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MEMBRANE BIOREACTOR (MBR) SYSTEM

SECTION 45 50 00

MEMBRANE BIOREACTOR SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

The specification sections listed below are an integral part of this equipment specification, and the Contractor shall be responsible for providing these sections to the equipment suppliers.

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1.02 DEFINITIONS

A. MBR/MBT System Supplier (called the MBR Supplier from here on in this document): The company responsible for supplying the membranes to be used in this project and for providing all equipment and services as described herein and for providing warranty support.

B. Contractor: The company responsible for construction and installation of the MBR System, including, but not limited to, site preparation, tank and basin construction, and mechanical and electrical installation.

C. Engineer: The Engineer is the prime professional with respect to the project.

D. MBR System: A collective term for all process and membrane zones that make a complete biological treatment system.

E. Process Train: A stand–alone combination of Process Zones designed and operated to achieve specific treatment objectives.

F. Process Zone: An area in a Process Train designed and operated to meet a specific biological treatment objective.

G. Membrane Zone: Any Membrane Tank or MBR containing membranes.

H. Membrane Tank: A tank or basin containing one or more large membrane sub–units that are operated as one unit. A Membrane Tank has an HRT at Average Design Flow (ADF) of less than 1.0 hr.

I. MBR: A tank or basin containing one or more large membrane sub–units that are operated as one unit. An MBR has an HRT at Average Design Flow (ADF) of more than 1.0 hr.

J. Membrane Bank: A grouping of large membrane subunits which share a common permeate header, a common air supply header, and that are taken off–line as an entity for any type of Clean–In–Place (CIP) procedure.

K. Submerged Membrane Unit (SMU): An assembly consisting of one or more SMU Subunits ("racks", "cassettes", etc.) and an integral diffuser assembly.

L. Membrane Cartridge: The smallest assembled unit of a delivered system that is designed to be removed from a SMU and replaced as a complete unit. This may be flat sheets attached to a support structure and may be referred to as a "module", "cassette", or other terms.

M. Plant Hydraulic Loading Criteria: The net permeate flow rate over a given period of continuous operation accounting for CIP procedures and relaxation. Production capacity requirements are given in terms of:

1. Average Annual Flow (AAF): The net daily flow requirement generally occurring during dry weather conditions.

2. Maximum Monthly Flow (MMF): The net daily flow requirement generally occurring during wet weather conditions.

3. Peak Week Flow (PWF): A net weekly flow total generally occurring during wet weather conditions

4. Peak Daily Flow (PDF): The net daily flow required during peak daily flow conditions.

5. Peak Hourly Flow (PHF): A net peak hourly flow requirement generally occurring during wet weather flow conditions.

6. Peak Instantaneous Flow: The highest allowable flow rate under any conditions.

N. Flux: Gallons of permeate flow per day per square foot of membrane area (gfd). Additional definitions of flux that are used to characterize design criteria and membrane performance include:

1. Instantaneous Flux: Calculated by dividing measured permeate flow rate by working membrane area at any instant.

2. Gross Flux: See Instantaneous Flux.

3. Net Flux: Calculated by dividing the total amount of permeate produced (available for discharge) in a given time frame by the working membrane area.

O. Backwash: Synonymous with back pulse and back flushing. Backwashing is any instance where water and or a chemical solution are charged to membranes in the reverse direction of permeate flow with a membrane soak time less than 0.5 hr. A Backwash is performed in–situ and in mixed liquor or activated sludge. Typical backwash characteristics are provided below.

Summary of Backwash Characteristics		
Parameter	**Value (Condition)**	**Type**
Membrane Soak Time	≤ 0.5 hr	Primary
Conducted In Mixed Liquor	Yes	Primary
Conducted In–Situ	Yes	Secondary
Typical Duration	15–60 sec	Secondary
Fill Direction	Reverse	Secondary
Tank Fill/Drain	No	Secondary
Chemicals Required	No	Secondary

P. Maintenance Clean: Synonymous with chemically enhanced backwash and CIP. A Maintenance Cleaning is performed in–situ and in mixed liquor or activated sludge. The procedure is conducted by charging cleaning chemicals to membranes in the reverse direction of permeate flow with a soak time lasting more than 0.5hr. Typical Maintenance Cleaning characteristics are provided below.

Summary of Maintenance Cleaning Characteristics		
Parameter	**Value (Condition)**	**Type**
Membrane Soak Time	> 0.5 hr	Primary
Conducted In Mixed Liquor	Yes	Primary
Conducted In–Situ	Yes	Secondary
Typical Duration	0.5 hr – 2.0 hr	Secondary
Fill Direction	Reverse	Secondary
Tank Fill/Drain	No	Secondary
Chemicals Required	Yes	Secondary

Q. Recovery Cleaning: Synonymous with intensive cleaning and CIP. A Recovery Cleaning is performed in–situ or ex–situ and in water or dilute chemical. The procedure is conducted by charging cleaning chemicals to membranes in either direction with variable soak times. Typical Recovery Cleaning characteristics are provided below.

Summary of Recovery Cleaning Characteristics		
Parameter	**Value (Condition)**	**Type**
Membrane Soak Time	Optional	Primary
Conducted in Mixed Liquor	No	Primary
Conducted In–Situ	Optional	Secondary
Typical Duration	6.0 hr – 24.0 hr	Secondary
Fill Direction	Optional	Secondary
Tank Fill/Drain	Optional	Secondary
Chemicals Required	Yes	Secondary

R. Mechanical Cleaning: Synonymous with manual cleaning, physical cleaning and hand cleaning. Mechanical Cleaning is any instance where membranes are cleaned by hand or machine (water jetting or other) for the purposes of removing fouling or localized dewatering.

S. Localized Dewatering: Synonymous with clogging, sludging and plugging. Localized dewatering is the excessive accumulation of solids at a membrane surface in the form of refractory cake and generally in discrete, localized areas. Often caused by excessive filtration in combination with unequal or inadequate air scouring.

T. Days: Defined as calendar days.

U. In–Situ: Inside the normal service area and submerged in mixed liquor.

V. MLSS: Mixed liquor suspended solids reported as mg/l.

W. Permeability: Equals the instantaneous flux rate divided by the transmembrane pressure (TMP). The units of permeability are gfd/psi.

X. Relaxation: A temporary suspension of membrane filtration with continued .air scouring for the purpose maintaining treatment capacity or reducing CIP requirements.

Y. Transmembrane Pressure (TMP): The effective pressure differential across the membrane during normal operation.

1.03 DESCRIPTION OF WORK

A. This Section specifies the requirements for the furnishing, testing, training, Startup, and Warranty Support of all process equipment required for upgrading the Travis Field WWTP submerged membrane bioreactor system for the treatment of wastewater. A separate Membrane Bioreactor Thickener System (MBT) shall be included as part of the treatment process.

B. The MBR/MBT System Supplier shall furnish and commission the MBR System as described in this specification, inclusive of all equipment, instrumentation, scope–specific piping systems, controls, integration, and warranty support.

C. The MBR/MBT System Supplier shall provide the MBR Product Engineering and Design Services in support of the treatment system design as described in this specification.

D. The Contractor shall furnish all labor, rigging, materials, and incidentals required for the installation of the MBR System in accordance with the installation instructions provided by the Supplier. Once installed, the MBR System shall be complete and operational with all control equipment and accessories as specified herein and described in the Contract Documents.

E. The Engineer shall decide as to the quality and acceptability of services and materials furnished and Work performed. All questions which may arise as to the interpretation of any or all Plans and Specifications and all questions as to the acceptable fulfillment of the Contract on the part of the Contractor and Suppliers shall be resolved by owner and the Engineer.

F. The MBR/MBT System Supplier must clearly identify in detail any and all exceptions to the Services and Scope of Supply described in this Specification.

1.04 SUBMITTALS

A. Project Submittal: The MBR/MBT System Supplier shall submit to the Contractor the complete descriptive information for all equipment, instrumentation, and component in the Supplier's Scope of Supply (A copy of the MBR/MBT supplier's scope is provided as an exhibit) prior to purchase of equipment. The Project Submittal shall contain the following:

1. Membrane installation drawings, detailing membrane unit dimensions, materials, weights, locations of lifting lugs/points, and anchor bolt locations.

2. MBR/MBT basin mechanical layout drawings, detailing the number of membrane units, air and permeate piping distribution, piping supports, in–basin instrumentation and valves, and all other components comprising the MBR basin systems. Drawings with detail information in plan and elevation/section views and include details as necessary to completely describe the installation requirements. Drawings will be based on the basin/structural design provided by the Engineer.

3. Plan view equipment and instrument drawings showing the location of all components provided by the MBR/MBT System Supplier. Locations and installation details are to be coordinated with the Engineer's drawings to avoid conflicting information.

4. MBR/MBT System Supplier's literature for all equipment in scope of supply will include (as applicable):

   a. Pump curves

   b. Blower curves

   c. Mixer velocity distribution profiles

   d. Materials of construction

   e. Shop drawings showing all dimensions, sizes and locations of anchors

   f. Minimum, maximum, and design duty points for all equipment including pumps, blowers, mixers, etc. (flow rates and pressures/TDH)

   g. Unit performance and efficiency data

   h. Motor horsepower and voltage

   i. Complete wiring and control diagrams which show the point of connection for the power supply and control system

   j. All project–specific installation data for use by the Contractor.

5. Where manufacturers' standard literature is submitted, it shall be clearly marked to indicate which features are to be furnished under this contract.

6. Process and Instrumentation Diagrams (P&IDs) showing all equipment and instrumentation which will be controlled by the MBR System Supplier control system, including components provided by others.

7. Instrumentation list and manufacturers' literature and cut sheets, clearly identifying manufacturer, models, ranges, features, materials of construction, installation details, power supply voltage, wiring information.

8. Valve list and manufacturers' literature and cut sheets, clearly identifying manufacturer, models, Cv range, orientation, flow direction, materials of construction, pressure rating, and dimensions.

9. Valve actuator manufacturers' literature and cut sheets, clearly identifying models, motor horsepower and voltage, control wiring, installation/connection details, torque rating, actuation times, duty cycle, and materials of construction.

10. Control panel drawings, detailing the interior and exterior layouts, components, panel dimensions, panel materials of construction and NEMA rating.

11. Control panel component manufacturers' literature, clearly denoting model numbers of all PLC components, relays, terminal blocks, power supplies, buttons, switches, fuse blocks, etc.

12. Control panel wiring schematics.

13. Warranty information, detailing membrane design fluxes for all flow conditions.

14. System start–up and test procedures.

15. Provide a List of Scope of Supply for the entire system, that clearly shows the number of all equipment supplied by the system supplier to include the # of duty and spare.

B. Installation and Operations Manual (IOM): The MBR/MBT System Supplier shall furnish an Installation and Operations Manual at least 2 to four weeks prior to the delivery of the Supplier's equipment on site. The IOM will include Supplier and manufacturer's manuals and drawings detailing dimensions, locations, wiring information, and any other information necessary to convey the correct assembly and installation of the MBR System components provided by the Membrane Manufacturer and MBR System Supplier. In addition to installation documents, the IOM shall include requirements for the Mechanical Inspection and a schedule of events for the System Commissioning. The Supplier is to provide three hard–copies and two flash drives containing all information organized by component.

C. Plant Operations Manual (POM): The MBR/MBT System Supplier shall furnish a Plant Operations Manual within 2–4 weeks before completion of the System Commissioning. The supplier is to provide three hard copies and two CDs containing the following information:

1. HMI (operator interface) User's manual, detailing screens and functions within the operator interface program.

2. Process variables and final control narrative

3. As–built P&IDs

4. As–built electrical schematics and control panel drawings

5. Safety guidelines

1.05 QUALITY ASSURANCE

The MBR/MBT System supplier shall be Kubota Membrane USA (KMU).

A. All the equipment and services specified under this Section shall be furnished by the Membrane system supplier and shall be standard units of proven ability as a competent organization that is fully experienced, reputable and qualified in the manufacture of the equipment to be furnished. The equipment shall be designed, constructed and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed.

B. All membranes furnished under this Section shall be new and unused and shall be the standard products of a Membrane Manufacturer having a successful record of manufacturing the flat plate/flat sheet membranes specified herein for a minimum of **fifteen** (15) years.

C. The membrane sheet, module construction, membrane pore size, polymeric materials utilized shall have a successful operation and proven track records.

1.06 WORK BY GENERAL CONTRACTOR

A. The following work and scope of supply is specifically excluded from the MBR Supplier scope:
   1. Construction of:
      a. Operation & Auxiliary building
      b. Buried pipe, including soil requirements, thrust blocks, galvanic protection
      c. Concrete basins
      d. Wall penetrations
      e. Support of piping outside of MBR scope
   2. Structural:
      a. Building(s) for housing MBR.
      b. Concrete tankage for process and membrane zones.
      c. Imbedded wall spools, pipe sleeves, pipe seals in concrete tank walls for the various process pipe connections/penetrations.
      d. Covers or grating over process and membrane zones.
      e. Equipment access platforms, walkways, stairs, etc.
      f. Protective coatings for concrete.
      g. Anchor bolts for any equipment outside of MBR basin.
   3. Mechanical:
      a. Mixed liquor recycle piping, including branch connections and headers.
      b. Membrane CIP piping, including branch connections and headers.
      c. Pipe supports and hangers unless otherwise noted.
      d. Hoist equipment above the membrane basin for installation and removal of the membrane subunits.
      e. Membrane tank drain piping, valves, operators, and pumps, if required.
      f. Installation of any kind, including equipment and piping within or outside of Scope of Supply.
      g. Installation materials for instrumentation and automatic valves, including, but not limited to, air / sample line tubing, fittings, and mountings.
   4. Electrical:
      a. Electrical wiring interconnections (including wiring, conduit and other appurtenances required to provide power connections as needed) from the electrical power source to the MBR System Control Panel.

b. Electrical wiring interconnections (including wiring, conduit and other appurtenances required to provide power connections as needed) from MCC and/or Panelboard(s) to all field equipment.
c. Instrumentation wiring, conduit and other appurtenances required to provide connections as needed between all field devices and the membrane PLC control panel or MCC.
d. Motor control centers, Variable Frequency Drives (VFDs), panel boards, transformers, and other equipment necessary to provide power distribution for equipment, unless specifically listed in **2.03** SUBSYSTEM SCOPE OF SUPPLY.
e. Network communications connections, conduit, wiring or fiber optic cable including fiber terminations to the Plant SCADA and the MBR System SCADA systems (if the two are different). Includes network communications connections from PLC control panels to remote I/O control panels.
f. Internet network provisions to permit remote access of MBR Control System.

5. Other Misc. Items:
a. Receiving, unloading and safe storage of equipment at site or a storage facility until ready for installation.
b. Equipment installation.
c. Instrumentation installation including continuity checks and assistance with related loop checkout.
d. Raw materials, chemicals and utilities during equipment testing. This includes potable water for system function testing and seed sludge per supplier requirements.
e. Laboratory services, operating and maintenance personnel during equipment checkout, startup and operations.
f. Onsite painting or touch-up painting of MBR, with the exception of painting required due to damage incurred prior to equipment being received onsite.
g. **Seed Sludge** – Contractor to provide approximately 150,000 gallons of seed sludge for commissioning of the plant. The sludge shall be from a healthy activated sludge plant (preferably an MBR plant) at a minimum concentration of 1%. (no digester sludge).

1.07 WARRANTY

A. MBR/MBT Manufacturer and System Supplier shall provide a guaranteed membrane replacement or additional purchase price as a cost per membrane module. Price shall be for membrane cassette only and shall not include associated air scour diffuser case.

B. MBR/MBT System Supplier shall warranty and replace the membranes under warranty for a period of 10 years. The warranty shall not be pro-rated.

C. All warrantee support, as defined in the warranty statement, shall be provided by the MBR/MBT System Supplier (Kubota, USA) directly.

D. MBR/MBT System Supplier shall warrant small membrane subunits under the following terms:

1. MBR/MBT System Supplier shall replace any small membrane Subunits that fail before 10 years (Not Prorated) from the date of successful completion of the System Commissioning and acceptance by City as specified herein.

2. Failure is defined as any of the following:

   a. Inability to meet production capacity requirements as specified herein.

   b. Inability to meet TSS and turbidity requirements as specified herein.

   c. Failure to meet MBT sludge concentration.

   d. Visual damage to membrane plates or sheets during normal operations and within membrane system supplier's guidelines. Examples of visual damage include plate breakage and membrane sheet separation. Plates or sheets with observed visual damage shall be fully replaced, regardless of whether or not membrane system is meeting effluent turbidity limits.

3. The following are specifically excluded from warranted membrane failure conditions:

   a. Exceeding TSS or Turbidity limits due to accidental physical damage of the membranes and/or loss of piping integrity.

   b. Loss of capacity due to failure to operate within design fluxes and permeability limits as defined in this Section.

   c. Loss of capacity due to failure to perform required Maintenance cleans.

E. Supplier shall warranty all other equipment, not specifically mentioned above, against defects in workmanship and materials for a period of 1 year. The warranty period shall begin following completion of the System Commissioning and acceptance by City as specified herein.

PART 2 - PRODUCTS

2.01 MBR PRODUCT ENGINEERING AND DESIGN SERVICES (Provided During Design)

A. The MBR Manufacturer and System Supplier will provide the following design services related to the MBR product to the Engineer during design process:

1. Biological Process Design Verification – The MBR Supplier shall support the Engineer in providing analysis and verification of the biological process design, based on the customer's influent mass loading, diurnal flow curves (if available), peak flow/loading numbers, and permit limits. The Supplier shall verify basin volumes, recycle rates, aerations requirements, chemical dosing requirements, and waste solids projections. The supplier shall provide a written report summarizing the design results.

2. Piping Hydraulic Analysis and Design – The MBR Supplier shall provide a detailed hydraulic analysis and mechanical design documentation of each process subsystem contained in the MBR System scope of supply. Piping design CAD files shall be provided to the Engineer for integration into the design package. The subsystems included in the hydraulic analysis shall include:

   a. Recycle pump systems

b. MBR air distributions systems

c. Permeate systems

d. WAS systems

3. Equipment Sizing and Installation Details – The MBR Supplier shall verify duty points and turn–down, supply voltages, materials of construction, communications IO, equipment access and serviceability, area classifications, and pressure ratings for the MBR System's pumps, blowers, mixers, and valves. In addition to identifying manufacturers and specific part numbers for each component, installation details and CAD drawings shall be provided for integration into the Engineer's design package.

4. Instrumentation Design – The MBR Supplier shall provide the Engineer with complete specification and documentation of all MBR System instrumentation. Installation details shall be provided in AutoCAD format for integration into the Engineer's design package.

5. Controls Design – The MBR Supplier shall supply MBR System Process and Instrumentation Diagrams utilizing the Supplier's standard symbols and tagging schemes,

2.02 SYSTEM PERFORMANCE REQUIREMENTS

A. The MBR System will be sized to hydraulically convey the flows shown in Table 2–1.

Table 2–1: Plant Hydraulic Loading Criteria					
Parameter	**Influent**		**Event Duration**	**Frequency**	**Total Duration**
Average Annual Daily Flow (AAF)	4.0	MGD	365 days	1/ year	265 days
Maximum Month Daily Flow (MMF)	4.0	MGD	30 days	3/ year	90 days
Peak Daily Flow (PDF)	8.0	MGD	24 hours	9/ year	9 days
Peak Hourly Flow (1)	7,000	GPM	2 to 4 hours	24/year	2 days

(1)- Max flow to MBR will be equalized to 8.0 MGD through Equalization pump station

B. The MBR System shall be designed to accommodate the diurnal pattern as indicated per Engineer.

C. The MBR System shall be capable of treating raw wastewater at listed flows to the specified effluent criteria shown in Table 2–2 & Table 2–3

Table 2–2: Travis Field WPCP Influent Criteria

Parameter	Annual Average Conditions	Maximum Month Conditions
cBOD5, mg/L	170	255
BOD, mg/L	200	300
COD, mg/L	435	653
TSS, mg/L	160	240
TKN, mg/L	33	40
NH3–N, mg/L	24	29
TP, mg/L	5.3	8.0
Design Temperature, °C	24	17
Alkalinity, mg/L CaCO3	185	185

Table 2–3: Travis Field WPCP Effluent Criteria

Constituent/Parameter (1)	Limits	
Effluent Flow Rate (MGD)	4.0	8.0
Five–Day Biochemical Oxygen Demand (mg/l)	10.0	5.0
Ultimate Oxygen Demand (lbs./day)	2,043.0	2,043.0
Ammonia, as N (mg/l) March–October November– Feb.	 2.0 4.0	 1.0 2.0
Dissolve Oxygen, Min. (mg/l)	5.0	5.0
Total Suspended Solids (mg/l)	20	20
Fecal Coliform Bacteria (count/100mL, geometric mean)	200	200
Total Phosphorus, as P (mg/l)	0.5	0.5
Total Residual Chlorine (TRC) (daily max) (mg/l)	0.28	0.14
pH (standard units)	6.0–9.0	6.0–9.0

(1) Values are maximum monthly average except as noted

D. System Configuration

1. The MBR System shall consist of:

   a. Anaerobic, Anoxic, Pre–Aeration and MBR basins.

   b. System must include 4 MBR zones and process 75% of Avg Day Flow with 1 basin out of service.

   c. MLSS range shall be 6,000 mg/l to 13,000 mg/l and shall be selected by MBR system supplier and shall be appropriate for membrane technology utilized.

   d. Total system HRT shall be no less than 7 hours at 4 MGD design flow condition

   e. Total HRT shall include volumes of Anaerobic, Anoxic, Pre–aeration and Membrane Zones. Design calculations provided shall verify HRT requirements are met.

f. Total System SRT shall be no less than 16 days at 4 MGD design flow condition. SRT shall assume a sludge yield factor of 0.75 lbs WAS/lb BOD applied from influent at Avg. day flow conditions. Design calculations provided shall verify HRT requirements are met.

2. The MBT system shall consist of:

a. One in-loop digester basin with a minimum volume of 246,000 gallons.

b. One isolated digester basin with a minimum volume of 65,000 gallons

c. One MBT thickener basin with a minimum volume of 21,000 gallons.

d. The MBT Thickener system shall include one membrane zone, one stage one, and one stage two digestion zone. WAS shall be thickened to 4% within the MBT system. A minimum of 20 days SRT at design conditions (4 MGD– see table 2.1 and 2.2 above) shall be provided. A sludge yield of 0.75 lbs. WAS/lb. BOD influent shall be utilized.

E. The proposed MBR System shall be designed in conformance to design guideline specified by submerged membrane unit (SMU) manufacturer.

F. The allowable MLSS concentration in the Membrane Zones shall range between 8,000 mg/l and 13,000 mg/l.

G. The allowable MLSS concentration in the MBT zones shall range from 8,000 mg/l to 40,000 mg/l.

H. The MBR basins shall be considered part of the biological process when calculating aerobic volume requirements.

I. Membrane CIP Procedures

1. Membrane subunits shall be cleaned in place using CIP methods to maintain production capacity and meet performance requirements specified herein. The allowable frequency of listed CIP methods shall be as follows:

a. Maintenance Clean frequency shall be as needed

b. Recovery Clean frequency shall not exceed 4/yr. (if Needed)

J. Not Used

K. The MBR shall be designed to operate at or below a trans-membrane pressure (TMP) of 3 psig.

L. The MBR System shall utilize self-priming centrifugal pumps to filter water.

M. Membrane Integrity Testing

1. Online membrane integrity testing shall be provided for each MBR zone.

N. Site Conditions

1. The elevation above sea level is 50 ft.

2. Influent wastewater shall contain less than 15% of the influent BOD_5 as fats, oils and grease (FOG).

3. No substances shall be placed in the system in quantities which are not biodegradable or toxic to the biological system.

4. The influent wastewater pH shall be between 6–8 SU.
5. Water hardness shall not exceed 300 mg/l as $CaCO_3$.

2.03 SUBSYSTEM SCOPE OF SUPPLY

MBR System Supplier shall furnish the Subsystem Components listed below in accordance with the requirements of this the project Specifications and Contract Documents. All components shall be shipped loose for installation by installing Contractor unless otherwise noted.

A. Anaerobic Basins,
   1. Mixers
   2. Basin high and low–level switches

B. Pre–Anoxic Basin
   1. Mixers
   2. Basin high and low–level switches
   3. Basin level sensor/transmitter

C. Pre–Aeration Basins
   1. Basin high and low–level switches
   2. Fine bubble diffusers
   3. Combination DO/temperature sensor/transmitter

D. Post–Anoxic Basins
   1. Mixers
   2. Basin high and low–level switches

E. Membrane Basins
   1. Membrane– Submerged Membrane Unit (SMUs)
   2. In–basin interconnecting air and permeate piping four (4) inches in diameter or less. In basin air and permeate **header** piping shall be supplied by installing contractor.
   3. Stainless steel pipe supports and support anchors for all Supplier–provided piping.
   4. Basin high and low–level switches.

5. Include air and permeate isolation valves as needed

F. MBT System
   1. Membrane– Submerged Membrane Unit (SMUs)
   2. In–basin interconnecting air and permeate piping four (4) inches in diameter or less. In basin air and permeate **header** piping shall be supplied by installing contractor.
   3. Pipe supports and support anchors for all Supplier–provided piping.
   4. Basin high and low–level switches.

5. Diffusers and in basin manifold piping for mixing of WAS solids at high concentrations.

G. Permeate Collection System

1. MBR/MBT permeate pumps
2. MBR/MBT permeate control valves
3. MBR/MBT Permeate process instrumentation
4. MBR Permeate turbidimeters (one per basin)

H. Cleaning Systems (for MBR and MBT Systems)

a. Maintenance Clean system pumps, valves, instrumentation, and tanks. Maintenance Clean shall be semi-automatic (fully automated skid) (when needed, operator shall be able to initiate the MC by simply pushing a button at the CIP skid and manually close the permeate valve and open chemical injection valves at each basin. All other valves, chemical injection, functions, etc. shall be automatic).

2. Backwash system pumps, valves, instrumentation, and tanks. Back pulse equipment shall be skid mounted for simplified installation. All required valves, actuators, back pulse tanks, pumps etc. shall be provided by MBR system supplier as part of the back-pulse skid.

3. Recovery Clean system pumps, valves, instrumentation, and other ancillary equipment as needed.

4. The **General Contractor** to provide one (1) Poly-processing 1,400 gallon 1.9SG XLPE Natural close top vertical Cylinder tank with (2) 2" 150# flanges connection for CIP storage tank. The tank shall be max 6 ft. in diameter.

I. WAS Handling System

1. WAS Pumps
2. WAS control valves
3. WAS instrumentation

J. Supplemental (Process) Aeration System

1. Process air blowers with one standby of equal or greater capacity

K. Membrane Zone (Scour) Aeration System (MBR and MBT)

1. Scour air blowers with one standby of equal or greater capacity
2. Scour air flow control valves
3. Scour air instrumentation

L. Internal Recycle System

1. RAS pumps with standby of equal capacity
2. RAS flow control valves (supplied by the contractor)
3. RAS instrumentation
4. Flow mag meters (numbers as needed)

M. Controls

1. MBR/MBT PLC control panel and if applicable remote I/O control panel(s)

2. MBR/MBT Human–Machine Interface (HMI) Computer and runtime software licensed to Owner

3. HMI and PLC programming

2.04 GENERAL EQUIPMENT DESIGN AND FABRICATION REQUIREMENTS

The requirements listed below are in addition to those called out in the Specifications listed in Part 1.01 of this Specification.

A. Submersible Mixers

1. Submersible mixers shall be direct driven, close–coupled, guide–rail–mounted, non–clogging propeller type designed for mixing of raw or processed sewage. All components of the mixer shall be capable of continuous submerged operation. The mixer shall be sized to provide complete mixing.

2. All major components of the submersible mixers shall be manufactured of 316 stainless steel. All bearings shall have a minimum B–10 rated bearing life of 100,000 hours.

3. Mixers shall have integral motor thermal overload protection and seal failure (moisture) sensor.

4. The mixers shall be provided with guide rails, guide brackets, and lifting cables.

B. Mixed Liquor Recirculation Pumps

<u>Note:</u> All submersible pumps regardless of size and location in the MBR system shall be manufactured by Flygt (Xylem). No other submersible pump is acceptable.

1. Mixed liquor recirculation pumps shall be capable of passing a three–inch spherical solid.

2. Major pump components shall be cast iron, ductile iron, or stainless steel.

3. Pumps shall be provided inclusive of check valves, isolation valves, inlet and outlet pressure gauges, and expansion joints.

4. Submersible pumps: Pumps shall have integral motor thermal overload protection and seal failure (moisture) sensor and be provided with guide rails, guide brackets, and lifting cables.

5. Dry–mount pumps: Pumps shall be horizontal, self–priming centrifugal type, designed specifically for handling municipal waste.

C. Fine Bubble Diffuser Systems

1. Fine bubble diffuser systems shall include in–basin aeration piping, submerged manifolds, laterals, diffusers, drain pipes, pipe supports, and purge system. Major air header piping at the top of the basins along with air drops to diffuser manifolds shall be provided by installing contractor.

D. Submerged Membrane Unit (SMU)

1. The MBR SMUs shall be the SP600 type as manufactured by KUBOTA. The MBT SMUs shall be RM200 type as manufactured by Kubota. Due to high MLSS concentrations within the MBT system, the maximum flux rate for MBT membranes shall be capped at 10 gfd.
2. The SMUs and supporting pipe work shall be designed for a cross–flow configuration by which the system will remove a portion of the water as the recycle flow circulates through the Membrane Zone.
3. Membrane Zone can be classified as an MBR or a Membrane Tank.
4. Each Membrane Zone shall include one or more Membrane Banks.
5. Each Membrane Bank shall consist of one or more Submerged Membrane Units (SMU). Each SMU shall be:
    a. Prefabricated, preassembled and factory certified before shipment to the site.
    b. Provided complete, with all necessary components, accessories and appurtenances required to make a complete and operable system.
    c. Furnished with 304 SS housing, appurtenances and fasteners (including nuts, bolts, screws, cables, washers).
    d. Furnished with integral diffusers designed to promote efficient air scouring of Membrane Elements. The diffuser must be manufactured by membrane manufacturer.
    e. Equipped with one or more SMU Subunits.
6. SMU Subunits contain multiple Membrane Elements. Membrane Elements shall:
    a. Be assembled into a housing called a cassette or other.
    b. Be constructed such that the membranes are held vertically and bonded firmly at the top and/or bottom of the Subunit.
    c. Be manufactured using materials suitable for use in submerged MBR applications and:
        i. Have an average pore size of 0.2 micron or less for Kubota.
        ii. Be physically strong enough to withstand the operating conditions associated with continuous operation in an aerated tank of mixed liquor at concentrations of up to the value as specified by SMU manufacturer in its operation manual.

E. Permeate Pumps

1. Permeate pumps shall be required when the hydraulic loading as described in this Specification cannot be met using gravity flow.
2. Permeate pumps shall be sized to handle peak instantaneous flow as defined in this Specification as well as rates associated with backwashing, maintenance cleaning, and aerator flushing.
3. Permeate pumps shall be provided inclusive of check valves, isolation valves, inlet and outlet pressure gauges, and expansion joints.

4. Permeate pumps shall be horizontal, self–priming centrifugal type or rotary lobe type, designed specifically for handling municipal waste.

F. Blowers

1. Blowers shall be provided complete with sound enclosure, inlet filters, discharge silencers, pressure relief valves, check valves, motors, temperature and pressure gauges, over–temperature sensor/switch, expansion joints, belts, and baseplates.

2. To facilitate simplified MBR basin operations, each MBR basin shall have a dedicated blower. A common standby blower shall also be provided.

3. Process aeration blowers shall be sized to maintain a residual DO of 2.0 mg/L at MMF flow rates and loadings and a minimum of a 2:1 turndown. Process aeration system shall include a standby blower of equal or greater capacity than the duty blowers.

4. MBR/MBT scour air blowers shall be sized such that sufficient scour air is provided to support MMF flows as described in this Specification without requiring additional maintenance cleans. The scour air system shall include a standby blower of equal or greater capacity than the duty blowers.

5. MBR/MBT scour air blowers shall accommodate a minimum surge of 1.5 psig under normal operating conditions.

G. Cleaning Systems

1. The Cleaning Systems shall include backwash, maintenance clean, and recovery clean systems as required by the Supplier's specific systems. CIP system shall be skid wall mounted.

2. A written statement from the Membrane Module Manufacturer must be included which confirms that all flux rates and CIP systems provided herein are in compliance with Membrane Manufacture's recommendations.

3. Cleaning Systems shall be <u>SEMI–AUTOMATIC</u> and inclusive of all chemical feed tanks, chemical feed pumps, valves, instrumentation, controls, and all other ancillary equipment necessary for a complete cleaning operation.

H. Waste Activated Sludge (WAS) Pumps

1. WAS pumps shall be capable of passing a three–inch spherical solid.

2. The pumps shall be sized to transfer the expected MMF waste sludge volumes in less than 3 hours.

3. Major pump components shall be cast iron, ductile iron, or stainless steel.

4. Pumps shall be provided inclusive of check valves, isolation valves, inlet and outlet pressure gauges, and expansions joints.

5. WAS pumps: WAS pumps shall be self-priming centrifugal pump.

6. Dry–mount pumps: Pumps shall be horizontal, self–priming centrifugal type or rotary lobe type, designed specifically for handling municipal waste.

I. Not Used

J. Valve Actuators

1. In order to reduce operating noise levels to nearby residents, it is preferred that all valves be electric actuated valves. Valves must have On/Off Manual options, at the valve and in SCADA.

K. Piping

1. All MBR System air scour piping, on the inlet side, shall be Type 304 stainless steel schedule 10, until the piping become submerged in the MLSS. The air scour piping on the outlet side may be schedule 80 PVC, as submergence in the MLSS will have cooled the process air, reducing thermal stress on the piping.
2. Permeate piping shall be schedule 80 PVC within the MBR tanks.
3. Piping shall have welded, glued, flanged, or mechanical groove (Victaulic) connections.
4. Pipe supports shall be 304 stainless steel Unistrut (or equivalent) systems, or 304 stainless steel angle and structural shapes with stainless hardware, clamps, and guides
5. Transitions from MBR Supplier piping to Contractor's piping shall use ANSI 150-pound flanges.
6. Insulation, heat tracing and or painting shall be provided by the Contractor.

L. MBR SYSTEM CONTROLS

1. The MBR/MBT System controls shall be housed in a NEMA 12 (indoor) unless otherwise specified. The control panel assembly shall be a UL 508a listed Industrial Control Panel. The control panel will house the MBR system PLC and I/O modules as necessary, and valve Open/Close/Auto switches. The panel shall include the following features:
   a. UL1449 listed Type1/Type 2 incoming power supply surge protective device capable of 50kA 8x20us
   b. Redundant 24 VDC power supplies connected through a protective diode such that failure of one power supply does not affect the other.
   c. PLC sized to handle all I/O for components in the MBR System as indicated on the P&IDs plus 10% spare I/O terminated to terminal blocks in each PLC or I/O panel.
   d. Power to each I/O module shall be fused. All instrument power fed from panel shall be fused per UL requirements.
   e. PLC user memory greater than 2MB and processor capable of connection to 32 Ethernet Nodes minimum.
   f. PLC, HMI and remote I/O devices shall connect via Ethernet/IP to an industrial managed Ethernet switch.
   g. System shall include a Phoenix Contact MGuard industrial VPN device for secure remote access.
   h. Control Panels shall include a pure sine wave UPS including UPS Maintenance/Bypass switch which permits seamless transfer of power to utility in case of UPS maintenance and relay contacts for UPS failure, on battery and low battery status.

2. The MBR System shall include one Human–Machine Interface (HMI), including Windows–based PC and HMI runtime software licensed to owner. System displays shall include graphical representations of all equipment and instrumentation and indication and trending of all process values.

3. The Supplier shall be responsible for all programming for the MBR System PLCs, database creation, generation of all graphic display screens, alarm configurations and trends for the operator stations.

4. MBR System controls shall be designed to allow for full manual (hand) operation in the event of PLC failure. Hand operations shall be manageable by two operators for a period of 72hrs.

M. Spare Parts.

Equipment	**Description**	**Manufacturer**	**Qty**
Blower	Filter elements, Bearing Seal	Per Bid Specs	2 sets
Feed forward pump	Seals, Bearings, O–rings	Per Bid Specs	2 sets
Anoxic Mixer	Repair Kit, Seals, Bearings, O rings	Per Bid Specs	2 sets
Permeate pump	Spare parts kit	Per Bid Specs	1 set
DO/ temp meter	Kit Sensor Cap replacement, LDO	Per Bid Specs	2
Level Transmitter	Full unit	Per Bid Specs	1
Level Switch	Full unit	Per Bid Specs	1
Pressure Transmitter	Full unit	Per Bid Specs	1
Turbidity meter	Lamp Assy, 1720D/E	Per Bid Specs	1
Actuators	Permeate Flow Control Valve	Per Bid Specs	1
Controls	Spare relays	Per Bid Specs	1 set
	Spare power supply	Per Bid Specs	1 set
	Panel mounted instruments, lights, push buttons	Per Bid Specs	1 set
	Spare Fuses	Per Bid Specs	1 set
	Indicating lights, bulb lights	Per Bid Specs	1 set

PART 3 - EXECUTION

3.01 MBR PRODUCT ENGINEERING AND DESIGN SERVICES (Provided During Design)

3.02 PROJECT EXECUTION

A. Unless otherwise required in the Contract Documents, the MBR Supplier shall provide all submittal documentation as described in this Section no later than 10 weeks after receipt of fully executed purchase order from the general contractor.

B. Unless otherwise required in the Contract Documents, the MBR Supplier shall deliver all components in their Scope of Supply, as described in this Section, no later than 36 weeks after receipt of written submittal approval.

C. Contractors must provide proof of adequate Payment Bond and Performance Bond before contracts will be finalized.

D. Startup and Commissioning Notes for General Contractor

During plant start-up, the General Contractor (GC) is responsible for providing Kubota field support technicians with sufficient support personnel to address any startup issues. The plant personnel are encouraged to participate in the start-up process. Operator participation during start up enhances confidence and speeds up the learning curve and allows for an easier transition upon assuming responsibility of the facility.

The general contractor is responsible for properly scheduling construction and startup activities. A normal workday during startup is 10 hours M-F. Kubota's startup team will include Project Manager, Startup Technician and Controls specialist. The Kubota Project Manager will remain as the primary point of contact for issues related to scope of supply, payments, change orders and other required tasks. Kubota is only responsible for scheduling personnel based on Kubota's scope of supply.

3.03 CONTROL SYSTEM FACTORY ACCEPTANCE TEST

A. The MBR/MBT System Supplier shall coordinate and conduct a factory acceptance test (FAT) of the MBR control system during which:

1. The PLC control logic and HMI operability shall be demonstrated by systematically forcing I/O to verify all controls functions and HMI screen representations defined in the system control narrative.

2. The MBR control panel shall be inspected for completeness, and workmanship.

B. The MBR System Supplier shall provide a minimum of 2 weeks' notice to the Owner and Engineer prior to the FAT. The Owner and Engineer may, at their option and their expense choose to attend and witness the FAT.

C. Whether or not the Owner and/or Engineer attend the FAT, the MBR Supplier shall provide written documentation and certification of the completed FAT.

3.04 MATERIALS INSPECTION (Kubota Technician on Site 2 trips 4 days)

A. The Contractor shall inspect delivered equipment upon arrival on site for completeness of scope delivery and to verify that all components have arrived undamaged. The Contractor is responsible for notifying the Supplier of deficiencies in quantities or conditions within 28 days from the ship date.

B. The Contractor shall provide all labor, materials, and equipment for unloading, de–crating, organizing, and compiling lists of received MBR equipment, components, and instrumentation.

C. The MBR Supplier shall make available, upon the request of the Contractor, personnel to assist in the inspection of the Supplier's equipment upon unload at the site. Supplier's personnel shall provide services in accordance with their standard daily rates.

D. Membrane Storage - The acceptable temperature range for membrane modules is 40˚F to 104˚F (indoor room temperature). Long-term exposure to direct sunlight may cause damage to the membrane material and should be avoided. Ideally, the membranes will be delivered to the jobsite once all construction related items for the MBR basins are completed so that time between delivery and installation of the membranes is minimized. Installing contractor is responsible for proper storage of membrane modules from time of delivery to time of installation and commissioning. Kubota project manager will work with the contractor team to coordinate an optimal delivery schedule, but contractor may want to consider short term storage of membranes near the jobsite if required.

3.05 MECHANICAL & ELECTRICAL INSPECTION (Kubota technician on site 1 trip 5 days)

A. The Contractor shall schedule with the MBR System Supplier to perform a Mechanical Inspection at least 2 weeks prior to the scheduled Commissioning of the System.

B. The MBR Suppler shall conduct a Mechanical Inspection of the MBR System to verify that the installation is complete and ready to begin Commissioning activities. The Supplier shall verify the following:

1. Installation of all equipment per the Engineer's and Supplier's drawings and Supplier's IOM information.
2. Installation of all instrumentation per the Engineer's drawings and IOM information.
3. Completeness of all piping installations.
4. Completeness of all electrical installations.
5. Proper installation of the MBR SMU diffuser assemblies per the Submittal and IOM information.
6. Completeness of all basins, including removal of all debris that may cause damage to the MBR SMU membranes.
7. Review of all pipe integrity testing results.

C. Upon completion of the Mechanical Inspection, the Supplier shall provide written documentation of the inspection results.

D. Follow up to Mechanical Inspection

1. If the MBR System is complete per the requirements of the Mechanical inspection, the MBR Supplier shall schedule the System Commissioning with the Contractor. The date for the System Commissioning is to be established within 2 weeks of the successful completion of the Mechanical Inspection.

2. If the MBR System is not complete at the time of the Mechanical Inspection, the Supplier shall document system deficiencies to the Contractor, Engineer, and Owner. The Contractor will then complete all necessary work and provide documentation (including digital photographs) of the completed work.

   a. Electrical and Control System Documentation Requirements

      i. Wire ring–out documentation signed by electrician

      ii. Pictures of completed terminations (terminations by contractor) in field and PLC panel including wire labeling.

      iii. Documentation and pictures of completed network cabling, Ethernet cable termination and fiber optic termination and patching.

      iv. Documentation and pictures of all motor and valve terminations, motor cable Insulation resistance testing

   After all the noted deficiencies are resolved to the satisfaction of the Engineer, Owner, and Supplier, the date for the System Commissioning is to be established within 2 weeks.

3. If the Mechanical Inspection deficiencies are deemed as sufficiently important by the Supplier, Owner, or Engineer, the Contractor shall arrange for the Mechanical Inspection to be repeated at the Contractor's expense.

4. If electrical and control system wiring is incomplete prior to system commissioning scheduling, Contractor must complete all necessary work and provide documentation of the completed work (as described in 3.05 D. 2. Above). The Contractor must update the Engineer, Owner, and Supplier of the progress so that a revised system commissioning date can be organized as soon as possible. In this scenario, penalties for project delay will become the responsibility of the Contractor.

5. Basin and Piping Integrity Testing - Suction side leaks in the permeate system can create issues during startup and normal operations. Failure to properly test the permeate system piping can result in unplanned startup delays and result in additional Field Service / Startup charges. General contractor must complete piping and basin integrity testing prior to engaging in startup/commissioning services.

E. Wiring/Instrumentation & Control **(Kubota Technician on site 1 trip 4 days)**

Wire / Loop Checks - Working with the GC's and Kubota integrator, Kubota's personnel will functionally test all (Kubota Scope) system inputs/outputs points to confirm wiring. Remediation of wiring problems is the responsibility of the GC.

Confirmation of wiring between any non-Kubota scoped panels, mcc or switchgear will require support from the supplier of that equipment. Remediation of wiring problems is the responsibility of the GC.

Device Calibration – All Kubota scope instrumentation will be setup and properly calibrated.

F. Electrical Equipment

1- GC is responsible for ensuring oil and lubrication levels are appropriate in mechanical equipment.
2- Kubota Engineer shall generate Equipment Acceptance forms for each piece of Kubota supplied equipment.
3- Actuated valves/gates shall be tested for proper operation and response to the HMI controls
4- Pumps and blowers shall be inspected for proper installation, tested for rotation, and response to the HMI controls
5- Where supplied by Kubota, VFDs shall be configured to min/max speed and other operating parameters.

3.06 SYSTEM COMMISSIONING

A. The MBR System Supplier shall coordinate with the Contractor, Engineer, and Owner for execution of the System Commissioning. In advance of System Commissioning the MBR System Supplier shall perform an onsite Mechanical Inspection of the facility and generate a punch–list of inconsistencies. The Contractor is required to resolve the punch–list items to the satisfaction of the System Supplier, prior to scheduling System Commissioning. The System Commissioning will consist of the following:

1. General inspection of systems (lubrication, rotation, calibration).
2. Loop checking, instrumentation, and control system verification.
3. Clean potable Water diffuser testing.
4. Clean potable water permeates pipe loss testing.
5. Sludge re–seeding.
6. Training of the City staffs.

B. The Contractor shall provide materials and personnel in support of the System Commissioning to fill basins with clean water, transfer fluids, repair/remedy all electrical and mechanical issues, provide temporary tie–ins, temporary piping, transfer pumps, etc.

C. The Contractor shall coordinate with the Engineer and Owner and provide seed sludge to start the MBR System at the end of the clean water testing.

D. Contractor to provide approximately **150,000 gallons of seed sludge**. The seed sludge shall be approved by the MBR supplier. The sludge shall be from a healthy activated sludge plant (preferably an MBR plant) at a minimum concentration of 1%. (no digester sludge). The MBR Supplier is not responsible for supplying the seed sludge.

E. The System Commissioning shall begin at the Contractor's discretion, within the limits defined herein:

1. Successful completion of a pre–commissioning Mechanical Inspection is required.

2. Start of Commissioning shall be no later than 60 days after completion of Mechanical Inspection.

F. The Owner may assist the contractor to operate the plant during the Commissioning Period. The contractor is responsible for operation of the entire plant during the plant Commissioning. The contractor shall engage a certified operator (approved by the MBR supplier) to operate the plant during commissioning and performance testing period and until the City acceptance of the plant.

G. Supplier is responsible for monitoring operating conditions and performance during the Commissioning Period.

H. Supplier shall provide the Owner with a Plant Operations Manual prior to the Commissioning Period. The manual shall include at a minimum:

1. As–built drawings
2. Safety Manual
3. HMI User's Manual
4. As–built control schematics
5. Process variables and control narrative.

I. Supplier shall submit the Plant Operations Manual four weeks prior to the Commissioning Period.

J. Membrane permeate quality shall be evaluated to determine compliance of the MBR System with Performance Requirements. If the MBR System fails to comply with requirements of membrane permeate quality, Supplier at their expense shall provide the Owner and the Engineer a written plan of modifications to the system (such as repairing damaged membranes, replacing seals, complete replacement of system) to achieve compliance with the requirements. Upon implementation of modifications plan, the permeate quality tests shall re–commence in their entirety.

❖ **Clean Potable Water Wet Testing (Kubota technician on site 1 trip and 5 days)**

Wet testing is the process of operating all or some of the process basins with clean water, prior to exposing any systems to MLSS. The purpose of these tests is to prove the integrity and functionality of various elements of the treatment process including pumps, valves, flow channels, etc.

There are various requirements for clean water testing during an MBR system startup. Kubota utilizes clean water testing for the purposes of conducting Pipe Loss and Clean Water Flux testing and fine/coarse bubble diffuser testing.

Flat plate membrane is not intended for sustained operations in clean water. Exposing the membrane to long periods of permeation in clean water can result in a decrease in initial performance and result in unnecessary chemical cleans.

Pipe Loss Testing - Testing involves disconnecting the membranes units from the permeate piping and filling the system with clean water to the normal operating level. The permeate systems will then be operated pulling a suction directly from the MBR tank. Level in the MBR basin must remain constant during this test.

Clean Water Flux Testing – like Pipe Loss Test, except the membranes are connected to the permeate header. These tests are intended to be short term with permeation not exceeding a total of 3 hours for each membrane unit tested. Level in the MBR basin must remain constant during this test.

❖ **Seeding the MBR Process** <u>**(Kubota technician on site 1 trip and 5 days)**</u>

Seed sludge must be from an acceptable source, at an appropriate concentration, and in sufficient volume.

A fresh nitrifying activated sludge from a nearby WWTP should be used as the seed for the MBR process. Quality sludge will have characteristics of:

- VSS >70%
- Sour 1 – 10
- Filterability >10
- No chemical additives
- No mal-odors
- No septic content
- Avoid sludge with excessive long sludge ages to reduce risk of membrane fouling.

A Kubota Commissioning technician shall inspect the seed sludge prior to seeding the MBR plant. All seed sludge entering the MBR system must be run through the fine screens, regardless of whether or not the seed sludge is from another MBR plant. For proper operation, the MBR process requires that MLSS concentrations be at least 3,000 mg/L. Concentrations below 3,000 mg/L do not provide sufficient Biofilm to protect the membrane surface from the impact of colloidal particles and can result in decreased membrane performance. See below table for guidance.

<u>MLSS Concentration Guidelines</u>

0 – 3,000mg/L = No Permeate System Operation
3,000 – 6,000 = Permeate System Limited to ½ Design Flow
6,000 – 12,000 = Design Operation

During the commissioning and the initial SRT period, regular analysis of the wastewater and mixed liquor characteristics, as well as the permeate quality will be required to monitor the performance of the process. Contractor must make arrangements to test for the following parameters. Testing may be done on-site using portable equipment or by an accredited laboratory.

- DO (on-site).
- pH (on-site).
- Temperature (on-site).
- Conductivity (on-site).
- Mixed liquor filterability (on-site).
- SS, MLSS, MLVSS.
- BOD, COD
- Total, calcium and magnesium hardness (site specific requirement)
- Alkalinity

❖ **Process Maturation**

Process maturation is the period after seeding and commissioning of the first membrane tank(s) and before the plant can treat the design flows (ADF). The maturation process is a stepwise increase in the maximum acceptable permeate flow rate depending on the mixed liquor suspended solids (MLSS) concentration and the stepwise increase in the number of membrane tanks brought on-line.

Full process maturation and biology stabilization can take up to 6 weeks.

The maturation period can be reduced and the ADF achieved within a shorter timeframe by:

- Sourcing seed sludge with higher MLSS concentration (concentrate up at source).
- Sourcing fresh and suitable seed sludge.
- Increasing the volume of seed sludge used to commission the process:
- Multiple MBR tanks can be commissioned (if applicable).
- Seed sludge can be concentrated in the MBR tank by batch fill and permeation of the sludge.
- Additional seed sludge can be used during the maturation period.
- Ensuring there is sufficient organic and nutrient load to the plant to quickly build-up the MLSS concentration.

3.07 STRESS TESTING **<u>(Kubota Technician on site 3 trips and 15 days)</u>**

A. A Stress Test shall be conducted following the System Commissioning and maturation period to demonstrate the ability of the MBR System to meet specification requirements for Annual Average Flow, Maximum Month Flow and Peak Daily Flow as described in Table 2–1. MBT system shall also be stress tested at design flux rate and design solids concentration to verify performance.

B. The Supplier shall be responsible for performing the test and shall coordinate as necessary with the General Contractor staff.

C. A certified representative of the Supplier shall be onsite as reasonably required for the testing.

D. Testing shall not commence until the MBR System is operational and the biological process fully stabilized as indicated by the following:

1. Mixed liquor suspended solids concentrations in the reactor shall be greater than 8,000 mg/L but less than 13,000 mg/L.
2. No excessive foaming indicative of upset conditions.
3. Filterability in excess of 10 mL in 5 minutes.

E. All reactors shall undergo testing per Table 3–2. Conditions shall simulate rated Annual Average, MMF, PDF and PHF per Table 2–1 for the plant. During testing:

1. Membrane cleaning, as required, shall be performed after each phase of testing outlined in table 3–2 below.
2. Instantaneous flux, trans–membrane pressure, permeability, temperature and airflow shall be recorded at one-minute intervals.

Table 3-2: Testing Conditions for MBR System				
Testing	**Duration**	**# MBR**	**# SMU**	**Air Scour Rate (SCFM)**
Annual Average	30 days	All	All	Supplier to provide
Max Month	1 week	All	All	Supplier to provide
Peak Daily Flow (PDF)	24 hrs.	All	All	Supplier to provide
Peak Hourly Flow (PHF) (1)	24 hours	All	All	Supplier to provide

(1)- Max flow to MBR will be equalized to 8.0 MGD (5,600 gpm) through Equalization pump station

Note: *MBT system shall be tested separately to insure membranes can meet required WAS thickness with systems provided.*

3. The net (average) output during testing must be within 5% of target MMF and PDF to be considered successful.
4. Failure to pass the Stress Test shall result in an evaluation and retest of the system. A second failure shall require a remedy at the expense of the Supplier up to and including the installation of additional membrane equipment at no additional cost to the Owner.
5. Testing of the MBR membrane at the flux rate of 17.2 gpd/sf

<u>**Common issues encountered during I & C testing:**</u>

- Inaccurate or incomplete wiring of electrical systems.
- Improperly labeled wires.
- Incorrectly wired 24VDC circuits (reversed polarity).
- Wires loose in the terminal strip.
- Incorrectly wired valve actuators.
- 24VDC wire in the same conduit as higher voltage circuits.
- Reverse rotation of 3 phase equipment.
- Airflow meters are tightened onto their fittings without being properly positioned. These are compression fittings and once the ferrule has compressed the shaft of the meter they cannot be repositioned. Please install these units finger tight only.
- Grounding rings are not installed on mag-tube flow meters.
- Instrumentation installed with the visual display facing the wrong direction. Most displays are adjustable; please review the O&M for specific directions.

<u>**Common Wet Testing Issues**</u>

- Permeate piping leaks.
- MBR tank wall leaking.
- Permeate pump suction leaks.
- Foaming can occur during clean water phase.
- Reverse motor rotation.

Common Seeding Problems

- Failure to define a realistic seeding plan in advance of startup.
- Failure to plan for the issues noted previously.
- Insufficient volume of quality sludge readily available.
- Under estimation of volume and hauling cost of seed sludge.
- Difficulty introducing seed sludge through fine screens.
- Foaming can occur during seeding and early in the start-up process.
- Insufficient growth yield and process inconsistencies due to low influent biological loading or inaccurate influent load estimations.

3.08 TRAINING **(Kubota Technician on site 2 trips and 10 days)**

A. The MBR System Supplier shall provide Training in the maintenance and operation of all systems included in the Supplier's control system.

B. Training shall be completed prior to the completion of the System Commissioning. All training shall be performed by the Supplier or a factory–certified representative of the supplier or component supplier. Training is to include:

1. Navigation of all HMI screens and menus.
2. Review of automatic operations and controls.
3. Changing process set points
4. Overriding controls from the HMI
5. Manual operation of the system in the event of a power failure
6. Maintenance cleaning
7. Trouble shooting.

3.09 PROJECT SCHEDULE

A. The MBR System Supplier shall provide the Scope of Supply and associated services specified in this specification in accordance with the Table 3–1.

B. Firm dates for Deliverables as listed in Table 3–3 will be established by Engineer, Contractor, and Customer upon initiation of the project.

Table 3–3: Project Schedule

Deliverable	Due Date
Submittal Documentation	Ten (10) weeks after fully executed notice to proceed from the GC
Installation Documentation (IOM)	Two to Four (2–4) weeks prior to Equipment Delivery at Site
Equipment Delivery at Site	Twenty (20) weeks after receipt of Approved Submittals
Mechanical Inspection	Two (2) weeks prior to System Commissioning
System Commissioning	To be scheduled upon successful completion of Mechanical Inspection

Training	Training to be provided at the conclusion of the System Commissioning
Plant Operations Manual (POM)	Two to Four (4) weeks before completion of System Commissioning

3.10 SUPPLIER SERVICES

A. In addition to the time necessary to complete the requirements established within this specification and elsewhere within the Contract Documents, the MBR System Supplier shall provide up to <u>54 person–days</u> and minimum 13 on–site visits in support of the Services shown in Tables 3–4 and 3–5 <u>or as needed</u> to commission the plant process to successful results.

Table 3–4: MBR Design Services

Item	Service	Person Days	Estimated Trips	Notes
1	Design Meetings	NA	NA	Meetings to be at Engineer's facility
2	Weekly Status Conference Calls	NA	NA	For duration of the design scope

Table 3–5: MBR Project Execution Services

Item	Service	Person Days	Estimated Trips	Notes
1	Material Inspection During Delivery	4	2	Supplier to verify completed shipment of material at unload
2	Mechanical Inspection	5	2	Supplier to verify Correct Installation
3	Commissioning	15	3	Inclusive of clean water testing and seeding support/startup
4	Stress Testing	15	3	Meeting Parameters
5	Training	10	2	Training during Commissioning
6	Follow -Up @ 6 Month	5	1	Tune-up Controls

B. Time spent remedying equipment deficiencies/problems <u>shall not</u> count toward the listed durations and trips.

C. MBR System Supplier shall be given a minimum of two-week notice prior to the scheduling of any of the listed Services.

D. All service shall be provided by a factory representative or certified subcontractor.

END OF SECTION 45 50 00