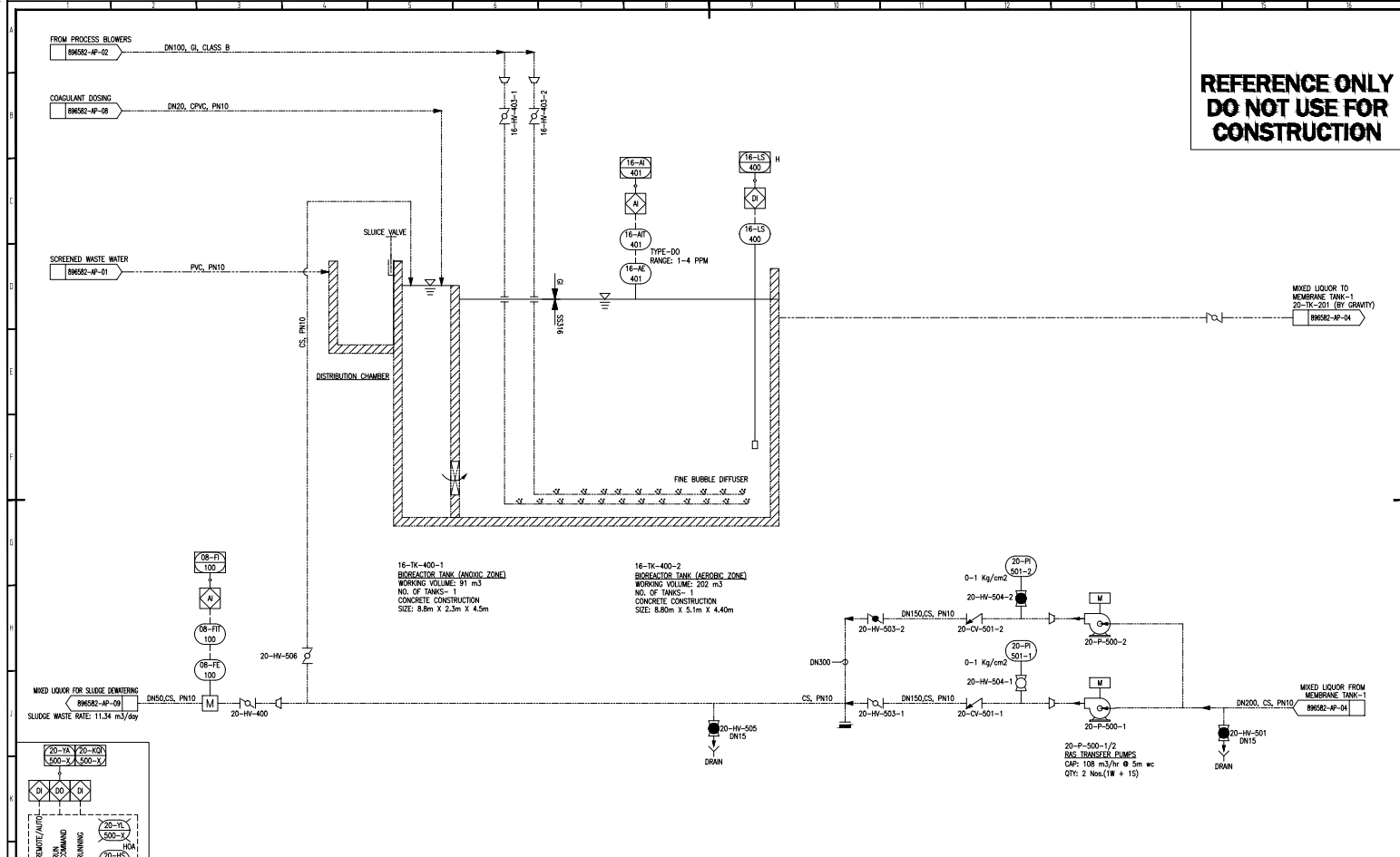
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1. THIS P&ID DOES NOT INDICATE SCOPE OF SUPPLY. FOR SCOPE OF SUPPLY PLEASE REFER BID DOCUMENT.



REV.	DESCRIPTION	ECO	DWN	APVD	DATE	CHKD	TOLERANCES UNLESS NOTED OTHERWISE	DESIGN BY	DATE	CLIENT/JOB	DWG DESCRIPTION	SIZE	DRAWING NO.	REV.
A	INITIAL RELEASE									IIT HYDERABAD STP 1 - 1x650KLD	PIPING & INSTRUMENTATION DIAGRAM BLOWER	A1	896582-AP-02	A

PROJECT: 896582
SCALE: N.T.S. SHEET 1 OF 1

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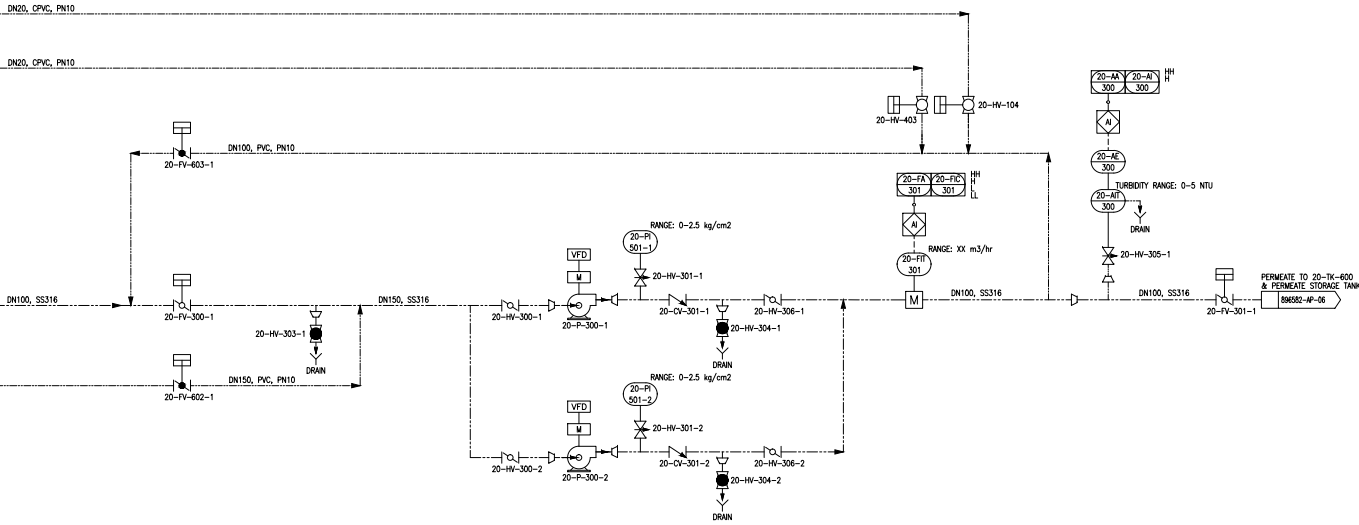
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A	INITIAL RELEASE			MK	DNN	08NOV17	CS			IIT HYDERABAD STP I - 1x650KLD	PIPING & INSTRUMENTATION DIAGRAM BIOREACTOR TANK	A1	896582-AP-03	A
													PROJECT	896582
													SCALE	N.T.S
													SHEET	1 OF 1

SODIUM HYPOCHLORITE SOLUTION
RECOVERY & MAINTENANCE
FROM 23-P-100

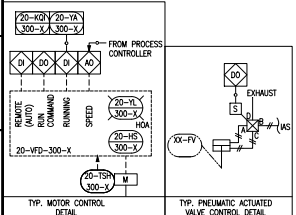
CITRIC ACID SOLUTION
RECOVERY & MAINTENANCE
FROM 23-P-450

PERMEATE/BACKPULSE/
RECOVERY & RECOVERY
CLEANS TANK FILL

BP WATER
FROM BP TANK



20-P-300-1/2
PERMEATE/BACKPULSE PUMP
PERMEATE FLOW: 320m³/hr EACH @ 7.2 m wc
BACKPULSE FLOW: 56m³/hr @ 10m TSH
QTY FOR PHASE I: 2Nos. (1W+1S)
MOC: CI BODY, SS316 IMPELLER
415V / 3PH / 50HZ



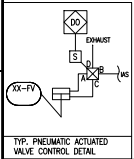
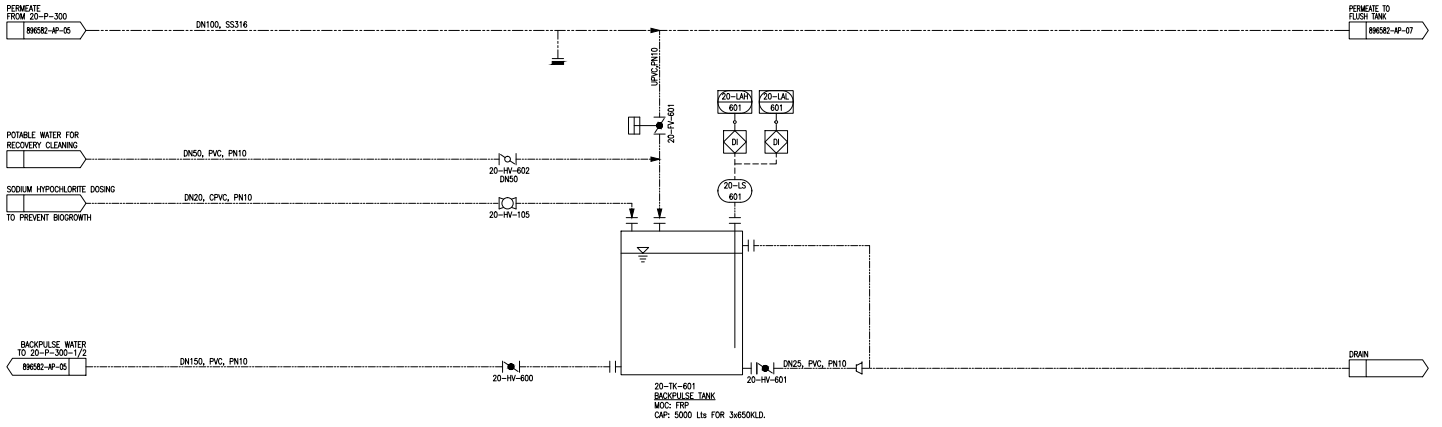
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REV	DESCRIPTION	EGG	DNN	APVD	DATE	CHKD	TOLERANCES UNLESS NOTED OTHERWISE	FRAC	DRAWN BY	DATE	CHECKED BY	DATE	CLIENT/JOB	DWG DESCRIPTION	SIZE	DRAWING NO.	REV
1	INITIAL RELEASE	MK	DNN		08NOV17	CS				08NOV17		08NOV17	IIT HYDERABAD STP I - 1x650KLD	PIPING & INSTRUMENTATION DIAGRAM PERMEATE/BACKPULSE PUMP	A1	B96582-AP-05	A

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MATERIAL/NCM NO. SCALE: N.T.S. SHEET: 1 OF 1



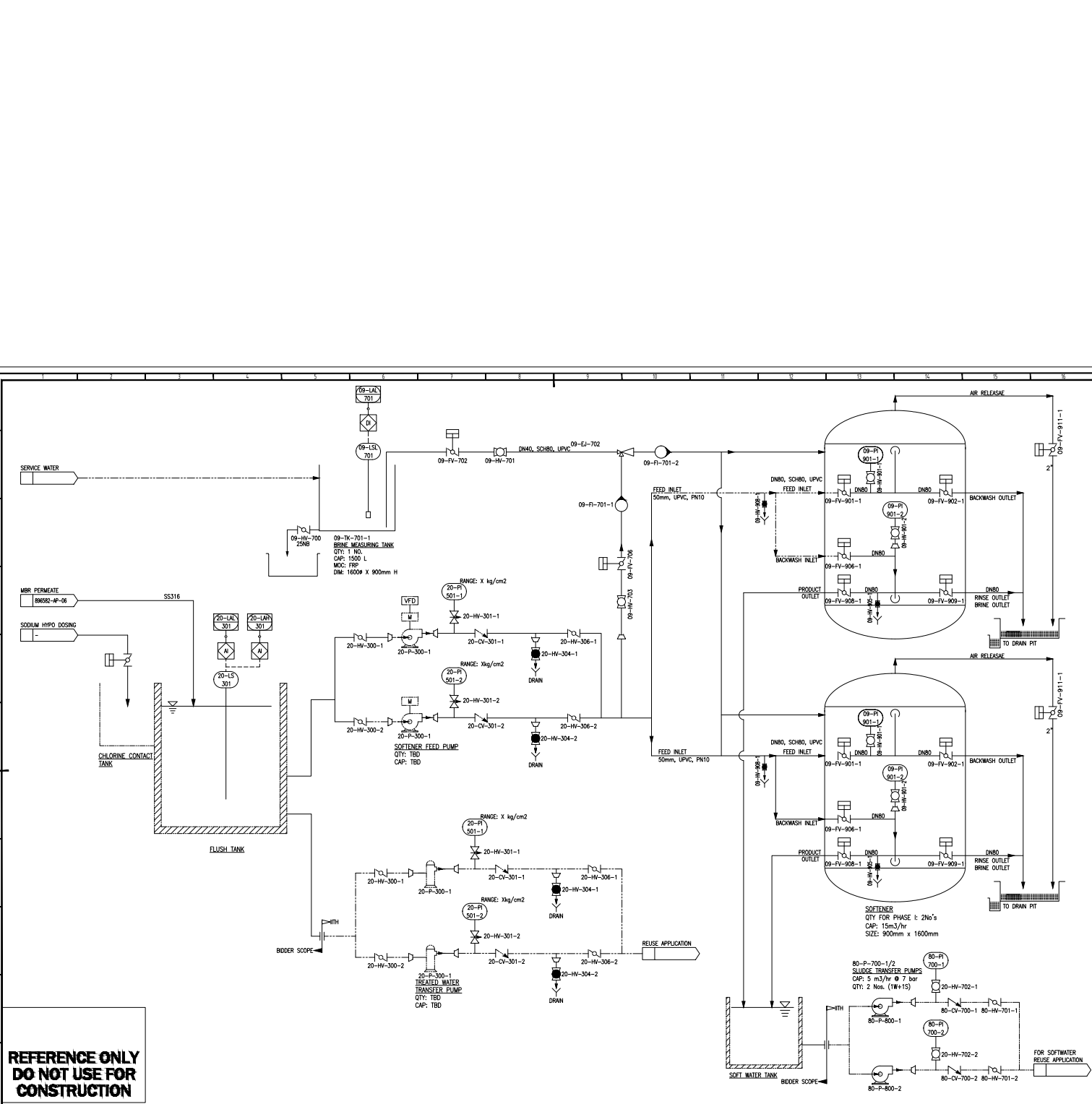
NOTES:
 1. THIS P&ID DOES NOT INDICATE SCOPE OF SUPPLY, FOR SCOPE OF SUPPLY PLEASE REFER BID DOCUMENT.

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							FRAC					IIT HYDERABAD STP 1 - 1x650KLD	PIPING & INSTRUMENTATION DIAGRAM BACKPULSE SYSTEM	A1	896582-AP-06	A
1A	INITIAL RELEASE		MK	DNN	08NOV17	CS										

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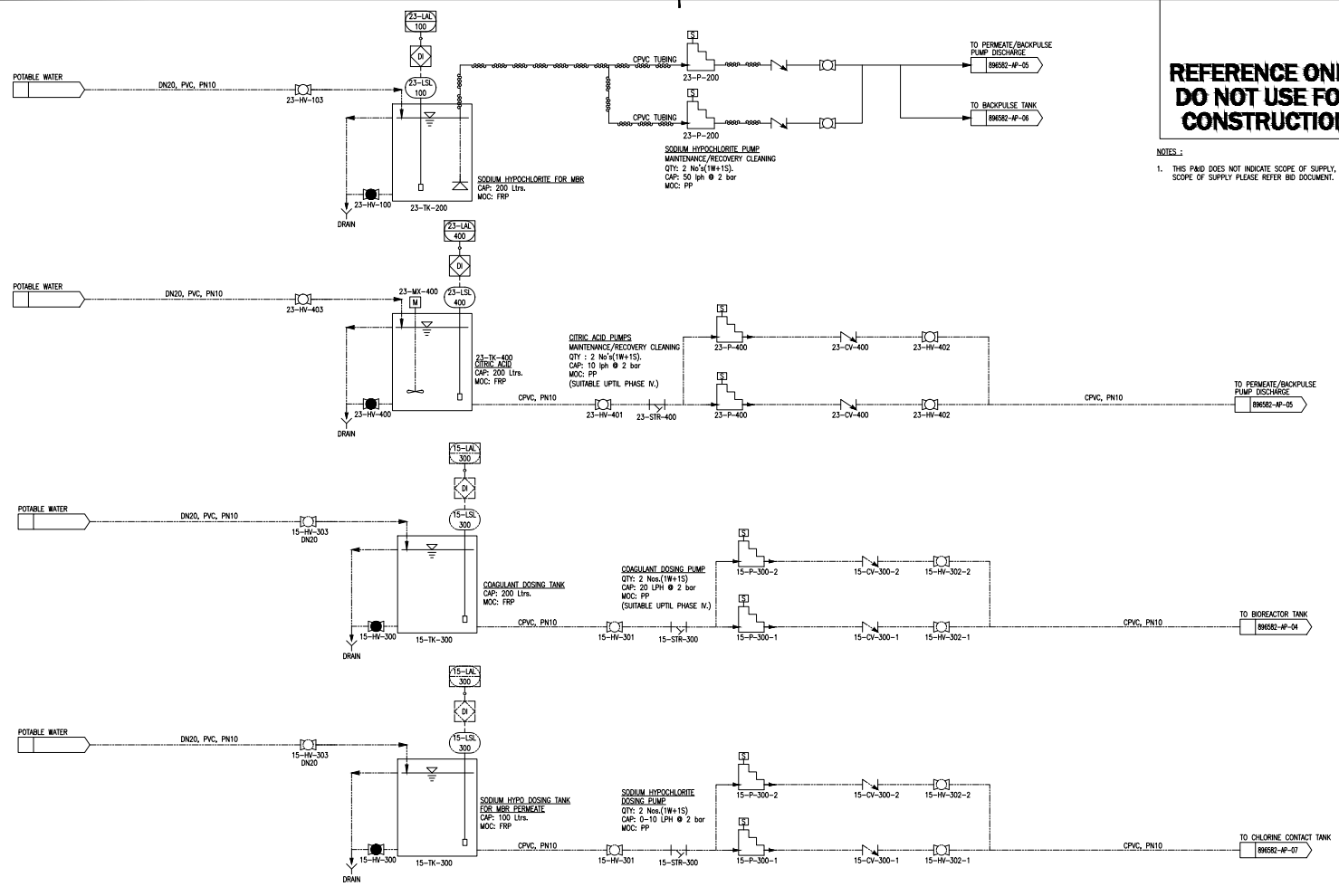
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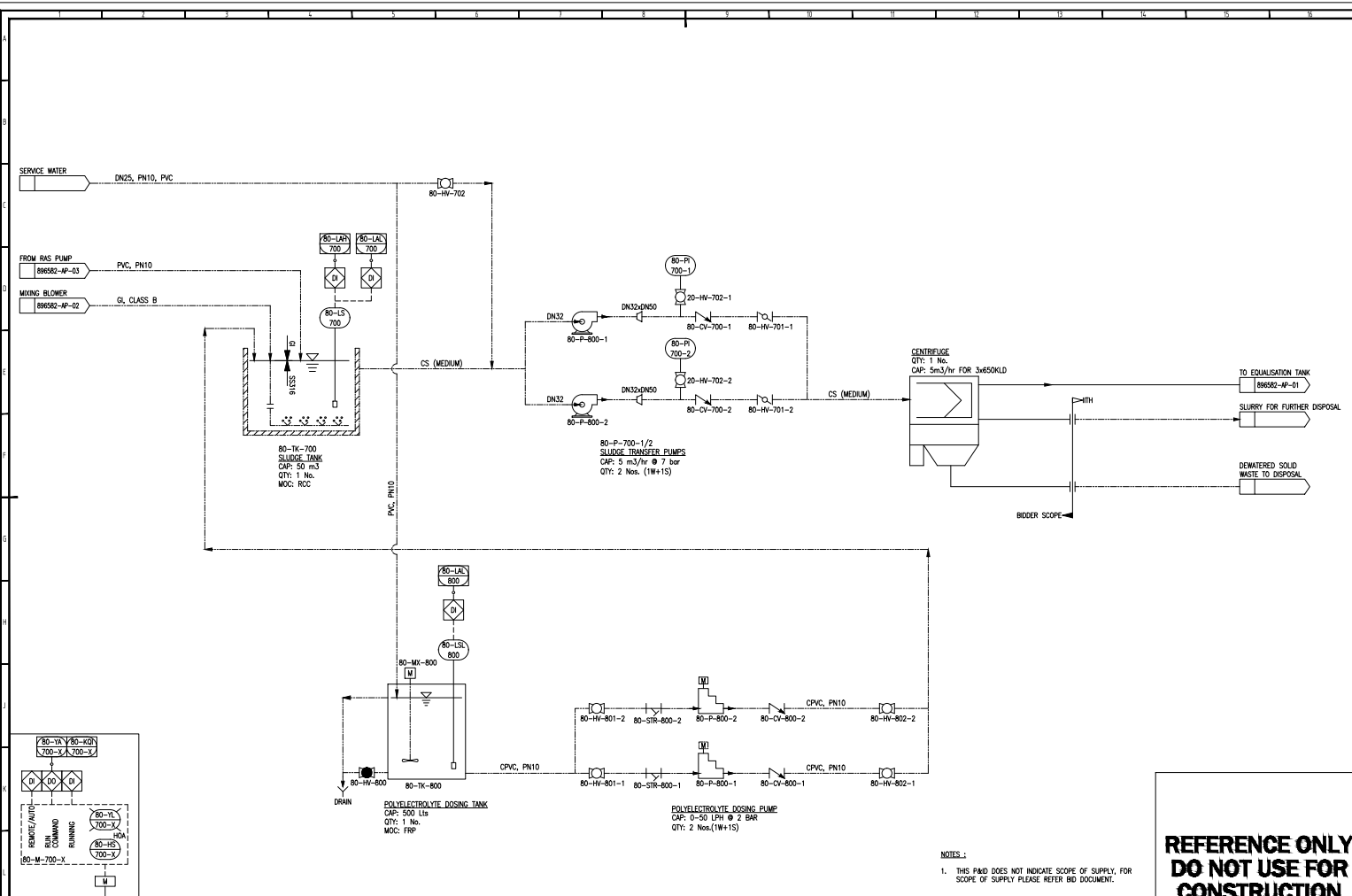
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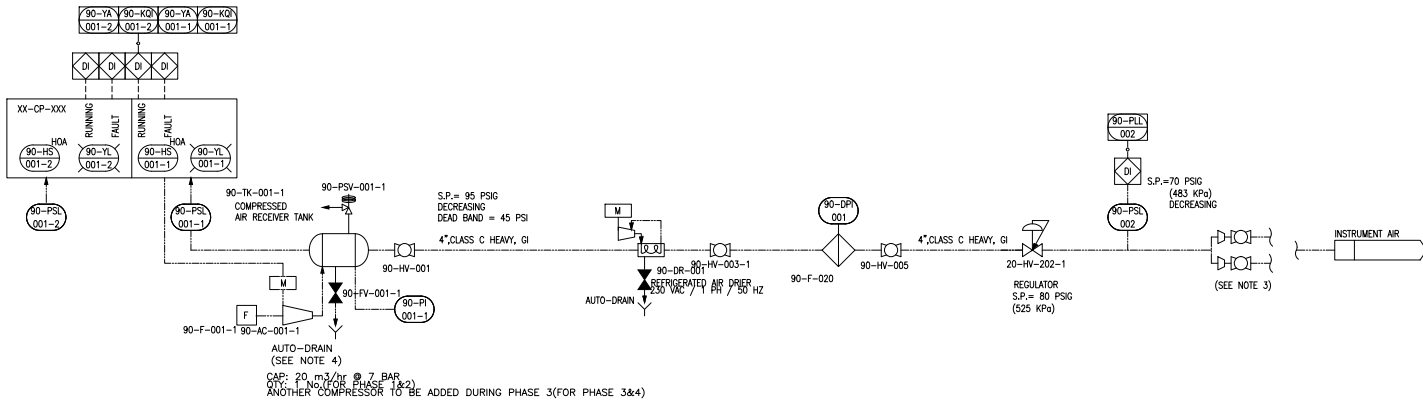


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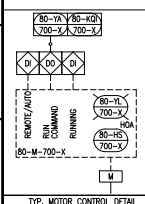
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CHECKED BY: CS
DATE: 08NOV17

APPROVED BY: DNN
DATE: 08NOV17

APPROVED BY: MKC
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Chapter 5

Technical Specifications

Technical Specifications of Membrane, Electro-Mechanical, Instrumentation and other items of STP work

5.1 General Requirements

This part of the IITH requirements sets out the general standards for Membranes/Electro-Mechanical equipment/Instrumentation/Automation/Piping etc. to be used by the Contractor for the works. All equipment used for the works shall, unless otherwise specified, comply with the provisions of this Technical Specification.

5.1.1 Material

All materials incorporated in the work shall be the most suitable for the service conditions and duty concerned. They shall be new and of approved make / approved quality, free from imperfections and selected for long life and minimum maintenance. Nondestructive tests, if called for in the Specification, shall be carried out. All submerged moving parts of the Plant, or shafts and spindles or faces etc. in contact with them shall be of corrosion resistant materials. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall maintain their properties without aging due to the passages of time, exposure to light or any other cause. All materials shall conform to the material standards as per BIS or any equivalent standard. All stainless steel materials used shall be of SS 304/304L as specified.

5.1.2 Workmanship

Workmanship and general finish shall be of first class quality and in accordance with best workshop practice. All welds shall be as per BIS standards. All tolerances and clearances shall be as per good and sound Engineering practices. Should the Engineer-in-Charge not consider any material acceptable, it shall be replaced.

5.1.3 Design Features

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

The equipment shall be designed to provide easy access to and replacement of component parts which are subject to wear without the need to replace whole units. Design features shall include the protection of equipment against damage caused by vermin, dirt, dust and dampness and to reduce risk of fire. Equipment shall operate without undue vibration.

The noise level produced by any equipment like pump sets, compressor sets and blower sets shall not exceed 85 dBA measured at a distance of 3 m from the outer surface of the equipment. At the time of operation, the mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 10816:1995.

Parts shall be designed to withstand the maximum stresses under the most severe conditions of normal service. All rotating elements shall be dynamically and statically balanced.

Table 5.1: Equipment Velocity of Vibration

S. No	EQUIPMENT	Velocity of Vibration (mm/sec)
1	All rotating equipment not having reciprocating parts with motor KW less than or equal to 15 KW	1.12
2	All rotating equipment not having reciprocating parts with motor KW more than 15 KW and less than or equal to 75 KW	1.8
3	All rotating equipment not having reciprocating parts with motor KW greater than 75 KW	2.8

5.1.4 Lubrication

The equipment shall be lubricated by long life lubricants such that working life is not less than 3000 operation hours or as recommended by equipment manufacturer. A complete schedule of recommended oils and other lubricants shall be furnished by the Contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the IITH for approval.

Lubricants shall be oil and grease. The Contractor shall indicate indigenous available equivalent lubricants, with complete specification. Where the lubricant is grease, prefer-

ence shall be given to a pressure system which does not require frequent adjustment or recharging. Preferably, life lubricated grease packed bearings shall be used. Where more than one special grease is required, a grease gun for each special type shall be supplied and permanently labeled.

5.1.5 Name Plates

Each equipment of the plant shall have permanently attached to it a name plate and rating plate in a conspicuous position, Upon these shall be engraved or stamped, the manufacturers name, type and serial number of the equipment, details of the loading and duty at which the equipment has been designed to operate, and such diagrams as may be required by the IITH . All indicating and operating devices shall have securely attached to them or marked upon them designations as to their functions and proper manner of use.

5.1.6 Painting

(i) At Manufacturers Works

The Contractor shall be responsible for the cleaning, preparation for painting, and priming or otherwise protecting, as specified, all parts of the Plant/ Equipment at the place of manufacture prior to packing.

Parts may be cleaned but surface defects may not be filled in before testing at the manufacturers works. Parts subject to hydraulic test shall be tested before any surface treatment. After testing, all surfaces shall be thoroughly cleaned and dried out, if necessary by washing with an approved de- watering fluid prior to surface treatment. Except where the specification provides to the contrary, all painting materials shall be applied in strict accordance with the paint manufacturers instructions.

A primer coat of a zinc rich epoxy resin based coating with at least 75 microns dry film thickness is to be provided. In addition, the parts for wet duty are to be provided with an adequate number of coats of coal tar epoxy polyamine coating to a dry film thickness of 175 microns excluding primer coating.

(ii) At Site

Immediately on arrival at the site, all items of Plant shall be examined for damage to the paint coat applied at the manufacturers works. Any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint. After erection, such equipment/ items which are not finish painted shall be done so. Items that have been finish painted at the manufacturers works shall be touched up for any damaged paint work.

For finish painting, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be at least 25 microns. The dry paint film thickness shall be measured by Elcometer or other instruments approved by the IITH. In order to obtain the dry film thickness specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained.

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

(iii) **Galvanizing**

Wherever galvanizing has been specified, the hot dip process shall be used . The galvanized coating shall be of uniform thickness. Weight of zinc coatings for various applications shall not be less than those indicated below:

- a) Fabricated steel : 460 g/sq. m
- b) Fasteners : 300 g/ sq. m

Galvanising shall be carried out, after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminum paint.

5.1.7 Supports for Pipe Work Valves

All necessary supports, saddles, slings, fixing bolts foundation bolts shall be provided to support the pipe work. Valve and other equipment mounted in the pipe work shall be supported independently of the pipes to which they connect.

All valves to be installed in straight lines shall be installed between the flanges with a dismantling joint or SS expansion bellow at one side of the valve. The dismantling joint must allow a minimum clearance of 20 mm. The pressure rating of the dismantling joint /expansion below shall be same as that of the valve.

5.2 Indicative Ultra Filtration Membrane System Design

General Process Overview

The hydraulic, biological and membrane design shall be based on the sewage characteristics described in the contract.

Domestic sewage from the IIT Campus is collected in the common collection sump of the STP. Then the sewage shall flow through Bar Screens, oil Skimmer and collected in equalization tank.

The homogenized and mixed waste water in the equalization tank shall be pumped through fine screening before entering the MBR.

An internally-fed screen with punched-hole openings less than or equal to 2 mm in diameter with no possibility of bypass or carryover is absolutely required to maintain both membrane protection and optimal MBR operation.

Effluent from the Equalization tank and Return Activated Sludge (RAS) being pumped from the membrane tank must be mixed and fed into the bioreactor tank.

Biological trains shall be equally divided into single/multiple trains on hydraulic loading and shall be operated in parallel. Each train shall comprise of an aerobic tank. The present scope of work includes single train/stream only.

Influent wastewater and re-circulated sludge shall be divided between all the biological trains as it enters each aerobic tank wherever required.

Biological process blowers and fine bubble diffusers in the aerobic tanks shall provide the oxygen required for the biological process as well as the mixing energy required to keep the mixed liquor in suspension. Dissolved oxygen shall be monitored in each aerobic tank to achieve a desired set point of 2 mg/L.

The mixed liquor overflows by gravity from the biological tanks to the membrane tanks where the solid/liquid separation takes place by means of the vacuum created by the process pumps. The permeate is stored in the permeate storage tank.

The mixed liquor from the end of the bioreactor aerobic zone shall proceed by gravity to the membrane filtration basins. At the outlet of each aerobic tank and inlet of each filtration basin there shall be isolation valve. Flow shall proceed by gravity through the valve. The sluice gate valve can be used to either isolate the membrane tank (i.e. during cleans). Plant demand shall be controlled by the feed flow into the system and can be trimmed by the level in the bioreactor/membrane tank.

One permeate pump per membrane train/stream is employed to draw water through the membranes. Treated water flows from the permeate pump to the treated water sump.

Under normal operation and average day flow conditions, permeation is stopped for a specific period of time at regular intervals. This membrane relaxation period, combined with air scouring, effectively removes solids that have accumulated on the membrane surface or within the fibers and reduces electrical costs.

Same permeate pump with valving arrangement are provided for backpulsing the mem-

branes.

From membrane tanks, Permeate pump draws treated effluent through the pores of the membrane fibers and into the backpulse tank. Once full, the treated effluent is automatically diverted away from the backpulse tank to a final disposal point. Clean water (permeate) is suctioned through ZW500D membranes by centrifugal permeate pumps. The membranes are air scoured with required capacity of membrane aeration blowers fitted with Mechanical Variable speed drives.

Waste activated sludge (WAS), shall be removed to the sludge handling facilities via a side stream on the discharge from the membrane tank by pumping in a controlled manner. Further details of the system design are provided below in the following sections.

5.2.1 Major Process Components for MBR system

(i) The plant shall comprise of the following major components (not limited to):

- Coarse and fine Bar screens, Oil and Grease Removal system
- Equalization tank, Mixing system

During recovery clean, no permeate water shall be generated from the membrane train. Hence the equalization tank shall be able to take care of the variable flow rates.

- Bioreactor/Aeration feed pump
- Mechanical Fine Screen 2 mm (Punched Hole configuration)

(ii) The following screening requirements shall be met: Screen raw wastewater with 2 mm punch hole mini screen type Design notes:

(iii) All screen openings are punch hole (dimensions in two directions). Bar or wedge wire fine screens are not acceptable.

- Bioreactor tank
- Fine bubble diffusers for aerobic tanks
- Biological process blowers
- Biological process chemical feed system
- Membrane tank with accessories for installing UF membrane

(iv) A membrane train is a treatment unit consisting of a single or multiple cassettes that are manifolded together, installed in an RCC tank (i.e. membrane tank) and connected to a common permeate pump.

- (v) Within each membrane tank, the cassettes are connected to permeate header and air supply header(s). The permeate header conveys permeate from the cassettes to the permeate pump suction and also delivers cleaning solutions to the membranes. The air headers deliver air to cassette aerators for air scouring to prevent solids accumulation on the membrane surface Design notes:
- (vi) Puddle pipes inside membrane tank to be SS 304 or FRP. Mild Steel is not acceptable.
- (vii) **UF membrane** The hollow fiber membranes shall be ZeeWeed500D membrane modules and cassettes. In the ZeeWeed MBR process, the membrane cassettes are immersed directly in the mixed liquor in the membrane tanks.

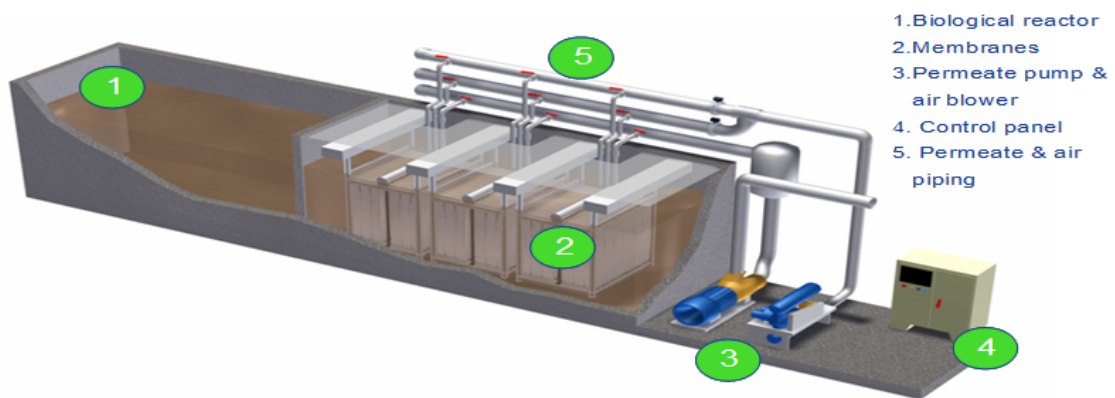


Figure 5.1: MBR System

5.2.2 Permeate pumps/back pulse pumps (process pumps) with VFD

The membrane cassettes in membrane tank are connected to a permeate header, which in turn is connected to the suction of a Permeate/Back-pulse Pump. This set of cassettes, the piping, and the pump is referred to as a membrane train. The vacuum generated by the Permeate Pump draws permeate from the outside in through the membrane fibers. All Permeate/Back-pulse pumps discharge into a common permeate collection header. The train in the plant is operated with a repeating filtration cycle. It consists of two phases: permeation (drawing) of water through the membranes followed by a short period of reverse flow (back-pulsing) or relaxation (no flow). For the proposed membrane filtration system the same pump shall be used for permeate and back-pulse with necessary valving arrangement

Pump parts and MOC:

Casing : CI

Impeller : SS316

5.2.3 Permeate Pump Priming system -Ejector system

After extended standby periods or when a train is first placed into automatic control, an automated valve which connects the top of the membrane train permeate header to an ejector (shown below) and an automated valve which connects the ejector to the Air Compressor opens. The compressed air drives the ejector to create a vacuum that draws air out of the train, pulling water through the membranes until water in the header hits a level switch. This indicates that both valves can be closed to ensure the system is primed and can be placed in operation. To simplify system control the ejector configuration consists of one unit per train and is controlled by PLC. Make of ejector shall be VACCON/PIAB only.

5.2.4 Air Scour Blowers for Membrane Aeration

Whenever a membrane train is in production, membrane aeration blowers shall produce the air scour required to remove solids from the membrane surface and maintain membrane permeability. A specially designed and highly efficient aeration system shall be used to scour the outside surface of the membrane and move mixed liquor solids away from the membrane fibres. This shall be accomplished by a SUEZ/ GE patented aeration system that uses a factory installed aeration grid, which is integrated into the base of each ZeeWeed500D cassette. The integration of diffusers within the cassette simplifies the installation of diffusers and enhances the operation of the membrane unit.

The blowers discharge into the membrane aeration manifolds. This manifold delivers air to the membrane distribution air headers installed above each membrane tank (train).

5.2.5 Conventional Cyclic aeration

For optimal balance between the energy requirements of the membrane aeration blowers and the amount of air scouring provided at the membranes, the system shall be designed to cycle air within each membrane cassette (10:10 mode or 10:30 mode). Each cassette is equipped with two air connections; one air connection from each cassette is connected to one of two air headers at each membrane tank, using a flexible hose. Airflow is cycled from one train header to the other (using pneumatic valves) so that half of each cassette is aerated at a time.

5.2.6 Recirculation Pump (RAS pumps) & Membrane tank Drain pump

The membrane tanks need to be drained for recovery chemical cleaning or other maintenance procedures. This can be achieved by using the above mentioned mixed liquor recirculation pumps (RAS Pumps).

5.3 Membrane system operation modes & Cleaning processes

Operation modes

The sections below highlight the main operational, control aspects and cleaning processes of the membrane system. **Off, Permeation and Stand-by Modes** Off Mode

In OFF mode, devices are off. However, for membrane protection, to ensure the membranes are submerged the feed valves are opened. When the water level is above the membranes the feed valves are closed.

Filtration/Production/Permeation Mode

Filtration, or permeation, consists of drawing clean water from the mixed liquor through the membrane fibers via the permeate pump.

Water is produced from each train during the filtration period for duration of 11 minutes, followed by a 30 second relaxation. There is permeate/process pump per train with 50% standby pump for filtration purposes. The vacuum generated by the permeate pump draws permeate from the outside-in through the membranes and discharges it to the Permeate Storage Tank. The variable speed pumps are controlled by PLC to maintain the permeate-flow demand. The PLC continuously runs a PID loop for Trans Membrane Pressure (TMP) while in production. The PLC uses the lower of the control outputs from the flow loop and TMP loop. All the permeate pumps are controlled at the same flow set points and are complete with premium efficiency VFD rated motors and discharge flow meter. Maximum pump capacity for permeation is achieved at the highest design level in the process tanks. All pump speeds shall gradually decrease as the liquid level in the process tanks decreases. If during low flow conditions this level drops below the design minimum, and the pumps cannot be slowed down any further, one or more trains shall automatically go into standby mode.

During or below average day flow conditions, all trains shall be in operation provided any trains are not required to go into stand-by mode. All permeate pumps and Mixed Liquor

RAS pumps shall be operating.

All permeate pumps shall discharge into a common permeate collection header. The Permeate Storage Tank and the Back-pulse Tank are both fed from the common permeate header.

Cleaning and Maintenance Procedures
As the feed is drawn through the membranes during filtration, solids are removed which accumulate on the membrane surface. As the solids accumulate, they restrict the flow through the membranes and eventually membrane cleaning is required in order to maintain the filtered water flow rate.

Membrane cleaning is absolutely critical to ensure sustainable operation over the life of the plant regardless of membrane type. Membrane cleaning features shall include the following: Membrane Air Scouring: used as a mechanical cleaning action, and shall be the most energy efficient membrane air scouring method in the industry.

Relax mode Back-pulse Ability: The ability to ensure an even distribution of chemicals across the fibers through back-pulsing under pressure. This reduces the potential for preferential flow of cleaning chemicals.

Cleaning: The ability to clean not only the inside of the membrane surface with maintenance cleaning, but also the outside of the surface with recovery cleaning.

Ability to clean quickly and easily through fully automated processes such as relaxation, back-pulsing, maintenance and recovery cleaning.

5.4 Membrane Performance

The multi-level approach to maintaining membrane performance is summarized in the following sections.

Membrane Scouring by Aeration Whenever a membrane train is in production, membrane scour aeration is required to maintain consistent permeability of the membrane.

Specially designed highly efficient coarse bubble aeration is used to scour the outside surface of the membrane and move mixed liquor solids away from the membrane fibers. This is accomplished by a SUEZ/ GE patented aeration system that uses a factory installed coarse bubble aeration grid which is integrated into the base of each ZeeWeed 500D cassette.

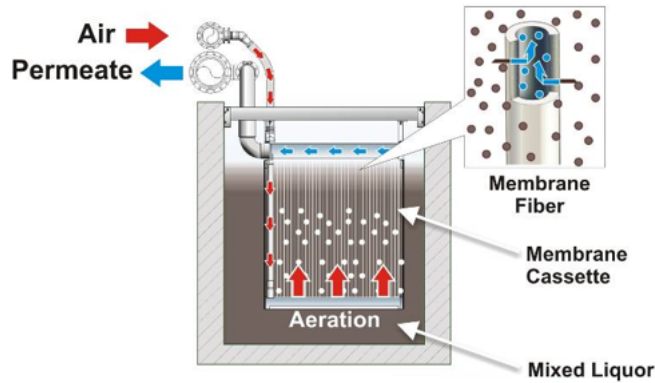


Figure 5.2: Schematic Representation of Aeration

The membrane cassette is aerated to provide a mechanical cleaning action. This air scour removes foulants that may deposit on the outside of the fiber, maintaining membrane permeability. The aeration also minimizes the effect of concentration polarization which is recognized as a significant membrane fouling mechanism.

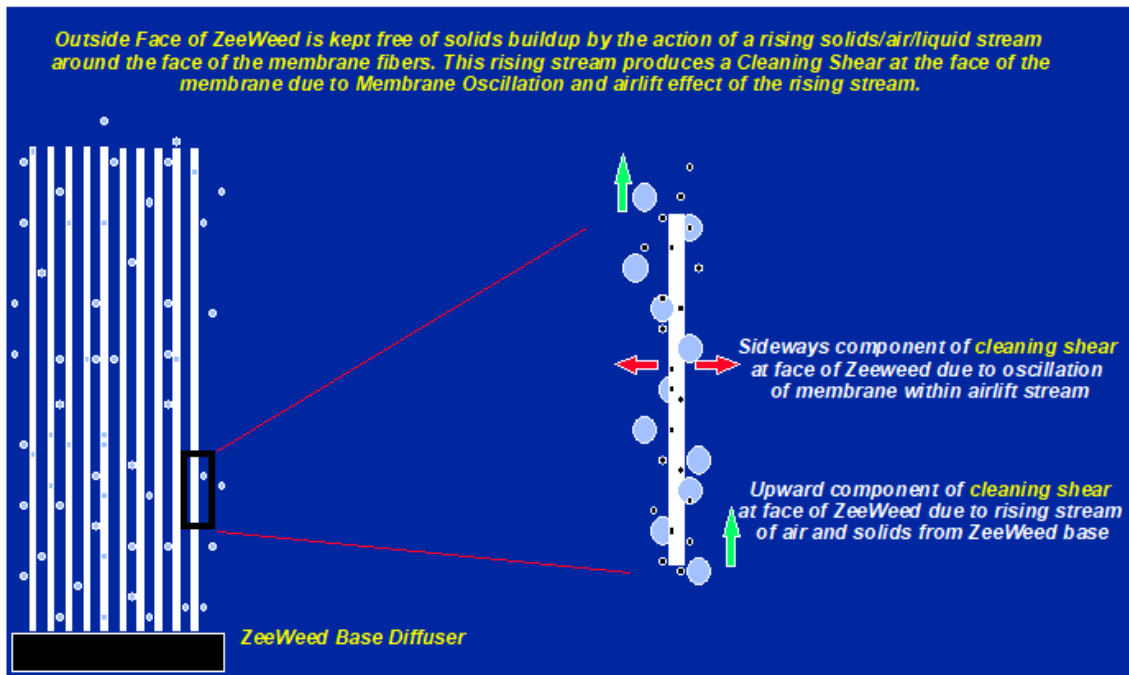


Figure 5.3: Schematic Representation of Air scour

The system shall be designed to supply Air to each air header of a membrane train at 10 seconds ON and 10 seconds OFF (10:10) aeration mode. A 10 to 30 seconds aeration mode shall be operated during normal operation of the plant resulting in overall decreased aeration energy consumption. The process shall be PLC-automated and provide among the lowest MBR energy consumption without sacrificing any performance.

Relaxation

Relaxation mode combined with air scouring is the routine cleaning mode during normal production. The combined stoppage of permeation and air scouring effectively removes solids that have accumulated on the membrane surface or within the fibers and reduces electrical costs.

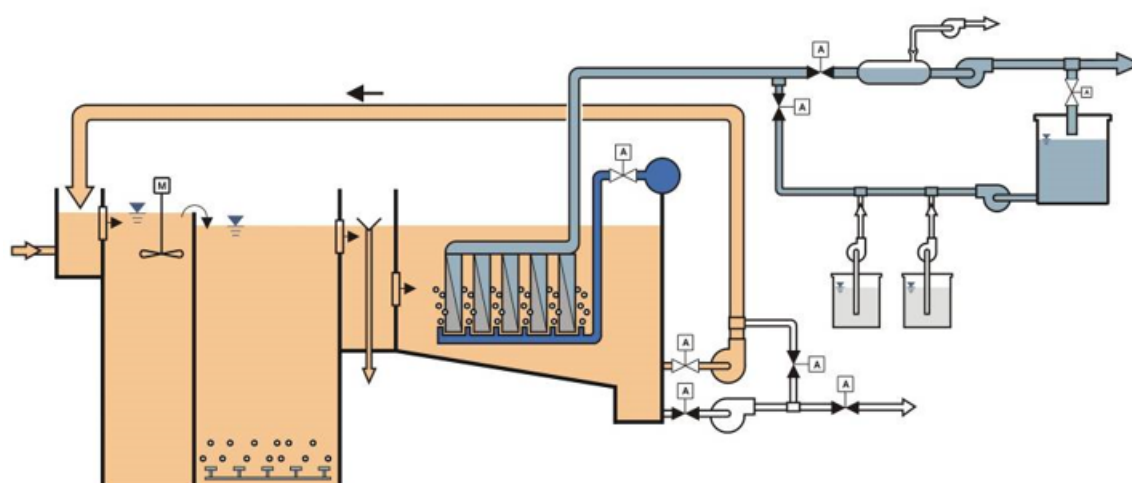


Figure 5.4: Schematic of Process Flow

While operating in relaxation mode, permeation for each train is stopped sequentially for a short period of time (30-60 sec) every 10-12 minutes to allow air scouring of the membranes without permeation. No chemical or permeate is used during relaxation mode. This is the normal operating mode of ZeeWeed MBR systems. The relaxation function shall be fully automated by the PLC with no contractor intervention.

Back-pulse or Backwash Back-pulsing is a cleaning tool which allows for reliable system performance during unexpected influent or process operating scenarios. Back-pulsing involves reversing the flow through the membranes to dislodge any particles that may have adhered to the membrane surface. As with relaxation, the back-pulse functionality is fully automated by the PLC with no need for contractor intervention.

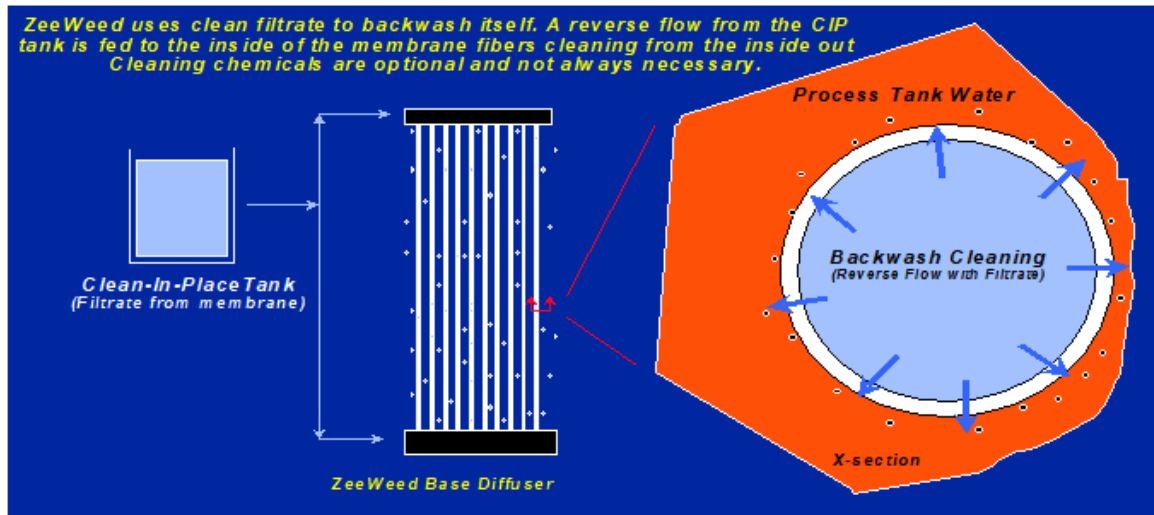


Figure 5.5: Schematic of Back Wash

The back-pulse system has also been incorporated into the automated membrane cleaning systems included in the proposed design. Back-pulsing is particularly critical for efficient membrane cleanings. Without back-pulse, deep chemical cleaning of membrane pores is impossible for any type of membrane, and can run the risk of membranes becoming deeply and irreversibly fouled with organic matter.

The back-pulse tank is automatically filled with permeate which is used for the back-pulse process. If required, hypochlorite may be added to the back-pulse tank to maintain a concentration of ≤ 5.0 mg/L to prevent bacterial growth.

Maintenance Clean Over time, the membranes can experience fouling caused by accumulation of organic matter or crystallized salts within the membrane fiber pores. Cleaning of the membranes in this circumstance to restore the permeability requires use of a Clean-In-Place system.

Clean-In-Place (CIP) membrane cleaning is a standard operational procedure for most membrane systems including the ZeeWeed system.

A maintenance clean is a regularly scheduled, fully automated cleaning that involves an extended back-pulse combined with low concentration of chemical addition. Maintenance cleans are intended to maintain membrane permeability and extend the time between recovery cleans.

The maintenance cleaning procedure is entirely automated and shall be scheduled to occur during off-peak hours of the day. The ZeeWeed membrane filtration system includes the capability to perform maintenance cleans using sodium hypochlorite (NaOCl) and citric acid to target organic and inorganic foulants respectively.

The maintenance cleaning procedure shall incorporate the following features:

Fully automated;

Performed without draining the membrane tank;

Low chemical concentration.

A maintenance clean consists of a series of short back-pulses with chemical solution, followed by a back-pulse with only permeate to flush the headers and membranes.

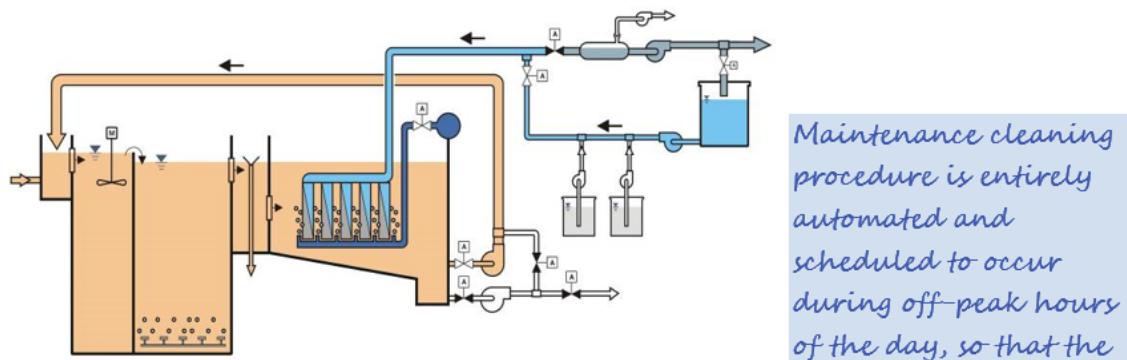


Figure 5.6: Schematic of Maintenance Clean

Recovery Clean:

Recovery cleaning is required to restore the permeability of the membrane once the membrane becomes fouled. The recovery cleaning procedure consists of a chemical back-pulse sequence, followed by a chemical soak period.

Key features of the recovery cleaning procedure for ZeeWeed MBR shall be:

- Fully automated once initiated by the contractor;
- Cleans all membrane cassettes in a train at the same time;
- Requires moderate chemical concentration
- Thoroughly cleans the surface of the membrane

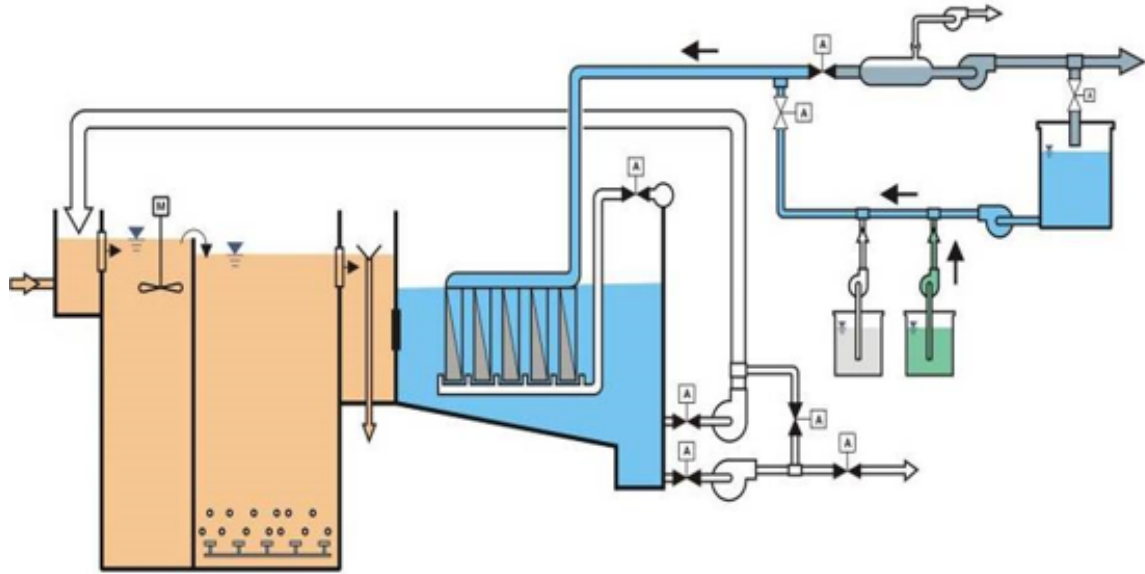


Figure 5.7: Schematic of Recovery Clean

5.5 System Design Details

The proposed MBR system shall be designed based on the design criteria and assumptions summarized in the previous sections above in consultation with Technology Provider.

Biological Process Design

Criteria for biological design based on the design flow and loading conditions shall be as mentioned in below table. Based on the influent characteristics, process configuration shall be selected .

Table 5.2: Biological Process Design Overview for STP

Parameter	Train -1 (650 KLD)	Units
Flow Basis of Biological Design	650	KLD
No of Biological train(s)	1	No(s)
*Anoxic Working Tank Volume	91	Cum
*Aerobic working Tank volume	202	Cum
*Total Biological Tank volume	293	Cum
*The volumes mentioned above are hydraulic volumes		

The table below lists the indicative main design assumptions and outputs at the design temperature for the average day flows for 1 train of 650 KLD.

Table 5.3: Biological Process Design Details for 650 KLD (Typical)

Parameter	Average Day	Units
Temperature	25	C
Design Bioreactor MLSS 1	8000	g/L
Design Bioreactor MLVSS/MLSS 2	45.3	%
Total HRT (Including Membrane Tank)	12.04	Hours
Total SRT	18.56	Days
Approx. sludge waste rates(from membrane tank)	14.3	Cum/day
Total Oxygen requirement for Aerobic Zone / bioreactor	270	kg/day

Notes:

1. Bioreactor MLSS refers to the MLSS in the aerobic zones.
2. MLVSS/MLSS ratio values obtained based on assumptions made by Technology Provider

The design shall be based on inlet BOD value for STP mentioned.

The sludge waste rates etc. are based on sludge yields assumed by Technogy Provider and have to be verified during detail engineering.

5.6 Ultrafiltration System Design

The membrane ultrafiltration system shall be designed to treat the design flows at the minimum mixed liquor temperature. The membrane system is designed to treat all flow with one train in operation with individual membrane modules assembled in cassettes and cassettes are installed in RCC membrane tank. Please refer to table below for details of the membrane system.

Table 5.4: Membrane System

Parameter	Phase -1	Units
Type of Membrane	ZeeWeed 500D	-
Surface area of each Module	370 (34.37)	ft2 (m2)
Number of membrane Tanks	1 nos. for 650KLD each	Nos.
Number of 48Module cassette installed per train	1 Nos	Nos.
Number of modules required per cassette	30 nos Modules Filled in 48 Module capacity Cassette for 650KLD	Nos.
Net flux (max)	30	Lmh (Litre/sqm/hour)

5.7 Control Narrative

5.7.1 Coagulant, Acetic Acid Dosing Control

5.7.1.1 Coagulant Dosing

Coagulant is dosed for phosphorus removal. There are two Coagulant dosing pumps one Working and one Standby. The pumps rotate on the duty cycle timer. The duty cycle of

the pumps can be set on the HMI. The stroke adjustment on the pumps is manual; it will be set during the commissioning. Further optimization of the pump stroke can be done during plant operation.

The PLC will request a coagulant dosing pump if one of the bioreactor feed Pump is running. If the running bioreactor feed pump stops, coagulant dosing pump will continue to run for 5 minutes and stop. It will start back again if one of the bioreactor feed pump starts running.

There is low level switch in the dosing tank, to provide feedback to the PLC for alarming on the HMI. The operator can take necessary action of loading the chemical in the tank. The pump running is interlock with the low switch. If the level low alarm is active the pump will stop.

5.7.1.2 Acetic Acid Dosing

Acetic Acid is dosed in the post-anoxic tank as a carbon source. There are two acetic acid dosing pumps one Working and one Standby. The pumps rotate on the duty cycle timer. The duty cycle of the pumps can be set on the HMI. The stroke adjustment on the pumps is manual; it will be set during the commissioning. Further optimization of the pump stroke can be done during plant operation.

The PLC will request an acetic acid dosing pump if one of the bioreactor feed Pump is running. If the running bioreactor feed pump stops, acetic acid dosing pump will continue to run for 5 minutes and stop. It will start back again if one of the bioreactor feed pump starts running.

There is low level switch in the dosing tank, to provide feedback to the PLC for alarming on the HMI. The operator can take necessary action of loading the chemical in the tank. The pump running is interlock with the low switch. If the level low alarm is active the pump will stop.

5.7.2 ZeeWeed UF Train Modes States of Operation

A UF train is functionally described as a group of ZeeWeed modules and cassettes connected by a common permeate collection header.

Each UF Train is sequenced by the PLC. The sequencing of each Train can be described by the mode and state of the Train. Each Train is in one and only one mode and one and only one state at any given time.

Buttons displayed on the HMI screen that the operator can press to initiate a mode or state or other operation are shown with the first letter capitalized. For example, one button that is used to put a train to the OFF mode is the Off button.

The specific sequencing of Modes and States and the steps involved are detailed in the OSC

5.7.3 Production Cycle

The Production Cycle is the alternation of the trains states between PRODUCTION and BACKPULSE.

This alternation is controlled by a timer.

5.7.4 ZeeWeed UF Train Modes

Modes define how the transitions occur for a Train from one operating state to another. A specific mode discussed in this document is shown in capital letters, such as AUTO. Modes can only be selected by the operator, using pushbuttons on the HMI. The mode button Semi-Auto is available in all states. The Off mode button is available in all states except OFF. The Auto mode button is available in all states except MAINTENANCE RECOVERY CLEANS. The modes of each UF Train are described in the following sections.

5.7.4.1 AUTO Mode

This is the normal mode of operation for a UF Train for production of clean water.

For the train equipment to operate automatically, the operator needs to have all related devices set to AUTO and the train set to AUTO. The operation of the train is automatic when in AUTO, and there is minimal operator attention required unless an alarm is activated.

In AUTO mode, the train changes state between the Production Cycle and STANDBY according to train start stop triggers, which are based on the membrane tank operating level. Please refer CLC for the membrane operating level.

5.7.4.2 OFF Mode

This mode immediately places the Train to OFF state and prevents the operator from manually selecting other states until the Train is placed in another mode.

The operator may turn a train OFF at any time. Pressing the Off button places the train into OFF mode and OFF state. It is the responsibility of the operator to ensure that if the Off button is pressed when a train is in a clean, the tanks contents are suitable for a train to proceed to another mode.

5.7.4.3 SEMI-AUTO Mode

This mode safely places the Train to OFF state, but permits the operator to manually select other sequences such as a Backpulse, Maintenance Clean, and Recovery Clean. Upon completion of a sequence, the Train will return to the OFF state and wait for further operator selection.

5.7.5 UF Train States

States are a series of steps the train follows to perform various operations, such as producing water. A specific state discussed in this document is shown in capital letters, such as PRODUCTION. The states available to each train are: OFF, PRIME, STANDBY, PRODUCTION, BACKPULSE, MAINTENANCE CLEAN, and RECOVERY CLEAN. Each of these states is discussed further in the following sections of the Control Narrative and detailed sequencing information is available in the OSC.

5.7.5.1 State Interlocks

The train proceeds to the selected state once the resources are available. There are interlocks preventing more than one train from entering the same state at the same time.

The state interlocks are:

Only one train can be in Prime at a time;

Only one train can be in Backpulse at a time;

Only one train can be in MAINTENANCE CLEAN, RECOVERY CLEAN at a time.

5.7.6 Priming System Control

Each train is provided with an ejector, which uses compressed air to operate and primes the permeate piping in PRIME and at the beginning of STANDBY, BACKPULSE, MAINTENANCE CLEAN, RECOVERY CLEAN.

The trains ejector compressed air valve opens which also opens the permeate header isolation valve. During this time, air in the permeate header is pulled up and out through

the ejector, which also pulls water into the membranes and Permeate pump suction. Any water that is drawn into the ejector drains out by gravity.

The PRIME state is used to remove air from the suction of the Permeate pump. A train proceeds to PRIME after the Auto button is pressed in the OFF state. The ejector operates for typically 60 seconds, a longer duration than what is used for intermittent operation, and the duration is adjustable at the HMI.

Trains are intermittently primed in STANDBY for an adjustable duration default is 15 seconds. The duration of the Master Ejector Cycle timer is adjustable and the default time is 8 minutes. The Master Ejector Cycle timer operates as long as there is at least one train in STANDBY, with a time assigned for each train when the ejector operates, provided the train is in STANDBY.

The operator can manually initiate PRIME by pressing the Prime button at the HMI. The Prime button is available in SEMI AUTO and the state OFF.

5.7.7 Standby and the Production Cycle

The UF trains switch between Standby and the Production Cycle based on Start Stop Train Triggers.

The Start trigger is based on the membrane tank operating level.

5.7.7.1 Standby

The steps for the STANDBY are:

1. Fills the membrane tank to a level above the membranes;
2. While a train is in Standby intermittently the ejector runs based on priming timers; the membranes are aerated based on the frequency and duration aeration timers. The train remains in this step until one of the following is active:
 - a start trigger;
 - maintenance clean request;
 - backpulse button is selected;
 - Prime button is selected.

5.7.7.2 Production

In Production, the train is producing permeate. The steps for the PRODUCTION are:

- (a) Align the valves;
- (b) The Permeate/Backpulse starts and runs until the production cycle timer triggers one of the following: BACKPULSE can be triggered by either the pushbutton or a scheduled time.

5.7.7.3 Backpulse

Treated water is periodically reversed back through the membranes to maintain stable transmembrane pressures.

The steps for the BACKPULSE are:

1. Stops the permeate/backpulse pump;
2. Align the valves;
3. Starts the permeate/backpulse pump and it runs for the backpulse duration time.

The water is drawn from the backpulse tank and pumped through the membranes into the membrane tank.

4. Stops the permeate/backpulse pump;

5. After the BACKPULSE is complete and if the membrane tank level is ok for the Production the train proceeds to PRODUCTION. After the BACKPULSE is complete and if the membrane tank level is below operating setpoint the train proceeds to STANDBY.

The PLC controls the permeate/backpulse pump speed to backpulse the trains at a set flow rate per train up to a maximum TMP. A transmitter on the membrane header is used to calculate the BACKPULSE TMP. This TMP limit provides membrane protection against over-pressurization. If the TMP is too high, the TMP high trigger is active and the flow control PID loop output is captured. This value becomes the maximum value for the output of the flow control PID loop.

When the TMP high trigger becomes active, the PLC gradually reduces the maximum for the flow PID loop output until the TMP high trigger is not active, (i.e., TMP is less positive). At the moment when the TMP high trigger becomes inactive, the maximum value is then gradually increased until the TMP high trigger is active again, or continues to increase until the maximum value for the flow control PID loop output equals 100%. This control strategy allows the PLC to vary the pump speed to maximize flow while avoiding excessive TMP across the membranes.

The Operator can enable or disable the TMP limiting function from the HMI. If the TMP limiting function is disabled the PID Output won't be limited. It will vary from 0-100

The backpulse duration, production cycle duration, TMP setpoint and flow setpoint for all UF trains can be set through the HMI. All UF trains in the plant share the backpulse duration, production cycle duration, TMP setpoint and flow setpoint.

The operator can initiate a BACKPULSE from the HMI for any UF train by pressing the Backpulse button. This button is disabled if any other train is in BACKPULSE.

Low and High Level switch is located in Back pulse tank to provide the level feedback to PLC. If the Level switch 20-LS-601 Low is active during backpulse the Process pump stops and the ZeeWeed continues without any back pulse. Refer CLC for further details.

High Level switch controls the opening of the Valve 20-FV-601. 20-FV-601 will open if the backpulse level high alarm is not active.

5.7.8 Membrane Tanks Level Permeate Flow Control

Flow set point will be entered for the ZeeWeed manually. The supervisor can do this by setting the production flow rate of the ZeeWeed on the HMI. The system will maintain the entered production flow rate up to a maximum Trans Membrane Pressure (TMP) or an operating membrane tank level.

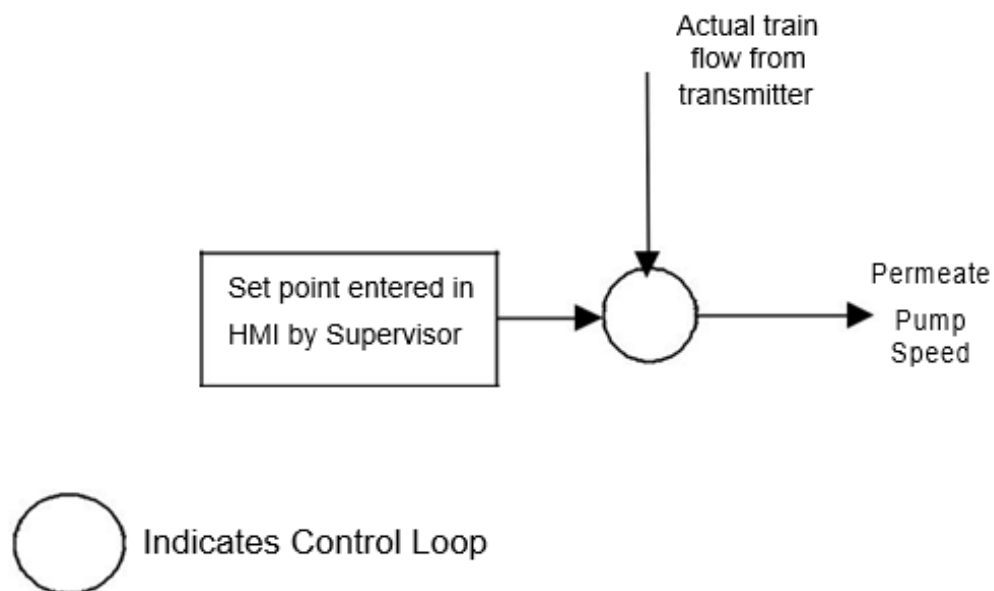


Figure 5.8: Schematic of Recovery Clean

5.7.9 Production Trans Membrane Pressure (TMP)

Trans Membrane Pressure is the differential pressure across the membranes as measured by the level transmitter in the membrane tank and pressure transmitter on the permeate header. In PRODUCTION, the process pump draws the water through the membranes so the pressure in the permeate header is lower than on the outside of the membranes resulting in a negative value for TMP. During BACKPULSE and backpulsing steps in CIP the water is flowing in the opposite direction so the pressure in the permeate header is higher than the outside of the membranes resulting in a positive value for TMP.

5.7.9.1 TransMembrane Pressure (TMP) Calculation

TMP is calculated by using the equation below. During PRODUCTION the value is negative, for backpulses and CIP, it is positive.

$$\text{TMP} = \text{Header Pressure} + C \times (\text{A} + \text{B} - \text{Membrane Tank Level})$$

Where:

A is the height of the pressure transmitter above the top of the membranes.

B is the height to the top of membranes in the membrane tank.

C is a conversion factor (water depth to pressure); consult the CLC for the value.

In PRODUCTION, an increased TMP value means a larger pressure differential because the pressure inside the membranes is lower than outside the membranes. This corresponds to a lower number as expressed in engineering units. Therefore a high production TMP is actually expressed as a Pressure Differential Alarm Low Low.

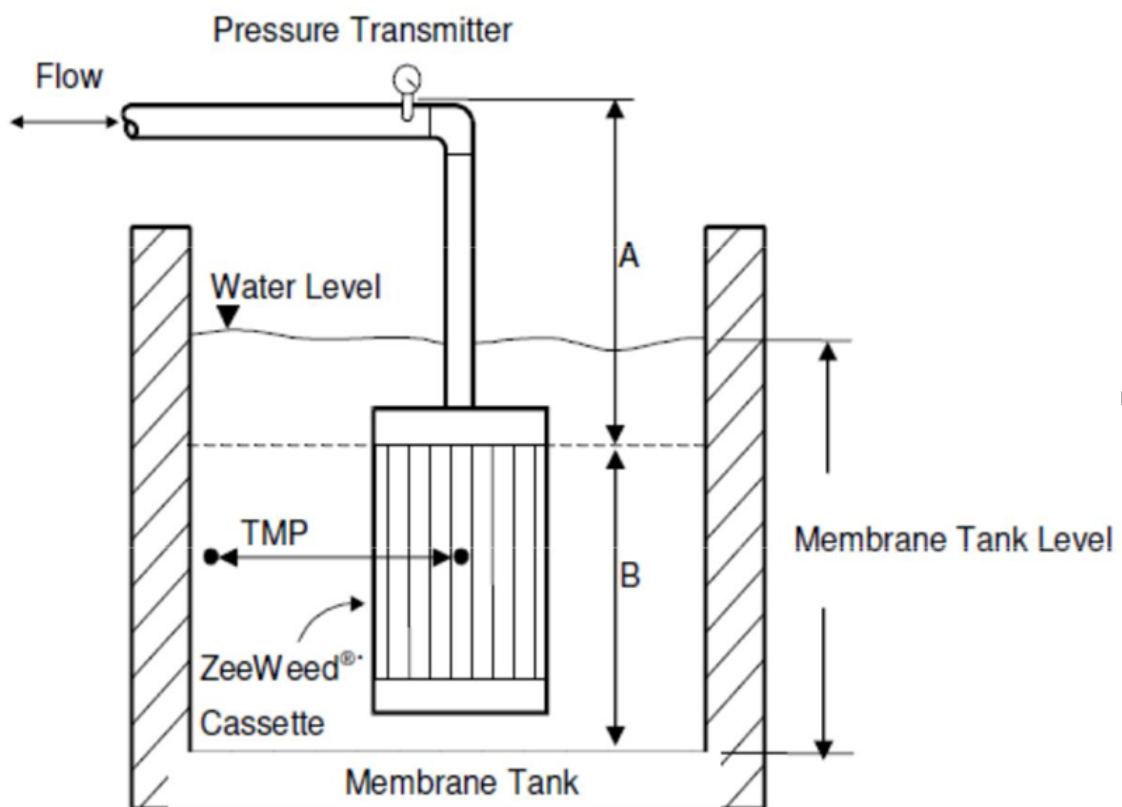


Figure 5.9: TMP Flow Chart

5.7.9.2 TMP Limiting the Permeate/Backpulse Pump Speed

The PLC continuously calculates the TMP value while in PRODUCTION. If the TMP is too low, (i.e., too negative) the TMP low trigger is active and the flow control PID loop output is captured. This value becomes the maximum value for the flow control PID loop output.

When the TMP low trigger becomes active, the PLC gradually reduces the maximum for

the flow PID loop output until the TMP low trigger is not active, (i.e., TMP is less negative). At the moment when the TMP low trigger becomes inactive, the maximum value is then gradually increased until the TMP low trigger is active again, or continues to increase until the maximum value for the flow control PID loop output equals 100%. This control strategy allows the PLC to vary the pump speed to maximize flow while avoiding excessive TMP across the membranes.

The Operator can enable or disable the TMP limiting function from the HMI. If the TMP limiting function is disabled the PID Output wont be limited. It will vary from 0-100

5.7.10 Start Stop Train Triggers

The trains in operation at any given time varies depends on a Start, Stop train trigger. When Start trigger is active, a train switches from STANDBY to PRODUCTION. When a Stop train trigger is active, a train switches from PRODUCTION to STANDBY. The Start,Stop trigger is based on the operating tank level in the membrane tank . The setpoint values for these triggers are defined in the CLC.

5.7.11 Permeate/Back pulse Pump

There are two Permeate/Backpulse Pump two working one dedicated pump for each train and one store standby. Each working Pump has a dedicated VFD for Flow Control. There are two set point entered by the operator one for Permeating and one for Backpulse. The PLC will start and stop Pumps as necessary based the OSC. The Permeate/Backpulse pump is interlocked by low level alarm in Membrane Tank during PRODUCTION or low level alarm in backpulse tank during back pulse.

Discharge of the Permeate/Backpulse pump is equipped with the flow transmitter. There will be three totalizer derived from the transmitter operator resettable Net totalizer, daily totalizer and non-resettable totalizer

5.7.12 Sodium Hypochlorite Dosing Permeate Line

Sodium hypochlorite is dosed in the permeate line for organic removal. There are two Hypo dosing pumps one Working and one Standby. The pumps rotate on the duty cycle timer. The duty cycle of the pumps can be set on the HMI. The stroke adjustment on the pumps is manual; it will be set during the commissioning. Further optimization of the pump stroke can be done during plant operation.

The PLC will request a Hypo dosing pump if one of the UF is in production.

There is low level switch in the dosing tank, to provide feedback to the PLC for alarming on the HMI. The operator can take necessary action of loading the chemical in the tank.

The pump running is interlock with the low switch. If the level low alarm is active the pump will stop.

5.7.13 Membrane Aeration Control

There are three membrane aeration blower two working and one selectable standby blower. The standby selection of the standby blower i.e. 20-B-200-2 is done at the HMI. The blower will start stop as required per the OSC.

A low air flow switch is located on the discharge of each blower, for blower protection. If the switch is active, an alarm occurs and the PLC changes the lead to the next available blower. If there is no other blower available, a different alarm occurs and the PLC shuts down the respective train.

There are selection button available on the HMI for selectin the standby blower. Blower 2 can be only be standby for Blower 1 or Blower 3 which is operator selectable on the HMI. Every time the selection is changed there will be pop up on the HMI for valve confirmation by the operator.

Post Anoxic tank is also aerated using the membrane blower. This can be achieved by opening either respective manual valve.

5.7.14 Turbidity

Integrity of the ZeeWeed is monitored with on-line turbidity meter when it is in PRODUCTION.

There are three manual valve one for each ZeeWeed permeate line and one for common header.

Depending upon the valve opening the analyzer will monitor the selected line for measuring.

The turbidity alarm set points are adjustable at the HMI. The time delays before the alarms become active are not adjustable.

5.7.15 ZeeWeed UF Train Triggers Alarms

5.7.15.1 ZeeWeed Triggers

A trigger is a normal event that can clear an alarm or be one of several points in a sequence of events.

5.7.15.2 ZeeWeed Alarms

Alarms are used to identify a problem with the system. Depending on the nature of the problem the alarm may either put the ZeeWeed, to STANDBY, or initiate a callout to notify the operator that there is a problem. It is understood that the operator will acknowledge

the alarm and address the situation. If the problem is not corrected, production quality and quantity will drop off quickly.

An alarm that is activated by an instrument, pressure transmitter, flow transmitters, or level instrumentation, typically requires a pump or certain device to be on to generate the required flow or pressure. Otherwise, the alarm will be ignored if the device to be protected is off.

All alarms are indicated with a message on the screen. The operator cannot reset the alarm without the correct password. All alarms and the time they occurred are recorded on the alarm history screen.

Devices which are being controlled remotely cannot have their status changed by the PLC.

Consult the CLC for details on specific alarms, the corresponding actions and reset procedures.

Typical alarms that shutdown a train are listed in the following table.

Table 5.5: Alarms

Alarm Description	Possible Causes for Alarm	Reset
High Flow Alarm - permeate	Suction disconnecting from fittings.	Alarm reset button
Low Flow Alarm - permeate	Loss of prime of process pump	Alarm reset button
Pressure High-High Alarm permeate (measured by pressure Transmitter)	Suction disconnecting from fittings.	Alarm reset button
Transmembrane Pressure Low,Low	Fouled UF membranes	Alarm reset button
Process pump Fault	VFD Fault	Alarm reset button
Compressed Air Low pressure	Insufficient Compressed Air Supply to operate pneumatically actuated valves	Automatic restart with sufficient compressed air pressure
Low Level Alarm membrane tank	Permeate flow rate is higher than the Feed flow rate	Automatic restart when the membrane tank is above a setpoint
Power Failure	Tripped breaker inside panel	Automatic restart after power is restored

5.7.16 ZeeWeed Cleaning

The membranes require cleaning to maintain performance. There are two types of cleaning methods; MAINTENANCE CLEANS and RECOVERY CLEANS.

Both MAINTENANCE CLEANS and RECOVERY CLEANS are operator initiated and should have the operator present during the majority of the clean. The maintenance cleans are short pulses chemical through the membranes without emptying the mem-

brane tank. These pulses with chemical are used to prevent biological growth inside the membranes and reduce the required frequency of recovery cleans.

Recovery Cleans are operator initiated and should have the operator present during the majority of the clean. The recovery cleans commonly occur only twice a year with sodium hypochlorite and twice a year with citric acid to remove fouling or scaling of the membranes.

5.7.16.1 Sodium Hypochlorite Cleaning Equipment

Sodium hypochlorite is used to remove organic contaminants from the membranes. The PLC will request a sodium hypochlorite pump for MAINTENANCE CLEANS and RECOVERY CLEANS per operator selection, to run in specific steps during the cleaning procedure. The stroke adjustment on the pump

is manual; it will be set during the commissioning. Further optimization of the pump stroke can be done during plant operation.

Consult the OSC for these steps.

There is low level switch in the dosing tank, to provide feedback to the PLC for alarming on the HMI. The operator can take necessary action of loading the chemical in the tank. The pump running is interlock with the low switch. If the level low alarm is active the pump will stop.

5.7.16.2 Citric Acid Cleaning Equipment

Citric acid is periodically used to remove inorganic contaminants from the membranes. The PLC will request a citric acid pump for MAINTENANCE CLEANS and RECOVERY CLEANS per operator selection, to run in specific steps during the cleaning procedure. The stroke adjustment on the pump is manual; it will be set during the commissioning. Further optimization of the pump stroke can be done during plant operation.

Consult the OSC for these steps.

There is low level switch in the dosing tank, to provide feedback to the PLC for alarming on the HMI. The operator can take necessary action of loading the chemical in the tank. The pump running is interlock with the low switch. If the level low alarm is active the pump will stop.

Citric Acid tank is provided with a mixer. The mixer will run if the level is not low in the citric acid tank.

It will stop in case of routine maintenance or failure or operator stops it in manual.

5.7.16.3 Maintenance Clean

Maintenance Cleans are operator initiated. During a Maintenance Clean there are several prompts which the operator must address. Consult the OSC and CLC for further details. As a result it is suggested to have the operator present during the Recovery Clean so that these prompts can be responded to in a timely manner.

The operator is required to turn the train in SEMI AUTO mode. The cleaning solution for MAINTENANCE CLEANS is either citric acid or sodium hypochlorite. The operator selects either M. Clean with Citric Acid button or M. Clean with Sodium Hypochlorite button to select the cleaning mode and the type of cleaning solution.

The default steps for Maintenance Clean are:

1. Aerate the membrane tank.
2. Close the feed Sluice gate.
3. Initial backpulse with chemical cleaning solution.
4. Relaxation period for all cassettes for a defined duration
5. Repeated Backpulse with chemical cleaning solution. Shorter pulse duration than step 2.
6. Relaxation period for all cassettes for a defined duration.
7. Repeats step 4 to 5 for pre-set number of iterations.
8. Aerate the membrane tank.
9. Open the feed sluice gate.
10. Proceeds to STANDBY.

5.7.16.4 Recovery Clean Controls

Recovery Cleans are operator initiated. During a Recovery Clean there are several prompts which the operator must address. Consult the OSC and CLC for further details. As a result it is suggested to have the operator present during the Recovery Clean so that these prompts can be responded to in a timely manner.

The operator is required to turn the train in SEMI AUTO mode. The cleaning solution for RECOVERY CLEANS is either citric acid or sodium hypochlorite. The operator selects either R. Clean with Citric Acid button or R. Clean with Sodium Hypochlorite button to select the cleaning mode and the type of cleaning solution.

The default steps for Recovery Clean are:

1. Aerates the membrane tank;
2. Close the feed Valves to the membrane tank and drain membrane tank to Aeration tank by starting of the RAS pump.
3. Drain the membrane tank to aeration tank using RAS Pump.

4. Backpulses the membrane tank for upto cleaning level then proceeds to next step or until the tank is at a defined level then proceeds to step 6.
5. Relaxation period for all cassettes for a defined duration and then proceed to step 4.
6. Aerates the membrane tank for a defined duration;
7. Drain the membrane tank by starting RAS pump. After the membrane tank is drained, stop the RAS pump;
8. Operator supervises the tank cleaning condition if there any debris and residue is cleaned by service water.
9. Initial Backpulse upto membrane tank cleaning level
10. Start respective chemical transfer pump for the define time duration.
11. Final, extended relaxation period with intermittent aeration;
12. Start the RAS pump and transfer the cleaning solution to Aeration Tank.
13. Open Membrane inlet valve and Fills the membrane tank to defined level with feed;
14. Aerates the membrane tank;
15. Proceeds to OFF.

Consult the OSC and CLC for specific details on the steps and setpoints used in this mode.

5.7.17 Password Access Privileges

The entire plant is controlled from the PLC through a HMI. The ability to silence the horn and acknowledge alarms does not require a password, but alarms cannot be reset.

To gain access to make changes on the HMI, the operator is required to enter the correct password. A screensaver blanks the screen after a set amount of time of inactivity. The screen is reactivated by a single touch. Reactivation cannot select a device or operating mode.

In order to access the control screens, the individual must enter a correct password then press Enter. There are three levels of password protection; Operator, Supervisor, ADMIN. The operator password is factory set. The supervisor password can be modified from the HMI. There is no limit to the number of times another password can be attempted. The password must be re-entered after a set amount of time of inactivity.

5.7.18 Screen Color-Coding

The color-coded train-status indicates whether the device or train is either running automatically, in STANDBY, off, manually overridden, etc.

The HMI uses the color-coding shown below.

Table 5.6: HMI Colour Code

Color	Valve	Pump
Green	Open	On
Red	Closed	Off
Yellow	Failure	Failure

5.7.19 Power Interruption / Power Up

When a loss of power occurs, the train will immediately turns off all equipment and proceed to Start-up step 1 after power returns, the plant powers up and train will start-up automatically as described in the CLC. The CLC also specifies the mode that a train will proceed to after power is restored.

5.8 Specifications of Membranes

The hollow fiber membranes of Zeeweed500 shall confirm to following specifications:

- (i) The membranes should be of Reinforced, Ultrafiltration, Hollow fiber type and the average pore size of the membrane shall not be more than 0.04 micron.
- (ii) The membrane filtration mode should be Out to In with Backwashing facility and the material used for the manufacturing of the membrane fibers shall be Polyvinylidene Fluoride (PVDF).
- (iii) The design flux should not exceed 30 LMH(Litres/Sqm/Hour).
- (iv) Clean-In-Place System: The membranes shall be cleaned in-place without removal from the membrane tank. The system shall consist of a chemical feed pump and storage tank and include all interior piping, valves, and in-tank piping and supports.
- (v) Back pulse flux shall be $\geq 34LMH$. Chlorine exposure shall be 500,000ppm/hrs

The minimum membrane warranty for life of membranes should be for 5 years where the membrane manufacturer should offer minimum 2 years full replacement warranty and additional 3 years on pro-rata basis which shall be reckoned from the date of commissioning of the plant.

5.9 Manual Coarse Screen 16mm and Manual Fine Screen 6mm

- (vi) The screens shall be rectangular in shape.

- The screens shall be fabricated out of Stainless steel 304 grade material and fixing bolts shall be of stainless steel.
- The rectangular screens shall be made of SS flats 10 mm thick and 50 mm wide in section (minimum dimensions).
- The screens shall be rigidly fixed to the frame. The screenings shall be first collected on a perforated tray or slab.
- All the bypass screens shall be provided with 2 sets of cleaning rakes.
- Four nos. portable containers of 0.50 cum capacity shall be provided with suitable hooks for lifting by chain pulley block.

5.10 Sludge Handling

As Sludge generated from different process units varies depending upon the process adopted, it is advised to provide sludge handling units and equipment like Sludge thickeners, Digesters, centrifuge, Vacuum filter press, and other ancillary units which is suitable for the process and which is sustainable from Operation Maintenance point of view. The units and equipment shall be selected accordingly which occupies less space, power, chemicals and maintenance.

5.11 Air blowers for Oxygenation

The blowers shall be provided for providing adequate oxygen into the reactor tank for aeration. The blowers shall be capable of developing the required total pressure at the rated capacity for continuous operation. The blowers shall be positive displacement rotary twin lobe type.

Air Blowers

(a) Compressor blowers shall be of the positive displacement type, each provided with inlet filter and silencer, pressure reducing valve, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend or silencer in the delivery branch. Bearing housings and gear boxes shall be separated from the blower housings by air spaces. The

blowers shall be housed in a separate sound proof room to reduce the noise level or inside acoustic enclosure. The noise level shall not exceed 85 dBA at 3 meter from the Blower.

(b) The bearings shall be generously designed to give long operational life. Bearings at the drive end may be oil or grease lubricated. The gears and bearings at the non-drive end shall be oil lubricated. The delivery velocity not exceeding 18 m/s and each blower shall be provided with following components but not limited to:

- Common base frame for Blower Motor
- inlet silencer and filter
- Discharge Silencer non-return valve in delivery branch
- Butterfly valves in both inlet and delivery branches
- pressure relief valve or excess pressure safety device
- Bellows type couplings on inlet and delivery branches.
- Acoustics Enclosure
- Motor-Blower Direct coupling.
- Isolating valves, Pressure reducing valves Pressure gauges

(c) The interconnecting pipe work shall be flanged to GI pipes of medium grade. A drain cock shall be provided at the lowest point in the each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.

(d) Blowers shall be driven by squirrel cage motors through a direct coupling. Blowers shall not run above 1200 rpm.

(e) Each delivery branch shall include a drain at the lowest part and a reflux valve.

(f) The blower equipment specified herein is standard equipment for blowers handling ambient air for use in aeration tank diffusers.

5.11.1 General Design Requirements

(i) The air blowers shall be of such design as to achieve energy efficient operation continuously over the range of design airflow rates at the discharge pressure that shall remain practically constant.

- (ii) Blower shall be fitted with a variable speed motor and be capable of operating between 80% and 110% of its nominal peak airflow demand. VFD not required for mixing blower and membrane blower.
- (iii) The discharge pressure shall be calculated by the Contractor dependent on the final design layout of the aeration system and of the delivery manifold.
- (iv) The blowers shall also be capable of supplying the design mass flow rate at maximum ambient inlet temperature of 50°C.
- (v) Each of the blowers shall be capable of operating without surge in parallel with the other duty blower at the maximum mass flow against designed maximum gauge pressure at the outlet pipe.
- (vi) Performance curves for the blower system shall be submitted. Standard certified factory test sheets showing the results of each test shall be supplied in triplicate to the Executive Engineer along with delivery of the blowers. The blower unit shall be capable to operate at maximum duty for continuous operation. The blower motor shall not exceed a maximum speed of 1500 rpm and the blower shall not exceed the manufacturers recommended maximum speed.

5.11.2 Blower General Arrangement

The blower arrangement shall have the following features:

- (a) The blowers shall be positive displacement type
- (b) Each blower shall be fitted with an acoustic enclosure;
- (c) The arrangement shall be such that all blowers are accessible for operation and maintenance.
- (d) The blowers shall be neatly arranged and housed in acoustic enclosure.
- (e) The inlet air to the blower house shall be filtered to suit the blowers and aeration diffusers selected;
- (f) A blower removal system shall be provided so that any one blower can be removed as a single unit and loaded onto a truck.

5.11.3 Ancillary Equipment for Blowers

The blowers shall be provided with the usual ancillary equipment for aeration duty, including:

- (a) Acoustic enclosure with fan cooling Discharge pressure switch, if required and recommended by the blower manufacturer for the given duty conditions.

- (b) Discharge pressure relief valve
- (c) Discharge check valve
- (d) Discharge isolation valves
- (e) Discharge silencer, designed to minimize noise propagation along the pipe work
- (f) Vacuum switch, pressure switch, oil level indicator and any other monitoring device shall be mounted outside the acoustic enclosure
- (g) Inlet and outlet pressure gauges shall be mounted outside the acoustic enclosure
- (h) Vibration absorbing mounting pads.
- (i) all required support structures.

5.11.4 Blower Noise limits

The blowers supplied under this Contract shall be quiet in operation. Under any loading condition from no load to full rated, the blower supplied shall comply with the noise requirements.

5.11.5 Materials of Construction

The materials of construction for the blowers shall be at least equal in quality to the following:

Table 5.7: Blowers: Materials of Construction

Casing	C I conforming to IS: 210 Gr FG 260
Rotor	Alloy steel
Shaft	Carbon steel C40/EN 24/19
Timing gear	Cast alloy steel
Pulley and gear side plates and cover	CI conforming to IS 210 Gr FG 260
Impeller	Manufacturers std
Base plate	Mild Steel
Nuts and Bolts	Stainless Steel

5.11.6 Testing

Table 5.8: Blowers: Tests

S.No	Tests	Specifications
1	Hydrostatic tests	Twice the maximum working pressure
2	Performance test	As per BS : 1571
3	Strip test	Clearances with tolerance limit
4	Mechanical balancing	ISO 1940 Gr. 6.3 or better
5	Visual Inspection	Before painting

5.11.7 Filters and Silencers

(a) Filters shall be used to remove dust, etc. contained in the suction air. For this purpose, a filter shall be mounted directly to the suction silencer of each blower. The filter element shall be non-textile cloth or equivalent, and the element passage speed shall be

2 m/s max. The Contractor shall indicate the useful life period for the diffuser.

(b) The blowers shall receive filtered air individual replaceable filter elements suitable for the intended duty.

(c) The filter elements shall be housed in an airtight housing which shall allow easy replacement of the filter elements. Replacement of elements shall be possible without the use of tools.

(d) If the filter/silencer elements supplied are located out of doors a weatherproof cover shall protect the filter element from rain.

(e) The filter unit shall be fitted with suitable vacuum gauges to indicate the suction pressure into each blower. The gauges shall be industrial Bourdon of Schaffer type gauges with a nominal diameter of 150 mm. The scale shall be suitably selected and shall include a red line to indicate the point at which the filter elements require renewal.

(f) Each blower intake shall be fitted with a differential pressure switch, which shall indicate an alarm signal in the event of excessive pressure drop in the blower intake.

5.11.8 Flexible Connections

(a) The blower discharge shall be fitted with an approved flexible sleeve with fixing clamps and a flanged outlet spigot for connection to site pipe work. If the blower inlet is via a common plenum the inlet pipe shall be also fitted with a flexible connection.

(b) Flanges shall be drilled to Table D and shall comply with the required standard. Sleeves shall be manufactured from an approved non-metallic material suitable for the duty and location in which the blowers are to be installed.

5.11.9 Pressure Relief Valve

(a) The pressure relief valve shall be sized and adjusted to allow the full flow of the blower to be discharged in the event of a blockage or valve closure in the downstream pipeline and without overloading the drive motor.

(b) Each blower shall be fitted with a suitable pressure switch, which shall shut down the blower in the event of excessive discharge pressure. The pressure setting shall be lower than the set pressure of the pressure relief valves.

(c) The pressure relief valve shall be installed at a height above 2m from the floor and away from blower suction point. The pressure relief valve shall be fitted with a silencer.

5.11.10 Non-Return Valve

A non-return valve shall be installed on the discharge pipe work of each blower, upstream of the blower isolation valve.

5.11.11 Isolating Valves

Isolating valves shall be installed on the delivery pipe work of the blowers; such that each blower and all associated pipe work and valves upstream of the common distribution manifold can be dismantled without disruption to the normal operation of the plant.

5.11.12 Temperature Measurement

Temperature sensor complete with gauge of an approved type shall be supplied for each main distribution pipe work and for the blower room.

5.11.13 Piping Vibration

If the blower type selected produces a discharge flow with a pulsating characteristic, flow pulsation dampers shall be installed on the blower intake and discharge, as required, to eliminate excessive noise or vibration from this source.

5.11.14 Air Compressors

Compressor system shall comprise of compressors, after-coolers and air/dryers, duty/standby air receivers together with control equipment, oil eliminating filters, flow regulators and oil mist lubricators as required.

Compressor sets with at least 1 standby shall be provided complete with the following:

- Common base frame for Compressor Motor
- Single stage air-cooled unit
- Isolating valves
- Air filter and silencer
- Pressure relief valve or excess pressure safety device
- Pressure reducing valves
- Pressure gauges
- Off loading piston

- Automatic changeover (failure of duty unit)
- drain pipes
- Isolating valve
- V-Belt drive arrangement with Belt Guard
- Stoppers
- Air-receivers
- Others necessary appurtenances

(c) Compressors shall be arranged for automatic changeover on failure of the duty unit. Failure of the duty unit shall initiate an alarm. Control equipment shall include automatic unloading valves, pressure switches for duty standby and alarm, and lockable changeover switches.

(d) 1 Duty 1 Standby after coolers shall be provided. Water- cooled or air blast types will be considered. Air receivers shall be designed and fabricated in accordance with relevant approved standards. They shall be mounted vertically on steel feet so that sufficient space is allowed for each access to the whole outside surface. Receivers shall be provided with drain cocks piped to drain pressure gauges and relief and check valves.

(e) Supply of all necessary electrical components, devices, equipment, control panels, etc. together with cabling, earthing provisions, etc. shall be the responsibility of the Contractor.

(f) Interconnecting pipe work shall be arranged to avoid low points, which may trap water.

(g) Unavoidable low points shall be provided with drain cocks piped to waste.

5.12 Diffused Air Aeration System

This section of the specification sets out the minimum requirements for the design and selection of diffused air aeration system equipment.

The pipe works, instrumentation and the diffusers shall be correctly sized to deliver the required quantity of air at the available pressure to meet all operating conditions. The pipe work to the tank shall be sized for 125% of the required oxygen transfer capacity to cater for the higher loading.

The aeration headers shall be designed for removal/replacement from/to the reactor without taking the reactor off-line or dewatering the reactor. The Contractor shall be required to demonstrate removal and replacement of the headers with the reactor on-line.

5.12.1 Aeration diffusers

(a) Air diffuser system consist of tube type porous membrane of Acid resistant silicon based rubber with diameter not exceeding 65 mm diameter size, Single piece injection molded PP support tube, SS clamps.

(b) Entire diffuser has to be manufactured, assembled, tested in factory premises no site work is permitted.

(c) Flat surfaces facing upwards as membrane surfaces shall not be accepted.

(d) The aeration tank is used to remove oxygen consuming organic matter from the effluent by biological treatment. Diffused aeration is used for air supply. The bubbles produced from the diffuser are of extremely small size between 0.5 - 0.8 mm, thus the total surface area that interacts is large and the contact time of bubble is large due to slow rise of bubbles. The system is thus extremely power efficient in terms of oxygen transfer efficiency. The flow of fine bubble of 0.8 mm in size provides a gentle mixing, which prevents flock shear.

(e) Fine bubble diffuser consists of a porous membrane made of Acid resistant silicon based rubber. Each diffuser is fully supported over the length and circumference on single piece injection molded polypropylene (PP) tube with a RIDGE on the top to hold the membrane in position against the velocity generated in the waste water.

(f) No drilled holes on the support tube are permitted and only channel type of arrangement for entry of air into membrane is desired. Air opening on the membrane should be 0.8 - 1 mm with staggered perforation.

(g) The diffuser will be retained in place by two clamps. It is fitted to the pipe lateral by CLIPIN arrangement. The laterals are connected to a pipe header. The wetted parts of the system are made of non-corrosive material specifically SS 304. During power shutdown at the sewage treatment plant the membrane will contract and lose around the PP support pipe and means shall be provided to prevent any back flow.

(h) Each diffuser shall consist of the following:

- Minimum 65 mm OD PP injection moulded support pipe.
- Porous membrane made of silicon based rubber lateral.
- RCC support block with SS 304 clamping.
- Flexible Hose pipe (drop pipe for each diffuser assembly)
- PP Ropes for Lifting and guide position.
- Hose clamp
- Pipe connector

- GI barrel nipple with connector for connection with pipe.
- (i) Complete diffuser shall be assembled at original factory level and site fabrication of diffuser is not acceptable.
- (j) All hardware accessories including clamps, fasteners, fan-hooks, eye bolts, should be of SS 304 materials only.

5.12.2 Air Supply pipe work

General Design Criteria

(a) Many factors need to be incorporated in the design of the air distribution pipe work to minimize the potential of noise problems occurring. Factors to be considered in the design of the air pipe work to minimize noise level shall include:

- The diameter of the pipe work, to keep velocities low.
- The connection of the blower discharge pipes to the manifold should be "wye", not at right angles.
- No blind flange at the end of the manifold.
- The manifold shall be designed to ensure air travels in one direction.
- The air pipe work shall be designed to minimize changes of direction and use large radius bends. Flexible connections shall be provided between the diffuser assembly nits and the main air supply pipe work to allow for any differential movements.
- Expansion and contraction shall be fully allowed for in the design and installation of the air distribution pipe work.
- Rain taps shall be provided on the air pipe work to allow draining of moisture.
- The pipe work and the support brackets shall be made of SS 304 grade of stainless steel.
- Pipe work shall have inbuilt flexibility such as packer flanges for reasonable construction tolerances on the structures to which it is attached.

(b) Pipe shall be designed to ensure the efficient operation of the aeration system and compliance with the noise limitations. All valves in the air delivery system shall be correctly selected for the duty. Calculations of Cv (head loss coefficient) values for the range of flows and pressure losses across each valve should be prepared to ensure that each valve has adequate range of control for the duty.

(c) However the air piping submerged in sewage has to be in SS304 conforming to I.S

specification. One spare drop pipe with diffuser elements shall be supplied by the Contractor. This will be used to replace the choked diffusers drop pipe or on preventive basis on rotation. The choked one will be attended to and used as spare drop pipe.

5.12.3 Air Supply Headers

The air supply headers run from the main air distribution pipe work to the down comers. Pipe work shall have inbuilt flexibility such as packer flanges for future modifications and to allow for reasonable construction tolerances on the structures to which it is attached. An isolation valve for each main air supply pipe shall be installed at the point of connection to the main distribution pipe work. The design of the main air supply header shall incorporate all components necessary to enable the easy connection of the main distribution pipe work to the main air supply header.

5.12.4 Blower Discharge Pipe work

The discharge pipe work from each blower shall be connected to a common manifold. Flexible connections shall be provided between the blower assembly units and the discharge pipe work to allow for any differential movements. The design of the manifold pipe work shall incorporate all components necessary to enable the easy connection to the main distribution pipe work.

5.12.5 Air Flow Measurement

(a) The amount of air being supplied to each air supply header shall be measured by the installation of Flow measuring devices. The flow measuring devices shall be suitable for the intended application. The sensor assembly shall be supplied with suitable fittings which shall enable easy removal during maintenance. The accuracy of the flow meter shall be within 5% of the minimum design flow rate. The installation shall provide adequate length of straight pipe upstream and downstream of the flow meter to ensure the accuracy of the meter is attained.

(b) Pressure and temperature sensors, shall be provided to measure the pressure and temperature of the air in the pipe, upstream of the flow measurement device.

(c) Pressure and temperature compensation measurements shall be provided for volumetric correction if the control air is based on airflow rate.

5.12.6 Pressure Gauges

Pressure gauges of an approved type shall be installed on each main distribution pipe work and main header.

5.12.7 Leak and Pattern Testing of Diffuser System

(a) The diffuser system shall be visually tested by filling the tanks with clean water to level 1m above the top of the diffuser assembly units. Air shall then be passed through the diffusers and a visual assessment of the diffuse operation shall be made.

(b) The visual assessment shall include the following minimum inspection:

- Checking all diffusers for installation level within the required tolerances
- Checking that all joints along the diffuser headers have been made airtight
- Checking the required air distribution of diffused air is achieved across the entire tank floor.

5.13 Sluice Gate

5.13.1 Design Requirements and Construction Features

(a) The construction of sluice gates shall be in accordance with the specification and generally as per AWWA C 560-00 /IS: 13349-1992 or other applicable standard. All sluice gates shall be of the rising spindle type.

(b) The sluice gates shall be capable of performing the duties set in this Specification without undue wear or deterioration. They shall be constructed so that maintenance is kept to a minimum. All parts of sluice gate, including lifting mechanism components shall be designed for the heads required with a minimum safety factor of five.

5.13.2 Frame

The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

5.13.3 Guide

Guide shall be bolted to the frame or cast integrally with it and shall be machined on all bearing and contact faces.

The length of guide shall be such that it should support the gate upon the horizontal line of stem nut pocket.

Arrangement shall be made to prevent lateral movement of bolted on guides. They shall be capable of taking the entire thrust produced by water pressure and wedging action. Wedges or wedge facings shall be attached securely to the guides at points where, in the closed position, they will make full contact with the wedging surfaces on the slides.

Seating Faces : Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished

dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.

The faces shall be of ample section and finished smooth.

5.13.4 Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position. All faces shall be machined accurately to give maximum contact and wedging action. Wedges shall be fully adjustable with suitable adjusting screws and lock nuts and so designed that they will remain in the fixed position after adjustment.

5.13.5 Lifting Mechanism

(a) Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required.

(b) Lifting mechanism shall be suitable for operation by one man under all conditions.

(c) Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.

(d) The manual contractor shall be of the hand wheel crank operated type and shall have a lift nut threaded to fit the operating stem. Crank shall be removable. Ball or roller thrust bearings shall be provide above and below the flange on the lift nut to take the load developed in opening and closing the gate with a torque of 14kg-m on the crank. Fittings shall be provided to lubricate gears and bearing.

(e) The design of the lift mechanism of the hand operated gates shall be such that the slide can be operated with a torque of not more than 7 kg-m on the contractor after the slide is unseated from wedges based on the operating head. The maximum crank radius shall be 380mm.

(f) All gears and bearings shall be enclosed in cast iron housing with labyrinth seals. The lifting mechanism shall be with a cast iron pedestal, machined and drilled to receive the gear housing and suitable for bolting to the operating floor. The gates shall close with clockwise rotation of the crank. The direction of rotation to close the gates shall be indicated on the lift mechanism.

(g) A suitable means shall be provided for lubricating the stem threads directly adjacent to the lift nut. An inspection cover shall be provided to access the lift nut and gearing.

(h) Stem shall be provided with a GI pipe cover shall be fixed to the head stock.

(i) Lift mechanism shall be provided with a suitable position indicator to show the position

of the gate at all times.

5.13.6 Lifting Lugs

Lifting lugs shall be provided for all gates.

5.13.7 Flush Bottom Seal

(a) When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.

(b) A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.

(c) Suitable arrangement shall be made for on all the sluice gates or actuators such that the portable electric actuator is capable of operating all sizes of sluice gates.

(d) 1 No. of Portable type of electric actuator for closing and opening of sluice gates shall be provided at each STP, so that the closing and opening operation time shall be maximum of 10 minutes

(e) Suitable arrangement shall be made on all the sluice gates or actuators such that the actuator is capable of operating all sizes of sluice gate, under this contract.

(f) Pipe hood shall be provided on the top of head stock to protect the spindle from damage, dirt, dust, water etc. The hood shall be made of transparent fracture resistant poly carbonate material. The hood shall have vent holes to prevent condensation.

(g) The material of construction of sluice Gate shall be as follows:

Table 5.9: Material of Sluice Gate

Component	Material
Wall Thimble	Cast Iron : IS 210 Gr. FG 200
Frame and Slide	Cast Iron : IS 210 Gr. FG 200
Seating faces	Stainless Steel: ASTM Countersunk fixing A276 type 316
Wedge	Stainless Steel : ASTM A743 CF8M or SS316
Stem	Stainless Steel: ASTM extension A276 type 316
Stem guide bracket	Cast Iron : IS 210 Gr. FG 200
Stem nut	Stainless Steel : ASTM A743 CF8M
Stem Coupling	Stainless Steel : ASTM A276 type 316
Fasteners, anchor	Stainless Steel : ASTM A276 type 316
Lifting mechanism, Pedestal gear house cover and stem guide	Cast Iron : IS 210 Grade FG 200
Lift nut	Bronze : ASTM B 148 (CA952, CA954 or CA958)
Headstock Body	Cast Iron : IS 210 Gr. FG 200

5.14 Open channel Gates

The manufacture of open channel gates shall be in accordance with the manufacturers standard.

All open channel gates shall be of the rising spindle type manually operated.

Open channel gates shall be tested as per manufacturers standard.

The open channel gates for pumping stations shall be CI sluice gates. All other gates shall be aluminum gates.

The material of construction shall be as follows.

Table 5.10: Material of construction-Open channel Gates

Components	Material	Specification	Grades
Gate frame, shutter, Headstock, Flush bottom seal support bar, Stop nut.	Cast Iron	IS: 210 1993	FG: 260
Sealing faces/ Seat facings	Stainless Steel	ASTM A276	AISI: 304, 316
Resilient rubber seal	Natural Rubber EPDM Rubber , Neoprene rubber		
Seal retainer bar	Stainless Steel	ASTM A276	AISI: 304, 316
Stem / Spindle	Stainless Steel	ASTM A276	AISI: 304, 316
Operating Nut/ Stem Nut	Leaded Tin Bronze	IS: 318 1981	LTB 1, LTB 2
Fasteners	Stainless Steel	ASTM A276	AISI: 304,
Anchor Bolts	Stainless Steel	ASTM A276	AISI: 304, 316
Yoke	Mild Steel	IS: 2062 1992	Grade A

5.15 Hand Operated Hoists and Trolleys

(a) Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

(b) Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S. 1663/B.S. 3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S.2525-32:1954. Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

(c) The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

5.16 Pipe Work

5.17 Piping

The following table lists the types of process piping supplied . These specifications do not include miscellaneous small bore tubing for instrument air, seal water lines, and so on.

Table 5.11: Piping

Permeate Header Piping in the Process Tanks	uPVC PN 10
All Blower Discharge piping	GI Pipes Class-B(Medium)
Blower line vertical drop pipes into all tanks	SS 316
Diffuser Grid piping in all tanks	uPVC PN 10
Chemical Feed System Piping	CPVC, PE Tubing
Permeate line from membrane tank to Chlorine Contact Tank (a portion of the line is buried)	SS316
All RAS pipes	Carbon Steel

5.17.1 uPVC

- Piping: Conforming to BIS/ASTM D1785
- Fittings: Conforming to BIS/ASTM D2467
- Flanges: Slip-ring (Van-Stone) Type

5.17.2 CPVC

- Piping: Conforming to BIS/ASTM F441
- Fittings: Injection moulded type
- Flanges: Slip-ring (Van-Stone) Type

5.17.3 Stainless Steel

- Rolled Pipe: Conforming to ASTM A778 for pipe >12" ASTM A312 for <12", ANSI B36.19
- Cast Fittings: Conforming to ASTM A778, ANSI B36.19 ANSI B16.9
- Fabricated Pipe: From sheet conforming to ASTM A240
- Fabricated Fittings: From sheet conforming to ASTM A240
- Fitting dimensions conform to ANSI B16.9

- Flanges: Welded or Slip-ring (Van-Stone) with drilling conforming to ANSI B16.9

The pipe works for the plant involves procuring, supply, laying and jointing of suitable size electrically welded steel, stainless steel SS 304 grade, cast iron, ductile iron, uPVC, RCC pipes along with matching specials etc. as required. All yard piping inside the plant shall be cast iron or ductile iron. All pipe work and fittings shall be a class rating in excess of the maximum pressure attained in service including any surge pressure. The pipe work installation shall be so arranged to offer ease of dismantling and removal of pumps or major items of equipment. CI/DI Piping above ground level shall be only flange jointed and adequately provided with structural/ masonry supports.

Stainless steel AISI 304 expansion bellows which can take radial and axial misalignment of minimum one percent of the valve nominal size and tie bolts shall be provided. All pipe work shall be adequately supported with purpose-made fittings. When passing through walls, pipe work shall incorporate a puddle flange. Flange adapters and union shall be fitted in pipe work runs, wherever necessary, to permit the simple disconnection of flanges, valves and equipment.

The Contractor shall be responsible for ensuring that the internal surfaces of all pipe work are thoroughly cleaned before and during erection and commissioning. Cleaning shall include removal of dirt, rust, scale and welding slag due to site welding. Before dispatch from manufacturers works, the ends of the pipe, branch pipes etc., shall be suitably removed until immediately prior to connections adjacent pipes, valves or pumps.

All bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of IITH . All underground-buried mild steel piping unless found otherwise necessary, shall be protected by the application of hot coal tar enamel and fiberglass wrapping. The coating shall consist of one coat of coal tar primer one coat, wrapping of fiber glass one more coat of enamel and the final wrap of enamel impregnated fiber glass.

All water supply plumbing pipelines shall be of UPVC Class-3 thick-walled inside the premises in concealed piping. They shall be GI class B in external locations and either anchored externally with SS AISI fasteners or appropriately buried below the ground with a sand cushion of 20 cm all round. All sanitary piping shall be of UPVC Type-B suitably buried below the ground with a sand cushion of 20 cm all round. Changes in direction on

the ground shall be achieved with inspection chambers of 45 cm x 45 cm and heavy-duty CI chamber covers.

5.17.4 Galvanized Iron pipe

The procurement, supplying, laying, jointing and testing at works and site of Galvanized Iron (G.I.) pipes and fittings shall be in accordance with IS 1239 (Part I and II) and its latest revisions. The general requirements relating to the supply of mild steel tubes shall conform to IS 1387. The sulphur and phosphorus requirements in steel shall not exceed 0.05 percent each. The galvanizing of the pipes shall be as specified in IS 4736. The zinc coating shall be uniform adherent, reasonably smooth and free from imperfections.

The pipes shall be galvanized before screwing. All screwed pipes and sockets shall have pipe threads conforming to the requirements of IS 554. Gauging in accordance with IS 8999 shall be considered as an adequate test for conformity of threads of IS 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

The specifications for G.I. pipes shall conform to relevant BIS code. The tolerances on the length of pipes shall follow clause 11.0 of IS 1239 (Part I). The fittings for G.I. pipes shall be of mild steel tubular or wrought steel fittings conforming to I.S. 1239 (Part II). The laying of G.I. pipes and fittings shall follow the relevant I S code of practice. These pipes shall be used for drinking water supply for the office and laboratory buildings. The pipes shall be painted with two coats of anti-corrosive bitumastic paint.

The G.I. pipes and fittings shall be tested at site, after they are laid and jointed as per standard specifications.

5.17.5 Unplasticized Poly Vinyl Chloride (uPVC) Pipes

The latest versions of Indian standards and codes of practice shall be adhered to for the design, manufacturing, inspection, factory testing, packing, handling, and transportation, laying, and jointing of the uPVC pipes. The rubber rings shall be vulcanized from Ethylene Propylene (EPDM) confirming to IS 5382. The uPVC pipes shall be of minimum 6 kg / sqcm and as per IS 4985 and the pipes for plumbing works in office building shall be SWR (Type B) as per IS 13592, with electrometric sealing rubber ring joints. The uPVC fittings shall be fabricated from Class 4 uPVC as per IS 4985.

Marking on Pipe:

Each pipe shall be clearly marked as indicated below:

- Manufacturers name and trade mark
- Outside diameter (OD) in mm
- Class of pipe and pressure rating
- Month and year of manufacturing
- Length of pipe
- Marking of insert depth of spigot

Marking on rubber ring:

Each sealing ring shall be permanently marked with

- The manufacturers name or trade mark.
- The month and year of manufacture
- Diameter of pipe for which the ring is suitable.
- Type of rubber material

5.17.6 Ductile Iron Pipes

The DI pipes shall be centrifugally cast (spun) for Water and Sewage and conforming to IS 8329-2000. The pipes used shall be both gasket joints and flanged joints. The minimum class of pipe to be used shall be class K-9 conforming to IS 8329. In general, pipes inside the buildings and below the structures shall be jointed as double-flanged pipes and those outside the building can be either EPDM gasket in accordance with IS 5382 and manufactured by the pipe manufacturer only.

The pipes shall be supplied in standard lengths of 5.5m and 6.00m length with suitably rounded chamfered ends. Any change in the stipulated lengths will be approved by the Engineer-in-Charge or his representative. The flanged joints shall conform to the Clause 6.2 of IS 8329. The pipe supply will also include one rubber gasket for each flange.

Markings

All pipes shall be marked as per clause 18 of IS 8329 and shown as below:

- Manufacturer name / stamp
- Nominal diameter
- Class reference
- A white ring line showing length of insertion at spigot end.

Specials for DI Pipes

The DI specials shall be manufactured and tested in accordance with IS 9523 . The mechanical test and hydro static test shall confirm to clause 9 and clause 10 respectively of IS 9523. The tolerances on dimensions shall be as per IS 9523. The manufacturer of the pipes shall supply the fittings.

Supply

All the DI fittings shall be supplied with rubber rings for each socket. The rubber ring shall conform to IS 12820 and IS 5382. Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts.

5.18 Sluice Valves

(a) Sluice valves shall be of rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage. Shoe and channel arrangement shall be limited to valves of 450 mm and above. The gap between the shoe and channel shall be limited to 1.5 mm.

(b) Valves of 450mm and above shall be provided with thrust bearing arrangement for ease of operation.

(c) Valves of diameter 450 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

(d) All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.

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

(f) The material of construction of Sluice valve shall be as follows:

Table 5.12: Sluice valve- Material of construction

SR.NO	COMPONENT	MATERIAL
(i)	Body and Doors	Cast Iron : IS:210 Gr FG 200
(ii)	Spindle	Stainless Steel: BS:970 Gr 431
(iii)	Seat Rings	Stainless Steel: BS:970 Gr 304
(iv)	Back seat bush	Bronze : IS:318 Gr LTB2
(v)	Shoe and channel linings	Stainless Steel : BS:970 Gr 304

5.19 Knife Gate Valves

The valve shall meet requirements of MSS SP 81. Outer body shall be provided with inner liner in corrosion resistant Stainless Steel which shall extend into the gland. The body shall be devoid of any wedge / dead pockets to avoid settling of suspended particles and solids in the service fluid.

The gate/plate shall be precision buffed and the edge contoured to a knife edge. The gate shall move along / be guided by the seat ring to ensure that it scrapes any deposit / scale, enabling smooth uninterrupted movement.

Seat shall be so designed that there is no recess / relieved groove to harbour deposition that could build-up and swamp the valve. The design to also incorporate bosses that guide the gate and avoid deflection, ensuring positive shut-off.

The stem shall have double start threads cut in order to ensure smooth and speedy operation. Gland packing shall offer minimal frictional resistance and precludes external lubrication. As positive sealing element, the packing shall also include a resilient rubber ring.

The knife edge and seat face in flow path shall be hard faced to a hardness of 400 to 450 BHN to counter erosion. In such cases, provision shall also be made to ensure the fluid contact with the seat ring is minimal.

The material of construction of valve shall be as follows:

Table 5.13: Knife Gate Valve-Material of construction

S.No	Component	Material
(i)	Body	Cast Iron : IS:210 Gr FG 260
(ii)	Inner lining	Stainless Steel: BS:970 Gr 304
(iii)	Knife gate / plate	Stainless Steel: BS:970 Gr 304
(iv)	Stem	Stainless Steel : BS:970 Gr 304
(v)	Seat ring / Boss	Stainless Steel : BS:970 Gr 304
(vi)	Gland housing	Ductile Iron : BS 2789 Gr 500
(vii)	Gland packing	Teflon impregnated with the asbestos +rubber

5.20 Butterfly Valve

- (a) This valve shall be installed at the pipe-line to seal the water or air and to adjust the flow.
 - (b) Valves shall be suitable for throttling operations and for infrequent operation after periods of inactivity.
 - (c) The body of the valve shall be made from cast iron or ductile iron.
 - (d) Valves shall have fabricated steel, cast iron or ductile iron discs with a resilient rubber sealing ring.
 - (e) Valve stem, shall be if stainless steel designed for both torsion and shearing stresses when the valve is operated with permanently self-lubricated shaft stub bearing, sized to withstand bearing loads.
 - (f) Butterfly valves shall be provided with hand-wheels and rack and pinion gearing operation. The valves shall be open by turning the hand-wheel in an anticlockwise direction. The direction of valve opening and closing shall be marked on the hand-wheel casting.
 - (g) The valves shall be designed to hold the disc in any intermediate position between fully opened and fully closed without creeping or fluttering by manual or electric operation.
- The material of construction of valve shall be as follows:

Table 5.14: Butterfly Valve-Material of construction

S.No	Component	Material
1	Body	Cast Iron or Carbon steel or equivalent
2	Disc	Carbon steel or Cast iron or equivalent
3	Stem	Stainless Steel or equivalent
4	Seat	Rubber or equivalent

5.21 Non Return Valve

- (a) The valves shall be suitable for mounting on horizontal pipe line.
- (b) The internal parts shall be easily accessible for inspection through inspection hole.
- (c) Hydraulic passages and doors shall be designed to avoid cavities.
- (d) Valves shall be of swing type or ball type. Ball valves must house a freely moving ball in such a way that return flow is effectively prevented.
- (e) Valves shall be quick closing type with non-slam characteristics. In case of swing type, the non slam characteristics shall be achieved by providing suitable combination of door and hydraulic passages without any external lever/damping arrangement.
- (f) Valves 450 mm and above shall be provided with supporting foot.
- (g) Swing door valves of size 600mm and above shall be of multi-door type.
- (h) Direction of the flow shall be clearly embossed on the valve body.
- (i) Maximum pressure drop across the valve shall be 0.4 mwc.

(j) Maximum allowable leakage rate shall be 7cc/hr/mm diameter.

The material of construction of valve shall be as follows:

Table 5.15: Non-return Valve-Material of construction

S. No	Component	Material
1	Body and Door	Cast Iron : IS 210 Gr. FG 200
2	Body and Door Ring	Stainless Steel : ASTM A743 CF8, BS970 Gr. 304 S11
3	Hinge Pin	Stainless Steel : BS970 431 S29
4	Bearings	Teflon

5.22 Telescopic Valve

(a) The telescopic valve shall be a proprietary item of proven design manufactured in cast iron and adjustable to cater for 1000mm variation in level.

(b) The bell-mouth height shall be controlled by a hand-wheel operated from top of the chamber.

(c) The bell-mouth, pipe work, spindle and head stock shall be robustly constructed with adequate brackets of cast iron.

(d) The bell-mouth shall be connected by swept tees to a cast iron sludge outlet pipe of 300mm diameter.

The material of construction of valve shall be as follows:

Table 5.16: Telescopic Valve-Material of construction

S.No	Component	Material
1	Bell Mouth	Cast Iron : IS:210 Gr. FG 200
2	Piping	Cast Iron : IS:210 Gr. FG 200
3	Spindle	Stainless Steel Gr. 304
4	Hand wheel	Cast Iron : IS:210 Gr. FG 200

5.23 Pressure / Vacuum relief valves

(a) Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a preset maximum allowable pressure. The valves shall be drops tight under no flow conditions.

(b) Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow conditions.

(c) The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

(d) The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

(e) Body ends shall be flanged and drilled to BS 4504.

5.24 Reduction Gear Units

(a) Reduction gear units, wherever provided shall be double reduction units without V-belt and pulley. Gears shall be cut from solid cast or forged steel blanks or shall be of stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, quality of steel, heat treatment, face, pitch of teeth and design shall conform to BS: 436 and BS: 721. Split gears shall not be used. Gears and pinions shall be pressed on and keyed to shafts.

(b) All pinions and gears are to be of the totally enclosed type up to the last stage of reduction in all motions and shall be carried in fabricated steel gear cases which must be dust-proof and firmly sealed to prevent oil leakages and shall be oil bath lubricated. The gear boxes shall have covers split horizontally and arranged so that top half can be removed for inspection. They shall be fitted with bolted type machined inspection covers and with cast steel cartridge housings for carrying roller bearings.

(c) Dip sticks or indicator shall be provided for indicating the oil level. Guards shall be strong enough to retain the whole gear or any part that might otherwise fall. No overhanging gears shall be used. Drain plugs shall be provided on all gear cases. Lifting lugs shall be provided for handling purposing.

5.25 Propeller Exhaust Fan

(a) The fan should comply with IS 2312.

(b) The blades shall be of mild steel and properly balanced so as to avoid noise and vibration. The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.

(c) Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent component parts.

(d) The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G.

5.26 Air conditioning Equipment

Wall mounted split type air conditioners of 2.0 TR capacity each (Inverter Technology) with five star rating shall be provided for the control room and the laboratory. Outdoor condensing unit shall be located on the roof of the building or grouted on the external side of the wall with suitable brackets.

5.27 Domestic Water Pump sets

The Pump shall be of Centrifugal type, self -priming and mono-block type, suitable for pumping the clear water. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non-return valves on the discharge side shall be forged steel. Piping shall be as per IS: 1239 heavy class.

5.28 Pumps

5.28.1 Open well Submersible Pumps

Submersible pumps shall be of the single entry design supplied complete with bolt-less self-aligning duck-foot assemblies giving automatic connection to the discharge pipe work.

Pumps to be used in Common Collection Sump shall be Cutter pumps.

The total head capacity curve shall be continuously rising towards the shut off with the highest at shut off.

Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

The pumps shall be designed to handle solid sizes of up to 80 mm.

Pumps shall run smooth without undue noise and vibration.

The pump set shall be suitable for starting with discharge valve open and/or closed.

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

5.28.2 Submersible Pumps: Features of Construction

Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, single stage type. (Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.

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

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

Impeller shall be non-clog open / semi open type for raw sewage and sludge application and enclosed type for clear water / treated sewage / file rate pumping application with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials. The number of impeller vanes for pumps up to 1000 m/hr shall be limited to two and shall be limited to three for the pumps higher than 1000 m/hr.

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

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

Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. All necessary stainless steel fixtures required for guiding the pumps during lifting / lowering shall be provided. The installation shall facilitate automatic installation and removal of pump without a person entering the wet well. Each pump shall be provided with a SS 304 lifting chain with suitable provision for engaging the hook of the crane at 1 m interval.

Each pump shall be provided with an automatic coupling device for attaching the crane hook to the pump at low level, even whilst the pump is submerged, without the need for

personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple the hoist hook and be complete with necessary accessories. All links and cables shall be multi-stranded stainless steel.

The submersible pumps shall be suitable for operation with or without submergence. The pump shall start and stop automatically based on level in the wet well. The synchronous speed shall not exceed 1500 rpm at 50 Hz supply.

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

Table 5.17: Materials of construction for submersible pumps

S.No	Component	Material
1	Impeller	Stainless Steel : ASTM A743 CF8M
2	Casing	Cast, Iron, to, IS:210, Gr, FG 200 with 1.5 to 2% Nickel
3	Shaft	Stainless Steel : BS:970 AISI Gr 316
4	Bush	Bronze IS 318 Gr. LT B2
5	Guide rail pipe	Stainless Steel : BS:970 AISI Gr 304
6	Fasteners and Foundation Bolts	Stainless Steel : BS:970 AISI Gr 316

Material test certificates shall be furnished by the Contractor and shall have the approval of Engineer-in-Charge.

The submerged cable shall be a multi-core flexible cord, vulcanized rubber insulated with tough rubber sheath and outer PCP sheath to BS 6500.

Where both thermal protective and moisture-sensitive devices are incorporated within the pump, both devices shall be brought out via separate conductors within the motor cable, although one such conductor may be common.

5.29 Centrifugal Pumps

- (i) Centrifugal pumps shall be of horizontal end suction type and shall have head/quantity characteristics which fall continuously from the maximum pressure at closed valve conditions and which are steep in order that variation in head shall have a minimal effect on the quantity discharged.
- (ii) The design speed of any pump with a duty flow greater than 20 l/s shall not exceed 1500 rpm. Pump motor ratings shall exceed the maximum pump power consumption over the operational range of the pump by at least 10%.

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

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

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

- (vi) The velocity of vibration shall be within 4.5mm/sec. Combined noise level of pump motor system shall be limited to 85dBA at a distance of 1.85m from the equipment, at manufacturers works.

- (vii) The pump shaft shall be of stainless steel to BS: 970 Grade 410S21 compatible with the impeller which shall be of stainless steel ASTM A743 CF8M and the impellers and shaft sleeves shall be secured to the shaft by means of a key or keys. The impeller retaining nut shall be fitted with a locking device. The pump casing shall be of Cast iron to IS210 Gr.FG260, wearing rings shall be of Bronze to IS: 318 Gr.LTB2 and shaft sleeve shall be of stainless steel to ASTM A 743 CA 15.

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

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

- (x) Bearing cooling arrangements if used shall be designed on the closed-circuit principle; open discharge of cooling water into the pumping station drainage system is not permissible.
- (xi) The pump casing and other parts of the pump subject to pressure shall be hydraulically tested by the manufacturer to at least one and a half times the maximum working pressure.
- (xii) Integral inlet and discharge flanges shall be provided and integral lifting lugs shall be incorporated.
- (xiii) Facilities shall be provided for the removal of air during priming and for draining.
- (xiv) Glands may be fitted with mechanical seals or conventional soft packing. The gland arrangement shall be designed for easy adjustment and removal of the seal.
- (xv) When soft packed glands are used suitable means shall be provided for collecting and preventing splashing of the gland leakage water.
- (xvi) Drainage and gland leakage water shall be piped into the building drainage system.
- (xvii) The shafts of pumps fitted with conventional packed glands shall be fitted with removable gland sleeves.
- (xviii) The rotating element of the pump and the motor shall be readily removable from the pump casing without the need to disconnect the adjoining pipe work.
- (xix) Rotating assemblies of pumps of 100 mm diameter inlet and over shall be statically and dynamically balanced and shall be designed so that the first critical speed is at least 50% greater than the maximum operating speed.

- (xx) Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.
- (xxi) On pumps of 75 mm inlet and over, tapping shall be provided at both the suction and discharge flanges of suitable size for pressure gauges.

5.30 End Suction Pumps

- (i) End suction pumps shall be horizontally mounted complete with drive motor on a common base plate. The pump/drive coupling shall be of the spacer type to facilitate removal of the pump rotating element and bearing housing without dismantling the pump casing, adjoining pipe work or drive motor. These types of pumps shall be used for Filter backwash, Chlorination motive water and service water pumping applications etc.
- (ii) The dimensions of the pump shall be metric conforming to BS 5257 or its equivalent standard. Flanges shall conform to BS EN 1092-2/BS 4504.
- (iii) The bedplate shall be of substantial fabricated steel construction with floor fixing bolt holes ready drilled. All holding down bolts etc. shall be supplied with the units.
- (iv) The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.
- (v) Impellers shall be provided with means to prevent abrasive matter reaching the glands and with fully shrouded impellers, to prevent the trapping of matter between the impeller vanes and the casing.
- (vi) The speed of any pump shall not exceed 1500 rpm.
- (vii) Glands may be fitted with suitable mechanical seals or conventional soft packing. The gland arrangement shall be designed for ease of adjustment or removal of the seal or packing material. Shafts shall be sleeved around the area of the gland when soft pack glands are used.

- (viii) Flushing facilities shall be provided for mechanical seals or packed glands where pump fluid may be contaminated with abrasive material. Where soft packed glands are used, means shall be provided for collection of the gland leakage water, which shall be piped into the drainage system through adequately sized ports.
- (ix) Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.
- (x) The pumps and associated pipe work shall be, wherever possible, arranged so that air can be completely expelled during priming. Where this is not possible, facilities shall be provided for the removal of the trapped air. Adequate facilities shall be provided for drainage of the pumps for inspection purposes.
- (xi) Tapping shall be provided at both the suction and discharge flanges for pressure gauge equipment.

5.31 Pump Performance Guarantees

- (i) The pump performance guarantee shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's work and shall obtain approval of Engineer-in-Charge.
- (ii) The pump shall operate at its design point within acceptance tolerances for flow rate and total head laid down in BS EN ISO 9906:2000.
- (iii) Each pump shall be tested at the manufacturer's factory in accordance with BS EN ISO 9906:2000 or other relevant standards in conjunction with one of the contract motors.
- (iv) This test shall be carried out on at least one pump set using the flexible coupling and contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.

- (v) Where similar drive shaft arrangements have been installed by the Contractor and have been proven satisfactory in service this requirement may be withdrawn subject to the approval of the Engineer-in-Charge.
- (vi) A test shall be carried out of the performance from closed valve to the maximum quantity that can be delivered under abnormally low discharge heads.
- (vii) Sufficient readings shall be taken at each test to produce accurate curves of the heads, flow, pump speed and power required at pump coupling throughout the operating range of the pump.
- (viii) Vibration and noise dB(A) levels shall be measured and shown to be acceptable and shall have Engineer-in-Charges approval. The Contractor shall have Engineer-in-Charge approval and provide acceptable test certificates, showing the NPSH requirement for the pump is at least 2 m less than the NPSH available under all working conditions.
- (ix) In the absence of the approved test certificates the supplier shall carry out a test on one pump of each type to verify the NPSH requirement based upon the 3% output drop criterion and shall take approval of Engineer-in-Charge.
- (x) Test Certificates in duplicate shall be submitted to the Engineer-in-Charge immediately following each of the tests mentioned above. Performance curves shall also be incorporated in the Operation and Maintenance Manual.

5.31.1 Single Pump Operation

- Head/quantity curve
- Motor kW input/quantity curve
- Overall efficiency/quantity curve
- NPSH required/quantity curve
- Vibration and Noise dB (A) levels

5.31.2 Parallel Pump Operation

- Head/quantity curves
- Motor kW input/quantity curve
- Overall efficiency/quantity curve
- NPSH required/quantity curve
- Vibration and noise dB(A) levels

5.32 Progressive Cavity Pumps

- (i) These pumps shall be used for handling thickened sludge transfer / feed applications.
- (ii) Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pump to give a uniform positive displacement.
- (iii) Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion resistant shroud shall be fitted to prevent fibre build-up on the shaft. Enlarged inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris.
- (iv) The shaft bearing shall be positively isolated from the fluid being pumped.
- (v) The rotor material shall be selected for corrosion and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome or other approved coatings shall be not less than 250 micron thickness and shall be diffused in to the base material. The rotor shall generally be single-stage and shall incorporate not less than 3600 of twist, but for high-head applications, it may be necessary to use more than a single-stage. The stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped.
- (vi) Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable-speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.

- (vii) Pumps shall normally be driven by a fixed-speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in-line on a common base plate. Alternatively, the drive motor may be top- mounted above the pump to minimize floor area, and shall be connected by external V- belts and pulleys. V-belt drives shall have full guards of the type that allow the belts observed without removal of the guard. Facilities shall be provided for ready adjustment of belt tension.
- (viii) Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections. All motor enclosures shall be provided with ingress protection to IP55. Motor anti-condensation heaters shall be provided and shall be suitable for use on a 220V single- phase, 50Hz supply.
- (ix) All bearing shall have a B10 design life of not less than 40,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading. Pumps shall be fitted with individual dry-running protection to initiate pump trip. Dry-running protection by under-current monitoring or pipeline-intrusive device shall not be used.

Table 5.18: Progressive Cavity Pumps:Material of Construction

Component	Material
Pump Housing	CI IS 210 GR. FG220 or FG260
Rotar	SS AISI 316(Hard chrome Plated)
Shaft	SS AISI 410(Hard chrome Plated)
Stator	Nitrite black
Type of drive	V belt & Pulleys
Base plate	MS fabricated
Seal type	Gland packing (Asbestos Free)

5.33 Chemical Dosing Pumps

- (i) Chemical dosing pumps shall be piston diaphragm or mechanical diaphragm type as specified. Pumps may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined base plate.
- (ii) Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self cleaning action. Ball and seat materials shall be resistant to abrasion.

- (iii) Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving step less adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.
- (iv) The normal operating range of dosing pump shall be not less than 6:1.
- (v) Mechanical Diaphragm: Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless. Accuracy: 3% of stroke.
- (vi) Piston Diaphragm Pumps: Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: 2% of stroke.
- (vii) Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, AISI 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.
- (viii) Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.
- (ix) A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.
- (x) Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

- (xi) Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.
- (xii) Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gear box shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.

5.34 Induction Motor (Submersible Motor)

5.34.1 Design Requirements

(a) The submersible motors shall generally conform to IS: 325 and the submersible cable shall conform to IS: 9968 or relevant equivalent internationally approved standards. Additionally the specific requirements mentioned in the following clauses shall also be met.

(b) The motor shall be three phase dry induction type with non-overloading characteristics.

5.34.2 Performance and Characteristics

Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

- Variation in supply voltage (+)/(-) 10%
- Variation in supply frequency (+)/(-) 5%
- Motors shall be suitable for full voltage direct-on-line starting or star-delta starting.
- Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage.
- Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.
- The motor vibrations shall be within the limits specified in the relevant standard.
- Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.

- The enclosure for motor shall be IP-68.
- Minimum three number thermistors in series are to be provided to sense the stator winding temperature.
- Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.
- The power rating of the motor shall be larger of the following:
 - 115% of the power input to the pump at duty point.
 - 105% of the power input to the pump at 75% head.
 Motors shall be suitable for full voltage direct-on-line starting or star delta starting. Minimum permissible starting voltage shall be 85% of the rated voltage.

5.34.3 Submersible Cable

- (i) The power cable shall be PVC insulated and PVC sheathed, flexible, 3 core flat type. The size of the conductor shall be adequate for continuous use under water and air. The half core shall be used for earthing.
- (ii) The control cable shall be PVC insulated PVC sheathed, flexible, flat type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor (Thermistors) 3 core x 2.5 sq. mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq. mm copper conductor shall be provided.
- (iii) In case a joint is required to be made between the lead cable supplied with the motor and the user's cable connectors, a detailed procedure of cable jointing to make a watertight joint shall be provided by the manufacturer.
- (iv) The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

5.34.4 Earthing

- (a) Earthing of the motor shall be done in accordance with the relevant provisions of IS3043:1966.
- (b) (For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

5.34.5 Insulation

Any joints in the motor insulation such as at coil connections or between slot and end winding sections shall have strength equivalent to that of the slot sections of the coil.

(a) The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.

(b) The stator winding shall be made from high conductivity annealed copper conductor, PVC insulated winding wires conforming to IS: 8783:1978 for wet type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII):1970 for dry type motors.

5.34.6 Temperature Rise

The temperature-rise test of the motor shall be taken with the motor coupled to the suitable pump to give the full load output of the motor. When the various temperatures are stabilized, the set is stopped and the temperature-rise of the stator winding by the resistance method shall not exceed 35°C. During the test, the temperature of the cooling water may not exceed 35°C. As the cable resistance will also be substantial, it is necessary that while calculating the temperature rise by resistance method, due care is taken to account for the correct hot and cold resistance of windings.

5.34.7 Constructional Features

(a) The motor shall be suitable for continuous duty as well as intermittent duty with or without full submergence of the motor.

(b) Aluminum die cast rotor to be provided for better starting torque characteristics.

(c) The electric motor shall be suitable for 10 starts & stops per hour. d. Single phasing and overload protection system shall be provided

(d) The motor degree of protection shall be IP68.

(e) Each motor shall be provided with minimum 25 m length of power control cables and 15 m length of lifting chain box (i.e.) for terminating power control cables for each motor.

5.34.8 Terminal Box

(a) Terminal box shall be of weather proof construction to eliminate entry of water and dust.

(b) The terminals shall be of the stud type with necessary plain washers, spring washers

and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

5.35 Induction Motor

5.35.1 General

All motors shall comply with IEC 60034, 60072 and IS-325, 4029, 4722 including standards referred to therein.

5.35.2 Performance and Characteristics

1. The performance and characteristics of the induction motor are as defined in the table below:

Table 5.19: characteristics of the induction motor

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	Kw	(*)
Rated Voltage	kV	0.415
Synchronous speed	Rpm	(*)
Quantity	Nos.	(*)
Type of mounting		Horizontal/,Vertical, (depending On application and process requirement)
Duty type		Continuous (S1)
Method of starting		Soft,starter/,Star-Delta,starter/Direct online (depending On application and process requirement **)
Class of insulation		F
Design ambient temperature	0C	50
Location		Indoor/ Outdoor (depending On application and process requirement**}
Degree of Protection		IP55
Cooling designation		IC411
Terminal box		LHS-looking from NDE end
External cable details		1.1,kV,,3C,x,(*),sq.,mm. Aluminum, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

(*) To be furnished by Contractor. Contractor should ensure that all the equipment ratings are based on their system requirement and subject to Engineer-in-Charge approval.

(**) Motors rating up to and including 5.5 KW shall be started by DOL starter, Motor ratings above 5.5KW and up to or equal to 30 KW shall be started by Star- Delta Starter and above 30 KW shall be started by soft starter.

2. Motors shall be energy efficient (IE 2 or better) squirrel cage induction motors (TEFC type) with degree of protection for enclosure of IP 55. They shall be capable of starting and accelerating the load for the method of starting, as per SLD without exceed-

ing acceptable winding temperatures, when the supply voltage is 80% of the rated voltage. Main conductor and insulation shall be non-hygroscopic and in accordance with Class F of IEC 60085.

3. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

- Variation in supply voltage 10%
- Variation in supply frequency 5%

4. Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding permissible winding temperatures, when the supply voltage is 80% of the rated voltage. Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.

5. The Power rating of the motor shall be the larger of the following:

115% of the power input to the pump at duty point.

105% of the power input to the pump between 110% to 75% head.

6. Motors shall withstand the voltage and torque stresses developed due to the vector difference between the motor residual voltage and the incoming supply voltage equal to 150% of the rated voltage, during fast changeover of buses. The duration of this condition is envisaged for a period of one second.

7. The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than the starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time, whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motor which is inclusive of 20% tolerance.

8. The motors shall be provided with class F insulation with temperature limited to that of class B insulation.

9. Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive

starts from cold conditions and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

5.35.3 Constructional Features

(a) Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.

(b) The motor construction shall be suitable for easy disassembly and re-assembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

(c) The rotor bars shall not be insulated in the slot portion between the inner core laminations for squirrel cage motors.

(d) All bearings shall be fitted with oil or grease lubricators. Motor bearings shall not be subjected to any external thrust load. Unless otherwise specified, motor bearings shall have an estimated life of at least 40,000 hrs. It shall be possible to lubricate the bearings without dismantling any part of the motor. All terminals shall be of the stud type of adequate size for the particular duty, marked in accordance with an approved standard and enclosed in a weatherproof box.

(e) The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed and treated with one coat of primer and finished with two coats of grey enamel paint.

5.35.4 Terminal Box

(a) Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degree in steps of 90 degree.

(b) The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied. (c) Separate terminal boxes shall be provided for each of the following:

–Stator Leads

5.35.5 Accessories

Drain Plugs: Motors shall be provided with drain plugs, so located to drain water, resulting from condensation or due to other causes, from all pockets in the motor casing.

5.35.6 Heating during Idle Period

(a) For motors rated below 30 kW, during idle periods, the stator winding will be connected to required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.

(b) Motors rated 30kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

5.35.7 Earthing Pad

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

5.35.8 Rating Plate

(a) The following details, in addition to those specified in applicable standards shall be included on the rating plate.

(b) Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.

(c) Type of bearings, recommended lubricant, lubricating interval re-lubricating quantity.

5.35.9 Tests

(a) Motor shall be subjected to all the type test (one from similar rating of each lot) and routine tests as per applicable standard, in the presence of the Engineer-in-Charge. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the IITH s approval.

(b) The Contractor shall ensure to use calibrated test equipment / instruments having

valid calibration test certificates from standard laboratories traceable to National / International standards.

5.36 Equipment selection

(a) Equipment means all items that are mechanical, electrical, instrumentation, panels, cables, switchgear, MCBs etc.

(b) Contractor shall select equipment to meet following criteria.

Equipment shall meet or exceed all the specifications mentioned in this Bid Document. Equipment consuming electrical energy, specially pumps and blowers, shall be of energy efficient design to have minimal possible OM cost, and shall be of standard approved makes.

Equipment must be serviceable in India. Contractor shall obtain performance and warranty certificates from the Manufacturers, and the same shall be in the name of the Contractor and transferable to the IITH.

Before procurement, Contractor shall obtain IITH s approval for all equipment satisfying the above conditions.

5.37 Manufacturer's Experience

The proposed manufacturers of different equipment should have manufactured and operated equipment in the last 5 years having specified constructional features equal to or higher than the specified size and rating.

Reference to specifications/ codes of practice

Table 5.20: References to Codes

Description	BIS No.
Centrifugally Cast (Spun) Iron pressure pipes for	
Water, gas and sewage Including fittings.	1536-1989
Specifications for Centrifugally Cast (Spun) D.I. Pipes for	
Water, Gas and Sewage.	8329-1990
D.I.Fittings for pipes for water, gas & sewage	9523-1980
Dimensional requirements of rubber gaskets for	
Mechanical joints and	12820-1986
push on joints for the use With C.I/ D.I.Pipes	

Table 5.20: References to Codes

Description	BIS No.
C.I. Specials for Mechanical and push on flexible joints for pressure pipe lines for water, gas & sewage	13382-1992
Horizontally cast iron double flanged pipes for water, Gas and Sewage	7181-1986
Cast iron fittings for pressure pipes for water, gas And sewage	1538-1976 (Part 1 to 24)
Rubber rings for jointing C.I.Pipes, R.C.C. Pipes & AC. Pipes	5382-1969
Rubber rings for jointing P.S.C. pipes	5382-1985
Hemp yarn	6587-1966
Rubber Insertion to be used in jointing CI/DI pipes	638-1979
Bolts & Nuts to be used in jointing CI/DI Pipes	1363-1967
Unplasticized PVC Pipes for potable water supplies	1363-1967
Injection moulded PVC socket fittings with Solvent cement joints for water supplies.	7834-1987 (Part 1 to 8)
Fabricated PVC fittings for potable water supplies	10124-1988 (Part 1 to 13)
Methods of test for unplasticized PVC pipes for potable water supply	12235-1986
Sluice valves for water works purposes (50 to 300 mm Dia	780-1984
Sluice valves for water works purposes (300 to 1200 mm Dia	2906-1984
Surface boxes for sluice valves	3950-1979
Manhole covers for sluice valves	1726-1974
Laying of Concrete pipes	783-1985
Laying of Cast-Iron Pipes	3114-1985
Laying of PSC Pipes	126 of APSS & 783-1985
Laying of C I Pipes	12288-1987
Laying and jointing of Unplasticized PVC pipes	7634-1975 (Part 3)
Stoneware pipes	IS:651-1992
Code of Practice for Ancillary Stonewares in sewerage system	IS:4111-1986 Part I & II

Table 5.20: References to Codes

Description	BIS No.
Precast Manhole covers and frames	IS:12592-1998 Part I & II
Code of Practice for plain and reinforcement concrete	IS:456:2000
Batch type concrete mixer	1791-1968
Sheep foot roller	4616-1968
Safety code for excavation works	3764-1966
Safety code for scaffolds and ladders	3696-1966 (Part-I &II)
Safety code for piling and other deep foundations	5121-1969
Safety code for working with construction machinery	7293-1974
Government of India Manual on Water Supply and Treatment	May 1999 (Revised)
Gravel for packing	4091 1967
Hard drawn Steel Wire	1785 1983 (Part I and II)
Structural Steel	226 1975
Hard rolled mils steel for concrete	1139 1966
Hard drawn Steel Wire	1566 1982
British Standard	2494 1955
Welding Electrodes	814 1970
Steel Sheets	225 19
Guniting	7322 1994
Welded Joints	3589 1966 and 2041 1962
Tensile Test	223 1950
Earthing	3043 1966

5.38 SPECIFICATIONS FOR ELECTRICAL WORKS

This section of the specification sets out the standard for items of electrical system to be executed by the Contractor. This section describes the basic system that has to be adopted for the electrical power distribution of sewage treatment plant. The selection of power distribution system equipment ratings and layout of the electrical equipment shall

consider ease of installation, maintenance and modular addition of equipment for future expansion. All the components of the electrical system shall withstand the environmental conditions of the region as described hereafter.

The equipment shall be complete in all respects and device not included in the specifications but essential from code, regulation, statutory requirement, standard practice or operational flexibility point of view shall be included by the Contractor.

5.38.1 Standards

The equipment standards applicable for the design and installation of the electrical, control, monitoring systems are the relevant Indian standards. Cognizance shall also be taken of International standards i.e. International Electro Technical Commission (IEC) where Indian standard is not available or not clear about the subject.

It shall be designed, assembled and tested to the satisfaction of the Executive Engineer and shall conform to the relevant standards published by the Indian Standards Institution, wherever available, in order that specific aspects under the Indian Conditions are taken care of.

The applicable standards established by the Bureau of Indian Standards govern the materials and workmanship employed in the manufacture of all equipment/items are:

IS 191 - Copper Specification

IS 319 - Free Cutting Leaded Brass Bars, Rods Specification and Section

IS 325 - Three phase induction motors

IS 335 - New insulating oils

IS 374 - Electric ceiling type fans and regulators

IS 379 - Anhydrous sodium sulphate, pharmaceutical

IS 513 - Cold reduced low carbon steel sheets and strips.

IS 694 - PVC Insulated cables for working voltage up to and including 1100 V.

IS 722 - Specification for AC Electricity Meters.

IS 732 - Code of practice for electrical wiring installations

IS 1079 - Hot Rolled Carbon Steel Sheet and Strip Specification. IS1169 - Electric pedestal type fans and regulators IS1248 - Direct acting indicating analogue electrical measuring instruments and their accessories

IS 1255 - Code of practice for installation and maintenance of power cables up to and including 33kV rating.

IS 1271 - Thermal evaluation and classification of electrical insulation.

IS 1293 - Plugs and socket- outlets of rated voltage up to and including 250 volts and rated current up to 16 amperes Specification. IS 1544 - Cotton calico IS 1554 - PVC insulated (heavy duty) electric cables

IS 1868 - Anodic Coatings on Aluminium and its Alloys Specification. IS 1897 - Copper strip for electrical purposes Specification.

IS 1944 - Code of practice for lighting of public thoroughfare: Part 5 Lighting for grade separated junctions, bridges and elevated roads.

IS 2026 - Power transformers

IS 2062 - Hot Rolled low, medium and high tensile structural steel

IS 2099 - Bushings for alternating voltages above 1 000 Volts

IS 2148 - Electrical apparatus for explosive gas atmospheres Flameproof enclosures.

IS 2190 - Selection, Installation and Maintenance of First-aid Fire Extinguishers code of practice.

IS 2206 - Flameproof electric lighting fittings

IS 2253 - Designation for types of construction and mounting arrangement of rotating electrical machines

IS 2309 - Code of practice for protection of buildings and allied structures against lightning.

IS 2419 - Dimensions for panel mounted indicating and recording electrical instruments

IS 2544 - Porcelain post insulators for systems with nominal voltage \leq than 1000 V.
IS 2546 - Specification for galvanized mild steel fire bucket. IS 2551 - Danger notice plates

IS 2629 - Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS 2633 - Methods for testing uniformity of coating of zinc coated articles
IS 2667 - Fittings for rigid steel conduits for electrical wiring
IS 2705 - Current transformers

IS 2925 - Specification for Industrial Safety Helmets

IS 2993 - A.C. motor capacitors

IS 3043 - Code of practice for earthing

IS 3070 - Lighting arresters for alternating current systems

IS 3156 - Voltage transformers

IS 3231 - Electrical relays for power system protection

IS 3347 - Dimensions for porcelain transformer bushings for use in lightly polluted atmospheres.

IS 3400 - Methods of test for vulcanized rubbers

IS 3419 - Fittings for rigid non-metallic conduits

IS 3427 - A.C. Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV. IS 3480 - Flexible steel conduits for electrical

wiring

IS 3646 - Code of practice for interior illumination

IS 3837 - Accessories for rigid steel conduits for electrical wiring

IS 3842 - Application guide for electrical relays for ac systems

IS 3854 - Switches for domestic and similar purposes.

IS 3975 - Mild steel wires, formed wires and tapes for armouring of cables

IS 4759 - Hot-dip zinc coatings on structural steel and other allied products

IS 4770 - Rubber Gloves - Electrical Purposes Specification.

IS 4795 - Holders for Indicator Lamps for Electronic and Telecommunication Equipment.

IS 5571 - Guide for selection of electrical equipment for hazardous areas

IS 5572 - Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installation

IS 5578 - Guide for marking of insulated conductors

IS 5621 - Hollow insulators for use in electrical equipment

IS 5819 - Recommended short-circuit ratings of high voltage PVC cables.

IS 5831 - PVC insulation and sheath of electric cables.

IS 6229 - Method for Measurement of Real-ear Protection of Hearing Protectors and Physical Attenuation of Earmuffs.

IS 6600 - Guide for loading of oil immersed transformers

IS 6665 - Code of practice for industrial lighting

IS 7098 - Crosslinked polyethylene insulated PVC sheathed cables

IS 7752 - Guide for improvement of power factor in consumer installation.

IS 8130 - Conductors for insulated electric cables and flexible cords.

IS 8224 - Electric lighting fittings for division 2 areas

- IS 8468 - On-load tap changers
- IS 8478 - Application guide for on-load tap changers
- IS 8752 - Towing hook for use between trailers of up to 5 tonnes gross mass and transport tractor
- IS 8789 - Values of performance characteristics for three phase induction motors
- IS 8828 - Electrical Accessories - Circuit Breakers for Over Current Protection for Household and Similar Installations.
- IS 9283 - Motors for submersible pump sets
- IS 9334 - Electric motor operated actuators.
- IS 9537 - Conduits for electrical installations
- IS 9583 - Emergency lighting units
- IS 9677 - Guide for limits of temperature-rise of the windings of electrical equipment when tested by different methods
- IS 9678 - Methods of measuring temperature rise of electrical equipment.
- IS 9921 - Alternating current disconnectors (isolators) and earthing switches for voltages above 1000 V
- IS 9974 - High pressure sodium vapour lamps
- IS 10118 - Code of practice for selection, installation and maintenance of switchgear and control gear
- IS 10322 - Luminaires
- IS 10418 - Drums for electric cables
- IS 10601 - Dimensions of terminals of high voltage switchgear and control gear.
- IS 10810 - Methods of test for cables

- IS 11037 - Electronic type fan regulators
- IS 11171 - Specification for Dry-Type Power Transformers.
- IS 11353 - Guide for uniform system of marking and identification of conductors and apparatus
- IS 12065 - Permissible limits of noise level for rotating electrical machines
- IS 12615 - Energy efficient induction motors- three phase squirrel cage.
- IS 13340 - Power Capacitors of Self-healing Type for AC Power Systems having Rated Voltage up to 650 V Specification.
- IS 13341 - Requirements for ageing test, self-healing test and destruction test on shunt capacitors of the self-healing type for ac power systems having a rated voltage up to and including 650 V.
- IS 13346 - Electrical apparatus for explosive gas atmospheres-General requirements
- IS 13369 - Stationary lead acid batteries (with tubular positive plates) in monobloc containers.
- IS 13383 - Methods of Photometry of Luminaires. IS 13440 - Code of safety for methyl chloride.
- IS 13703 - Low Voltage Fuses for voltages not exceeding 1000V AC or 1500 V DC.
- IS 13779 - AC Static Watt-hour Meters, Class1 2
- IS 13849 - Specification for portable fire extinguisher dry powder type (constant pressure).
- IS 13875 - Digital measuring instruments for measuring and control.
- IS 13925 - Shunt capacitors for ac power systems having a rated voltage above 1000 V.

IS 13947 - Low-voltage switchgear and control gear

IS 14697 - AC Static transformer operated Watt hour and VAR Hour Meters

IS 14981 - Live working-Earthing or earthing and short-circuiting equipment using lances as a short-circuiting device-lance working

IS 14927 - Cable trunking and ducting systems for electrical installations

IS 14993 - Saddles, pole clamps (stick clamps) and accessories for live working

IS 15086 - Surge arresters

IS 15652 - Insulating mats for electrical purposes Specification.

Other applicable standards established by the International Electro technical commission (IEC), NFC etc. govern the materials and workmanship employed in the manufacture of all equipment/items are:

IEC 60076 - Power transformers - Part 11: Dry-type transformers.

IEC 60335 - Household and similar electrical appliances - Safety - Part 1: General requirements.

IEC 60669 - Switches for household and similar fixed-electrical installations - Part 1: General requirements.

IEC 60751 - Industrial platinum resistance thermometers and platinum temperature sensors.

IEC 60789 - Medical electrical equipment - Characteristics and test conditions of radionuclide imaging devices - Anger type gamma cameras.

IEC 60896 - Stationary lead-acid batteries - Part 22: Valve regulated types Requirements.

IEC 60947 - Low-voltage switchgear and control gear - Part 1: General rules. IEC 61537 - Cable management - Cable tray systems and cable ladder systems. IEC 61643 - Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power distribution systems - Selection and application principles.

IEC 61921 - Power capacitors - Low-voltage power factor correction banks.

IEC 62305 - Protection against lightning - Part 4: Electrical and electronic systems within structures.

IEC 62271 - High-voltage switchgear and control gear - Part 101: Synthetic testing

Where provisions of the pertinent codes and standards conflict with these Specifications, Drawings and Datasheets or with each other, comply with the more stringent provision. In such cases, the decision of Engineer-in-Charge, IITH shall be final and binding .

5.38.2 Regulation

It is essential that the electrical power distribution system will comply in all respects with the relevant statutory and regulatory instruments of state of Telangana and that of India. The relevant, state and national, statutory and regulatory instruments for electrical installations are as follows:

The Indian Electricity Rules 1956

The Electricity Act 2003

5.38.3 Safety and security

It is essential at all times to maintain a safe system of working and to comply with all enactments, regulations and working rules relating to safety, security, health and welfare of all persons who may be affected by the work.

In particular it has to be ensured that only persons who are properly trained for their duties are employed, and that the correct tools and procedures are used.

Nothing which has been written into or omitted from this document shall be taken to relieve the Contractor from the obligations under this clause. No clause in this specification shall prevent the executing agency from drawing the attention of the Engineer-in-Charge to any feature of the works which is not consistent with normal safety practices nor prevent him putting forward proposals at any time which would increase the safety of the

installations.

The design should include all reasonable precautions and provisions for the safety of operating and maintenance personnel.

5.38.4 Electrical switchgear room environment

Electrical switchgear rooms shall be designed to provide a non-hazardous, clean and dry location for the switchgear/motor control centers/power control centers and associated equipment. Rooms shall be ventilated with air taken from non-hazardous and clean areas.

5.38.5 Drawing, Instructions and Certificates

The Contractor shall supply with the tender a schematic electrical circuit diagram showing thereon the various switches, cables and motors. Dimensions shall be in metric units.

On acceptance of the tender the Contractor shall submit 3 sets of the following drawings for prior approval of Engineer-in-Charge:

Layout with cable, sizes and all details.

Circuit diagram

Wiring diagram of starters, factory-made panels.

Front elevation of the control panel.

5.38.6 Voltage and frequency variations

Electrical equipment shall function satisfactorily during voltage fluctuations within +10% and -10% of the stated voltage levels and at frequencies within +/-5% of the stated frequency.

5.38.7 Phase sequence

Phase sequence shall be specified in alphabetical order, each phase reaching its maximum in time sequence in this order. Bus bars shall be marked as R.Y.B. and N as seen from the front or operating side of a switchboard or panel.

Cable terminals and apparatus which are to be connected directly or indirectly to supply conductors shall be marked U.V.W. The neutral and earth shall be marked as N, E respectively.

5.38.8 Compatibility

Components used with electrical switchgear, motor control gear and control panels shall be uniform throughout the works in order to reduce spare holdings. Electrical enclosures housing switchgear, motor control gear, control systems, terminations shall each be of similar construction throughout the works in order to achieve a consistent appearance.

5.38.9 Enclosures

Enclosures shall be constructed to provide an adequate level of protection from the environment. The following minimum standards shall be applied unless otherwise specified:

- * Switchgear and control panels located in switchgear or control rooms - IP 54
- * Switchgear and control panels located in plant rooms - IP 55
- * Equipment located externally in sheltered locations - IP 56
- * Equipment located externally in exposed locations - IP 65
- * Equipment liable to be periodically submerged - IP 68.

The IP ratings are defined by IEC 529.

5.38.10 Potentially explosive areas

Ventilated dry wells and wet wells open to the atmosphere shall be considered to be non-hazardous. Equipment shall be selected and installed and inspected in accordance with the requirements IS 5571.

5.38.11 Identification

Each main and auxiliary item of plant shall have permanently attached to it in a conspicuous position a nameplate and rating plate. Upon these shall be engraved, in English, the manufacturers name, direction of rotation, type and serial number of plant, details of the loading and duty at which the item of plant has been designed. All indicating and operating devices shall have securely attached to them or marked upon them designations as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes as indicated on the layout drawings.

Such nameplates, rating plates and labels shall be of a rigid type, at least 3 mm thick, laminated and engraved plastic material, with black block capitals on a white background. The labels shall be fixed by non-ferrous or stainless steel screws.

Warning labels shall be of similar construction with black block capitals on a yellow background. Weatherproof labels for use outside the buildings shall be rigid type laminated plastic. All field items shall be tagged with 50 x 25 mm engraved labels. The label shall state the item tag number and hazardous area classification in case it falls under

it and shall be attached by a corrosion resistant ring to a fixed portion of the item. The ring shall retain the tag securely but shall allow transfer to a replacement item when necessary.

Warning labels shall be provided where necessary to warn of dangerous circumstances or substances. Inscriptions or graphic symbols shall be black on yellow background and to internationally recognized standards.

Instruction labels shall be provided where safety procedures such as wearing of protective clothing are essential to protect personnel from hazardous or potentially hazardous conditions. These labels shall have inscriptions or graphic symbols in white on a blue background.

5.38.12 Harmonics

The limits for harmonics in the power system as a result of non-linear loads are to be limited to those standards imposed by the power supply company i.e. TSSPDCL.

5.38.13 Surge Protection

Surge protection shall be provided at the main control panel end of instrumentation cabling connecting equipment located external to buildings.

5.38.14 Cable Support Systems

5.38.14.1 Trays for Power Cables:

Ladder type cable trays shall be used for power cables. Material of construction shall be of hot dip galvanized steel. Minimum thickness of all ladder type cable trays shall be 2 mm for trays up to 300 mm width, thickness shall not less than 2.5mm for trays above 300mm up to 600mm. Height of all power cable trays shall be minimum 100mm

5.38.14.2 Cables External to Buildings and Structures

Cables external to buildings and structures shall be installed underground through suitable sized uPVC conduits , concrete ducts or shall be directly buried.

Where cables passes below internal or external roads or areas of hard standing, cables shall be laid through concrete ducts. Cable concrete duct systems shall incorporate suitably located draw- pits/inspection chambers/pull boxes whenever there is change in direction of route of the cable. Cables crossing below the walls or structures shall be laid through uPVC conduits.

Minimum 30 % space inside uPVC conduits and concrete ducts shall be kept for future expansion. The minimum depth LV cable installation shall be 700 mm. Cable trays and supports shall be in accordance with IEC 61537. Cable tray supports shall provide adequate strength with minimum rigid support to the fully laden cable tray along its entire length. All cable trays inside the control room, pump room and out of the trench shall be closed. A maximum of two layers of cable shall be installed on any tray. All cable trays shall be supported to prevent sagging.

5.38.14.3 Corrugated Flexible Conduit

uPVC corrugated flexible conduits shall be manufactured as per IS 9537 ideally suited for electrical wiring and cable protection.

Use liquid tight flexible uPVC conduit for termination at Junction boxes, Local control stations (LCS), termination to motors, field instrumentation and process equipment unless otherwise specified.

5.38.14.4 Conduit Fittings:

Fittings, as required, for use with conduit specified, with coating and colour same as conduit shall be provided.

All conduit fittings and covers shall be weatherproof and watertight as per Indian standard 3419, unless otherwise noted.

5.38.14.5 Conduit Fastenings

Use uPVC straps for uPVC conduits and steel straps for galvanized steel / galvanized iron conduits.

Channel type supports shall be provided for two or more conduits.

All surface installation horizontal runs of conduits should be secured at maximum distance of 0.9 meters and vertical runs of conduits should be secured at maximum distance of 1.2 meters.

Fastening should be properly tightened to restrict thermal movement of conduit.

5.38.14.6 Expansion Fittings or couplers

Appropriate water tight expansion sleeves with bonding where conduit crosses a structural expansion joint or to accommodate for thermal movement due to temperature change on surface installations, complete with grounding strap and clamps shall be provided.

Expansion couplers shall be installed with a short side coated with solvent cement and coupler pushed firmly over the conduit down the nib. The slip side coated with silicon grease receives the conduit to a midpoint to the nib. This will then permit for expansion or contraction providing the conduit is free to move in the saddle.

5.38.14.7 Outlet and Conduit Boxes

Outlet boxes shall be sized in accordance with IS 3419.

Appropriate Switch boxes shall be provided where wiring devices such as switches, fan regulators etc. are grouped.

Blank cover plates shall be provided for boxes without wiring devices.

Where outlet boxes are used for more than one system appropriate combination of barriers shall be provided.

Outlet boxes made from uPVC or galvanized steel and shall be suitable for mounting/fixing on masonry and/or concrete construction and shall be flush mounted or surface mounted as per site requirement.

All fittings, boxes and covers, in below grade areas, shall be weatherproof conforming to relevant IS unless otherwise noted.

Outlet boxes, conduit boxes and fittings for hazardous locations shall be as per IS 5571.

uPVC and galvanized steel boxes with fittings (bends elbows, tees crosses etc) for surface wiring of switches and receptacles.

5.38.14.8 Hazardous Areas

For hazardous areas, provide epoxy coated rigid galvanized steel conduit, conduit fittings, compound, etc., to conform to the code requirements for the specific type of hazardous i.e. Zone 1. All boxes, fittings and joints shall be threaded for connection to conduit terminations and shall be explosion proof. Threaded joints shall be made up with at least five threads fully engaged. For flexible connections at motor terminals, provide liquid tight flexible conduit and fittings approved for Zone 1 locations. Conduit, conduit fastener and conduit fittings shall be of rigid galvanized steel as manufactured by recognized manufacturers.

5.38.14.9 Markers

300 mm wide polyethylene Cable Marker Tape, Red in colour with the following imprinted continuously over its entire length: DANGER-sign of Skull Bones BURIED ELECTRIC CABLE BELOW.

The Cable route marker post in circular in shape made up of hot dip galvanized steel of approximate diameter 100 mm and thickness not less than 4 mm. shall be used for cable route indication. The inscription shall indicate the presence of a cable below, the depth and voltage rating.

5.38.14.10 Sealing Compound

Conduit fitting shall be installed in the system using solvent cement for restriction of water in it and silicon grease where installation is subject to frequent changes.

PVC solvent cement shall be used as a method of joining uPVC conduit into fitting like couplings, adaptors, bends and boxes, especially formulated for watertight joint.

5.39 LV switchgear

The switchgear shall be designed and manufactured in accordance with IS 13947 and IEC 60947. The Motor Control Centre (MCC) shall be intelligent. A MCC is considered intelligent when the MCC utilises intelligent components, such as overload relays, starters, controller and functional units are interconnected via fieldbus systems.

The MCC shall be designed using Form 4 separation and shall contain, at the minimum, the following items:

Main Incomer Feeders including 20% spare feeders. Plant end equipment starters. The MCC shall have top cable entry with front access only.

The MCC Main Incomer protective device shall be rated to ensure discrimination with all upstream and downstream protective devices.

The MCC shall be provided with an earth bar and shall form the main earth terminal for the installation.

The MCC shall be fitted with thermostatically controlled anti-condensation heaters where required. Provision of communication with each feeder with PLC shall be provided. MCC incomer shall be MCCB for rating up to 630A. For rating above 630A, ACB shall be preferable.

5.39.0.1 PCC / MCC:

Unless otherwise specified, every 415 V motor control centre (MCC) shall be of the floor-standing multi-compartment type complying with IS 13947 and IEC 60947.

The overall enclosure of the MCC shall be to IP54 for indoor use. Except for any with drawable circuit breaker, busbar and cabling alley, a hinged door shall be provided for each compartment of the MCC. The door shall be interlocked with any switch-fuse or MCCB/MPCB fitted in the compartment and intended as a means of isolation for the circuits inside the compartment so that the door can only be opened when the switch-fuse or MCCB/MPCB is in the Off position.

Every motor starter and other functional unit shall be installed in a dedicated compartment.

Except for with drawable air or moulded case circuit breakers, every motor starter and other functional unit shall be of the fixed or swing-out type, where:

fixed means that, except for those components which must be mounted on the compartment door, the starter or other functional unit is fixed within the compartment

swing out means that, except for those components which must be mounted on the compartment door and any components fixed within the compartment, the starter or other functional unit is mounted on a hinged panel which can swing out when the compartment door is open. Swing- out units will only be acceptable for starters, rated equal to or less than 7.5 kW.

Except for the compartment doors, all removable covers, the removal of which gives access to live electrical circuits shall be fixed by means of bolts.

Switches and indicating meters such as ammeters, voltmeters, etc shall not be positioned above 1800 mm or below 300 mm. Devices for isolation and switching shall be accessible within the zone 300 mm to 1800 mm above floor level.

Every fuse in the power circuit shall be of the HRC type unless otherwise stated.

Wiring inside the MCC shall incorporate copper conductors, the minimum acceptable cross-sectional area being 2.5 mm² for power circuits and 1.5 mm² for control and monitoring circuits. Wiring for power circuits shall be phase colour identified throughout in accordance with IS 732. Alphanumeric identification ferrules shall be fitted to each end of each wire forming part of a control and monitoring circuit. Each ferrule shall completely encircle the wire. The identification of each wire shall be unique and shall correspond to that shown on the manufacturers schematic and wiring diagrams.

5.39.0.2 Busbar:

The cable connections from the busbars to the functional units shall be kept as short as practicable and shall be sized, routed and supported to minimise the risk of a fault.

It shall be necessary to use tools to remove the covers from the busbar system compartment. Each removable cover shall bear a warning label engraved on it.

Wherever a voltmeter, kW, kWh, kVA, kVAh or similar meter is fed directly from the busbar system or from the cable side of an air circuit breaker, it shall be protected by MCB or fuses.

5.39.0.3 Distribution board

All the switch Boards, Panels shall be neatly wired using 1100/660V PVC insulated stranded copper cable of minimum 2.5 sq.mm. Copper Bus Bars also may be provided to suit the requirements.

Each wire shall be identified at both ends with cable marker.

Distribution Boards shall be housed in metal clad case or board conforming IS 4237. The Sub- distribution Boards (SDB) shall be equipped with rigidly fixed miniature circuit breaker complying IS 8828 in the phase leads with over load and short circuit protection. The MCBs shall have adequately sized terminals for the outgoing leads. The distribution boards shall have adequately rated phase and neutral bus bars of high conductivity copper. Earth the bus bar with the necessary number of terminals for connecting the earth continuity conductors.

Each SDB shall have schematic diagram or single line diagram pasted or permanently fixed inside the cover stating the details of circuit incomer and rating of MCB. Non-flammable insulating shields shall be provided to prevent fire hazards during operation of MCBs. The SDB shall not be mounted at a height exceeding 1800 mm from ground level.

Main Distribution Boards shall be wall mounted. Main Distribution Boards shall be erected in each switching room, and sub-distribution boards shall be located according to the distribution of load and the equipment to be connected and its location.

Each lighting distribution board (LDB) Incomer shall be provided with ELCB. Each outgoing feeder of LDB shall be provided with MCB. Power distribution board shall be provided to cater window/split/cassette type air-conditioning load and auxiliary load (e.g. welding, drill machine, Grinder, EPABX etc.)

5.39.0.4 Spare compartment

Minimum 20% of spare feeders shall be provided in each MCC panel. Each spare compartment shall be equipped to the extent that would enable it to be converted into a direct on line starter/star delta/soft starter at a later date without having to de-energise the busbars or shutdown any other circuit.

5.39.0.5 Local push button station

Construction features

The constructional features of the local push button stations shall be as follows :

(a) Metal enclosed, weather proof, suitable for mounting on wall or steel structures. The enclosure shall be sheet metal of 2 mm thickness.

(b) Outdoor type push buttons shall be completely weather, dust and vermin proof and shall be provided with canopy. Degree of protection shall be IP:55.

(c) Metal parts shall be given tropicalising treatment as per standards and painted with one coat of epoxy primer and two coats of light grey epoxy paint.

(d) Provided with inscription plates of rear engraved with white letters on black background.

(e) The letter size shall be 6 mm.

(f) Provided with two earthing terminals suitable for 14 SWG G.I. wire.

(g) Provided with removable undrilled gland plate and cable glands for appropriate sizes of cable. The cable entry shall be from the bottom.

(h) Push button contacts shall be designed for extra robust both mechanical and electrical operation. High quality material shall be used in their construction to ensure mechanical life exceeding 10 million switching operations. The contact shall be of silver alloy of 10 A continuous current rating.

Push buttons

(a) All push buttons shall be:

i. Fitted with two (2) normally open and two (2) normally closed contacts rated to carry and break 6 Amps at 415 Volts (10 A at 240 V AC). ii. Provide integral escutcheon plates marked with its function.

(b) The open/close/start push buttons shall be of the momentary contact push to actuate type and shall be green in colour. (c) The stop push buttons shall be stay put type with mushroom knob and shall be red in colour.

Type of Push Button Stations

The following types of push button stations shall be supplied:

(i) Push button station type A - Each P.B. station suitable for indoor installation and shall comprise two push buttons viz. START and STOP for control of non-reversible motors.

(ii) Push button station type B - Each P.B. station for indoor installation and shall comprise of three push buttons viz. OPEN CLOSE and STOP for control of reversible motor.

5.39.0.6 Earthing conductor:

A suitably sized tinned copper earth-bar shall be provided in an accessible location inside and along the length of the motor control centre. If the MCC is to suit bottom-entry cables, the earth-bar shall be at the bottom of the MCC. If the MCC is to suit top-entry cables, the earth-bar shall be at the top of the MCC.

5.39.0.7 Air Circuit Breaker(ACB):

Air circuit breakers shall be utilised for rated current equal to or greater than 630 ampere. Where air circuit breakers are specified, the operating mechanism of each air circuit breaker shall have mechanical 'ON' and 'OFF' indicators and a manual trip device fitted with means for locking. Hand charged and motor charged spring mechanisms shall have mechanical indicators to show 'SPRINGS CHARGED' and 'SPRINGS DISCHARGED'.

Operating mechanisms of the hand charged and motor charged spring types shall be arranged so that release of the springs to close the circuit breaker can only be achieved by a deliberate action. It shall not be possible for vibration or mechanical shocks to release the charged springs. Motor charged spring mechanisms shall be arranged so that charging is initiated automatically following a discharge, and the necessary limit stops and switches for the automatic control of the charge once initiated, shall form an integral part of the mechanism. It shall be possible to hand charge a motor charged spring mechanism in an emergency.

Spring operated mechanisms shall be provided with volt-free contacts to give indication that the springs are charged.

The closing solenoids of d. c. solenoid operated mechanisms shall be suitable for operation at a minimum of 80% of the nominal supply voltage and shall not malfunction or cause excessive vibration when energised at 120% of the nominal supply voltage.

To facilitate maintenance and adjustment of contacts, it shall be possible to slow-close the circuit breaker. This operation shall only be possible in the fully withdrawn position. Any necessary operating handle, lever or tube shall be supplied.

Each circuit breaker shall be trip free and be provided with the following mechanical interlocks:

It shall not be possible to withdraw or to replace the circuit breaker from the service position unless the breaker is open.

It shall not be possible to attempt to close the breaker unless the closing springs are fully charged.

It shall not be possible to remove the circuit breaker from its fixed cassette without manually overriding a catch.

Each circuit breaker shall be versatile enough so as to accommodate rating plug.

Each circuit breaker shall have mechanical indicator to display the deterioration status of the contacts.

5.39.0.8 Moulded case circuit breaker (MCCB)

Moulded Case Circuit Breaker(MCCB) shall be a circuit breaking device which can make, withstand and break current whose intensity is atmost equal to its nominal current and protection device which can automatically break over current which may occurs as a result of fault in the installation.

The terminals and connections between all current carrying parts shall be designed to assure permanently low resistance connections.

MCCB shall have rated operational voltage of 415V, 50Hz power supply system.

MCCB shall have minimum fixed symmetrical interrupting capacity i.e. ICS=50

MCCB shall have at least 2 Numbers each NC and NO spare auxiliary contacts as required. MCCB shall conform to the latest application of standard IS 13947-2. MCCB shall have minimum power loss as defined by the standard IS 13947.

MCCB shall be current limiting type with let through energy limit as specified in IS/IEC 60947. MCCB housing shall be heat resistant and having high impact strength.

MCCB shall have under voltage release feature.

All incomer MCCB shall be microprocessor based with adjustable overload (40% to 100%), short circuit (2 to 10 IN) and earth fault protection (10 to 50%) and shall have RS 485 communication compatibility. All Incomer MCCB shall be provided with rotary handle. All other MCCBs will be thermal magnetic type with earth fault protection.

MCCB terminals shall be protected against finger contact to IP 2X degree of Ingress Protection to provide total safety to the operating personnel.

Considering MCC panel, 3Pole + Neutral MCCBs will be used as a main incomer and for power distribution and 3Pole MCCB will be used for outgoing for each motor load. Also 3Pole + Neutral MCCB/MCB with ELCB will be used as an incomer to lighting DB.

MCCB Operating mechanism shall be quick- make, quick-break and trip-free type. The ON, OFF and TRIP positions of the MCCB shall be clearly indicated and visible to the Contractor when mounted as in service.

MCCBs shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relays settings of the motor starting equipment and the mechanical stress caused by the peak short-circuit current of value associated with the switchgear rating. The maximum tripping time under short circuit shall not exceed 20 milliseconds.

MCCB terminals shall be suitable for accepting spreader links to receive cable lugs for cable sizes relevant to circuit ratings. Phase barriers should be provided for isolation of the poles.

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the off position. The on and off positions of each switch shall be indicated clearly.

5.39.0.9 Miniature Circuit Breaker (MCB):

MCBs required shall be of single-pole or three pole (with or without neutral) types.

The rated voltage for single pole and three pole (with or without neutral) shall be 240 V 415 V, 50 Hz frequency respectively.

All Single pole and three pole (with or without neutral) MCBs shall be suitable for 10 KA as per IS: 8828. The procedure for making the Short Circuit test and the test circuit etc. shall be in accordance with the IS: 8828.

5.39.0.10 Instrument Transformers

Potential Transformers:

Potential transformers shall conform to IS 3156 and IEC 186, dry type for indoor use, with following characteristics:

Nominal voltage : 415 V. Rated frequency: 50 Hz. Voltage ratio: as per control circuit requirement.

Potential transformer shall be equipped with fuse holder and fuses.

Current Transformers:

Current transformers(CT) shall conform to IS 2705, IEC 60044-1, dry type for indoor use complying with following characteristics:

The CTs shall be of solid core with round window type with accuracy 0.2% for consumer check metering.

The secondary leads shall be terminated with tinned Cooper rose contact terminals with arrangements for sealing purposes.

Polarity (both for primary and second leads) shall be marked.

The CTs shall be varnished, fiberglass tape insulated or cast resin, air-cooled type. Only super enameled electrolytic grade copper wires shall be used.

The CTs shall have marking and nameplate as per IS 2705 in addition to class of insulation ISF. The markings shall be indelible. The nameplate shall be securely fixed

to the body of the CT and contain following data

Nominal voltage class: 415V. Rated frequency: 50 Hz. Rated primary current: as indicated in approved SLD or as per feeder requirement. Secondary Ampere rating of CT shall be 5A where CT and metering /protection units are in same panel. 1A -where CT and metering /protection units are in different panel.

Short-time dynamic current rating, 2.5 times the rated short-time thermal current rating. Short-time thermal current rating shall be 100 times primary rating.

5.39.0.11 Metering and Switchboards Instruments

Indicating Instrument and Meters:

Measuring instrument i.e. ammeter,volt meter and Energy meters mounted on each cubicle of control panel shall be digital. Digital energy meter for measuring total wattage, power factor with all electrical parameter shall be provided at incomer side and shall have 0.5 class accuracy.

5.39.0.12 Digital Indicating Instruments

Digital Indicating Instruments shall be of 96mm square

For digital meters, display shall be red colour LED.

All digital meters (ammeter, voltmeter) will be of 3 1/2 digits display. Accuracy class shall be Class 1.0 unless otherwise specified. Auxiliary Supply shall be 230V AC.

Digital Meter shall conform to IS 13875 and IEC 61010.

Type test report from NABL/ERTL or NABL accredited lab shall be provided.

Digital Energy Meter (Multifunctional Meter): General Requirements The meter shall be suitable for operation in 3 - phase networks, balanced as well as unbalanced load, four quadrant metering.

It shall be possible to use the multifunction meter directly in 415V (L-L) networks.

The current primary inputs shall be configurable at site in steps for measuring x / 5 A or 1 A current transformers through front buttons.

The multifunction meters shall be suitable for operation up to 45 Degree Celsius. The meters shall be work on 230V AC power supply. The multifunction meters shall have degree of protection against ingress of dust water. The multifunction meters shall have backlit LCD/LED display with adjustable contrast. The meter shall be tamper-proof (password protected) to avoid mishandling by unauthorized person.

Accuracy of meter shall be 0.5 unless otherwise specified.

It shall conform to IS14697, IS13779, IEC62052, IEC 62053.

5.40 Measured Values requirement

All metered values will be in "true RMS" values. The monitor shall include a keypad allowing for the viewing of different selected values. The monitor shall display the following values:

Table 5.21: Measured Values requirement

Voltages	Phase-phase / phase-neutral
Currents	Per phase / neutral
Apparent, active and reactive power	Three phase total
Power factor	Individual phase and total average
Frequency	50 Hz +/- 5%
Minimum / maximum values	a) Voltage - phase-phase
	b) Line current
	c) Active, Reactive and Apparent Power
	d) Power factor
	e) Frequency
Active energy	Import/ export
Reactive energy	Import/ export
Energy demand per measuring period	Three phase average rating for active and reactive power: 30 min.
Minimum / maximum rating values within the measuring period	Shall be possible to be measured

Measurement Accuracy

The meter shall have at least 3 pulse Input and 2 volt free pulse output as standard

The meter shall have LED output configurable for active, reactive and apparent energy for testing of accuracy communication.

The meters shall have inbuilt RS485.

5.40.0.1 Indicating Lamps:

Indicating lamps shall be of the LED type, with low watt consumption. Indicating lamp shall be of the double contact, glass lens cap type rated for operation for either a 230 V a-c voltage. Indicating lamps shall be provided with series resistances to avoid short circuiting of control supplies in the event of fusing of the LED. Lamps shall be provided with translucent lamp covers. Bulbs and lenses shall be interchangeable and easily replaceable from the front.

5.40.0.2 Push Buttons

Illuminated type, momentary action, flush type pushbuttons shall be provided. It shall be sealed to at least IP54. Push button colors will be Green for Start and Red for Stop. Contact shall be silver plated. Operating voltage of push button will be 230V AC. "Start" and "Stop" push buttons shall be provided for non-reversible motors. Mechanical life of push

button shall be minimum 1, 00,000 cycles. Operating temperature of push button is 45 °C.

5.40.0.3 Fuses

For short circuit protection, Semiconductor fuses shall be used for soft starter operated motors. HRC Fuses of suitable characteristics shall be provided for feeders unless otherwise specified.

5.40.0.4 Control Switches

Positions labeled, heavy-duty Contactors standard, multiple contacts rated 230V, 5A, AC. For Mode Selectors use make before break contacts. The selector switches shall be bump-less.

5.41 Motor Starter

Each motor starter shall incorporate the following features in addition to complying with the requirements specified elsewhere in the specification.

A suitably rated 3-phase neutral (four pole) MCCB as a means of isolating the starter from the busbars and to provide short-circuit protection. A facility shall be provided to enable the MCCB to be padlocked in the Off position only.

Where any control or monitoring circuit inside the starter compartment operates at a voltage in excess of 24 V d.c. and is energised from outside the starter compartment, both poles of the circuit shall enter the starter compartment via miniature circuit breaker (MCB) so that the circuit inside the starter is isolated when the MCB is open.

An isolating transformer shall be provided to feed the control and monitoring circuit. The primary of the transformer shall be fed from one phase and the neutral; the phase connection shall be protected by fuse. The output from the secondary shall be 110V/240 V. One pole of the transformer secondary shall be earthed and a fuse shall be fitted in the other pole. An earthed metallic screen shall be provided between the transformer primary and secondary windings.

A test switch to enable the control and monitoring circuit to be tested while the main circuit feeding the motor is isolated. The test switch shall only be accessible when the starter compartment door is open. The switch shall take the form of a pushbutton which has to be pulled out to select the test position and pressed in to select the normal position. The test button shall be located in the compartment so that the starter cannot remain in the test mode when the compartment door is shut.

An ammeter shall be provided to measure the line current drawn by the motor. The

ammeter shall be connected on the compartment door with help of Ammeter selector switch. The ammeter shall have an extended range to suit the motor locked rotor current and an adjustable red pointer which can be used to indicate the motor full load current.

Following Relay Protection shall be provided

A Run relay, the coil of which shall be rated at energised from the relevant control and instrumentation compartment

An Available relay

An Inhibit relay, where appropriate

One or more Trip relays, where appropriate

A Local switch-disconnector closed relay, where appropriate. This relay shall only be energised when the switch-disconnector local to the pump is closed.

An overload and single phasing protection device

A motor over-temperature protection device to suit the thermistors or thermostat fitted in the motor

Other drive protection relays, as appropriate

The following control devices mounted on the starter door: A Red Start pushbutton

A Green Stop pushbutton

A Yellow Lamp test button

The following indicator lamps mounted on the starter door: A Red lamp for pump Stopped

A green lamp for pump Running

An amber lamp for Fault

Motor Starting

In selecting the appropriate type of fixed speed starter for a motor, account shall be taken of the following factors:

The torque/speed curves of the driven equipment and of the motor

The calculated frequency of starting each motor and the starts/hour for which the motor is suitable

5.41.1 Voltage regulation

The motor starter shall be one of the following types:

Direct-on-line

Star-delta

Soft start

Variable frequency drive

Of these, direct-on-line starters shall be provided wherever the voltage regulation which results is within the specified limits. DOL starter shall be used for the motor rating up to 7.5kW

For the motor rating above 7.5 kW, star delta starter shall be utilized

If soft-start units shall be provided for motor rating above 55 kW, the appropriate characteristics (e.g. voltage ramp, pump start and possibly soft stop) shall be determined.

Variable frequency drive (VFD) shall be used where speed variation is essential or can be done by keeping process requirement unchanged. Selection of proper VFD shall be done to save the energy.

5.42 Electric Motor

Matching to Driven Equipment

The kW rating of each electric motor shall greater than 10% of the power absorbed by the drive at the duty point. For motors to be operated by variable frequency drives (VFD), the kW rating to be used in this computation shall be the nominal kW rating of the motor derated as required, to allow for diminished cooling and increased losses .The torque/speed characteristic of each motor shall be adequate to accelerate the drive to the required operating speed in an acceptable time.

Frequency of Starting

The Contractor shall calculate the maximum number of starts per hour which could occur for each drive under automatic control. Each motor shall be suitable for the calculated maximum number of hot/cold starts per hour.

Energy Efficient Motors

All motors shall comply with IS 325.

All motor shall be of EFF-2 class as per IS 12615.

Motors to be installed in classified areas shall conform to the requirements of IS: 5571. Motors for Use in Variable Frequency Drive Systems Every motor which is to be fed from a frequency converter (variable frequency drive) shall be suitable for continuous operation at any speed within the specified speed range and with the harmonics generated by the frequency converter. Enhanced cooling and design of the motor windings shall be provided where necessary to meet this requirement.

Anti-Condensation Heaters

Except for the motors in submersible pumps, submersible mixers and submersible propellers, an anti-condensation heater shall be fitted to every motor located in areas where condensation on the motor may occur (e.g. damp, unheated room).

Anti-condensation heaters shall be sized to raise the temperature inside the motor

several degrees above the dew point temperature. The heater surface temperature shall not exceed 200C.

A warning label, black letters on a yellow background shall be fitted to the relevant terminal box to indicate that the heater may be energised while motor is de-energised. Heater terminals shall be shrouded. On larger motor, a separate terminal box shall be provided.

Over-Temperature Protection

The protective over-temperature device shall be in close thermal contact with each phase of the stator windings. For upper and lower bearing also over temperature protection shall be provided. These shall be provided for every motor which satisfies any of the following criteria:

It is operated as a variable speed drive.

It is subject to onerous operating conditions such as a high maximum number of starts per hour or a long run-up time.

It is installed in a potentially hazardous area. Motor rating equal to or greater than 22kW. For submersible pump motors, thermostatic devices will be an acceptable type of over-temperature sensor. Otherwise, each over-temperature sensor shall be a thermistor. All thermistors shall be connected together to provide a single electrical circuit for connection to an external relay which will be capable of tripping the motor.

Overload Protection

Electric motors having a rating equal to or greater than 0.37 kW shall be provided with control equipment incorporating overload protection of the motor.

5.42.1 Cable Termination Facilities

Wherever a motor forms part of a submersible machine, it shall be supplied complete with a factory-fitted cables and IP 68 terminal box. These cables shall be long enough to permit termination in a conveniently located junction box and shall, in any event, be not less than 15 metres long.

For every other motor, cable termination boxes shall be provided and be suitable for air termination of cables. They shall be sealed with a neoprene gasket to provide dust and weather protection. Each box for the termination of power cables shall be the largest standard box which the motor manufacturer can offer for the motor frame size concerned.

Cable termination boxes for phase-to-phase voltages in excess of 1000 V shall be treated with anti-tracking varnish.

5.42.2 Other Requirements

Every electric motor rated at 0.37 kW or more shall be three phase squirrel cage induction type and type of duty shall be as per process requirement. The type of duty shall conform to IS 12824. Any motor rated under 0.37 kW shall be of the same type or shall be a single phase motor if this is more appropriate. All motors excluding motors for submersible application shall be Totally Enclosed Fan Cooled (TEFC) type.

Motor bearings shall be provided with facilities to add additional lubricant. For grease lubricated bearings grease nipples shall be provided and a grease relief feature incorporated. Oil lubricated bearings shall be provided with sight glasses which provide an accurate indication of bearing oil level when the motor is in use.

Unless otherwise specified, motors shall be provided with class F insulation, the permissible temperature rise above the specified ambient temperature shall be limited to that specified in the applicable Indian standards for class B insulation.

The Motor shall conform to IS 12065 for limits of noise levels and shall conform IS 12075 for vibration severity limit.

5.43 Portable Emergency luminaries

Portable Emergency luminaries shall be provided as follows:

1 number each, 2 X 18 W CFL, inside each PMCC, Control room, Office etc. (minimum 1 hour emergency duration)

1 number each , LED type single beam light for Dry well, Wet well, process areas etc. (minimum 1 hour emergency duration)

Emergency EXIT facias using photoluminescence material in green colour at strategic locations (e.g. Dry well exit, PMCC room, Control room etc.) shall be provided.

5.44 Electrical Protection

Over-Current Short Circuit Protection:

All electrical Plant and Materials shall be provided with over-current and short circuit protection. This shall be arranged, as far as is practicable, so that a fault on any item of electrical plant is automatically interrupted without interrupting the operation of any other healthy plant.

Residual Current (Earth fault) Protection:

Residual current protection (sensitivity 100 mA) shall be provided for all socket outlets except those for hand lamps.

Residual current protection (sensitivity 300 mA or Primary winding of every fed by a

circuit breaker (instantaneous operation) and every motor rated at 30 kW and over. The residual current protection shall operate within 5 seconds of the fault being detected.

Other Forms of Drive Protection

Where specified, recommended by the driven equipment manufacturer or where otherwise appropriate, other forms of drive protection such as low power, low current or over-torque based on the measurement of electrical parameters shall be provided. Each type of such protection device shall be of a type tested by the equipment manufacturer.

Wherever low power or low current protection is provided, the motor starter circuit shall be arranged so that the low power and/or low current protection is overridden:

For a suitable time after starting the motor, to prevent spurious tripping of the drive before it has achieved its steady state operating condition

Whenever the Test mode has been selected at the motor starter

In the starter for each screen drive, an over-torque protection relay, type tested by the manufacturer of the protection relay shall be provided to prevent damage to the equipment.

Following Protection shall be provided for the motors

Short circuit protection Overload Protection Earth fault Phase Unbalance/ Failure Locked Rotor/ Stall Protection Warning before occurring of fault Thermistor protection (if applicable)

Components

Components for use in low voltage assemblies shall be in accordance with IEC 60947

Fuses and Links

Fuses used for the protection of power circuits shall be of the high rupturing capacity, HRC type. Semiconductor fuses shall be utilised to protect the soft starter.

Fuses shall comply with IEC 60947. Fuse carriers and bases shall be black. The carrier and base for each neutral link shall be white. Fuses and links shall be positioned to enable easy removal of the carrier without risk of contact with live parts.

Switches, Switch Disconnectors and Switch-Fuses

Every switch, switch disconnector and switch-fuse for use in a power distribution or motor power circuit at up to 1 kV A.C. shall comply with IEC 60947, utilisation category shall be AC 23B, and shall be suitable for padlocking in the Off position only.

Contactors for Use at Below 1 kV

Utilisation category for each contactor for use at below 1 kV shall comply with IEC 60947. It shall be maintenance free and where possible allow replacement of the coil, without disturbance to the wiring.

Indicator Lamp Circuits

Every indicator lamp circuit shall be fused separately from any functional circuit so that an indicator lamp failure will not result in the failure of any functional circuit. A lamp test facility shall be provided for each logical group of indicator lamps, as follows: Common lamp test button shall be provided on the front facia of the switchboard or motor control centre for which indicator lamps are provided

Holding the lamp test button shall cause all the related indicator lamps to be illuminated. On releasing the button, the lamps shall return to there normal state.

Indicator lamps shall be based on LED semiconductor technology. Harmonics The arrangement of the electrical system shall be such that any harmonics generated by the electrical do not:

Exceed the limits permitted at the point of common coupling with the electricity supply companys electricity distribution system

Cause malfunction of any electrical Plant or of any electrical system

Lead to overheating of any electrical Plant, Materials or of any electrical system.

To limit the harmonics generated by electrical Plant, every rectifier rated in excess of 3 kVA shall be of the 6, 12, 18 or 24 pulse type.

When designing a system utilising variable frequency drives (VFDs), provision shall be made to minimise the introduction of additional harmonics into the power grid as per standard IEEE 519.

5.45 Earthing

Earthing of Power or Motor Control Centre, Distribution Boards:

Each switchgear, control panel and distribution boards shall be provided with an earth busbar running along its entire length. The earth busbar shall be located at the bottom of the Switchgear, Control Panel and Distribution Board.

Earth busbars shall be of Galvanized Iron except in PMCC where it has to be of copper and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second. Earth busbars shall be supported to withstand stresses induced by the momentary current of value equal to the momentary current rating of the associated switchgear/switchboard.

Positive connection of all the frames of equipment mounted in the switchboard to the earth busbar shall be maintained through conductors of size equal to the ground busbar or the load current carrying conductor, whichever is smaller. Earthing of draw out equipment frames shall be achieved through a separate plug-in contact.

All instrument and relay metallic cases shall be connected to earth busbar by means of 1100 V grade, PVC insulated, stranded, tinned copper, 2.5 sqmm. Conductor shall be

looped through the case earth terminals. The earthing Galvanized iron conductor located below ground level shall be coated with the tar material and also every welded joint for earthing shall be coated with tar material.

5.46 Equipment Erection and Commissioning

a) In accordance with the specific installation instructions, as shown in manufacturers drawings or as directed by the Engineer-in-Charge or Engineer-in-Charge's Representative the Contractor shall unload, erect, install, wire, test and place into use all electro mechanical equipment included in the contract. Equipment shall be installed in a neat manner so that it is level, plumb, square, and properly aligned and oriented.

b) The Contractor shall furnish all supervision, labour, tools, equipment, rigging materials and incidental materials such as bolts, wedges, anchors, concrete inserts etc. required to completely install, test and adjust the equipment.

c) Manufacturers drawings, instructions and recommendations shall be correctly followed in handling, setting, testing and commissioning of all equipment and care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts.

d) The Contractor shall erect and commission the equipment as per the instructions of the Engineer-in-Charge .

e) In case of any doubt/misunderstanding as to correct interpretation of a manufacturers drawings or instruction, necessary clarification shall be obtained from the Engineer-in-Charge or the Engineer-in-Charge's Representative. The Contractor shall be held responsible for any damage to the equipment consequent to not following a manufacturers instructions correctly.

f) The Contractor shall move all equipment into the respective buildings through regular doors or floor openings provided specifically for the equipment. The Contractor shall make his own arrangement for lifting of equipment.

g) Where assemblies are supplied in more than one section, the Contractor shall make all necessary mechanical and electrical connections between sections including the connections between bus bars /wires. The Contractor shall also carry out the adjustment/alignments necessary for proper operation of the circuit breakers. All insulators and bushings shall be protected against damage during installation. Insulators or bushings chipped, cracked or damaged due to negligence or carelessness shall be replaced by the Contractor at his own expense.

h) The Contractor shall take utmost care in handling instruments, relays and other deli-

cate mechanisms. Wherever the instruments or relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. The blocking material/mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the Engineer-in-Charge or Engineer-in-Charge's Representative.

i) Switchgear and motor control centre shall be installed in accordance with the latest Indian Standard Code of Practice 10118 and manufacturers instructions. The switchgear and motor control centre panels shall be installed on finished surface or concrete or steel sills. The Contractor shall be required to install and align any channel sills which form part of the foundations. Tape or compound shall be applied where called for by manufacturers drawings. The base of outdoor type units shall be sealed in an approved manner to prevent ingress of moisture.

j) Care shall be taken during handling of insulating oil to prevent ingress of moisture or foreign matter. In the testing, circulation, filtering, or other wise handling of oil, rubber hose shall not be used. Circulation and filtering of oil, the heating of oil by regulated short- circuit current during drying runs and sampling and testing of oil shall be in accordance with manufacturers and the latest Code of Practice IS : 10028.

k) After installation of all power and control wiring, the Contractor shall perform operating tests on all switchgear and power control centre / motor control centre to verify the proper operation of switchgear/panels and the correctness of the interconnections between various items of equipment. This shall be done by applying normal a-c or d-c voltage to the circuits and operating the equipment. Megger tests for insulation, polarity checks on the instrument transformer, operation tests on equipment, and manufacturers installation tests shall be carried out by the Contractor who shall also make all necessary adjustments as specified by the manufacturer for proper functioning of the equipment.

l) Equipment furnished with finished coats of paint shall be touched up by the Contractor if their surface is spoiled or marred while handling.

m) Foundation work and grounding - in of fixing bolts or channels for all switchgear, motors, motor control centre will be carried out by the Contractor.

n) All commissioning tests shall be carried out at site after completion of installation.

o) Contractor shall ensure to use calibrated test equipment having valid calibrations test certificates from standard laboratories traceable to National Standards.

p) All the electrical equipment will be run on a trial basis for a minimum period of 30 days.

q) Following safety procedure and practice shall be implemented by Contractor in switchgear

room as per latest edition of IS: 5216.

(1) Rubber mat

a) In front of LV switchgear in switchgear room.

(2) Shock treatment charts

a) One chart near LV switchgear.

(3) Caution/Danger board

a) LV switchgear/motor : 3 Nos.

b) PDB/MLDB/LDB : 2 Nos.

Painting

a) All sheet steel work shall be phosphated in accordance with relevant standards for phosphating iron and steel.

b) Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. c) Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying. d) After phosphating, thorough rinsing shall be carried out with clean water, followed by final rinsing with dilute dichromate solution and oven drying. e) The phosphate coating shall be sealed by the application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be flash dried while the second coat shall be stoved. f) After application of the primer, two coats of finishing synthetic enamel paint shall be applied, with each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The colour for the finishing paint shall be as specified. g) Each coat of primer and finishing paint shall be of a slightly different shade to enable inspection of the painting. h) The final finished thickness of paint film on steel shall not be less than 100 microns, and shall not be more than 150 microns. i) Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces. j) Material not complying with the foregoing requirements are liable to be rejected.

Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Galvanising shall be carried out after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

Galvanising of material shall be carried out in accordance with the latest editions of IS:2629, 2633, 4759 and 6745.

5.47 Erection, Testing and Commissioning

5.47.1 Testing General

Testing of the critical items (LV Switchgear and cables etc., in case of electrical discipline) at the manufacturers premises will be required in accordance with the conditions of contract. All inspection, examination and testing shall be carried out in accordance with appropriate national and or international standards.

All instruments used for such tests shall be calibrated and certified by an approved independent testing authority not more than 9 months prior the test in which they are used. The Engineer-in-Charges Representative reserves the right to impound any instrument immediately after test for independent testing. A certificate shall be produced by the Contractor prior to carrying out every test showing the reading obtained, calculations and full details of the calibration certificates referred to.

If the Engineer-in-Charges Representative witnesses a test he shall be given a copy of the test results and certificates immediately. Whether he witnesses a test or not, copies of test certificate shall be sent to the Engineer-in-Charges Representative. No item of the plant shall be forwarded to the site until its test certificate has been approved in writing by the Engineer-in-Charges Representative. Six copies of the test certificates shall be supplied in suitable folders with proper index.

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.

5.47.2 Inspection at Manufacturer's Premises

The inspection of all critical equipment (required to be supplied to complete the works) shall be done as detailed in this specification. Only defect free and sound material meeting the technical requirements of this specification and in accordance with a high standard will be acceptable to the Engineer-in-Charge.

To meet the requirements of inspection, testing (including testing for chemical analysis and physical properties) arrangement shall be made by the Contractor and test certificates shall be submitted to the Engineer-in-Charge. Engineer-in-Charge will have the right to witness or inspect the above mentioned testing/inspection at final stage as desired by him. Calibration certificates or test instruments shall be produced for the Engineer-in-Charges consent in advance of testing and if necessary instruments shall be recalibrated or substituted before the commencement of the test. Items of plant or control systems not covered by standards shall be tested in accordance with the details and programme agreed between the Engineer-in-Charge and Contractor.

If during or after testing, any item of the plant fails to achieve its intended duty or otherwise prove defective it shall be modified or altered or replaced as necessary, retested and re-inspected as required by the Engineer-in-Charge.

At least 21 days advance notice shall be given to the Engineer-in-Charge before the specified tests are to be carried out.

No material is to be delivered to site without the above described inspection having been carried out and clearance is given for dispatch or officially waived off in writing by the Engineer-in-Charges Representative

5.48 Automation of Sewage Treatment Plant

The complete Sewage Treatment Plant, shall be fully automatic based on PLC based control system. PLC based automation system with application software shall be offered to control all pumps, valves, blowers, VFDs, probes etc., as per Contractors design including I/Os with 20% spares. HMI Panel to comprise up-to-date standard PC with CPU, monitor, printer, SCADA software with dynamic flow charts, pictures, screens, alarms, historical trends, reports etc. SACDA based Automation system to monitor and control the plant continuously. The Contractor shall submit a detailed plant control philosophy for the approval of the IITH .

5.49 Instrumentation & Automation Specifications

This part covers the general requirements for the Design, Delivery, Installation, Inspection, Testing and Commissioning of the Instrumentation, Control, Automation / Supervisory Control and Data Acquisition (SCADA),HMI system.

5.49.1 PLC Specification

Table 5.22: Specifications of PLC

Sl. No.	SPECIFICATIONS	DESCRIPTION
A	Design	PLC Makes : Siemens / Allen Bradley /Honeywell
1	Type of PLC Panel	Free Floor Standing Modular Type Suitable For Indoor Installation With 1No Front Opening/ Rittal Panel
B	PLC Specifications	
1	Controller	Din Rail Mounted Micro PLC With Panel Mounted HMI, or Suitable Controller With Provision For Future expansion and Ethernet Port
2	I/O Module	32Ch/16Ch/8Ch/4Ch As Per The IO Configuration
3	Power Supply	24V DC SMPS
4	Ethernet Switch	As per IO Configuration Requirement
C	SCADA & PC Or 16 inch Panel Mounted HMI	
1	SCADA Specifications	SCADA Runtime Lic With Suitable Tags Runtime Lic, Latest Version. With Control, Monitoring, Alarm Status, Data Logging, Report Generation (Excel & Crystal), Trends, Graphical, Unlimited Screens, Analysis, Push Mail (Optional), Process Flow Diagrams, Animations
2	PC	Dell/HP Make PC With 22 inch LED Monitor, 1TB HDD, I 7, 64Bit Processor, 4GB RAM, licensed Antivirus & Windows OS Loaded, 4 GB graphic card
D	General Requirements	
1	Degree Of Protection	Ip 54- Certificate Required
2	Fabrication-Base	75 Mm Ismc- Invert "C"
3	Frame/Gland Plate And Cover/Doors	Non Ferrous Gland Plates
4	Gaskets / Blanking Plates	Neoprene Rubber /To Be Provided For All Modules
5	Hardware/Bolts & Nuts/Washer	Corrosion Resistant
6	Cable Entry	From Top/Bottom Will Be Confirmed With Detachable Gland Plate
7	Max Operating Height	2000 mm
8	Panel Make	Rittal
E	UPS	
1	Specifications	1KVA Offline UPS
F	Others	
1	Web View	PC/Laptop based web view shall be provided for monitoring trends, alarms etc.,
2	Specifications	Including PLC Programing And Logic Development and SCADA Customisation

5.49.2 MCC Specifications

Table 5.23: MCC Specifications

SR NO	SPECIFICATIONS	DESCRIPTION
A	DESIGN	

1	TYPE OF MCC	FREE FLOOR STANDING, COMPARTMENTALISED, NON DRAWOUT TYPE, MODULAR TYPE SUITABLE FOR INDOOR INSTALLATION WITH DOUBLE FRONT OPENING.
2	INCOMER RATING OF MCC	4P, ----- amps ELECTRICALLY OPERATED MCCB WITH LSIG PROTECTION
3	MCCB	4P, ----- amps ELECTRICALLY OPERATED MCCB WITH LSIG PROTECTION
4	METERING FOR INCOMER	DIGITAL MULTIFUNCTION METER TO MEASURE V, A, KWH, KVAR,PF,HZ
5	SYSTEM FAULT LEVEL	50 KA FOR 1 SEC
6	SYSTEM NEUTRAL GROUNDING	SOLIDLY EARTHED
7	INCOMING VOLTAGE /FRE- QUENCY	415V AC,+/- 10% / 50 Hz +/- 3%, 3PHASE-4WIRE,
8	CONTROL VOLTAGE	230V AC OR 110V AC (THRO CONTROL TRANSFORMER)
9	TYPE OF ISOLATOR	MCCB / MPCB SELECTED FOR TYPE 2 CO ORDINATION
10	TYPE OF MCCB	NON DRAWOUT TYPE FOR MCCB, SINGLE FRONT 3PHASE WITH NETURAL (TPN),
11	TYPE OF FEEDER	DOUBLE FRONT,SHALL NOT OPEN IN ON CONDITION, UNLESS FEEDER IS SWITCHED OFF.
12	SEISMIC CONDITION	IF APPLICABLE
B	STARTERS	
1	TYPE OF STARTERS	DOL/ STAR DELTA/ VFD /SOFT STARTER (REFER ELECTRICAL LOAD LIST)
2	MOTOR STARTER	CONTACTOR , WITH MPCB
3	SPARE MOTOR STARTER	REFER ELECTRICAL LOAD LIST

4	MOTORS WITH LOCAL ISOLATOR SWITCH/MAINTENANCE SWITCH WITH FEEBACK TO PLC	LPBS FOR ALL 3 PH MOTORS & ISOLATOR BOX FOR ALL SINGLE PH MOTORS
C	VFD	
1	SUITABLE FOR	PUMP/BLOWR APPLICATION
3	RFI FILTERS	REQUIRED
4	CURRENT HORMONIC FILTERS	IF REQUIRED (OPTIONAL)
5	OPERATING CONSOLE	SURFACE MOUNTING TYPE
6	PROVISION FOR THERMISTER CONNECTIVITY	REQUIRED FOR MOTORS >75KW
7	INCOMING CABLES TO VSD	XLPE/PVC TYPE
D	GENERAL REQUIREMENTS	
1	DEGREE OF PROTECTION	IP 54
2	EXTENSION FACILITY /INTER-CHANGABILITY	TO BE PROVIDED AT BOTH ENDS
3	FABRICATION-BASE	75 MM ISMC
4	FRAME/GLAND PLATE AND COVER/DOORS	NON FERROUS GLAND PLATES
5	GASKETS / BLANKING PLATES	NEOPRENE RUBBER /TO BE PROVIDED FOR ALL MODULES
6	HARDWARE/BOLTS & NUTS/WASHER	CORROSION RESISTANT
7	CABLE ENTRY	FROM TOP WITH DETACHABLE GLAND PALTE
8	MAX OPERATING HEIGHT	2200 MM
E	BUSBAR	
1	AUXILIARY BUS BARS	ALUMINIUM
2	MAIN / VERTICAL BUSBARS	HIGH CONDUCTIVITY ALUMINIUM (E91E GRADE)
3	MINIMUM SIZE OF MAIN / VERTICAL BUSBAR	SIZING SHALL BE 20% HIGHER THAN LOAD
4	BUS BAR INSULATION	COLOUR CODED HEAT SHRINKABLE PVC SLEEVES OF 1.1 KV GRADE WITH SUITABLE SUPPORTS

5	PROTECTION FOR AUXILIARY BUSBARS	PERFORATED SHEET STEEL / INSULATING MATERIAL
6	PHASE TO PHASE TO EARTH CLEARANCE	MIN 25 MM

F	CURRENT TRANSFORMER / POTENTIAL TRANSFORMER	
	TYPE	CAST RESIN - SQUARE TYPE
G	WIRING	WIRING WILL BE CARRIED OUT WITH 600/1100 V GRADE PVC INSULATED STRANDED COPPER CONDUCTOR
1	CONTROL CIRCUIT WIRING	1.5 SQ.MM.
2	CT CIRCUIT WIRING /POWER CIRCUIT WIRING	2.5 SQMM/ as per switch gear rating
3	FERRULES	PVC, FEEDER IDENTIFICATION AT BOTH ENDS
4	NO OF SPARE TERMINALS	MIN 10%
H	INTERFACEING WITH PLC	For DOL : 2 DI : Auto /Manual , Run feedback, 1 DO : command from PLC
		For VFD : 2 DI : Auto /Manual , Run feedback, 1 AO : SPEED REF.
I	INDICATION (LED LAMPS)	
1	MCC INCOMER FEEDER	MAIN SUPPLY L1, L2, L3 ON.
2	MCC OUTGOING FEEDER(MOTOR)	ON, OFF, TRIP, AUTO/MANUAL SELECTED
J	EARTHING	COPPER STRIP THROUGHOUT THE BOTTOM LENGTH OF MCC,ALL DOOR, MOVABLE PARTS SHALL BE EARTHED USING FLXIBALE COPPER WIRE.
	SIZE	50X6 MM GI GLAT
K	PAINTING	FINAL PAINT POWDER COATED WITH COLOR SIEMENS GREY RAL 7035 AND BASE CHANNEL COLOR BLACK

L	Documents to be submitted for approval	SINGLE LINE DIAGRAM, SCHEMATIC DIAGRAM FOR EACH TYPE STARTER, BOM. PANEL GA DRAWING, MOUNTING ARRANGEMENT DRAWING
M	ROUTINE TESTS	ALL ROUTINE & ACCEPTANCE TESTS SHALL, BE CARRIED OUT AT MANUFACTURER'S PLACE UNDER HIS CARE & EXPENSE AS PER APPROVED QAP
N	DESIGN CODES & STANDARD	IS 3427 METAL ENCLOSED SWITCHGEAR
O	MAKES OF THE COMPONENTS	
1	MCC SWITCHGEAR	ABB/SCHNIDER/SIEMENS
2	VARIABLE FREQUENCY DRIVES	ABB/SCHNIDER/SIEMENS/DANFOSS
2	CONTCATORS- POWER /AUXIL- LIARRY	ABB/SCHNIDER/SIEMENS
3	FUSES - POWER / CONTROL	ANY REPUTED MAKE
4	DIGITAL METERS / ANALOG ME- TER	CONSERVE
5	PUSH BUTTON/SELECTOR SWITCHES /INDICATION LAMPS	TECHNIK
6	TERMINALS	ELEMEX / PHEONIX
7	CURRENT TRANSFORMER	KAPPA / KALPA

5.49.3 Reference Standards

Unless otherwise approved, instrumentation and Automation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

Table 5.25: Reference Standards

BS 89-2:1990, EN 60051-2:1989, IEC 60051-2:1984	Direct acting indicating analogue electrical measuring instruments and their accessories.
BS 1042 (Various)	Measurement of fluid flow in closed conduits

BS 1646-1:1979, 3511/ I-1977	Symbolic representation for process measurement control functions and instrumentation. Basic requirements
BS EN 837-1:1998	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
BS EN 60751:1996, IEC 60751:1983	Industrial platinum resistance thermometer sensors
BS 3680 (Various)	Measurement of liquid flow in open channels.
BS 3693:1992	Recommendations for design of scales and indexes on analogue indicating instruments
BS EN 60770-1:2011, IEC 60770-1:1999	Transmitters for use in industrial-process control systems. Methods for performance evaluation
BS 4675-2:1978, ISO 2954-1975	Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity
BS EN 60584-1:1996, IEC 60584-1:1995	Thermocouples. Reference tables
BS 5308 (Various)	Instrumentation cables
BS EN 60529:1992	Specification for degrees of protection provided by enclosures (IP Code)
BS ISO 11631:1998	Measurement of fluid flow. Methods of specifying flowmeter performance
BS 5863-1:1984, 60381 1:1982	Analogue signals for process control systems. Specification for direct current signals
BS 5863-2:1980, 60381- 2:1978	Analogue signals for process control systems. Specification for direct voltage signals
BS EN 60654-1:1993, IEC 60654-1:1993	Industrial-process measurement and control equipment. Operating conditions. Climatic conditions
BS 6739:1986	Code of practice for instrumentation in process control systems: installation design and practice
BS EN 60073:2002	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators

BS 1553 (Various)	Specification for graphical symbols for general engineering
ISA-5.1-1984 - (R1992)	Instrumentation Symbols and Identification
ISA-5.4-1991	Instrument Loop Diagrams
ANSI/ISA-7.0.01-1996	Quality Standard for Instrument Air
ANSI/ISA-18.1-1979 -(R1992)	Annunciator Sequences and Specifications
ISA-26-1968	Dynamic Response Testing of Process Control Instrumentation
ISA-37.1-1975 - (R1982)	Electrical Transducer Nomenclature and Terminology
ISA-37.3-1982 - (R1995)	Specifications and Tests for Strain Gage Pressure Transducers
ANSI/ISA-50.00.01-1975 (R2002)	Compatibility of Analog Signals for Electronic Industrial Process Instruments
ANSI/ISA-51.1-1979 - (R1993)	Process Instrumentation Terminology
ISO 9000 and ISO 9004	Quality Management Systems
IEEE 60587	Power Supply Surge Protection
IEC 61131-3	Programmable Controllers- Programming Languages
IEC 61158-2	Industrial Communication Network- Communication Protocols
BS /ISO 9075	Information technology -Structured Query Language (SQL)
BS 5515	Code of practice for Documentation of Computer Based Systems
BS 7165	Recommendation for Achievement of Quality in Software
BS EN 50081	Electromagnetic Compatibility
ISO 3511	Symbolic representation for process measurement control functions - instrumentation
ISO-OSI	Information technology - 7 Layer Communication Model
IEEE 472-1974	Surge protection.

(b) All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Engineer-in-Charge for consent before any design against that standard proceeds.

5.50 Qualification Criteria for Instrumentation and Automation System integrator

- (i) Instrumentation and Automation system integrator hereinafter called system integrator(SI) shall be in possession of minimum ISO 9001, Quality Management System certification, conferred by an accredited agency.
- (ii) The SI must be an authorized system integrator for the PLC hardware and SCADA and Operational Database Management Software (ODMS) manufacturer. Valid authorization certificates shall be submitted for verification.
- (iii) The SI shall have minimum of 10 years experience of ICA projects execution within India. It shall demonstrate capability and resources for integrating/interfacing control systems for different Original Equipment manufacturers products/system as well as coordination with multiple agencies for contract execution. References for minimum of (5) locations where the automation equipment (software hardware) has been successfully installed, along with name, address and contact number shall be submitted.
- (iv) SI must have their branch in Hyderabad to ensure timely after sales service.
- (v) SI shall use latest technology/versions of hardware and software products/components from Instrumentation and Automation original component/original equipment manufacturers (whose products are proposed) shall be in possession of an ISO 9001 or above, Quality Management System certification, conferred by an accredited agency.
- (vi) All hardware and software proposed shall have been successfully in operation in a waste water application for a period of at least five (5) years and be from established

and reputed OEM.

5.50.1 Documents to be submitted during Bid Submission

- (i) (a) Include a complete conformance to each and every reference standards or part of the specifications. Use a chart format with specification part identified, indicate whether each part is in compliance, a deviation or an exception to the specific part. If an exception or deviation, include a narrative description as to how the deviation or exception can benefit the end-user of the system over that item specified.
- (ii) Provide a Schematic block diagram of the proposed system showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces.
- (iii) Provide a written summary on operation and control philosophy of the proposed automation system, covering the principal functions and capabilities of the systems PC, PLCs, system communications and general system capabilities (maximum number of network nodes and I/O points, communication protocols available, etc.).
- (iv) Provide an equipment list with descriptive literature for the proposed system. List shall include all major hardware items, the name of the manufacturer, the quantity provided, and selected model numbers. Technical schedules for Instruments, PLC SCADA, ODMS shall be duly filled in with relevant details.
- (v) Provide an operating system and software applications list with descriptive literature for the proposed system. Include all major software items, supplier name, quantity, and model numbers. (No proprietary software shall be accepted).
- (vi) Information is required for:
 - (1) Name and version of the operating system.
 - (2) Name and version of the proposed computer Contractor graphical user interface, software package (SCADA).
 - (3) Name and version of the PLC on-line/off-line programming software for all controllers
 - (4) Name and version of any required communications software, firmware, etc.

(5) Name and version of the specified report application software, Operational data management software(ODMS).

(6) Name and version of the specified maintenance application software if any.

- (vii) Describe how system data points are linked from the system database into various applications such as reporting or maintenance. If via DDE (Dynamic Data Exchange) describe specifically the steps required to import data automatically and on-line into the proposed software applications.
- (viii) Briefly describe the required procedure for configuration and/or programming of the proposed system to add a simple PLC and additional I/Os to the system in the future. Describe in detail, specifically how communications are programmed for the future remote PLC and the necessary changes required at the main controller.
- (ix) Provide a description of any software required to program, troubleshoot or diagnose any devices in the system.
- (x) Provide a tentative construction schedule for completion of the project within the specified Contract period. Indicate the following activities with milestones: Mobilization, radio communications licensing, submittal preparation, submittal review, equipment procurement, equipment assembly, system configuration and programming, factory testing, system delivery, system installation, start up, field testing and training, and post acceptance routine service intervals.
- (xi) Describe the SIs provisions for service, technical assistance and replacement parts for the proposed system. Do provide the SIs contact number. Identify with resumes, all personnel who will be providing technical support services for the project after it is accepted.
- (xii) The Contractor shall provide the above required details/documents during the bid submission. Failure to do so will be treated as a non-responsive bid and lead to technical disqualification. Contractor to take note the importance of this obligation.

5.51 General Submissions

- (a) The Contractor shall make submissions to the Engineer-in-Charge of all design drawings, schedules and complete documentation relating to instrumentation, control and Automation equipment and systems provided under this Contract. (b) These submissions shall include, where relevant,

the following:

5.51.1 Functional design specification

- (i) The Contractor shall submit a complete functional design specification (FDS) for approval by the Engineer-in-Charge within 3 months of the award of contract. This document shall serve as the primary mechanism by which the Engineer-in-Charge may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.
- (ii) The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. Proposed SCADA screens shall form an integral part of FDS submission.
- (iii) The format of the program details may be chosen by the Contractor, however it is suggested that this format be chosen to satisfy the requirements of the software design documentation, if applicable, as described elsewhere.
- (iv) The FDS shall describe the fail-safe features incorporated into the design, for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.
- (v) The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.
- (vi) The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
- (vii) The Contractor shall submit and obtain approval of the FDS from the Engineer-in-Charge before beginning the detailed control system design.

5.51.2 Drawings and schedules

- (i) Process and instrumentation diagram shall comply with BS 1646 and BS 1553.

- (ii) General arrangement drawings of field-mounted instruments showing installation details.
- (iii) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
- (iv) Layout drawings of panel facias showing instruments, controls and details of all labels.
- (v) Layout drawings of panel interior showing equipment, terminal blocks and cable ways.
- (vi) Annunciator arrangement and engraving details.
- (vii) Internal circuit and wiring diagrams for instrument and control panels.
- (viii) Schematic control diagrams.
- (ix) Instrument loop diagrams.
- (x) Instrument wiring and piping diagrams.
- (xi) Interconnection wiring diagrams.
- (xii) Cable block diagrams, drawings and schedules.
- (xiii) Instrument system and panel power distribution diagrams.
- (xiv) Programmable-device functional design specifications which shall include hardware details, logic flow charts, ladder diagrams and program listings.
- (xv) Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
- (xvi) Labeling schedules.
- (xvii) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.
- (xviii) All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels and the like and for the complete understanding of the operation, maintenance and extension of the system including any required for the contractor to dismantle, repair, maintain, modify or extend the Plant.

5.51.3 Data and calculations

- Manufacturers catalogues and data sheets.
- Calculations to support control system design.
- Specification for protective coatings and painting.
- Certificates
- Manufacturers works tests.
- Pre-installation checks.
- Pressure-testing schedules.
- Instrument loop test check sheets.
- Installed instrument performance tests.
- System tests.
- Statutory certificates of compliance (such as hazardous area equipment).

5.51.4 Operation and maintenance instructions

Operation and maintenance instructions shall include

- (a) Composite manual describing the functional and operation of each piece of equipment.
- (b) Composite manual for testing and servicing every system and individual item.

5.52 Design

5.52.1 Basic Features

Instrumentation, Control, Automation/SCADA / HMI system shall be designed, manufactured and installed to achieve the following basic requirements:

- (a) to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- (b) to suit the abilities of the staff who will:
 - i. use the systems;

ii. Service the systems;

(c) to measure, indicate, process, store and control the relevant parameters, as specified;

(d) to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of operations and maintenance personnel and plant and to store and collate the data, as required;

(e) to derive, present and utilize, as required, such additional data as required to facilitate:

i. the most efficient operation of the plant;

ii. the routine maintenance of the plant

5.52.2 Design Requirements for Instrumentation, Control, Automation (PLC/SCADA / HMI) Systems

(a) The instrumentation, control, automation (SCADA / HMI) installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

(b) The electrical plant installations, associated instrumentation, control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

(c) All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

(d) The instrumentation, control and monitoring system equipment and materials shall have an operational life of not less than 15 years, unless otherwise approved by the Engineer-in-Charge.

5.52.3 Site Conditions

(a) Temperature and Humidity Range.

The equipment shall be installed in an environment having a temperature range of 0 C to 50 C and a maximum relative humidity of 100 % (non-condensing). The SI shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.

(b) EMI/RFI Noise Immunity.

The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal- borne interference.

(c) Generated Interference.

The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1 or equivalent Indian Standard for noise emissions.

(d) Coordination.

The SI shall check with other disciplines to ensure that equipment and material can be installed in space provided. Coordinate with other disciplines, to share the information necessary for them, to execute their work. Details on Drawings, which are specific, regarding dimensions, are for information purposes.

5.52.4 Enclosure/Panel Details

Enclosures and mounting boards

(a) Enclosures shall be in any form of, board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, control equipment.

(b) All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The top of enclosures shall have downward slope i.e. from front to rear.

(c) Enclosures mounted for indoor application or inside buildings shall have a minimum rating of protection as IP 54.

(d) Enclosures for outdoor applications or in places where splashing may occur, shall have

a minimum rating of protection as IP 65. When enclosures are to be provided for outdoor application and are located, where exposure to direct sunlight will give rise to high surface temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure. The sun shield shall prevent direct sunlight from reaching the instrumentation for the full day throughout the year, and shall have louvered ventilation.

(e) Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

(f) Enclosures shall have hinged access doors, fitted with recessed lockable handles.

(g) Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

(h) Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

(i) Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

(j) Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

5.52.5 Panel design and construction

(a) Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

(b) The design and dimensions of control consoles and desks shall be determined according to their intended function and shall be in accordance with the requirements of the Specification. The height shall not exceed 1400mm above the finished floor level.

(c) Unless otherwise specified the height of panels shall be not greater than 2130mm

(overall) (excluding lifting devices) above finished floor level.

(d) Controls, switches and push-buttons shall be positioned below or adjacent to any associated indicating instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings.

(e) The side, rear and front clearance of apparatus shall allow safe and unobstructed access to all terminals and to parts, requiring maintenance.

(f) Panel layout drawings shall include a list of all instruments, accessories and components contained therein. Separate schedule or bill of material of instruments, accessories and components shall be provided. The panel drawing shall display a legend of each item/component as provided in Separate schedule or bill of material.

5.52.6 Panels Major

(i) Panels shall be constructed generally as specified in the preceding clause. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

(ii) Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance.

(iii) Flanged edges shall be straight and smooth.

(iv) Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of center of gravity and method of fabrication, with the following minimum thickness:

(1) instrument bearing surfaces, gland plates and pneumatic distribution plates; 3mm;

(2) internal mounting plates, 3mm;

(3) doors, covers and filler panels, 2mm.

(v) No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted.

- (vi) When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

- (vii) Each panel shall be mounted on a self-draining base frame fabricated from 150mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

- (viii) Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel.

- (ix) A chequer-plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables where applicable.

- (x) Sufficient removable un-drilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface mounted enclosure may form a part of the base or top.

- (xi) Panels containing instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipe work.

- (xii) All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

- (xiii) Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvers to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air circulation louvers shall be sealed.
- (xiv) No equipment other than front-of-panel items shall be mounted on panel wall surfaces.
- (xv) If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections.
- (xvi) All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection.
- (xvii) Provision shall be made for safe and easy handling during transit and installation.
- (xviii) If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary
.
- (xix) Where equipment is specified to be installed at a future date, space shall be allocated, and cutouts with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.
- (xx) Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

5.52.7 Panels Minor

- (i) Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be classed as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause.

- (ii) Panels shall be fabricated from sheet steel or other approved material not less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.
- (iii) The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where wall/surface-mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.
- (iv) Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 1800 mm and not less than 300mm from floor level.
- (v) The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

5.52.7.1 Panel protection

(a) Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

(b) All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic molded insulating material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control

desk shall not trip on over-voltage or under-voltage.

(c) Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.

(d) At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

(e) Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainders are unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level.

5.52.7.2 Panel isolation

(a) Clearly-labeled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the off position. The 'on' and 'off' positions of each switch shall be indicated clearly.

(b) Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position.

(c) Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the off position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labeled with suitable warning notices.

(d) Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the free plug and a socket mounted adjacent to the device.

(e) The power supply connector shall be a socket.

5.52.7.3 Panel terminal blocks

(a) External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analyzers, resistance thermometers, retransmitting slide-wires and thermocouples may be terminated at their appropriate instruments.

(b) A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

(c) Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty.

(d) Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for Panel internal wiring which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

(e) All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal moldings shall be in melamine to BS 1322, polyamide or equivalent. Terminal rails shall be hot-dip galvanized. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Clip on type SAKC or equivalent which permit the connection of a test millimeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

(f) No more than one core of external cables or two internal wires shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate

loom shall be provided for each cable.

(g) Each row of terminal blocks shall contain at least 20% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit.

(h) Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

(i) All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalized where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labeled to minimize the risk of accidental contact.

5.52.7.4 Panel internal wiring

Panel circuits shall be segregated into the following categories:

(a) Group 1: Power control and very-high-level signal wiring (above 50V):

- (1) AC power supplies;
- (2) DC power supplies;
- (3) AC current signals above 50mA (such as CT circuits);
- (4) AC voltage and control signals above 50V (such as PT circuits).

(b) Group 2: High-level signal wiring (6V to 50VDC):

- (1) signals from conventional electronic transmitters and controllers (such as digital or 4mA to 20mA);
- (2) circuits to alarm annunciators and other solid-state devices
- (3) digital signals;
- (4) emergency shut-down and tripping circuits;
- (5) on/off control circuits;
- (6) intrinsically safe circuits;

(c) Group 3: Low-level signal wiring (5V DC and below):

- (1) signals from thermocouples;
- (2) signals from resistance thermometers and re-transmitting slide-wires;
- (3) signals from analytical equipment and strain gauges.

(d) For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

(1) The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel;

(2) The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

(3) Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multithreaded, twisted pair, 0.75mm minimum copper conductors with HPDE or PVC- insulated cable of adequate grade and rating.

(4) Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm minimum copper conductors with 250V grade, PVC-insulated cable of adequate grade and rating.

(5) Wiring sheath colors shall be black for AC circuits, and grey for DC circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V DC shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

(6) Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals.

(7) All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than 75% of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unim-

peded.

(8) Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

5.52.7.5 Panel wiring identification and termination

(a) Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a color coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally.

(b) The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling.

(c) Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

5.52.7.6 Panel Earthing

(a) A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armoring of all incoming and outgoing cables to the station earthing system.

(b) A second continuous copper earth bar of not less than 25mm X 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armoring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 20% spare terminals

(c) In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

(d) The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and

insulated.

(e) Surge Protection Device associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturers recommendations.

5.52.7.7 Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by totally enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three metres of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

5.52.7.8 Panel ventilation

(a) Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturers recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably-labeled enclosed switch mounted internally in an accessible position.

(b) Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

5.52.7.9 Panel labels

(a) All control gear shall be fully labeled with the KKS code identifying the equipment designation/function, all external and internal components, all rating data, detailed equipment operating data and for danger and hazard warning.

(b) Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as detailed in the Specification. Wording shall be clear, concise and unambiguous and shall be subject to review by the Engineer-in-Charge before manufacture. Each label shall be permanently secured to the surface near the item to which it refers. Externally- fitted labels

shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black.

(c) The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

(d) Laminated materials or rear-engraved and filled plastic shall be used for internally fitted labels, which shall be white with engraved black letters.

(e) Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- i. to describe or identify circuits or circuit components;
- ii. to identify DC polarity;
- iii. to warn or remind about dangerous or potentially-dangerous circumstances;
- iv. wherever elsewhere specified.

(f) Unless otherwise specified, all engraving shall be in plain block letters, 4mm high.

(g) The minimum practicable number of different sizes shall be used.

5.52.7.10 Panel finish

(a) For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, finish shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Engineer-in-Charge. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer.

- (b) The overall dry film thickness (DFT) shall be between 100 and 150 microns.
- (c) Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanized or otherwise finished to an approved standard.

5.53 Instruments and ancillaries

5.53.0.1 General

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

(b) All equipment shall be fully tropicalised and suitable for the worst environmental operating conditions. Panel-mounted instruments shall be of the electrically operated flush mounted type and shall have damp-proof and dust-proof cases.

(c) Instruments mounted outside instrument panels shall have weatherproof and dust-proof cases. Instrument cases shall be of corrosion-resistant material or finish.

(d) Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust. Where applicable instruments shall be easily withdraw able from its housing for maintenance without interrupting its signal.

(e) Unless otherwise specified, instruments shall be finished in the manufacturers standard colour. Instrument dials shall be of such material that no peeling or discolouration will take place with age under tropical conditions.

(f) Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 150mm except where forming part of standard instruments and accessories such as air-sets.

(g) Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

(h) Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal transmission systems shall be in accordance with BS 5863: Part 1 or equivalent and shall use a signal of digital or 4mA to 20mA DC. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

(i) Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the BS EN 60770-1 or equivalent. For the important and critical processes the transmitting devices, such as pressure, temperature and level gauges, shall have a reference gauge installed locally for easy reference for the operation and maintenance staff.

(j) The transmitters shall be provided with LCD meters.

(k) Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

(l) Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory configured ranges, measuring instruments shall have zero and span adjustment.

(m) Field mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance.

(n) Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

(o) Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

(p) In order that maintenance and inspection may be carried out safely and conveniently, instruments mounted in elevated and open work areas shall be provided with safety ladders and a sufficiently sized working platform with weather shade.

5.53.0.2 Indicating Instruments and Meters

(a) All instruments and meters shall be flush mounted and generally of the same pattern and appearance throughout and those which perform similar duties shall be of uniform type and manufacture.

(b) Indicating instruments shall be fitted with an externally accessible zero adjuster. They shall have no parallax error and their normal maximum reading shall be approximately 60% full scale deflection.

(c) Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The ammeter shall have an adjustable and sealable red pointer set to indicate normal full load current. The physical size of the ammeter shall be in line with the size of the relevant starter. The minimum size to be used is 0.25 DIN.

(d) Indicating instruments shall comply with IS 1248, BS 89 or IEC 60051 and shall be of industrial grade accuracy.

(e) Kilowatt-hour meters shall comply fully with IS 722 or BS 5685 Class 2 and shall have industrial grade accuracy (2.5%). Three element units shall be used for 3 phase 4-wire systems. Two element units shall be used for 3 phase, 3-wire systems.

5.53.0.3 Indicator Lights

(a) Indicator lights shall not be less than 20 mm in diameter and shall be panel mounted type with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lamp holder or panel wiring. Lamp holder shall be keyed into panels to prevent rotation. Lens colors shall comply with BS EN 60037 as follows:

- i. power 'on' - white*
- ii. running - green
- iii. tripped/alarm - red
- iv. status (open, closed, etc) - blue
- v. ready to start - blue
- vi. warning (no imminent danger) - amber

Note: *white may be used where doubt exists as to which other colour to use.

(b) The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% normal value or by using higher voltage lamps.

(c) The indicating lamps on control panel shall be cluster of LED's.

5.53.0.4 Push buttons

(a) Colours of pushbuttons shall generally comply with IS 6875, BSEN 60947, 60037 or IEC 60073 and in particular shall be as follows:

- i. stop, emergency stop - red
- ii. start -green
- iii. jogging/inching - black
- iv. reset (when not also acting as a stop) - blue
- v. lamp test - blue
- vi. override/alarm accept -yellow

5.53.0.5 Cable

Instrumentation cable

(a) Instrumentation cable in between conventional measuring transmitters and analogue process controllers, such as digital or 4mA to 20mA DC output from a constant-current source, (hereinafter referred to as high-level signals) shall be of polyethylene or PVC insulated with stranded conductors and laid up as twisted pairs with one twist per 50mm approx. Each cable shall have an overall screen of braided copper or mylar backed aluminium foil giving a minimum coverage of 85%, a steel wire armouring shall be insulated from the screen and from any ducting and an overall PVC sheath shall be provided. For runs exceeding 30 metres or for all inputs to a data logger, computer or microprocessor, multi-core cables shall have an individual screen of braided copper or mylar-backed aluminium foil for each signal pair. The minimum conductor size shall be 24/0.2mm but shall be of greater cross-sectional area if required for the satisfactory operation of associated plant. Cables for intrinsically safe systems shall comply with BS 5308 and the relevant certificate.

(b) Cables from strain gauges, analyzers and the like, such as 0 to 100mV (hereinafter referred to as low-level signals see also below) shall be as specified above and shall have an individual screen for each signal pair.

(c) Cables from indicating devices to alarm or tripping circuits shall be as specified above for high level signals but shall use cables, cable trays, ducts and conduit separate from those for other high-level circuits.

(d) Cables for high-level signals, low-level signals, resistance thermometers and thermo-

couples shall be segregated from each other and each shall be separated from cables for power, communications and other electrical services. Other cables running in the vicinity of instrumentation cables shall be twisted at the rate of one twist per 50mm approximately and shall be separated from instrumentation cables by a distance of not less than 300mm.

(e) Initiating devices for plant protection and personnel safety shall be connected by individual cables directly to the tripping or safety device and shall not be routed via any intermediate junction, marshalling box, cabinet, relay etc. The outer sheaths of such cables shall be orange coloured.

5.53.0.6 Cable termination boxes

(a) Cable termination boxes shall have double-ended screw terminals with removable links to facilitate core isolation during testing. Each box shall contain sufficient terminals for every conductor plus 20% spare terminals. Cable termination boxes shall have cable sealing chambers and insulated glands with earthing terminals so that the armouring may be earthed or isolated from earth, as circumstances dictate.

(b) Termination boxes for use within buildings shall be of sheet steel with hinged or removable front covers. All other termination boxes shall be cast steel or heavy gauge sheet steel construction giving protection to IP55. All termination boxes shall be hot-dip galvanised or approved equivalent finish. Each terminal box shall have a removable, undrilled gland plate and the Contractor shall supply and fit the requisite number of cable glands.

(c) At each cable termination box, each cable core (including spares) shall be identified by a numbered slip-over type collet. The numbering for a particular cable core shall be the same throughout its length.

(d) Cable joints shall be only at points approved by the Engineer-in-Charge.

(e) Each cable joint shall be of the straight-through type. The conductors shall be ferrule-jointed with the insulation maintained by heat-shrink sleeving. Joint closure shall be made with epoxy resin and the completed joint shall be impervious to water if submerged or in waterlogged ground. If cast iron joint boxes be used, they shall be provided with cable glands and, after installation and testing, shall be covered with Densomastic HD compound or equal; so that all sharp corners, bolts and projections are moulded to a smooth surface. Two lappings of Densopol grade ZN 50mm tape, or equal, shall then be applied overall. Jointing shall be carried out on each conductor, including any provided in excess of the minimum quantity specified. All materials and things of every kind re-

quired for the cabling jointing shall be provided by the Contractor.

5.53.0.7 Cable labeling

(a) At each end of each cable, in a uniform and visible position, a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels shall be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corrodible binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

(b) Three-phase power cable cores shall be identified R, Y, B or colour-coded red, yellow, blue so that the correct three-phase sequence is preserved throughout the system. Single-phase power cable cores shall be colour-coded red and black.

(c) Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of colour-coded ferrule markers. The size of these ferrule markers shall be such as to match the overall diameter of conductor plus insulation. Numbering shall read from the termination upwards on all cores.

(d) Each cable and core shall bear the same number at both ends of the cable and core respectively.

i. Power terminations colour, number or letter.

ii. Control terminations letter or number or both.

5.53.0.8 Cable terminations

(a) All PVCSWAPVC, PVC/PVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide adequate mechanical support. Each cable gland shall be protected by corrosion-resistant molded PVC hoods, covering the entire assembly from the overall sheath to the gland neck.

(b) Glands for armoured cables shall provide a positive armour clamp to the enclosure so that no tension is applied to the termination. The clamp shall also provide a high level of earth continuity and be of adequate size to withstand the full fault current of the system

for one second.

(c) All glands shall be provided with an earthing tag. For cables of 4mm or less, a serrated washer may be used instead for earth continuity.

(d) The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturers instructions.

(e) Through joints shall be permitted only on long cable runs outside buildings.

(f) Where such joints are necessary; the cables shall be jointed with epoxy or acrylic resin Cold-setting compound which has been pre-measured and pre-packed ready for use. The boxes shall be of a split moulded plastic type with filling vents for compound.

(g) Bonding straps shall be fitted with armour clamps across the joint for filling the box with compound. Wrapped pressure type joints shall not be accepted.

(h) Conductor cores shall be jointed number to number or color to color.

5.53.0.9 Cable installation-general

(a) Cables which are to be run on walls, ceilings or other building structures shall, unless otherwise agreed by the Engineer-in-Charge, be secured on cable trays or enclosed in conduit or trunking.

(b) Every cable shall be neatly laid vertically or parallel to adjacent walls, beams or other structural members. Cables shall preferably not to be installed in areas of direct sunlight.

(c) Where this is unavoidable, approved sun shields shall be supplied and installed.

(d) Where the building structure incorporates purpose-built covered duct or trench systems for main cables, instrumentation cables shall be segregated and installed on tray work or otherwise secured to the sides of the duct or trench.

(e) Where the structure incorporates general service ducts or trenches containing pipe work, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the walls unless otherwise agreed by the Engineer-in-Charge.

(f) Cables shall be spaced to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

(g) The spacing of clips, saddles and cleats shall prevent the sagging of the cables. The method of fixing clips etc. shall be by means of non-corrodible screws inserted into wall fixings, e.g. raval plugs.

(h) Cable hangers, cleats, saddles, brackets, wall fixing and similar supporting devices shall be of an approved type and shall provide adequate strength for the cables it supports. All these wiring accessories shall be non-corrosive. Self-locking plastic buckle clips and strapping shall not be used. The arrangement and fixing of each cable shall permit the removal and replacement of any cable without disturbance to any other cable or the fixings thereof.

(i) When cables are terminated in any particular item /equipment, special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

5.53.0.10 Drawings and schedules

(a) Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.

(b) Cable route and layout drawings. For those items which are underground, these drawings shall include the following:

i. route plans and sectional views for all cable runs, cable trays, cable ducts and cable trenches;

ii. the position of all marker posts, joints, draws pits etc.

iii. cable schedules shall detail the cable number, type, voltage, size, route length and number of cores or pairs. Control-cable schedules shall detail the connected and spare core numbers, diagram number for connected equipment, core ferrule and terminal reference number.

5.53.0.11 Data and calculations

Manufacturers catalogues and data sheets for all cables and fittings. Cable sizing Calculations.

Test certificates:

(a) Routine Tests and Type Test certificates shall be submitted.

5.53.0.12 Cable trays and cable tray support

- (a) Cable trays shall be ladder type and of heavy-gauge galvanized steel.
- (b) Cable trays shall be installed using factory-made supports, joints and junction/bend pieces. Wherever tray and cable tray supports/sections are cut and shaped on Site, cut edges shall be dressed and painted with at least two coats of cold galvanizing compound .
- (c) Cable tray support systems shall be secured to walls and ceilings by pre-formed galvanized interlocking channel.

5.53.0.13 Flexible conduits

(a) Flexible conduit shall be of the waterproof galvanized type of PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

(b) Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough-type box. The flexible conduit shall extend from this box to the equipment; the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws and the like will not be permitted. Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

5.53.0.14 PVC conduit

(a) Where galvanized conduit would be liable to corrosion, PVC conduit shall be installed.

(b) PVC conduit shall be of the oval or round high impact non-flame-propagating type as specified and self-extinguishing, conforming to BS EN 61386-21. Surface and concealed installations shall be generally as described for steel conduit.

(c) PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

(d) Jointing shall be carried out using PVC solvent and socketed accessories.

(e) Expansion couplers shall be fitted in straight surface runs at a distance of every 12m.

The free end shall be sealed with non-setting mastic to form a waterproof seal.

(f) Purpose-made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

(g) The conduit shall be suitable for use in ambient temperatures of between 5C and +50C and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth continuity conductor) shall be installed.

(h) Adaptable boxes and accessories shall be made from heat-resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes, the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaries or other heat sources shall have either external fixing lugs riveted to the metal inserts or utilize steel insert clips.

5.53.0.15 Cable installation methods

General

(a) All cabling installation methods shall be subject to the approval of the Engineer-in-Charge.

Installation directly into the ground

(a) Where cables are buried in the earth, the bottom of the excavated trenches shall be freed of sharp stones and other projections and covered with sand to a depth of 50mm.

(b) Cables shall be unrolled from drums without loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp projections.

(c) Cables shall be snaked into the trenches to avoid tension in the cables during back-filling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100mm of compacted sand and shall have a layer of red bricks for protection. The bricks shall be overlaid with marker tape.

(d) When cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.

(e) ICA and communication cables shall be laid not closer than 750 mm to high voltage cables.

(f) A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

5.53.0.16 Installation in underground ducts

(a) Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 500mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, Upvc ducts of minimum diameter 100mm shall be laid at a minimum depth of 1000mm (to the duct centre). The ducts shall be encased by 150mm concrete on all sides.

(b) When installing cables in ducts, the following measures shall be observed:

(1) Cables shall be pulled in a straight line;

(2) Rollers shall be positioned at the edges of draw pits both at the drawing-in and drawing out points over which the cables shall be drawn;

(3) UPVC pipes and cable sheaths shall be coated with an approved lubricant;

(4) Sufficient draw-in points shall be provided and adequate room allowed for installation of cables;

(5) The pulling rope shall be guided by rollers.

(6) Only one power cable shall be drawn into each duct.

(c) Whenever a duct is laid in the ground, a draw-wire shall be pulled through with at least 1000mm excess at each end and the draw-wire left in position if the duct is not to be used immediately.

5.53.0.17 Sealing cable entries into buildings

(a) Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with silicone foam or similar.

(b) All cable entries into a building shall be in ducts and where the cables pass in or out of ducts, together with any spare ducts, the ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer-in-Charge. The stopper shall have a fire resistance of at least 30 minutes.

5.53.0.18 Marking of underground cables

(a) The location of all underground cables shall be identified by

(1) Brass plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall;

(2) Marker posts in road verges and the like at intervals of not more than 30 mtrs and at all junctions and changes of direction along the route;

(3) Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

(b) Marker posts shall be of concrete, not less than 200mm high above ground with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of a cable below, the depth, classification and voltage rating.

(c) A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer-in-Charge.

5.53.0.19 Installation in cable trunking

(a) Cable trucking shall be manufactured from mild steel of not less than 1.25mm and shall be hot-dip galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity. Trunking shall have minimum dimensions of 50mm X 50mm.

(b) Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick-fix type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose-made by the manufacturer and of a matching design to the main trunking.

(c) Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

(d) Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes

(e) Trunking shall be supported at intervals not greater than 2m horizontally or 2.5m

vertically.

(f) Crossings over expansion joints shall be made in flexible conduit

(g) Should it be necessary to cut or drill a section of trunking, the bared ends shall immediately be given a coat of zinc-rich cold galvanizing paint.

(h) Cable and trunking runs shall be determined by the Contractor and approved by the Engineer-in-Charge before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services.

(i) Trunking systems erected outside a building shall be weatherproof.

5.53.0.20 Installation in buildings

(a) Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or simply at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

(b) All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. (c) The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings.

(d) Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

(e) Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.

(f) Cables shall be located between 50mm pegs spaced at 40mm centers across a rung so that a 40mm or 80mm space is maintained between cable centers. Cleats shall be used where the ladder racking is vertical.

(g) Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipe work.

5.53.0.21 Cable installation in conduits

(a) Conduits shall be either galvanised heavy-gauge steel screwed type or light-gauge steel non-screwed type, steel or PVC. Accessories shall either be malleable cast iron or pressed steel.

(b) A space factor of 40% shall not be exceeded and, in any case, conduit shall have a

minimum diameter of 20mm. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed and all sharp edges removed before erection.

(c) Where conduits converge, adaptor boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25mm diameter, straight through joint boxes shall be of the trough type. Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used

(d) Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All function boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

(e) Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.

(f) Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.

(g) Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

5.54 Process Instrumentation

General

(a) Instrumentation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

(b) All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalised. The outdoor equipment shall be designed to withstand tropical rain. Wherever necessary space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.

(c) Electronic instruments shall utilize solid state electronic components, integrated cir-

cuits, microprocessors, etc., and shall be of proven design.

(d) No custom made hybrid type integrated circuits shall be used.

(e) Unless otherwise stated, overall accuracy of all measurement systems shall be 1% of measured value, and repeatability shall be 0.5%.

(f) Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.

(g) On resumption of the supply following a power failure the instruments and associated equipment shall start working automatically.

(h) The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

(i) Unless otherwise stated, field mounted electrical and electronic instruments shall have minimum ingress protection as IP-66.

(j) The instruments shall be designed to work at the temperature, humidity, and chlorine contamination that may prevail at site. Instrument enclosure shall have corrosion-resistant properties.

(k) Enclosures of all the field instruments shall have locking arrangement.

(l) All field instruments, and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the IITH for approval before any labels are manufactured.

(m) All coated parts of sensors shall be made out of non-corrosive material capable of working against chlorine content up to 5 ppm.

(n) For all field instruments, surge protection devices (SPD) shall be provided at both ends of the connecting cable for protection against static discharges / lightning and electromagnetic interference.

(o) Individual pair screened, overall screened, armoured cables shall be used for analogue signals and armoured, overall screened cable shall be used for digital signal cables.

5.55 Flow Measuring Systems

(a) Flow measuring system shall consist of flow sensor / transducers, flow transmitter and flow computer.

(b) Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waste waterproof construction and shall be suitable for installation in underground /above ground pipelines.

(c) To avoid the effects of disturbances in the velocity profile, a straight and an uninterrupted run, on upstream as well as on downstream side of the location of the flow

sensor/transducer shall be provided in accordance with the recommendations of the flow meter manufacturer.

(d) The flow transmitter shall be suitable for field or panel mounting. It shall process the input signal and provide 4-20 mA DC and RS 485 output signal with open bus protocol, proportional to flow rate. The flow range shall be adjustable.

(e) A zero span adjustment facility shall be provided for flow transmitter and indicator.

(f) Within given limits, flow measurement shall not be affected by physical properties of sewage viz., temperature, pressure, viscosity, density etc. Contractor shall provide compensating electronic circuits if required. The overall accuracy of flow measuring systems shall be at least 1.0 % of the measured value unless otherwise stated.

5.56 Open Channel Flow meter

(a) Open channel flow measuring systems shall consist of level transducer, flow transmitter cum flow computer. The level of the fluid in the flume shall be measured by the ultrasonic level transducer. The flow measurement shall be take help of physical characteristics of the flume.

(b) The level transducer shall be suitable for flange or bracket mounting as per site requirement and shall have minimum ingress protection as IP66. It shall have ambient temperature compensation and adjustable datum setting facilities.

(c) The design and application of ultrasonic level transmitters shall take into account the flume/channel physical dimensions, construction details, process fluid, the presence of foam, granules, size etc.

(d) The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For application where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

5.57 Level Measuring System

5.57.1 Ultrasonic Level Meters

(a) Ultrasonic level measuring devices applied for fluid level measurement shall comprise a transducer, transmitter and remote indicator.

(b) The transducer shall be suitable for flange or bracket mounting as per site requirement and shall have an ingress protection as IP 65. It shall have ambient temperature compensation and adjustable datum setting, facilities.

(c) The accuracy of the sensor shall be 0.25% of the measurement or better.

(d) It shall have an integral programming keyboard and shall provide a digital display of the measured variable. It shall be provided with diagnosis facilities and shall provide an isolated 4 to 20 mA DC and RS 485 output signal with open bus protocol, proportional to the range of measurement.

(e) The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

(f) The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

(g) If turbulence exists, shielding, stilling tubes, still well or other measures shall be provided to avoid its effects on the measurement.

5.57.2 Conductivity Level Switches

(a) The electrodes used for conductivity level switches shall be stainless steel. Single electrode systems (one electrode per holder) shall be used (except where their use is impractical) with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level.

(b) Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall be fitted with conductivity discs.

(c) Where relay or control units are not mounted in control panels, they shall be provided with surface mounting enclosures with a degree of protection as IP 52 for indoor location and IP 65 for outdoor location.

Pressure gauges and transmitters

(a) Pressure gauges shall comply with BS EN 837-1 or equivalent and have concentric scales. For especially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerin-filled dial and line snubbers shall be

used. Bourdon-tube type differential-pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material.

(b) The minimum diameter for round pressure gauges shall be 150mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

(c) Unless specified elsewhere the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges and for differential gauges 1.5% of range or better.

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

(e) The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed 0.1% of the span.

(f) Pressure transmitters shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP 65 standard or higher standard. For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP 68 standard and shall operate up to maximum submergence of 20 metres of water.

(g) Pressure transmitters shall provide a digital or 4mA to 20mA DC output proportional to the pressure range.

(h) Pressure gauges and transmitters shall have primary isolating valves, 2 or 3 way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.

5.57.3 Strain-gauge pressure transducers and transmitters

(a) Strain-gauge pressure transducers shall use thin film sensors without bonding.

(b) Each instrument housing shall be of all-welded Grade X 4 CrNiMo 17 12 2 stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a non-corrodible barrier diaphragm. The mean time between failure for any model of strain-gauge transducer shall be not less than 15 years, and the perfor-

mance of the measurement system shall be as given below, or higher performance:

- i. accuracy: 0.1% of calibrated span, including linearity
- ii. hysteresis and repeatability;
- iii. repeatability: 0.05% at maximum span; iv. stability: 0.1% of upper range limit over 6month period;
- v. over-pressure: sustain a 400% over-pressure without damage;
- vi. RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact; power-supply variation effect: 0.01% per volt variation.
- vii. load variation effect: 0.0002% per ohm of loop-resistance variation.
- viii. temperature: 29°C to +82°C range; total thermal error of 0.75% of span over 0°C to 50°C;
- ix. protection: IP 65.

(c) Strain-gauge transducers which do not have terminals for their cable connection, shall have integral sealed-cable assemblies, installed in conduit and terminated at weatherproof junction boxes, protected to IP 65 each mounted near to its associated process transmitter. A digital or 4mA to 20mA dc output signal proportional to the transducer range shall be provided.

(d) Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal.

(e) Provision for transducer venting shall be provided.

5.58 Analytical Analyzers and Transmitters

(a) General:

This section covers individual elements to measure and transmit pH. Transmitters shall convert the sensor measurement to a 4 to 20 mA dc signal capable of transmission into at least a 500 ohm load at 50 V or less. Power supply shall be 240 Vac, 50 Hz. Reference accuracy of the output signal shall be 1 percent of measured span or better. Output signal shall be electronically isolated from ground to permit connection to a receiver with a grounded input. Transmitters shall be provided with an indicating scale having at least a 0.1 meter calibrated length. Operating ambient temperature shall be -5 to + 50 degree C or better. Transmitted signals shall be linear with the measured variable excepting pH

which shall be linear with pH.

5.58.1 Sensor Measurement Principles and Features

Each type of sensor shall use the measuring principle and incorporate the features appropriate to it as specified below:

i. pH sensors shall measure hydrogen ion activity and oxidation-reduction potential respectively in the process medium. The pH sensor shall consist of a glass measuring electrode, a reference electrode, a solution ground and a temperature sensor for compensation in the transmitter. The reference electrode shall be the non flowing type with an electrolyte diffusion rate through a non-reactive porous membrane or plug which shall not require electrolyte refill more often than once per year. ORP sensors shall use the same elements specified for pH sensors except that electrode shall be platinum and no temperature compensation is required. pH and ORP sensor assemblies shall incorporate an integrally mounted preamplifier for the measuring electrode. Sensors shall operate over a temperature range of -5 to + 100 Degree Celsius or better.

5.58.2 Construction

Transmitter and sensor enclosures shall be rated NEMA 4 . If not so specified, they may be the manufacturer's standard which is compatible with the corrosivity of the atmosphere normally in contact with the enclosure. All parts of sensors, their assemblies and supporting parts which are wetted by the process medium shall be constructed of stainless steel and/or plastic unless specified otherwise on the Schedule. When specified on the Schedule, pH assemblies shall be provided with integrally mounted ultrasonic cleaners.

5.58.3 Total Dissolved Oxygen Monitoring System

(a) The Dissolved Oxygen (D.O) monitoring system shall consist of a sensor, transmitter, indicating converter and electrode cleaning equipment. Accuracy shall be + 0.5% full scale for DO, barometric pressure + 0.27 kPa and temperature + 0.3Degree Celsius.

(b) The sensor shall not require zero point calibration and shall last approximately 2 years with a DO level of 3-5 mg/l and 3-5 years with a DO level of 1-2 mg/l. The transmitter shall allow the DO sensor to be fitted without the use of tools. The transmitter

shall deliver an output signal proportional to the DO level and measured temperature. The following alarms shall be detected and transmitted.

- i. Membrane puncture
- ii. Depleted or worn out DO sensor
- iii. System/electronic fault.

(c) The indicating converter shall perform auto calibration of the system and compensate for sensor age, temperature, barometric pressure, relative humidity and liquid salinity. It shall display OD concentration, temperature, sensor balance lifetime (mg/l x hours or %) and rh selected for calibration.

(d) **Construction:** The DO sensor shall consist of a prefabricated, disposable, sealed cartridge that slides easily into the transmitter without special tools. Systems that require re-generation (refill of electrolyte and membrane change) will not be acceptable. The sensor shall use the Clarks principle, with a gold cathode, silver wire anode and a non toxic electrolyte of potassium chloride. The pre-stressed membrane shall be of Teflon and bonded onto the DO sensor.

(e) The transmitter shall be protected to IP 67 and supplied with 6m of cable for connection to a junction box. The converter shall be housed in a NEMA 4 x enclosure and be mounted on handrail or panel up to 200m from the sensor. It shall be interchangeable without the need for recalibration or reprogramming of the system by using a sensor specific storing device continuing all settings and calibration.

(f) The sensor and transmitter shall be installed in a self cleaning polystyrene ball float, which shall float on the surface of the water and allow the sensor to be inserted by approximately 125mm into the water. The ball shall be constructed to fit the sensor and transmitter and leave a smooth surface to prevent accumulation of dirt or grease. Constructions where the sensor protrudes will not be acceptable.

5.59 Surge Protection Devices

(a) Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Tranzorb, zener diodes; varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the

excess voltage to the ground. The SPD shall be self resetting to minimize the down time of the measurement loop

(b) SPD s shall be provided to protect devices transmitting and receiving analogue and digital signals derived from outdoor field instrumentation.

(c) The surge protection device shall be rated for surge rating of 10 KA.

5.60 Programmable Logic Controllers

General

(a) Programmable Logic Controllers (PLC) shall be provided to perform combinational and sequential logic functions, status monitoring and report functions with counter and timer facilities. The entire STP shall be designed in a way to facilitate complete automatic mode of control via PLC based SCADA systems.

(b) PLC shall comprise of necessary processors, Simplex input/output (I/O) modules, communication interface modules and Human-Machine Interface (HMI) required performing the desired functions.

(c) PLC shall have the following attributes

- i. carry out sequential logic implementation for operations of plant;
- ii. carry out computation and interfacing for data acquisition, data storage and retrieval;
- iii. it shall accept downloaded program from a programmer;
- iv. it shall have different functional modules to perform the desired functions;
- v. it shall scan the inputs in time cycles and update the status of its outputs.

(d) The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

(e) PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

(f) In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

(g) The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

(h) PLC shall be of an approved type from a major international manufacturer.

(i) PLC System (Panel) should be housed in a dust free environment.

5.60.1 PLC Coding

(a) The Contractor/SI shall supply, install, program and commission the PLC using the PLC manufacturer recommended windows based, PLC code and documentation software. The PLC code shall be structured as per best industry standard and shall have comprehensive sub-routine and rung annotation. PLC shall be coded using FBD language.

(b) The Contractor/SI shall provide a suitable PC complete with PLC code and documentation software as specified in the bid document as agreed with the Engineer-in-Charge based on the FDS submitted.

5.61 HMI (Human Machine Interface)/SCADA

General

(a) The HMI shall be suitable for day to day operation by non-computer literate personnel in the monitoring and operation of the treatment works.

5.61.1 Human Machine Interfaces (HMI)

(a) Human Machine Interface (HMI) shall be provided at Monitoring Room.

(b) The SCADA system shall provide efficient and safe operation of the process plant by detection of alarm and error conditions, to alert the Contractor to these conditions by both visual and audible alarm, to monitor all important system parameters and providing facilities for plant optimization. The system will allow Contractors, technicians and Engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Contractor Workstations (OW) and Engineering workstation (EW), after successful log-on by security password.

(c) The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

(d) The HMI shall be constructed to a high standard to provide a high profile feature and focal point for visitors to the Sewage Treatment Plant (STP).

(e) SCADA/HMI system shall be housed in an air-conditioned environment.

5.61.2 Uninterruptible Power Supply (UPS)

(a) The power for Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA/HMI) shall be derived from independent UPS.

(b) The UPS provided shall be sized to provide power to maintain system operation for a period of minimum 30 minutes back up, in case of power failure.

(c) The above feature should be demonstrated during Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

Recommended Equipment Specifications

5.62 Major Equipment

5.62.1 Air Blowers

PD Blowers

Table 5.26: PD Blowers

Range	As per P & ID
Blower Type	Positive displacement Rotary Twin Lobe Blower
Model	As per Manufacturer Specification
Manufacturer	Kay International / Everest / Usha/ Kulkarni / Swam/ Equivalent
Casing and Lobes	C.I FG 260 ; IS 210
Shafts	EN 24 (817 M 40; BS 970)
Gears	EN 353 (817 M 40; BS 970) (Case Hardening & Ground)
Common Base Frame	MS Fabricated; IS 2062
Bearings	SKF/Equivalent Make
Drive Type	V Belt Drive
Guard	Perforated Plate V Belt drive Guard
Motor	TEFC, Class F Insulation
Accessories	Common base frame, suction filter, Suction silencer, discharge silencer, pressure gauge, non return valve, safety valve, V belts, V belt guard, drive & driven pulleys, foundation bolts, all fixing nuts & bolts, Inter connecting piping with motor

5.62.2 Process Pumps (RAS Pump)

Recirculation Pumps The following table lists typical specifications for MLSS Recirculation Pumps. This specification applies to pumps that will be drawing mixed liquor from the bioreactor or Membrane Tank for recirculation.

Table 5.27: Recirculation Pumps

Pump Type	Submersible
Manufacturer	KSB/ Grundfos/ABS
Flow, M3/Hr	As per P & ID
Dis. Pressure, Bar	As per P & ID
Configuration	Submersible
Casing	Cast Iron
Stuffing Box Cover	As Per Manufacturer
Impeller	SS
Seal Manufacturer / Type	As per Manufacturer / Process requirement
Seal Lubrication	Water
Coupling	Flexible
Motor	TEFC
	NEMA Design B
	Class F insulation
	Class B Temperature rise

5.63 Centrifuge

Centrifuge is used for sludge dewatering.

Table 5.28: Centrifuge

Capacity Range	As per P & ID
Manufacturer	Alfa Laval / Andritz / Humboldt/ Pennwalt/ Hiller
Type	Screw conveyor with gear box Centrifuge
Bowl Material	SS316/304
Material for other parts in contact with sludge	SS316/SS304
Start Up method	DOU, Star Delta, VFD

5.64 Ejectors

The following table lists typical specifications for ejectors which are used to remove air for the process piping.

Table 5.29: Ejectors

Manufacturer	PIAB
Model	
Feed Pressure (MAX)	101.5 psi
Noise Level	65-70 dBA
Temperature Range	14F - 176F
Weight	3.74lb - 3.96lb
Material	AL, PA, NBR, SS, TPE

5.65 Chemical Pumps

The chemical pumps, listed below, are used with the membrane CIP systems for adding high volumes of chemical solution within a short period of time, for example, to the CIP

wash flow through the membranes during cleaning.

5.65.1 Metering Pump (Chemical Dosing Pumps)

Metering pumps are used in chemical feed applications where a higher degree of accuracy is required.

Table 5.30: Chemical Dosing Pumps

Capacity Range	As per P & ID
Manufacturer	Prominent / Asia LMI / Equivalent
Type	Diaphragm Positive displacement pumping action
Wetted Ends	PVDF
Diaphragm	PTFE (Teflon)
Balls	Alumina Ceramic/glass
Drive	Motor
Motor	TEFC
	NEMA Design B
	Class F insulation
	Class B Temperature Rise

5.66 Air Compressors Driers

5.66.1 Air Compressors

Air compressors are used for pneumatic valve operations. Where possible they will be freestanding, tank mounted units. The compressor system, air receivers and other equipment will be sized to provide adequate air for the ZeeWeed system operation. The final sizing of the compressor will depend on the air requirements of the actuators provided with the valves included with the Membrane Filtration System. **Oil Lubricated Compressors:**

Table 5.31: Oil Lubricated Compressors

Operating Range	As per P & ID
Manufacturer	ELGI
Series	PLT Series or equal
Compressor Type	Two Stage, Oil-Lubricated
Maximum Pressure	Up to 175 PSIG
Lubrication	Pressure lubrication with Positive Displacement Oil Pump
Drive	Belt driven with belt guard
Motor	EPAct High Efficiency, Up to 25 HP, 1800 RPM
Accessories	Pressure Gauge, Pressure Relief Valve, Tank Drain, Shut-Off Valve, Enclosed Belt Guard, Pressure Switch and Inlet Filter.

5.66.2 Air Receivers

Receivers will be horizontal standing with compressors mounted whenever possible. ASME Code Construction supplied with a pressure gauge, pressure relief valve, and automatic

drain valve.

Table 5.32: Air Receivers

Receiver Tank	Horizontal Painted Carbon Steel
Receiver Tank Volume	Based on MIT and/or plant service air requirements
Accessories	Receiver Tank Solenoid Auto Drain, Receiver Tank Discharge Isolation Valve, Pressure Relief Valve, Pressure Gauge

5.66.3 Refrigerated Air Drier

Refrigerated air driers are supplied for operation with the compressor units. Each drier has a condensing unit, refrigerant evaporator, mechanical separator, automatic condensate discharge valve, pre-filter, and after-filter. The drier is equipped with filters to remove oil carryover, oil aerosols, and other particulate matter.

Table 5.33: Refrigerated Air Drier

Air Dryer	Refrigerant Air Dryer
Manufacturer	Reputed Make as approved by EIC
Model	QPNC
Capacity	Based on MIT and/or plant service air requirements
Connections	NPT Threaded
Accessories	Auto Drain

5.67 Miscellaneous Appurtenances

The compressor system is supplied with the necessary pressure relief valves, coalescing filters, particulate air filters, process air regulator assemblies, automatic drain valves, and controls, as required, to provide a complete functional system.

General Service Filter for Valve Service Air

Table 5.34: General Service Filter for Valve Service Air

Type	General Purpose Coalescing Filter
Manufacturer	Reputed Make as approved by EIC
Connections	Inlet & Outlet= Threaded 3/8" 1" NPT; Automatic Brass Drain= Threaded 1/8"NPT (size varies based on system capacity)
Body	Aluminum
Filter Size	1 Micron
Accessories	Includes differential gauge, audible alarm, internal automatic drain and liquid presence indicator.
Approvals	ISO 8573.1 Class 2 solids, Class 4 oil

5.68 Pre-Screening

5.68.1 Coarse and Fine Screen (6mm Mechanical Screen)

Table 5.35: 6mm Mechanical Screen

Capacity Range	As per P & ID
Manufacturer	Contec/ Andritz/Jash/Bilfinger/Auric Equivalent
Type	Internally Fed inline, In channel, Drum Screen with integral or separate screening, Compactor
Service	Raw Sewage
MOC	SS 304
Operation	Automatic
Screen Size	6 mm 10 mm
Water Type	Raw sewage upstream of equalization tank

5.68.2 2 mm punched hole Screen

Table 5.36: 2 mm punched hole Screen

Capacity Range	As per P & ID
Manufacturer	Contec/ Andritz/Jash/Bilfinger/Auric Equivalent
Type	Drum screen/ In Channel Screen
MOC	SS 304
Operation	Automatic
Screen Size	2 mm
Water Type	Equalized sewage

5.69 Fine Bubble Diffuser System

The aeration system is designed for installation within the bioreactor process tanks to provide air for the biological process. A typical fine bubble aeration(retrievable type) system is described in the chart located below.

The diffuser unit is a fine pore, flexible membrane diffuser capable of providing a high level of oxygen transfer efficiency with maximum operating flexibility.

Table 5.37: Fine Bubble Diffuser System

Type	Fine Pore flexible membrane type
Manufacturer	EDI/ SSI/ OTT
MOC	EPDM
Diameter x Length	90mm x 1000mm / 90mm x 500mm
Accessories	SS316 Clamps

5.70 Valves

The following are the general specifications for the main types of valves to be used.

5.70.1 Butterfly Valve 4 to 12" diameter

Table 5.38: Butterfly Valve 4 to 12" diameter

Type	Butterfly Valves
Service	Vacuum Rated /Non-Vacuum Rated
Manufacturer	AUDCO/ Inter Valve / Crane / Tyco /BDK/Bray
Style	Wafer Pattern (Lug Pattern Valves for Tank drain Applications, Maint Purposes)
Body	Cast Iron, Epoxy Coated
Disc	316 Stainless Steel Shaft 416 Stainless Steel
Shaft	416 Stainless Steel
Seat	EDPM
Manual Operators	Under 6 Manual Lever 6 & Larger Gear

5.70.2 Butterfly Valve 14 to 24" diameter

Table 5.39: Butterfly Valve 14 to 24" diameter

Type	Butterfly Valves
Service	Vacuum Rated /Non-Vacuum Rated
Manufacturer	AUDCO/ Inter Valve / Crane / Tyco /BDK/Bray
Style	Wafer Pattern (Lug Pattern Valves for Tank drain Applications, Maint Purposes)
Body	Cast Iron, Epoxy Coated
Disc	316 Stainless Steel Shaft 416 Stainless Steel
Shaft	416 Stainless Steel
Seat	EDPM
Manual Operators	Gear

5.70.3 Process check Valves

Table 5.40: Process check Valves

Type	Wafer Butterfly Check
Manufacturer	AUDCO/ Inter Valve / Crane / Tyco/BDK/Bray
Style	Wafer suitable for installation between ANSI # 150 flanges
Body	Cast Iron
Disc	316 Stainless Steel
Shaft	316 Stainless Steel
Seat	BUNA N

5.70.4 Chemical Feed Lines

Table 5.41: Chemical Feed Lines

Type	Check
Manufacturer	George Fischer/Equivalent
Style	Ball or Swing Check
Body	PVC
Disc	PVC

5.70.5 Waste water, Mixed Liquor and Sludge Lines

Table 5.42: Waste water, Mixed Liquor and Sludge Lines

Type	Elastic Swing Check
Manufacturer	AUDCO/ Inter Valve / Crane / Tyco/BDK/Bray
Flow Area	Design allows full Pipe size flow area when fully open
Style	Flanged Suitable for installation between ANSI # 150 flanges
Body/Cover	Ductile, Iron IS
Disc/ Flapper	Viton (durometer 70) internally reinforced with steel and fabric reinforcement; removable without removing the valve body from the line. Disc/ flapper captured in the body by the cover to allow the disc to have elastic flex from the closed position to full open position.
Disc/Flapper Arm	Viton with an elastic spring to assist the closure against a small head to minimize disc slamming.
Style	Wafer suitable for installation between ANSI # 150 flanges
Shaft	316 Stainless Steel
Seat	BUNA N
Internal Coating	Epoxy NSF approved coating
Exterior Coating	Blue Metal Primer
Position Indicator	External Position indicator W/ Proximity switches for the closed position
Pipeline Pressure	50 Psig
Body	316 Stainless Steel
Disc	316 Stainless Steel
Shaft	17.4 PH
Seat	Teflon

5.70.6 Chemical Feed Lines (<3")

Table 5.43: Chemical Feed Lines

Type	Ball
Manufacturer	George Fischer/Equivalent
Style	Tru Union
Body, Plug, Shaft	PVC
Seals	EPDM or Viton
Manual Operators	Manual Lever

5.70.7 Control Valves

Control Valves are valves (butterfly, gate or ball) with double acting pneumatic actuators and electro- pneumatic positioners.

Mixed Liquor Re-circulation Wasting Lines (2" 36")

Table 5.44: Control Valves

Type	Knife gate
Manufacturer	AUDCO/ Crane / Tyco/BDK/Bray
Style	Lugged, AR Series
Body	GG25 (Cast Iron)
Gate	304 Stainless Steel
Shaft	Carbon Steel
Seat	EPDM
Manual Operators	All Sizes Handwheel Operated
End Caps	Ductile Iron
Pistons	Ductile Iron
Output Shaft	Plated Alloy Steel C4140
Shaft bushings	Stainless Steel
Piston Guidelines	Reinforced PTFE
Fasteners	18 8 Stainless Steel
Piston O Rings	Buna N
Air Solenoid	4 way NEMA 4, 120/1/60
Limit Switches	Tyco Avid ZR Plus with Position monitor and T Sensor Proximity Switches

5.71 Miscellaneous Valves

5.71.1 Instrument Isolation Valves

The Instrument isolation valves typically used throughout the membrane system are listed in the following table.

Table 5.45: Instrument Isolation Valves

Type	Ball Valve
Manufacturer	AUDCO/ Crane
Style	Reduced Port Threaded
Body/ Ball	316 Stainless Steel
Seat	PTFE
Connection	Typically 0.5"NPT

5.71.2 Solenoid Valves

The Solenoid valves typically used throughout the membrane system are listed in the following tables.

Table 5.46: Solenoid Valves

Type	Solenoid Valve
Service	Air/Water
Manufacturer	Tyco / Inter Valve
Model	As per Manufacturer
Style	F NPT, Normally Closed
Body	316 Stainless Steel / Brass

5.71.3 Pneumatic Actuators

Table 5.47: Pneumatic Actuators

Type	Double Acting Cylinder Rack & Pinion Drive
Manufacturer	
Operating Pressure	550 Kpa (80 Psig)
Body Material	Extruded Aluminum Alloy, Anodized
Travel Shop	304 Stainless Steel
End Caps	Die Cast Aluminum Alloy
Pistons	Die Cast Aluminum Alloy
Output Shaft	Carbon Steel (Zinc Plated)
Shaft Bearings	Engineered Polymer Devlon
Fasteners	Stainless Steel
O Rings	Nitrile
Air Solenoid	4 Way, NEMA 4 or Equal
Additional Features	Open and Closing Speed Control
Position Control	Electro Pneumatic Avid Eazical Intelligent Positioner 4 20mA Input

5.71.4 General Service PVC Valves

Table 5.48: General Service PVC Valves

Type	Double Acting
Manufacturer	George Fisher / Equivalent
Operating Pressure	550 Kpa (80 Psig)
Body Material	Poly Amide w/Glass Fiber
End Caps	Poly Amide w/Glass Fiber
Pistons	Die Cast Aluminum Alloy
Output Shaft	Stainless Steel
Fasteners	Stainless Steel
O Rings	Nitrile

5.72 Process Instrumentation

The following process instruments are included with the ZeeWeed System. Output signals from all these instruments are connected to the PLC System.

5.72.1 Flow switches

Flow switches are included to provide flow confirmation in air or water lines from blowers and pumps respectively.

Table 5.49: Flow switches

Application	Air	Liquid
Manufacturer	Switzer/ Emerson/ E & H	Switzer/ Emerson/ E & H
Series recommendation	As per Manufacturer	
recommendation	As per Manufacturer	
Sensor Type/Material	Probe Sensor 316 Stainless Steel	Flat Face Sensor 316 Stainless Steel
Process Connection	O.75" NPT	
Accuracy	+/- 5%	
Housing	304 Stainless Steel NEMA 4X	
Integral LCD	Yes, 4 Digit	
Power/Connection	18 30 VDC/0.5"NPT	

5.72.2 Electromagnetic Flow meters (Flow transmitter)

Flow meters are included for monitoring the permeate flow from each train, the reject flow from each train and back pulse/CIP flow to the membranes as well as a train's recirculation flow.

Table 5.50: Electromagnetic Flow meters

Manufacturer	E & H / Emerson /
Series	As per Manufacturer recommendation
Process Connection	ANSI # 150 flanged
Housing	Aluminum NEMA 4X
Flow tube	304 Stainless Steel
Liner	PTFE
Accuracy	+/- 0.5%
Operator Interface	Local
Output	HART, 4 20 mA DC, Scaled pulse Output
Power/connection	85 260 VAC 60 Hz/ 0.5" NPT
Seal	EPDM
Power	120 VAC/60
Power Connection	0.5" NPT Conduit, Type H Electrical

5.72.3 Level transmitters

Level transmitters are included for monitoring the liquid levels in the membrane tanks or in the inlet flow distribution channel to each series of membrane tanks. They are also included on the back pulse/CIP tank, if applicable. Two basic types of level transmitters, top and side entry, are generally used with ZeeWeed Membrane Systems depending on the application and both are described below.

Table 5.51: Level transmitters

Manufacturer	E & H or equivalent as approved.	
Application	Top Entry	Side Entry
Process Connections	3" 150 # Flange (316 Stainless Steel)	1.5" to 3" 150# Flange (316 Stainless Steel) & 1.5" NPT Connections available.
Mounting	1.5", 2" and 3" 150 # Flange (316 Stainless Steel) & 1.5" NPT Connections available.	
Output Signal	HART 4 20 mA	
Voltage	11.5 to 30 VDC	
Diaphragm	Contite Sensor with metallic diaphragm alloy C4	
Housing	Aluminum NEMA 4X	
Integral LCD	Yes	

5.72.4 Pressure Transmitters

Pressure transmitters monitor the vacuum applied to the membranes during permeating and the positive pressure applied during back pulsing. The pressure transmitters are mounted on the permeate collection header pipes included with the ZeeWeed system and are typically calibrated at 15 psi to +20 psi. Typical specifications are listed in the following table.

Table 5.52: Pressure Transmitters

Manufacturer	E & H/ Emerson/ Eq
Model	As per Manufacturer recommendation
Output Signal	4 20mA HART PROT
Voltage	11.5 30 VDC
Diaphragm	Ceramic
Housing	Aluminum NEMA 4X
Integral LCD	Yes

5.72.5 Turbidi meters

Continuous on-line turbidi meters are included as a means of verifying the integrity of the membranes by taking water samples from the discharge side of the permeate pumps. Typical component specifications are listed below.

Table 5.53: Turbidi meters

Manufacturer	Hach /Equivalent
Model	As per Manufacturer recommendation
Range	0- 100 NTU
Inlet	0.25" FNPT
Outlet	0.5" FNPT
Outlet Signal	4 20 mA
Power	220V/1ph/50 Hz
Display	SC 100
Accessories	Sensor, analyzer unit, interconnecting cable, alarm relays for indication of alarm conditions and one (1) Formazin Calibration Kit.

5.72.6 Dissolved Oxygen Sensors Analyzers

Dissolved oxygen sensors are immersed within the bioreactor and signal cabled to the PLC. Sensors are typically installed within the aerated zone of each bioreactor tank and other areas of the plant at Istitute's discretion. Typical specifications are listed in the following table.

Table 5.54: Dissolved Oxygen Sensors Analyzers

Manufacturer	E& H/HACH/EMERSON/Eq
Model	OXY 1100/4100
Range	0-10 mg/L
Resolution	0.1 mg/L
Transmitter	OXY 4100, Ball/Float Type
Output Signal	2 x 4-20 mA
Power Supply	85-264 V AC
Display	LCD supplied on Signal Convertor
Accessories	Sensor & Float
	Transmitter
	Mounting Bracket
	Signal Converter (sized as needed)

5.72.7 Float Level Switches

Where included, float level switches are to be provided.

5.72.8 Pressure Gauges

Pressure gauges are included for the various pumps and blowers included with the Zee-Weed system. Pressure gauges are liquid filled and are Ashcroft or equal with 316SS wetted parts. Pressure gauges are supplied complete with isolation ball valves gauge cocks between the pressure gauge and the process line.

5.72.9 Pressure Switches

Pressure switches are provided for high-pressure alarm on the permeate collection pipes to prevent over-pressurizing of the membranes during back pulsing. In addition, pressure

switches are included to provide low pressure warning for the compressed air for the pneumatic valves. The types of flow switches used in the different applications are listed in the following table.

Table 5.55: Pressure Switches

Permeate Lines	United Electric J6 Series or equal with 316 Stainless Steel wetted parts and bellows
Compressed Air Line	United Electric H100 Series or equal with 316 Stainless Steel wetted parts and bellows

5.73 Motor Specifications

General Duty Electrical Motors supplied with the equipment generally have the specifications outlined in the following table.

Table 5.56: Motor Specifications

Less than 0.5 HP	230 VAC/ 1 ph/ 50 Hz
0.5HP or More	415V/ 3pH/ 50 HZ
	NEMA Frame
	Design B
	NEMA Class B Temperature Rise
	Meeting EPACT Efficiency Requirements

5.74 Control Systems

5.74.1 Motor Control Center (MCC)

The MCC will house the circuit breakers, motor starters, and VFDs for all electrical motors on equipment that is supplied by GE ZENON ULC. The MCC will be supplied with a main breaker, appropriately rated for the motor loads noted above.

The MCC, with the following feature and specifications:

Table 5.57: MCC

Section Dimensions	90" high x 20" deep x 20" wide
Number of Sections	To Be Determined
MCC Connection	3 Pole Main Circuit Breaker
Enclosure Type	NEMA 1 fully gasketed with bottom plates
Cable Entry	Top
Ground Lug Size	#6 AWG 250 kcmil (2 supplied as standard)
Main Bus Rating	To be confirmed during final design
Main Bus	Bracing 42 kA (RMS)
Main Bus	Material Copper/ Tin Plated
Horizontal Ground Bus Size	0.25" x 1 (may vary according to application)
Horizontal Ground Bus Location	Bottom
Vertical Ground Bus Type	Copper / Tin Plated

5.74.2 Variable Frequency Drives

The Variable Frequency Drives (VFDs) will be mounted within the MCC, as described above, and will be of the same manufacturer as the MCC. The VFDs will be Cutler-Hammer SVX9000, with the following features and specifications:

Table 5.58: VFD

Input Voltage Range	208 -240V, 380 -500V or Range 525 -690V
Input Voltage Tolerance	-15% of Minimum; +10% of Maximum
Input Frequency Tolerance	45 to 66 Hz
Service Factor	1.0
Efficiency	97.5% at rated amps

Recommended Equipment Specifications

5.75 Major Equipment

5.75.1 Air Blowers

PD Blowers

Table 5.59: PD Blowers

Range	As per P & ID
Blower Type	Positive displacement Rotary Twin Lobe Blower
Model	As per Manufacturer Specification
Manufacturer	Kay International / Everest / Usha/ Kulkarni / Swam/ Equivalent
Casing and Lobes	C.I FG 260 ; IS 210
Shafts	EN 24 (817 M 40; BS 970)
Gears	EN 353 (817 M 40; BS 970) (Case Hardening & Ground)
Common Base Frame	MS Fabricated; IS 2062
Bearings	SKF/Equivalent Make
Drive Type	V Belt Drive
Guard	Perforated Plate V Belt drive Guard
Motor	TEFC, Class F Insulation
Accessories	Common base frame, suction filter, Suction silencer, discharge silencer, pressure gauge, non return valve, safety valve, V belts, V belt guard, drive & driven pulleys, foundation bolts, all fixing nuts & bolts, Inter connecting piping with motor

5.75.2 Process Pumps (RAS Pump)

Recirculation Pumps The following table lists typical specifications for MLSS Recirculation Pumps. This specification applies to pumps that will be drawing mixed liquor from the bioreactor or Membrane Tank for recirculation.

Table 5.60: Recirculation Pumps

Pump Type	Submersible
Manufacturer	KSB/ Grundfos/ABS
Flow, M3/Hr	As per P & ID
Dis. Pressure, Bar	As per P & ID
Configuration	Submersible
Casing	Cast Iron
Stuffing Box Cover	As Per Manufacturer
Impeller	SS
Seal Manufacturer / Type	As per Manufacturer / Process requirement
Seal Lubrication	Water
Coupling	Flexible
Motor	TEFC
	NEMA Design B
	Class F insulation
	Class B Temperature rise

5.76 Centrifuge

Centrifuge is used for sludge dewatering.

Table 5.61: Centrifuge

Capacity Range	As per P & ID
Manufacturer	Alfa Laval / Andritz / Humboldt/ Pennwalt/ Hiller
Type	Screw conveyor with gear box Centrifuge
Bowl Material	SS316/304
Material for other parts in contact with sludge	SS316/SS304
Start Up method	DOU, Star Delta, VFD

5.77 Ejectors

The following table lists typical specifications for ejectors which are used to remove air for the process piping.

Table 5.62: Ejectors

Manufacturer	PIAB
Model	
Feed Pressure (MAX)	101.5 psi
Noise Level	65-70 dBA
Temperature Range	14F - 176F
Weight	3.74lb - 3.96lb
Material	AL, PA, NBR, SS, TPE

5.78 Chemical Pumps

The chemical pumps, listed below, are used with the membrane CIP systems for adding high volumes of chemical solution within a short period of time, for example, to the CIP wash flow through the membranes during cleaning.

5.78.1 Metering Pump (Chemical Dosing Pumps)

Metering pumps are used in chemical feed applications where a higher degree of accuracy is required.

Table 5.63: Chemical Dosing Pumps

Capacity Range	As per P & ID
Manufacturer	Prominent / Asia LMI / Equivalent
Type	Diaphragm Positive displacement pumping action
Wetted Ends	PVDF
Diaphragm	PTFE (Teflon)
Balls	Alumina Ceramic/glass
Drive	Motor
Motor	TEFC
	NEMA Design B
	Class F insulation
	Class B Temperature Rise

5.79 Air Compressors Driers

5.79.1 Air Compressors

Air compressors are used for pneumatic valve operations. Where possible they will be freestanding, tank mounted units. The compressor system, air receivers and other equipment will be sized to provide adequate air for the ZeeWeed system operation. The final sizing of the compressor will depend on the air requirements of the actuators provided with the valves included with the Membrane Filtration System. **Oil Lubricated Compressors:**

Table 5.64: Oil Lubricated Compressors

Operating Range	As per P & ID
Manufacturer	ELGI
Series	PLT Series or equal
Compressor Type	Two Stage, Oil-Lubricated
Maximum Pressure	Up to 175 PSIG
Lubrication	Pressure lubrication with Positive Displacement Oil Pump
Drive	Belt driven with belt guard
Motor	EPAct High Efficiency, Up to 25 HP, 1800 RPM
Accessories	Pressure Gauge, Pressure Relief Valve, Tank Drain, Shut-Off Valve, Enclosed Belt Guard, Pressure Switch and Inlet Filter.

5.79.2 Air Receivers

Receivers will be horizontal standing with compressors mounted whenever possible. ASME Code Construction supplied with a pressure gauge, pressure relief valve, and automatic drain valve.

Table 5.65: Air Receivers

Receiver Tank	Horizontal Painted Carbon Steel
Receiver Tank Volume	Based on MIT and/or plant service air requirements
Accessories	Receiver Tank Solenoid Auto Drain, Receiver Tank Discharge Isolation Valve, Pressure Relief Valve, Pressure Gauge

5.79.3 Refrigerated Air Drier

Refrigerated air driers are supplied for operation with the compressor units. Each drier has a condensing unit, refrigerant evaporator, mechanical separator, automatic condensate discharge valve, pre-filter, and after-filter. The drier is equipped with filters to remove oil carryover, oil aerosols, and other particulate matter.

Table 5.66: Refrigerated Air Drier

Air Dryer	Refrigerant Air Dryer
Manufacturer	Reputed Make as approved by EIC
Model	QPNC
Capacity	Based on MIT and/or plant service air requirements
Connections	NPT Threaded
Accessories	Auto Drain

5.80 Miscellaneous Appurtenances

The compressor system is supplied with the necessary pressure relief valves, coalescing filters, particulate air filters, process air regulator assemblies, automatic drain valves, and controls, as required, to provide a complete functional system.

General Service Filter for Valve Service Air

Table 5.67: General Service Filter for Valve Service Air

Type	General Purpose Coalescing Filter
Manufacturer	Reputed Make as approved by EIC
Connections	Inlet & Outlet= Threaded 3/8" 1" NPT; Automatic Brass Drain= Threaded 1/8"NPT (size varies based on system capacity)
Body	Aluminum
Filter Size	1 Micron
Accessories	Includes differential gauge, audible alarm, internal automatic drain and liquid presence indicator.
Approvals	ISO 8573.1 Class 2 solids, Class 4 oil

5.81 Pre-Screening

5.81.1 Coarse and Fine Screen (6mm Mechanical Screen)

Table 5.68: 6mm Mechanical Screen

Capacity Range	As per P & ID
Manufacturer	Contec/ Andritz/Jash/Bilfinger/Auric Equivalent
Type	Internally Fed inline, In channel, Drum Screen with integral or separate screening, Compactor
Service	Raw Sewage
MOC	SS 304
Operation	Automatic
Screen Size	6 mm 10 mm
Water Type	Raw sewage upstream of equalization tank

5.81.2 2 mm punched hole Screen

Table 5.69: 2 mm punched hole Screen

Capacity Range	As per P & ID
Manufacturer	Contec/ Andritz/Jash/Bilfinger/Auric Equivalent
Type	Drum screen/ In Channel Screen
MOC	SS 304
Operation	Automatic
Screen Size	2 mm
Water Type	Equalized sewage

5.82 Fine Bubble Diffuser System

The aeration system is designed for installation within the bioreactor process tanks to provide air for the biological process. A typical fine bubble aeration(retrievable type) system is described in the chart located below.

The diffuser unit is a fine pore, flexible membrane diffuser capable of providing a high level of oxygen transfer efficiency with maximum operating flexibility.

Table 5.70: Fine Bubble Diffuser System

Type	Fine Pore flexible membrane type
Manufacturer	EDI/ SSI/ OTT
MOC	EPDM
Diameter x Length	90mm x 1000mm / 90mm x 500mm
Accessories	SS316 Clamps

5.83 Valves

The following are the general specifications for the main types of valves to be used.

5.83.1 Butterfly Valve 4 to 12" diameter

Table 5.71: Butterfly Valve 4 to 12" diameter

Type	Butterfly Valves
Service	Vacuum Rated /Non-Vacuum Rated
Manufacturer	AUDCO/ Inter Valve / Crane / Tyco /BDK/Bray
Style	Wafer Pattern (Lug Pattern Valves for Tank drain Applications, Maint Purposes)
Body	Cast Iron, Epoxy Coated
Disc	316 Stainless Steel Shaft 416 Stainless Steel
Shaft	416 Stainless Steel
Seat	EDPM
Manual Operators	Under 6 Manual Lever 6 & Larger Gear

5.83.2 Butterfly Valve 14 to 24" diameter

Table 5.72: Butterfly Valve 14 to 24" diameter

Type	Butterfly Valves
Service	Vacuum Rated /Non-Vacuum Rated
Manufacturer	AUDCO/ Inter Valve / Crane / Tyco /BDK/Bray
Style	Wafer Pattern (Lug Pattern Valves for Tank drain Applications, Maint Purposes)
Body	Cast Iron, Epoxy Coated
Disc	316 Stainless Steel Shaft 416 Stainless Steel
Shaft	416 Stainless Steel
Seat	EDPM
Manual Operators	Gear

5.83.3 Process check Valves

Table 5.73: Process check Valves

Type	Wafer Butterfly Check
Manufacturer	AUDCO/ Inter Valve / Crane / Tyco/BDK/Bray
Style	Wafer suitable for installation between ANSI # 150 flanges
Body	Cast Iron
Disc	316 Stainless Steel
Shaft	316 Stainless Steel
Seat	BUNA N

5.83.4 Chemical Feed Lines

Table 5.74: Chemical Feed Lines

Type	Check
Manufacturer	George Fischer/Equivalent
Style	Ball or Swing Check
Body	PVC
Disc	PVC

5.83.5 Waste water, Mixed Liquor and Sludge Lines

Table 5.75: Waste water, Mixed Liquor and Sludge Lines

Type	Elastic Swing Check
Manufacturer	AUDCO/ Inter Valve / Crane / Tyco/BDK/Bray
Flow Area	Design allows full Pipe size flow area when fully open
Style	Flanged Suitable for installation between ANSI # 150 flanges
Body/Cover	Ductile, Iron IS
Disc/ Flapper	Viton (durometer 70) internally reinforced with steel and fabric reinforcement; removable without removing the valve body from the line. Disc/ flapper captured in the body by the cover to allow the disc to have elastic flex from the closed position to full open position.
Disc/Flapper Arm	Viton with an elastic spring to assist the closure against a small head to minimize disc slamming.
Style	Wafer suitable for installation between ANSI # 150 flanges
Shaft	316 Stainless Steel
Seat	BUNA N
Internal Coating	Epoxy NSF approved coating
Exterior Coating	Blue Metal Primer
Position Indicator	External Position indicator W/ Proximity switches for the closed position
Pipeline Pressure	50 Psig
Body	316 Stainless Steel
Disc	316 Stainless Steel
Shaft	17.4 PH
Seat	Teflon

5.83.6 Chemical Feed Lines (<3")

Table 5.76: Chemical Feed Lines

Type	Ball
Manufacturer	George Fischer/Equivalent
Style	Tru Union
Body, Plug, Shaft	PVC
Seals	EPDM or Viton
Manual Operators	Manual Lever

5.83.7 Control Valves

Control Valves are valves (butterfly, gate or ball) with double acting pneumatic actuators and electro- pneumatic positioners.

Mixed Liquor Re-circulation Wasting Lines (2" 36")

Table 5.77: Control Valves

Type	Knife gate
Manufacturer	AUDCO/ Crane / Tyco/BDK/Bray
Style	Lugged, AR Series
Body	GG25 (Cast Iron)
Gate	304 Stainless Steel
Shaft	Carbon Steel
Seat	EPDM
Manual Operators	All Sizes Handwheel Operated
End Caps	Ductile Iron
Pistons	Ductile Iron
Output Shaft	Plated Alloy Steel C4140
Shaft bushings	Stainless Steel
Piston Guidelines	Reinforced PTFE
Fasteners	18 8 Stainless Steel
Piston O Rings	Buna N
Air Solenoid	4 way NEMA 4, 120/1/60
Limit Switches	Tyco Avid ZR Plus with Position monitor and T Sensor Proximity Switches

5.84 Miscellaneous Valves

5.84.1 Instrument Isolation Valves

The Instrument isolation valves typically used throughout the membrane system are listed in the following table.

Table 5.78: Instrument Isolation Valves

Type	Ball Valve
Manufacturer	AUDCO/ Crane
Style	Reduced Port Threaded
Body/ Ball	316 Stainless Steel
Seat	PTFE
Connection	Typically 0.5"NPT

5.84.2 Solenoid Valves

The Solenoid valves typically used throughout the membrane system are listed in the following tables.

Table 5.79: Solenoid Valves

Type	Solenoid Valve
Service	Air/Water
Manufacturer	Tyco / Inter Valve
Model	As per Manufacturer
Style	F NPT, Normally Closed
Body	316 Stainless Steel / Brass

5.84.3 Pneumatic Actuators

Table 5.80: Pneumatic Actuators

Type	Double Acting Cylinder Rack & Pinion Drive
Manufacturer	
Operating Pressure	550 Kpa (80 Psig)
Body Material	Extruded Aluminum Alloy, Anodized
Travel Shop	304 Stainless Steel
End Caps	Die Cast Aluminum Alloy
Pistons	Die Cast Aluminum Alloy
Output Shaft	Carbon Steel (Zinc Plated)
Shaft Bearings	Engineered Polymer Devlon
Fasteners	Stainless Steel
O Rings	Nitrile
Air Solenoid	4 Way, NEMA 4 or Equal
Additional Features	Open and Closing Speed Control
Position Control	Electro Pneumatic Avid Eazical Intelligent Positioner 4 20mA Input

5.84.4 General Service PVC Valves

Table 5.81: General Service PVC Valves

Type	Double Acting
Manufacturer	George Fisher / Equivalent
Operating Pressure	550 Kpa (80 Psig)
Body Material	Poly Amide w/Glass Fiber
End Caps	Poly Amide w/Glass Fiber
Pistons	Die Cast Aluminum Alloy
Output Shaft	Stainless Steel
Fasteners	Stainless Steel
O Rings	Nitrile

5.85 Process Instrumentation

The following process instruments are included with the ZeeWeed System. Output signals from all these instruments are connected to the PLC System.

5.85.1 Flow switches

Flow switches are included to provide flow confirmation in air or water lines from blowers and pumps respectively.

Table 5.82: Flow switches

Application	Air	Liquid
Manufacturer	Switzer/ Emerson/ E & H	Switzer/ Emerson/ E & H
Series recommendation	As per Manufacturer	
recommendation	As per Manufacturer	
Sensor Type/Material	Probe Sensor 316 Stainless Steel	Flat Face Sensor 316 Stainless Steel
Process Connection	O.75" NPT	
Accuracy	+/- 5%	
Housing	304 Stainless Steel NEMA 4X	
Integral LCD	Yes, 4 Digit	
Power/Connection	18 30 VDC/0.5"NPT	

5.85.2 Electromagnetic Flow meters (Flow transmitter)

Flow meters are included for monitoring the permeate flow from each train, the reject flow from each train and back pulse/CIP flow to the membranes as well as a train's recirculation flow.

Table 5.83: Electromagnetic Flow meters

Manufacturer	E & H / Emerson /
Series	As per Manufacturer recommendation
Process Connection	ANSI # 150 flanged
Housing	Aluminum NEMA 4X
Flow tube	304 Stainless Steel
Liner	PTFE
Accuracy	+/- 0.5%
Operator Interface	Local
Output	HART, 4 20 mA DC, Scaled pulse Output
Power/connection	85 260 VAC 60 Hz/ 0.5" NPT
Seal	EPDM
Power	120 VAC/60
Power Connection	0.5" NPT Conduit, Type H Electrical

5.85.3 Level transmitters

Level transmitters are included for monitoring the liquid levels in the membrane tanks or in the inlet flow distribution channel to each series of membrane tanks. They are also included on the back pulse/CIP tank, if applicable. Two basic types of level transmitters, top and side entry, are generally used with ZeeWeed Membrane Systems depending on the application and both are described below.

Table 5.84: Level transmitters

Manufacturer	E & H or equivalent as approved.	
Application	Top Entry	Side Entry
Process Connections	3" 150 # Flange (316 Stainless Steel)	1.5" to 3" 150# Flange (316 Stainless Steel) & 1.5" NPT Connections available.
Mounting	1.5", 2" and 3" 150 # Flange (316 Stainless Steel) & 1.5" NPT Connections available.	
Output Signal	HART 4 20 mA	
Voltage	11.5 to 30 VDC	
Diaphragm	Contite Sensor with metallic diaphragm alloy C4	
Housing	Aluminum NEMA 4X	
Integral LCD	Yes	

5.85.4 Pressure Transmitters

Pressure transmitters monitor the vacuum applied to the membranes during permeating and the positive pressure applied during back pulsing. The pressure transmitters are mounted on the permeate collection header pipes included with the ZeeWeed system and are typically calibrated at 15 psi to +20 psi. Typical specifications are listed in the following table.

Table 5.85: Pressure Transmitters

Manufacturer	E & H/ Emerson/ Eq
Model	As per Manufacturer recommendation
Output Signal	4 20mA HART PROT
Voltage	11.5 30 VDC
Diaphragm	Ceramic
Housing	Aluminum NEMA 4X
Integral LCD	Yes

5.85.5 Turbidi meters

Continuous on-line turbidi meters are included as a means of verifying the integrity of the membranes by taking water samples from the discharge side of the permeate pumps. Typical component specifications are listed below.

Table 5.86: Turbidi meters

Manufacturer	Hach /Equivalent
Model	As per Manufacturer recommendation
Range	0- 100 NTU
Inlet	0.25" FNPT
Outlet	0.5" FNPT
Outlet Signal	4 20 mA
Power	220V/1ph/50 Hz
Display	SC 100
Accessories	Sensor, analyzer unit, interconnecting cable, alarm relays for indication of alarm conditions and one (1) Formazin Calibration Kit.

5.85.6 Dissolved Oxygen Sensors Analyzers

Dissolved oxygen sensors are immersed within the bioreactor and signal cabled to the PLC. Sensors are typically installed within the aerated zone of each bioreactor tank and other areas of the plant at Istitute's discretion. Typical specifications are listed in the following table.

Table 5.87: Dissolved Oxygen Sensors Analyzers

Manufacturer	E& H/HACH/EMERSON/Eq
Model	OXY 1100/4100
Range	0-10 mg/L
Resolution	0.1 mg/L
Transmitter	OXY 4100, Ball/Float Type
Output Signal	2 x 4-20 mA
Power Supply	85-264 V AC
Display	LCD supplied on Signal Convertor
Accessories	Sensor & Float
	Transmitter
	Mounting Bracket
	Signal Converter (sized as needed)

5.85.7 Float Level Switches

Where included, float level switches are to be provided.

5.85.8 Pressure Gauges

Pressure gauges are included for the various pumps and blowers included with the Zee-Weed system. Pressure gauges are liquid filled and are Ashcroft or equal with 316SS wetted parts. Pressure gauges are supplied complete with isolation ball valves gauge cocks between the pressure gauge and the process line.

5.85.9 Pressure Switches

Pressure switches are provided for high-pressure alarm on the permeate collection pipes to prevent over-pressurizing of the membranes during back pulsing. In addition, pressure

switches are included to provide low pressure warning for the compressed air for the pneumatic valves. The types of flow switches used in the different applications are listed in the following table.

Table 5.88: Pressure Switches

Permeate Lines	United Electric J6 Series or equal with 316 Stainless Steel wetted parts and bellows
Compressed Air Line	United Electric H100 Series or equal with 316 Stainless Steel wetted parts and bellows

5.86 Motor Specifications

General Duty Electrical Motors supplied with the equipment generally have the specifications outlined in the following table.

Table 5.89: Motor Specifications

Less than 0.5 HP	230 VAC/ 1 ph/ 50 Hz
0.5HP or More	415V/ 3pH/ 50 HZ
	NEMA Frame
	Design B
	NEMA Class B Temperature Rise
	Meeting EPACT Efficiency Requirements

5.87 Control Systems

5.87.1 Motor Control Center (MCC)

The MCC will house the circuit breakers, motor starters, and VFDs for all electrical motors on equipment that is supplied by GE ZENON ULC. The MCC will be supplied with a main breaker, appropriately rated for the motor loads noted above.

The MCC, with the following feature and specifications:

Table 5.90: MCC

Section Dimensions	90" high x 20" deep x 20" wide
Number of Sections	To Be Determined
MCC Connection	3 Pole Main Circuit Breaker
Enclosure Type	NEMA 1 fully gasketed with bottom plates
Cable Entry	Top
Ground Lug Size	#6 AWG 250 kcmil (2 supplied as standard)
Main Bus Rating	To be confirmed during final design
Main Bus	Bracing 42 kA (RMS)
Main Bus	Material Copper/ Tin Plated
Horizontal Ground Bus Size	0.25" x 1 (may vary according to application)
Horizontal Ground Bus Location	Bottom
Vertical Ground Bus Type	Copper / Tin Plated

5.87.2 Variable Frequency Drives

The Variable Frequency Drives (VFDs) will be mounted within the MCC, as described above, and will be of the same manufacturer as the MCC. The VFDs will be Cutler-Hammer SVX9000, with the following features and specifications:

Table 5.91: VFD

Input Voltage Range	208 -240V, 380 -500V or Range 525 -690V
Input Voltage Tolerance	-15% of Minimum; +10% of Maximum
Input Frequency Tolerance	45 to 66 Hz
Service Factor	1.0
Efficiency	97.5% at rated amps

Chapter 6

List Of Approved Makes

The items of supply included in the foregoing lists are only indicative and not exhaustive. Any item not mentioned in the above lists and is required for satisfactory completion of the DSITC Works shall be procured after obtaining approval of the make and MOC from Engineer-in-Charge.

6.1 List of Approved Makes for STP Components

Table 6.1: List of Approved Makes-STP

Sl No	Item	Make
1	Manual Coarse screen of 16 mm & fine screen of 6 mm of 162.5m ³ /hr for 3 streams of 650 kld and peak factor is 2.0	ASR/AuricTechno ser- vices/Jash Procedyne
2	Mechanical fine screen of 6mm of 162.5m ³ /hr for 3 streams of 650 kld and peak factor is 2.0	ASR/AuricTechno ser- vices/Jash Procedyne
3	Oil and grease removal system (Belt Oil Skimmer) of 162.5m ³ /hr for 3 streams of 650 kld and peak factor is 2.0	Potential Engineering
4	Collection sump transfer pumps Cap: 65m ³ /hr@ 11mwc TDH Submersible centrifugal for each 650 kld	Johnson/KSB/Kirloskar /Grundfos
5	Mixing Blowers with acoustic hood for equalization tank only for each 650kld Capacity: 195Nm ³ /hr @ 6 MWC. Twin Lobe blowers.	Kay Engineering/Everest/ Kulkarni
6	Mixing Blowers with acoustic hood for SHT and sewage collection sump tanks. Capacity: 110Nm ³ /hr @ 4.5 MWC. Twin Lobe blowers.	Kay Engineering/Everest/ Kulkarni

Table 6.1: List of Approved Makes-STP

Sl No	Item	Make
7(a)	Coarse Bubble Diffuser in equalization tank retrievable type for 650kld	EDI/OTT/Rehau /Titan aeration
7(b)	Coarse Bubble Diffuser in CCS and SHT retrievable type/fixed type for 650kld	EDI/OTT/Rehau /Titan aeration
8	Bioreactor feed pump for 650kld	Johnson /KSB/ Kirloskar/ Grundfos
9	Mechanical Screen 2mm punched hole at inlet of Aeration tank	ASR/AuricTechno services /Jash Procedyne
10	Process Blowers with acoustic hood and VFD for 650 kld Type: Twin Lobe type	Kay Engineering/Everest/Kulkarni
11	Membrane Blowers with acoustic hood for 650 kld Type: Twin Lobe type	Kay Engineering/Everest/Kulkarni
12	Fine Bubble Diffuser for 650 kld aeration tank (approx. 36 nos.)	EDI/OTT/Rehau/Titan aeration
13	ZW500D Leap 48 Module short cassette, 27.9 sqm per module	GE
14	RAS (Recycle) pump Type: non-submersible type	Johnson/ KSB/ Kirloskar/ Grundfos/KBL
15	Permeate Pumps with VDF for 650kld	Johnson/ KSB/ Kirloskar/ Grundfos/KBL
16	FRP Back pulse tank	Milton Roy / Grundfos / Prominent
17	FRP Sodium Hypochlorite dosing tank system for membrane cleaning	Milton Roy / Grundfos / Prominent
18	FRP Sodium Hypochlorite dosing pumps for membrane cleaning	Milton Roy / Grundfos / Prominent
19	FRP Citric acid dosing tank	Milton Roy / Grundfos / Prominent
20	FRP Citric acid dosing pumps for membrane cleaning	Milton Roy / Grundfos / Prominent
21	Sludge transfer pump @ 3.5 m ³ /hr	Johnson/KSB/Kirloskar/ Grundfos/KBL

Table 6.1: List of Approved Makes-STP

Sl No	Item	Make
22	Centrifuge suitable for 3.5 m ³ /hr flowrate	Alfa Laval/ Hiller/Andritz/Pennwalt
23	Poly electrolyte dosing tank and mixer for sludge dewatering- 0- 100 lph @ 2bar	Milton Roy / Grundfos / Prominent
24	Poly electrolyte dosing pump for sludge dewatering- 500 litres	Milton Roy / Grundfos / Prominent
25	Post Hypochlorite dosing tank system for permeate side- 200 litres	Milton Roy / Grundfos / Prominent
26	Post Hypochlorite dosing pumps for permeate side- 5-10 lph @ 1.5bar	Milton Roy / Grundfos / Prominent
27	Air Compressor 20 Nm ³ /hr @ 7 bar	ELGI/Ingersoll
28	MCC for equipments noncompartmental type floor mounted.	Siemens/Schneider/ABB
29	DIN rail mounted Micro PLC with panel mounted HMI equipments	Control panel Skytech/ I Logicon/ Cotmac and assembled with components of GE/ Allen Bradley / Siemens/AB
30	UPS for 30mins power supply.	Emersion, Liebert, Numeric
31	Computer System with computer table	Hp,DELL,Lenovo
32	Laser Printer	Hp,Samsung, Canon
33	Air Conditioner	Daikin/Hitachi
34	Ball, butterfly, check valves etc.	Inter valve/ Bray/FIP/ GF /BDK/ Astral/Hav VASS/Tyco/Jash
35	Respective motors and VFD	ABB/Bharat Bhi- jilee/Crompton Greaves/Siemens /Dan- foss

Table 6.1: List of Approved Makes-STP

Sl No	Item	Make
36	1no. Flowmeter at drum screen inlet, 1no. level switch in Equilization tank, 1.no. air flow switch in process blower line, 1no. flow meter in sludge line of RAS pump, 1no. pressure transmitter in permeate line, 1no. level transmitter in membrane tank, 1no flowmeter in permeate pump line, 1no. Turbidity meter at outlet of permeate pump, 1no. level switch in sludge holding tank. Respective level switches, pressure indicators.	Endress & Hauser/Emerson/ Forbes marshall/Krohne/Hach/GE Sensing/Pune Techtrol / Levco/Wika/Waree/Forbes marshall/General Instruments/ Waree
37	uPVC pipes	Astral/Finolex/Supreme
38	GI Pipes/ MS Pipes	Tata, SAIL, Jindal
39	DI pipes	Tata Kubuto, Electrosteel
40	Raw materials, chemicals, and utilities during equipment start-up and operation.	As approved
41	Disposal of Initial Start-up wastewater and associated chemicals.	As approved
42	Laboratory Assistance during Erection and commissioning of STP plant as required.	As approved
43	STP room ventilation system and fire fighting	As approved
44	Storage of Equipments	As approved
45	Eye wash and safety shower	As approved
46	5 ton manual Chain pulley for membrane tank area.	As approved
47	chain pulley block of required capacity	Indef or As approved
48	Equipment Lifting system and arrangement for other equipments if required.	Indef or As approved
49	Treated water transfer pumps	As approved
50	UV system	As approved
51	Softener feed pumps and hydro-pneumatic pumps	As approved
52	Softener system	As approved
53	Puddle pipes and insert plates	As approved

Table 6.1: List of Approved Makes-STP

Sl No	Item	Make
54	Bulk Chemical storage tanks (if required)	As approved
55	Equipment anchor bolts	As approved
56	Disposal of membrane preservative	As approved
57	Hydro testing of all field installed piping	As approved
58	Emergency lighting	As approved

6.2 List Of Approved Makes for Electrical Works

Sl No	Item	Approved Make
(a)	Motors	ABB/Crompton Greaves/Kirloskar/Siemens
(b)	LV switch gear/PMCC	ABB/ Larsen and Toubro/ Legrand/ /Siemens.
(c)	Air circuit breaker/ MCCB / MCB	ABB/Larsen and Toubro/ Schnei- der Electric / Siemens
(d)	Switch/fuse unit	ABB/Larsen and Toubro/ Schnei- der Electric / Siemens
(e)	DOL /Star Delta Starters / Soft starters	ABB/Larsen and Toubro/ Schnei- der Electric / Siemens
(f)	Contactors	ABB/Larsen and Toubro/ Schnei- der Electric / Siemens
(g)	Indicating lamps	Ess Bee (L&T)/ Siemens/ IEC/ Technik
(h)	Instrument Transformers	ABB/KAPPA/Jyoti /Pragati Elec- tricals/Siemens
(i)	Push button	EssBee (L&T) / Siemens/Technik or equivalent
(j)	Indicating meters	Automatic Electric /IMP/ Secure / Meco.
(k)	Terminal blocks	Connect well/ELMEX/WAGO
(l)	Lugs	DOWELL /Jainsons
(m)	Cables	Polycab / RPG / Finolex /Havells
(n)	Cable tray	Profab /Delta System, Legrand
(o)	Cable glands	Braco / Comet
(p)	Annunciation	Minilec / Proton
(q)	Digital energy meter	Secure / Larsen and Toubro/Conzerve
(r)	Control switch	Kaycee /Switron
(s)	Fuse	Copper Bussman / Larsen and Toubro Siemens
(t)	Conduit	AKG Industries /BEC conduit /Precision ppi/

6.3 Preferred makes for Instrumentation and Automation Equipment

Table 6.2: Preferred makes for Instrumentation and Automation Equipment

Sl No	Item	Make
(a)	Pressure Gauge	Altop Industries /Aadarsh Industries / WAAREE
(b)	Pressure Transmitter	Siemens /Forbes Marshall Pvt. Ltd / Endress + Houser Pvt. Ltd / Klay Instruments B.V. / Precision Instrument Co.
(c)	Float level switch	ABS/ITT/SBEM Pvt.Ltd.
(d)	Ultrasonic Level Transmitter	ABB/ Endress + Houser Pvt. Ltd / Nivo Control Pvt. Ltd./ SBEM Pvt. Ltd./Siemens
(e)	Magnetic Flow Meter	ABB/ Endress + Houser Pvt. Ltd / Nivo Control Pvt. Ltd. / Forbes Marshal /Siemens.
(f)	Ultrasonic flow Transmitter	ABB/ Endress + Houser Pvt. Ltd / Nivo Control Pvt.Ltd./ Forbes Marshal /Siemens
(g)	PLC	Honeywell/ ABB/ LARSEN &TOUBRO/ Schneider Electric/ Siemens
(h)	Analytical Instruments	Endress + Houser Pvt. Ltd/ HACH instrument
(i)	UPS	APC

Chapter 7

Annexures

7.1 Form of Performance Security (Guarantee) Bank Guarantee Bond

Performance Security (Guarantee) Bank Guarantee Bond

In consideration of the Director, IITH (hereinafter called The Government) having offered to accept the terms and conditions of the proposed agreement between and (hereinafter called the said Contractor(s)) for the work (hereinafter called the said agreement) having agreed to production of an irrevocable Bank Guarantee for Rs..... (Rupeesonly) as a security/guarantee from the contractor(s) for compliance of his obligations in accordance with the terms and conditions in the said agreement.

1. We, (hereinafter referred to as the Bank) hereby undertake to pay to the Government an amount not exceeding Rs. (Rupees Only) on demand by the Government.

2. We, (indicate the name of the Bank) do hereby undertake to pay the amounts due and payable under this guarantee without any demure, merely on a demand from the Government stating that the amount claimed as required to meet the recoveries due or likely to be due from the said contractor(s). Any such demand made on the bank shall be conclusive as regards the amount due and payable by the bank under this Guarantee. However, our liability under this guarantee shall be restricted to an amount not exceeding Rs. (Rupees only)

3. We, the said bank further undertake to pay the Government any money so demanded notwithstanding any dispute or disputes raised by the contractor(s) in any suit or proceeding pending before any court or Tribunal relating thereto, our liability under this present being absolute and unequivocal. The payment so made by us under this bond shall be a valid discharge of our liability for payment there under and the Contractor(s) shall have no claim against us for making such payment.

4. We, (indicate the name of the Bank) further agree that the guarantee herein contained shall remain in full force and effect during the period that would be taken for the performance of the said agreement and that it shall continue to be enforceable till all the dues of the Government under or by virtue of the said agreement have been fully paid and its claims satisfied or discharged or till Engineer- in-Charge on behalf of the Government certified that the terms and conditions of the said agreement have been fully and properly carried out by the said Contractor(s) and accordingly discharges this guarantee.

5. We, (indicate the name of the Bank) further agree with the Government that the Government shall have the fullest liberty without our consent and without affecting in any manner our obligation hereunder to vary any of the terms and conditions of the said agreement or to extend time of performance by the said Contractor(s) from time to time or to postpone for any time or from time to time any of the powers exercisable by the Government against the said contractor(s) and to forbear or enforce any of the terms and conditions relating to the said agreement and we shall not be relieved from our liability by reason of any such variation, or extension being granted to the said Contractor(s) or for any forbearance, act of omission on the part of the Government or any indulgence by the Government to the said Contractor(s) or by any such matter or thing whatsoever which under the law relating to sureties would, but for this provision, have effect of so relieving us.

6. This guarantee shall not be discharged due to the change in the constitution of the Bank or the Contractor(s).

7. We, (indicate the name of the Bank) lastly undertake not to revoke this guarantee except with the previous consent of the Government in writing.

8. This guarantee shall be valid up to unless extended on demand by the Government. Notwithstanding anything mentioned above, our liability against this guarantee is restricted to Rs. (Rupees) and unless a claim in writing is lodged with us within six months of the date of expiry or the extended date of expiry of this guarantee all our liabilities under this guarantee shall stand discharged.

Dated the day of for (indicate the name of the Bank)

7.2 Form of Earnest Money Deposit Bank Guarantee Bond

Form of Earnest Money Deposit Bank Guarantee Bond

WHEREAS, contractor (Name of contractor) (hereinafter called "the contractor") has submitted his tender dated (date) for the work of (name of work) (hereinafter called "the Tender")

KNOW ALL PEOPLE by these presents that we (name of bank) having our registered office at (hereinafter called "the Bank") are bound unto Indian Institute of Technology Hyderabad in the sum of Rs (Rs. in words) for which payment well and truly to be made to the said Indian Institute of Technology Hyderabad the Bank binds itself, his successors and assigns by these presents.

SEALED with the Common Seal of the said Bank this day of 20 THE CONDITIONS of this obligation are:

(1) If after tender opening the Contractor withdraws, his tender during the period of validity of tender (including extended validity of tender) specified in the Form of Tender;

(2) If the contractor having been notified of the acceptance of his tender by the Indian Institute of Technology Hyderabad

(a) fails or refuses to execute the Form of Agreement in accordance with the Instructions to contractor, if required;

OR

(b) fails or refuses to furnish the Performance Guarantee, in accordance with the provisions of tender document and Instructions to contractor,

OR

(c) fails or refuses to start the work, in accordance with the provisions of the contract and Instructions to contractor,

OR

(d) fails or refuses to submit fresh Bank Guarantee of an equal amount of this Bank Guarantee, against Security Deposit after award of contract.

We undertake to pay to the Indian Institute of Technology Hyderabad up to the above amount upon receipt of his first written demand, without the Indian Institute of Technology Hyderabad having to substantiate his demand, provided that in his demand the Indian Institute of Technology Hyderabad shall note that the amount claimed by his is due to him owing to the occurrence of one or any of the above conditions, specifying the occurred condition or conditions.

This Guarantee shall remain in force up to and including the date* after the

deadline for submission of tender as such deadline is stated in the Instructions to contractor or as it may be extended by the Indian Institute of Technology Hyderabad , notice of which extension(s) to the Bank is hereby waived. Any demand in respect of this Guarantee should reach the Bank not later than the above date.

DATE

WITNESS

SIGNATURE OF THE BANK SEAL

(SIGNATURE, NAME AND ADDRESS)

*Date to be worked out on the basis of validity period of 6 months from last date of receipt of tender.

7.3 Affidavit to be submitted by the bidder

Proforma of affidavit to be submitted by the bidder regarding eligibility.

"I/We undertake and confirm that eligible similar work(s) has /have not been got executed through another contractor on back to back basis. Further that, if such a violation comes to the notice of IITH, then I/We shall be debarred for bidding in IIT Hyderabad contracts in future forever. Also, if such a violation comes to the notice of IIT Hyderabad before date start of work, the Engineer-in- Charge shall be free to forfeit the entire amount of Earnest Money Deposit/ Performance Guarantee."

(SIGNATURE, NAME AND ADDRESS)

7.4 Form of Supplementary Agreement

FORM OF SUPPLEMENTARY AGREEMENT

This Agreement made this day the 20 between **Executive Engineer, IIT Hyderabad, Kandi-502285, Sangareddy (District, Telangana, India**, on behalf of Director, IIT Hyderabad, hereinafter called the First Party and M/s, having registered office at, hereinafter called the Second Party, which expression shall include his successors and assigns, shown as under :

(1) That this Agreement shall be called Supplementary Agreement to the Agreement No.

relating to the **Design, Supply, Installation, Testing, Commissioning and Operating 650 kLD STP at IIT Hyderabad**

entered into by the parties to this Agreement.

(2) That WHEREAS the Second Party has substantially completed the execution of Part A of the work described in and covered by the Agreement No. except the items mentioned in the Schedule annexed to this Agreement and whereas the items of the work mentioned in the Schedule annexed to this agreement cannot now be executed on account of being operational and maintenance items;

and whereas both the parties are desirous that the items mentioned in the Schedule annexed to this Agreement should be executed by the Second Party after the completion of the Part A of the said agreement, it is hereby further agreed as under : (a) That Second Party shall and will execute the work covered by the items mentioned in the Schedule annexed to this Agreement at the rates and as per the terms and conditions and scope of work and services listed in the original Agreement No. whatsoever called upon to do so by the Engineer-in-Charge, within a period of three years from the date hereof.

(b) That the Second Party shall have absolutely no claim of whatsoever nature against the Second Party for doing the work mentioned in the Schedule under Part B of the original Agreement No. (c) That the Second Party shall have to execute all the items which the Engineer-in-charge consider necessary. (d) That the Second Party shall start with the work of the remaining items mentioned in the Schedule under Part B of the original Agreement No. within days from on the receipt of a letter to the effect from the Engineer-in-Charge or from any date fixed in the said letter and shall complete the said work within the time fixed by the Engineer-in-Charge or as extended by him from time to time. (e) That on the due execution and completion of this Agreement by the parties, the bill of the Second Party in relation to the work already done by him under the Original Agreement No. shall be provisionally finalized by the First Party and payment on account, if any amount due, shall be made to the

Second Party provided that the First Party shall have a right to retain such amount as is considered reasonable by him as a security for the execution of the work mentioned in the Schedule under Part B of the original Agreement No. and the First Party shall have right to deal with the said amount of security as he thinks proper under the terms and conditions of the Original Agreement. Further, on the due execution and original completion of this Agreement, the Second Party shall be entitled to claim back his security deposit relating to the work in question, subject to the right of the First Party to retain such amount as he thinks reasonable as mentioned above soon after or three months or as the case may be mentioned in clause of the Original Agreement, is over.

(f) That the final bill relating to the entire work under the two agreements shall be prepared after the completion of the entire work covered by Agreement No. and this Agreement.

(3) Except as modified by this Agreement the said Agreement No. shall remain in full force and effect.

IN WITNESS WHEREOF THE ABOVE MENTIONED PARTIES HAVE PUT THEIR SIGNATURE ON THIS DAY THE

7.5 Proforma of Guarantee Bond for Performance of Treatment System

PROFORMA OF GUARANTEE BOND FOR PERFORMANCE OF TREATMENT SYSTEM

This agreement made this day of two thousand between M/s (hereinafter called the Guarantor of the one part) and the Director, IIT Hyderabad hereinafter called the Government of the other part).

Whereas this agreement is supplementary to the original contract (hereinafter called the Contract) dated made between the Guarantor of the one part and Government of the other part, whereby the Contractor, inter alia, undertook to render the Sewage Treatment Plant in the said Contract recited, completely to treat the sewage to meet the effluent treated water parameters as specified below:

Required Effluent Quality

Table 7.1 shows the expected effluent quality upon equipment start-up and running of the plant.

Table 7.1: Required Effluent Quality Parameters

Parameter	Unit	Required
Biological Oxygen Demand 5-day (BOD5)	mg/l	<5
Total Suspended Solids	mg/l	<5
Turbidity	NTU	<1
Hardness of softened water	mg/l	<50
Total coliform, MPN per 100 ml, Max		<100
Oil and grease		Not detectable
Colour and Odour		Clear, Not objectionable
Residual Chlorine	mg/l	>1 as total Cl

And whereas the Guarantor agreed to give a guarantee to the effect that the said sewage treatment plant will perform for three years to be reckoned from the date of commissioning of the plant.

During this period of guarantee the Guarantor shall make good all defects and for that matter, shall replace at his risk and cost the electro-mechanical equipment, instrumentation listed in Section-6 of contract and in case of any other defect being found he shall render the electro-mechanical equipment, instrumentation listed in Section-6 of contract at his cost to the satisfaction of the Engineer-in-charge, and shall commence the works of such rectification within seven days from date of issuing notice from the Engineer-in-charge calling upon him to rectify the defects, failing which the work shall be got done by the Institute by some other Contractor at the risk and cost of the contractor, and in the later case the decision of the Engineer-in-charge as to the cost recoverable from the Guarantor shall be final and binding.

That if the Guarantor fails to execute the sewage treatment plant meeting the parameters of required effluent quality or commits breaches hereunder then the Guarantor will indemnify principal and his successors against all loss, damage, cost, expense or otherwise which may be incurred by him by reason of any default on the part of the Guarantor in performance and observance of this supplemental agreement. As to the amount of loss and/or damage and/or cost incurred by the Government, the decision of the Engineer-in-charge will be final and binding on the parties.

In witness whereof these presents have been executed by the Obligor and by for and on behalf of the President of India on the day, month and year first above written. Signed, sealed and delivered by OBLIGOR in the presence of

1

2.

Signed for and on behalf of THE PRESIDENT OF INDIA by in the presence of.

7.6 Information Regarding Eligibility Letter of Transmittal

INFORMATION REGARDING ELIGIBILITY LETTER OF TRANSMITTAL

(To be submitted on the Letter Head of the bidder)

From:

.....

.....

.....

To

The Engineer-in-Charge

IIT Hyderabad

Subject: Submission of bids for the work of

Sir,

Having examined the details given in press notice and bid document for the above work, I/we hereby submit the relevant information.

1. I/we hereby certify that all the statements made and information supplied in the enclosed forms A to H and accompanying statement are true and correct.
2. I/we have furnished all information and details necessary for eligibility and have no further pertinent information to supply.
3. I/we submit the requisite certified solvency certificate and authorize the Engineer-in-Charge, IIT Hyderabad to approach the Bank issuing the solvency certificate to confirm the correctness thereof. I/we also authorize Engineer-in-Charge, IIT Hyderabad to approach individuals, employers, firms and corporation to verify our competence and general reputation.
4. I/we submit the following certificates in support of our suitability, technical knowledge and capability for having successfully completed the following works:

Name of work:

Certificate from:

Enclosures:

Date of submission:

Signature(s) of Bidder(s).

Seal of bidder

7.7 Proforma of Forms A,B,C,D,E,F,G for Evaluation Criteria

PROFORMA OF FORM A,B,C,D,E,F ,G FOR EVALUATION CRITERIA

FORM A

FINANCIAL INFORMATION

I. Financial Analysis Details to be furnished duly supported by figures in balance sheet/ profit loss account for the last five years duly certified by the Chartered Accountant, as submitted by the applicant to the Income Tax Department (Copies to be attached).

Financial Year	Gross Annual Turnover from Construction Works	Profit/ Loss
2016-17		
2015-16		
2014-15		
2013-14		
2012-13		

II. Financial arrangements for carrying out the proposed work.

III. Solvency Certificate from Bankers of the bidder in the prescribed Form B.

Signature of Chartered Accountant with Seal Signature of Bidder(s).

FORM B FORM OF BANKERS CERTIFICATE FROM A SCHEDULED BANK

This is to certify that to the best of our knowledge and information that M/s./ Sh having marginally noted address, a customer of our bank are/is respectable and can be treated as good for any engagement up to a limit of Rs (Rupees)

This certificate is issued without any guarantee or responsibility on the bank or any of the officers.

(Signature)

For the Bank

NOTE (1) Bankers certificates should be on letter head of the Bank, sealed in cover addressed to tendering authority.

(2) In case of partnership firm, certificate should include names of all partners as recorded with the Bank.

**FORM C: DETAILS OF ALL WORKS OF SIMILAR CLASS COMPLETED DURING THE
LAST SEVEN YEARS ENDING LAST DAY OF THE MONTH**

Table 7.2: Form 'C'

S.No.	Name of work/project and location	Owner or sponsoring organization	Cost of work in crores of Rupees	Date of commencement as per contract	Stipulated date of completion	Actual date of completion	Litigation /Arbitration* case in pending/progress with details*	Name and address /telephone number of officer to whom reference may be made	Remarks

* Indicate gross amount claimed and amount awarded by the Arbitrator.

Signature of Bidder(s)

7.8 Projects Under Execution or Awarded

FORM D PROJECTS UNDER EXECUTION OR AWARDED

Table 7.3: Form 'D'

S.No.	Name of work/project and location	Owner or sponsoring organization	Cost of work in crores of Rupees	Date of commencement as per contract	Stipulated date of completion	Upto date percentage progress of work	Slow progress ,if any and reasons there-of	Name and address /telephone number of officer to whom reference may be made	Remarks

* Indicate gross amount claimed and amount awarded by the Arbitrator.

Signature of Bidder(s)

7.9 Performance Report of Works

FORM E PERFORMANCE REPORT OF WORKS REFERRED TO IN FORMS B & C

1. Name of work/project location:
2. Agreement no.:
3. Estimated cost:
4. Tendered cost:
5. Date of start:
6. Date of completion:
 - (i) Stipulated date of completion:
 - (ii) Actual date of completion:
7. Amount of compensation levied for delayed completion, if any:
8. Amount of reduced rate items, if any:
9. Performance Report:

Quality of work	:	Very Good/Good/Fair/Poor
Financial soundness	:	Very Good/Good/Fair/Poor
Technical Proficiency	:	Very Good/Good/Fair/Poor
Resourcefulness	:	Very Good/Good/Fair/Poor
General Behaviour	:	Very Good/Good/Fair/Poor

Dated:

Engineer-in-Charge or Equivalent:

Phone, Fax and Mobile Number:

e mail address:

7.10 Structure & Organization

FORM "F" STRUCTURE ORGANISATION

1. Name address of the bidder:
2. Telephone no./Telex no./Fax no.:
3. Legal status of the bidder (attach copies of original document defining the legal status):
 - (a) An Individual
 - (b) A proprietary firm
 - (c) A firm in partnership
 - (d) A limited company or Corporation
4. Particulars of registration with various Government Bodies (attach attested photocopy):

Organisation/Place of registration Registration No.

- i.
- ii.
- iii.

5. Names and titles of Directors Officers with designation to be concerned with this work:
6. Designation of individuals authorized to act for the organization:
7. Was the bidder ever required to suspend construction for a period of more than six months continuously after he commenced the construction? If so, give the name of the project and reasons of suspension of work:
8. Has the bidder, or any constituent partner in case of partnership firm, ever abandoned the awarded work before its completion? If so, give name of the project and reasons for abandonment:
9. Has the bidder, or any constituent partner in case of partnership firm, ever been debarred/black listed for tendering in any organization at any time? If so, give details:
10. Has the bidder, or any constituent partner in case of partnership firm, ever been convicted by the court of law? If so, give details:
11. In which field of Civil Engineering construction the bidder has specialization and interest?:
12. Any other information considered necessary but not included above.:

Signature of Bidder(s)

7.11 Details of Technical & Administrative Personnel to Be Employed for The Work

FORM "G" DETAILS OF TECHNICAL & ADMINISTRATIVE PERSONNEL TO BE EMPLOYED FOR THE WORK

S.No.	Designation	Total Number	Number available for this work	Name	Qualifications	Professional experience and details of work carried out	How these would be involved in this work	Remarks

Signature of Bidder(s)

7.12 Details of Construction Plant and Equipment Likely To Be Used in Carrying Out the Work

FORM "H" DETAILS OF CONSTRUCTION PLANT AND EQUIPMENT LIKELY TO BE USED IN CARRYING OUT THE WORK

Sl. No.	Name of equipment	No.	Capacity or Type	Age	Condition	Ownership status			Current location	Remarks
						Presently owned	Leased	To be purchased		

Signature of Bidder(s)

7.13 Application Form for Purchase of Bid Documents

To

The Engineer-in-Charge,
Indian Institute of Technology Hyderabad

Subject: Purchase of Tender documents

Sir,

*I/We am/are registered with the CPWD as Class contractor/contractors and our Registration no. is It is certified that the said registration is valid as on date

2. *I/We am/are not registered with CPWD.

3. *I/We am /are registered contractor(s) with MES/Railways/PT/State PWD also.

Particular of the Authority, class and tender amount/limit upto which I/we am/are eligible to tender are furnished below:

Authority	Class	Tendering limit

It is certified (confirmed) that this registration/these registrations is/are valid as on date and we shall inform the department ourselves as soon as my / our registration expires or is cancelled/revoked.

The particulars of work done are furnished/enclosed (for State PWD contractors) *I/We request that permission may be granted to me/us for the purchase of tender document for the work of

Your faithfully,

(Contractor)*

(*Strike out inapplicable portion)

7.14 Running Account Bill Form 27A and Final Bill Form 27B (For scheduled payments to Contractor)

FORM 27-A
RUNNING ACCOUNT BILL
(Referred to in paragraph 11.3.2)

(To be used for "intermediate payments" to contractors on lump-sum contracts)

Cash Book Voucher No.

date

Name of Contractor –

Name of Work –

Serial No. of the Bill –

No. and date of his previous Bill for this work –

Reference to agreement –

Date of written order to commence work –

I. - ACCOUNT OF WORK

	Rs.
1. Approximate value of work done up to date excluding the measured up additions and alterations.	
2. Value of measured up additions and alterations.	
3. <i>Deduct</i> amount to be withheld.	
4. Balance i.e. "up to date" intermediate payments (Items 1+2-3)K	
5. <i>Deduct</i> intermediate payment already made as per entry "K" of the last Running Account Bill	
6. Intermediate payment now to be made (Item 4 – 5) D	
7. Amount of 'Secured' advances as per entry "E" of Account II	
8. Total payments now to be made as detailed below* -	
(a) By recovery of amounts creditable to this work G	

(b) By recovery of amounts creditable to other works or heads of account H	
(i) Taxes _____	
(ii) Security Deposit _____	
(iii) Other recoveries _____	
(c) By Cheque	

* The total figures against item 8 should be tested to see that it agrees with the total of items 6 & 7

FORM 27-A – Contd

II. Account of “Secured” Advances Allowed on the Security of Materials Brought to Site

Quantity outstanding from previous bill	*Deduct quantity utilized in work measured since previous bill	Quantity outstanding (including quantity brought to site since previous bill)	Full rate as assessed by the Divisional Officer	Description of materials	Unit	Reduced rate on which advance is made	¶ Up to date amount of advance	Reference to Divisional Officer's written order authorizing the advance	Reasons for non-clearance of advance when outstanding more than three months
1	2	3	4	5	6	7	8	9	10
							Rs.		
Total amount outstanding as per this account									
Deduct : - amount outstanding as per entry (c) of previous bill									
Net amount since previous bill (in words) Rupees.									
(c)									
(E)									

* Entries relating to each description of materials should be posted in column 3. First enter the difference between the quantities in columns 1 and 2, then show this entry below the quantities if any brought to site against which a further advance has been authorised, this entry being prefixed by the plus sign. Finally, strike the total of the two entries which will represent the total quantities outstanding.

¶ Entries in column 8 show the money values of the total quantities outstanding as in column 3.

III. CERTIFICATES AND SIGNATURES

I have satisfied myself by *
that the value of work done up to date excluding the measured up additions and alterations is not less than Rs. Conformably with the contractor's agreement and that with the exception of authorised additions and alterations the work has been done according to the prescribed drawings and specification.

2. The detailed measurements of authorised additions and alterations upto date were made by on and are recorded at page of Measurement Book No.

3. Certified that the plus quantities of materials shown in column 3 of Account II above have actually been brought by the contractor to the site of the work and the contractor has not previously received any advance on their security (2) that those materials are of imperishable nature and are all required for use on the work for which a lump sum for finished work has been agreed upon and (3) that a formal agreement signed and executed by the contractor in accordance with paragraph 10.2.24 (a) of the central P.W.A. code is recorded in the Divisional office.

Signature of Contractor

Dated signature of officer
Preparing the bill

{
Rank.....

Pay ₹ (Rs.....only)

Dated signature of officer
Authorizing the payment

{
Rank.....

FORM 27-A – Contd

V – REMARKS

(This space is reserved for any remark which the Disbursing Officer or the Divisional Officer may wish to record in respect of the execution of the work/check of measurements or the state of contractor's account.)

For use in Divisional Office

Checked

A/c. Clerk

Divi. Actt.

For use in Pay and Accounts Office

Audited

Reviewed

Accountant

JAO/AAO

Pay & Accounts Officer

To be printed on yellow papers only

**FORM 27-B
FINAL BILL**

*(Referred to in paragraph 11.3.1,11.3.3,11.4.5 and 11.5.3 of C.P.W.A Code.)
(To be used for “final payments” to contractors on lump-sum contracts)*

Cash Book Voucher No. _____

dated _____

Name of Contractor – _____

Name of Work – _____

Serial No. of this Bill – _____

No. and date of his previous Bill for this work – _____

Reference to agreement – _____

Date of written order to commence work – _____

Date of actual completion of work – _____

I. - ACCOUNT OF WORK EXECUTED

Sub-work, Sub-Head or item of work	Rate	Unit	Up to date		Remarks
			Quantity	Amount	
	Rs.	Lump sum for each		Rs	
Additional Work					
Deduct Omissions					
Total Value of Works done to date 'F'					

FORM 27-B – Contd.

II. Certificates and signatures

I certify that the work has been completed in accordance with the prescribed drawings and specification and after taking into account all the authorized additions and alterations the value of work done, up-to-date, conformably with the terms of the contractos’s agreement, is Rs.

2. The detailed measurements of the authorized additions and alterations mentioned above were made byon..... and are recorded at page.....of Measurement Book No..... and I am satisfied that they are correct.

Signature of Contractor

Dated signature of the certifying Engineer.

Rank.....

* This certificate must be signed by the Executive Engineer or any officer empowered by the local Administration to sign it.

III. Memorandum of payments

1. Total Value of Work done up-to-date as per ‘F’ of Account I Of this Bill		Rs.
2. Deduct:-		
(i) Up-to-date intermediate payments already As per entry ‘K’ of Account I of last Bill No.....dated..... (D)		
(ii) Total Secured Advances outstanding as per Entry ‘C’ of Account II last Bill No..... Dated..... (E)		
3. Payments now to be made:-		
(a) By recovery of amounts creditable to this Work (G)		
(b) By recovery of amounts creditable to Other works or heads of account.....		
(C) By Cheque..... (H)		

Pay ₹ (Rs.....only)

Dated signature of officer
Authorizing the payment

{
Rank.....

V – REMARKS

(This space is reserved for any remarks which the Disbursing Officer or the Divisional Officer may wish to record in respect of the execution of the work, check of measurements or the state of contractor's account.)

For use in Divisional Office

Checked

A/c. Clerk

Divi. Actt.

For use in Pay and Accounts Office

Audited

Reviewed

Accountant

JAO/AAO

Pay & Accounts Officer

7.15 MoU with Technology Provider

MEMORANDUM OF UNDERSTANDING

Between

..... (Bidder)

And

Suez Water Technologies Solutions (I) Pvt. Ltd. (Technology Provider)

Entered into this day of....., 2017, by and between Suez Water Technologies Solutions (I) Pvt. Ltd., a company incorporated in India under the Companies Act, 1956, having its registered office at (hereinafter called or Technology Provider) and (hereinafter called Bidder) a company incorporated in India under the Companies Act 1956, having its head office at

RECITALS:

1. WHEREAS Technology Provider is in the business of
2. WHEREAS Lead Bidder is in the business of
3. WHEREAS this MEMORANDUM OF UNDERSTANDING is applicable solely for DSITC (Design, supply, Installation, trial run and Commissioning) of electro-mechanical, instrumentation ,electrical, piping, automation works of the 1 * 650 KLD UF Hollow Fiber MBR based STP project of IIT Hyderabad (the Project).
4. WHEREAS the Technology Provider agrees to provide the necessary design, engineering of the MBR systems to the Bidder for the Project, subject to mutually agreed Terms Conditions. Design and Engineering support shall be as described in Chapter 5 : Scope of Work and Services, Section 4.5 of the bid document.
5. WHEREAS the Technology Provider agrees to supply the MBR membranes and cassettes along with technical advisory services and supervision of installation and commissioning to the Bidder for the Project, subject to mutually agreed Terms Conditions
6. WHEREAS the Technology Provider agrees to provide membrane warranty for a period five years (2 year full replacement and 3 year pro-rated warranty) , subject to mutually agreed Terms Conditions. Process guarantee (limited to TSS, Turbidity, Flow

and BOD) would be applicable as per the Tender requirements of the Project provided the Bidder supplies equipment as per the Technology Provider design specifications.

7. WHEREAS the Bidder agrees to take support of the Technology Provider for post-commissioning periodic reviews (once in every three months) and services to ensure STP and MBR process health check-up for a period of Three(3) years after commissioning of the STP, subject to mutually agreed Terms Conditions

8. WHEREAS this MEMORANDUM OF UNDERSTANDING would be valid for the period of Project bidding, execution and commissioning and OM period of three (3) years with an option to renew on a mutually agreeable basis.

In addition to the above, the scope of technology provider shall include the following:

7.15.1 Technical Advisory Services during Pre-Construction

The Contractor shall undertake the design of the proposed sewage treatment plant in consultation with the Technology Provider. Technology provider shall scrutinize the design calculations of all electro-mechanical, instrumentation, piping, electrical and automation of control systems and vet the same. Similarly, all deliverable drawings/documents including Maintenance Manual shall be vetted by the Technology Provider duly affixing the signature of authorized signatory along with seal of Suez Water Technologies & Solutions (I) Pvt. Ltd., .

7.15.2 Technical Advisory Services during Equipment Installation

In support of unloading the equipment, rigging the equipment into place, installing interconnecting piping, installing interconnecting wiring, installing power wiring, installing pneumatic lines, verifying adequate drainage, testing for adequate water and air pressure, testing power supply and testing interconnecting wire circuitry.

7.15.3 Technical Advisory Services during Post-Installation

Inspection of installation work, address questions, develop punch list of completion items necessary prior to next visit including technical advisory services in support of loading membrane elements / cassettes (if not loaded in factory)

7.15.4 Technical Advisory Services during Equipment trial run

Includes technical advisory services in preparing the equipment to operate I/O verification, support for flushing & back washing system, operating the equipment manually,

I/O verification, operating the equipment automatically, testing control system, technical advisory services in support of membrane loading, flushing preservative, and system sanitization

7.15.5 Technical Advisory Services during Commissioning of plant (Performance Test)

Includes technical advisory services in support of set-up of and witness performance test of 72 hours / 3 days continuous operating run without intervention beyond normal operational activities.

7.15.6 Formal Training

This shall include formal on-site training to staff of Contractor and IITH that typically takes place after the commissioning of the plant. This does not include informal training that takes place with an operator being present and assisting the technicians performing start-up. The on-site training program shall also include site safety training. The training program shall be properly documented and a report shall be submitted to IITH.

7.15.7 Other Services

The technical services listed above shall include at least 4 trips to site with total 20 working days on-site availability for above mentioned services. Travel time to and from the job site for Technology Provider's Field Service personnel is not included in the 20 days period.

In addition to above technical services, the contractor shall arrange representative of Technology Provider at kick-off meeting to be held at site after award of work.

As specified in the Conditions for O&M Services, the contractor shall arrange visits of the Technology provider to the plant once in every three months for complete performance audit of the plant and submit such audit report to the Institute.

7.15.8 Performance Guarantee

As specified in the bid document the Technology Provider shall submit performance guarantee bond for the quality of treated sewage by furnishing to IITH a joint undertaking with Contractor to this effect.

IN WITNESS WHEREOF, THE PARTIES HAVE EXECUTED THIS MEMORANDUM OF UNDERSTANDING ON THE DATE, MONTH AND YEAR FIRST ABOVE WRITTEN.

FOR AND ON BEHALF OF

FOR AND ON BEHALF OF

(Bidder)

(Technology Provider)

IN THE PRESENCE OF:

WITNESS

1.

2.