SECTION 11011

MEMBRANE BIOREACTOR SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope
   1. Contractor shall provide all labor, materials, equipment and incidentals as shown, specified, and required to furnish and install an immersed membrane bioreactor (MBR) system for the treatment of wastewater complete and operational.
   2. Included, but not limited to, are the following components for each system:
      a. Membranes system with modules, racks, piping, and supports for the membrane racks and headers.
      b. Anchors systems.
      c. Vacuum eductors.
      d. Services during installation, startup, training, and process support.
   3. Membrane bioreactor system is specified in this Section but is provided as part of an overall system by the biological treatment system Supplier as specified in Section 11010, Biological Treatment System – General Provisions. The biological treatment system Supplier shall have overall system responsibility for the membrane bioreactor equipment as specified in this Section and shall be responsible for coordination and integration of the membrane bioreactor system into the overall biological treatment system. Overall system responsibility shall include field testing, start-up, training, calibration, and overall successful operation of the equipment.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the membrane bioreactor system Work.
   2. Notify other contractors in advance of the installation of the membrane bioreactor system to provide them with sufficient time for the installation of items included in their contracts that must be installed with, or before, the membrane bioreactor system Work.
   3. Supplier shall program the control equipment furnished under Section 11019 to meet the requirements of the membrane bioreactor system equipment detailed in the Functional Description.

C. Related Sections:
   1. Section 03300, Cast-In-Place Concrete.
   2. Section 03600, Grout.
   3. Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.
   4. Section 09900, Painting.

5. Section 11010, Biological Treatment System – General Provisions.
6. Section 11012, Process Aeration Equipment.
7. Section 11013, Residuals Reduction System.
8. Section 11014, Sodium Hypochlorite and Citric Acid Feed Equipment.
9. Section 11015, Compressed Air System.
10. Section 11016, Filtrate Pumps.
11. Section 11017, Biological Treatment System – Valves.
12. Section 11018, Biological Treatment System – Instrumentation.
13. Section 11019, Biological Treatment System – Controls, Interface, and Hardware.
14. Section 11020, Biological Treatment System – Functional Descriptions.
15. Section 11115, End Suction Pumps-Dry Pit.
16. Section 11426, Chemical Containment Equipment.
17. Section 11612, Rotary Positive Displacement Blowers.
18. Division 13, Applicable Sections on Instrumentation and Controls.
19. Section 13202, Polyethylene Tanks.
20. Section 14602, Hoisting Equipment.
21. Division 15, Sections on Piping and Valves.
22. Division 16, Electrical.

1.2 REFERENCES

A. Standards referenced in the Section are listed below:
   1. American National Standards Institute, (ANSI).
   2. National Electric Code, (NEC).
   3. ANSI B16.5 Pipe Flanges and Pipe Fittings.
   4. ASTM A312/A 312M, Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
   5. ASTM A36 Standard Specification for Structural Steel.

1.3 QUALITY ASSURANCE

A. Suppliers Qualifications:
   1. Supplier shall have a minimum of five years experience producing substantially similar equipment and shall be able to show evidence of at least five installations in satisfactory operation.
   2. All membranes, modules, and racks shall be manufactured in facilities that are ISO-9000 certified.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single biological treatment system Supplier.
   2. The biological treatment system Supplier shall review and approve or shall prepare all Shop Drawings and other submittals for all components furnished under this Section.

3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall assembly by the biological treatment system Supplier.

1.4 SUBMITTALS

A. Shop Drawings, Submit the following:
   1. Manufacturer's literature, data sheets, fabrication, assembly and mounting drawings of all components showing materials and significant dimensions in sufficient detail to demonstrate compliance with specified requirements, including information for the following components and systems:
      a. Membrane, modules, and racks.
      b. Vacuum eductors.
   2. Detailed drawings in plan and elevation of all equipment in the membrane tanks including all internal piping and all supporting systems. Drawings shall show relationships and connections to adjoining concrete work and other equipment and piping.
   3. Setting drawings, templates, and directions for the installation of anchor bolts, and other anchorage systems.
   4. The materials list should include a complete bill of materials for all equipment including: manufacturer of all components supplied, model numbers of all components supplied, capacity, weights of each item of equipment, and descriptive brochures.

B. Warranty:
   1. Submit Membrane Warranty as specified in Paragraph 1.6.
   2. Submit Membrane Module Price Warranty as specified in Paragraph 1.6.

C. Field Quality Control:
   1. System Conformance Test procedures and results.
   2. Submit a written report giving the results of the required field tests.
   3. Submit Supplier's Installation Certification Form as specified in Section 01732, Installation.

D. Instruction of Operations and Maintenance Personnel:
   1. Comply with the requirements of Section 01821.

E. Operation and Maintenance Data:
   1. Submit complete Installation, Operation and Maintenance Data, including, test reports, maintenance data and schedules, description of operation, and spare parts information.
   2. Furnish Operation and Maintenance Data in conformance with the requirements of Section 01781.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling and Unloading:
   1. Deliver materials to the Site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of that Work.

B. Storage and Protection:
   1. Contractor shall store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.
   2. Contractor shall store membranes modules indoors in a climate controlled building and protected from harm according to the Supplier's instructions. Protect modules from direct sunlight or other sources of UV radiation. Keep modules in Supplier's sealed packaging until installation.

C. Acceptance at Site:
   1. All boxes, crates and packages shall be inspected by Contractor upon delivery to the Site. Contractor shall notify Engineer, in writing, if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with Supplier's instructions.
   2. Contractor shall inspect membrane module packing upon delivery to Site. If the packaging seal has been broken, the membrane module shall not be used. Notify Engineer in writing of all damages and replace affected modules.

1.6 WARRANTY

A. Membrane Warranty:
   1. The biological treatment system Supplier shall warrant the membrane modules for a period of five years (60 months) beginning on the date of Substantial Completion or 42 months from the Date of Commencement, whichever is sooner ("Membrane Warranty Start Date"). Additionally, all other components of the membrane bioreactor system are subject to all warranty provisions of the Contract Documents.
   2. Remedy and Conditions: The Supplier shall provide replacement membrane modules per the repair and replacement schedule listed below under the following warranty conditions:
      a. If the membrane module(s) fail to meet the Suppliers standard integrity test and cannot be repaired.
      b. If the membrane module(s) fail to meet the design flux rates listed in Paragraph 2.1.B of this Section.
      c. If the membrane module(s) cause the system to exceed the effluent quality limits specified in Section 11010.
   3. Warranty Repair and Schedule: The Supplier shall provide replacement membrane modules according to the following schedule:

a. First 12 months: If a membrane module meets any of the above warranty conditions during the first 12 months from the Membrane Warranty Start Date, a replacement module shall be provided by the Supplier at no charge. Module repair and replacement shall include site visit, equipment removal, and equipment installation.
b. Subsequent 48 months: If a membrane module meets any of the above warranty conditions during the subsequent 48 months from the Membrane Warranty Start Date, a replacement module shall be provided by the Supplier and invoiced based upon a pro-rata value of a total of 60 months. Invoice amount shall be calculated by using either $1,734 per module or the prevailing list price, whichever is less, and reducing the price by one-sixtieth for each month remaining in the 60-month warranty period.

4. Exclusions: The Supplier shall not be liable to furnish replacement membrane modules under the following conditions:
   a. Unless written notice of the Warranty claim is received within the warranty period.
   b. If any person other than a representative of the Supplier has altered the membrane operating system without prior approval of the Supplier.
   c. For damages caused by the Owner causing or permitting the membrane modules to dry or to have moisture content below that specified in the operation and maintenance manual either during storage or operation.
   d. For damages or defects caused by unusual plant upsets, or other potential transients or undefined operating conditions that affect membrane performance or life, such as polymer dumps, inadvertent bypass of the influent screens, excessive rags or debris, and toxic wastes.
   e. For damages or defects caused by chemical or physical conditions such as (but not limited to) pH, temperature, chemicals, or climate factors outside the recommended operating parameters in the appropriate section of the operations and maintenance manual.
   f. If the mixed liquor suspended solids concentration exceeds a maximum of 14,500 mg/l in the membrane tank.
   g. Unless the total membrane permeability and influent and effluent flow rates are monitored and recorded.
   h. Unless the membranes undergo periodic chemical cleans, as specified in the Supplier's operation and maintenance manual.
   i. If neutralization and/or reduction of chemical cleaning solutions are performed in the membrane tank without written approval from the Siemens.
   j. Unless the influent, effluent, and mixed liquor parameters are monitored per the Supplier's operation and maintenance manual.
   k. Unless the capillary suction time (CST) is less than 100 seconds for mixed liquor entering the membrane tank.
   l. The warranties set forth herein are Supplier's sole and exclusive warranties. Supplier makes no other warranties of any kind, express or implied, including without limitation, any warranty of merchantability or fitness for purpose. Fulfillment by Supplier of its obligations under Section 11011, Paragraph 1.6 A.2., shall be the Owner's sole and

exclusive remedy against Supplier for any failure by Supplier to satisfy any requirement of this warranty. Except for such obligations identified in this Section, in no event shall supplier be liable for any damages of any nature whatsoever for any breach of this warranty, including without limitation any direct, indirect, consequential, incidental, special, punitive or other damages. The foregoing limitations apply regardless of whether the liabilities or damages arise or are alleged to arise under contract, tort, strict liability or any other theory.

B. Membrane Module Price Warranty:
   1. The Supplier shall warrant that the future replacement modules will be sold to Owner at market price, but not to exceed $1,734 escalated to the Consumer Price Index as described below, at any time within 20 years from Substantial Completion.
   2. The Membrane Module Price Warranty shall be subject to escalation equal to the change in the Consumer Price Index (CPI) – All Urban Consumers (US City Average). The base point for the CPI escalation calculation shall be the latest CPI index published as of the date of the Agreement. The comparison point for the CPI escalation calculation shall be the latest CPI index published as of the date when a replacement module order is placed.

PART 2 - PRODUCTS

2.1 EQUIPMENT PERFORMANCE

A. General:
   1. The membrane bioreactor (MBR) system shall use hollow-fiber membranes modules submerged within concrete tanks.
   2. During filtration, water shall be drawn through the membranes removing particulate matter at the surface of the membrane.
   3. Mixed liquor shall be continuously pumped into the membrane tank through a two-phase jet scrubbing system. The jet system shall use a combination of air and mixed liquor introduced at the base of the module to provide scouring efficiency to ensure solids do not build-up on the membrane surface.
   4. The concentrated return mixed liquor shall overflow the tank weir into a common trough where it will be returned back to the biological system.

B. Design Requirements:
   1. The MBR system shall produce the average daily flow rate (ADF) specified in Section 11010, Biological Treatment System – General Provisions with two tanks in operation and one in standby.
   2. Influent Characteristics: Refer to Section 11010, Biological Treatment System – General Provisions.
   3. Effluent Requirements: Refer to Section 11010, Biological Treatment System – General Provisions.

4. Design Flux Rates: The MBR system shall operate at the design flux rates listed below. These flux rates are instantaneous, temperature corrected values.
    a. At average daily flow rate (ADF) with two tanks in operation – 13.3 gallons per foot per day.
    b. At peak daily flow rate (PDF) with three tanks in operation – 26.4 gallons per foot per day.
    c. At peak hourly flow rate (PHF) with three tanks in operation – 26.4 gallons per foot per day.
5. Maximum Design Mixed Liquor Concentration at PHF – 14,500 mg/l.
6. Chemical Cleaning Requirements: The membrane system shall be capable of meeting the effluent requirements specified with the maximum cleaning requirements listed below.
    a. Sodium Hypochlorite Clean-In-Place: Once in every 90 days of in-service usage.
    b. Citric Acid Clean-In-Place: Once in every 90 days of in-service usage.
    c. Sodium Hypochlorite Maintenance Clean: Once in every 7 days of in-service usage.

C. Expansion Requirements:
1. The membrane equipment shall be manufactured to have the capability to add 17.5 percent additional membrane area in the future to reduce the operating flux rate if desired. All internal piping and systems shall be sized so that no other changes to the membrane equipment will be required if the additional membrane area is added in the future.
2. The addition of membrane modules in the future shall not require expansion or modification of the membrane support system.

2.2 SUPPLIERS

A. Supplier: Provide equipment by Siemens Water Technologies.

2.3 DETAILS OF CONSTRUCTION

A. General:
1. The membrane bioreactor system shall be provided complete, with all equipment, accessories, and appurtenances as specified in this Section and as necessary for a complete and operating installation.
2. Each membrane bioreactor tank shall include the following basic components as specified and shown on the Drawings.
    a. Two mixed liquor feed manifolds and lateral systems consisting of 17 laterals with 16 jet nozzles.
    b. Seventeen removable membrane rack assemblies, each with 16 membrane modules.
    c. Two air header and two filtrate header systems.
    d. Membrane rack supports, rails, and rack guides.

B. Membranes:
   1. Membranes shall be the hollow fiber type operating in an outside-in mode.
   2. Membranes shall be constructed of chemically resistant polyvinyldiflouride (PVDF) with a nominal pore size of 0.1 microns.
   3. Membranes shall be capable of being washed in acidic solutions with a pH as low as 2.0 for a period of 10 hours.
   4. Membranes shall be capable of being washed in 1,500 mg/l chlorine solution with a pH as high as 10.0 for a period of 10 hours.
   5. Membrane fibers shall be a polymeric monolith. The fiber shall be self-supporting and homogeneous with no backing material.

C. Membrane Modules:
   1. Assemble membrane fibers into serviceable membrane modules.
   2. Membrane modules shall be constructed such that the membranes are held vertically and bonded firmly at the top and bottom of the modules. Seal at both ends with polyurethane potting material.
   3. The modules shall be connected to allow filtrate to be withdrawn from the top end of each module.
   4. The modules shall be constructed so that only one end shall allow filtrate to be withdrawn from the module.
   5. Slots shall be provided in the base of the module to allow mixed liquor to flow into the fiber bundles and around the fibers during operation.

D. Membrane Racks:
   1. Assemble membrane modules into membrane racks to manifold the modules together.
   2. Each rack shall include a filtrate and air header and a mixing chamber for air and mixed liquor.
   3. Each rack shall be individually replaceable and isolatable from the remainder of the system without the use of valves.
   4. Each membrane rack frame shall be fitted with a lifting eye at each end to allow the entire membrane rack to be lifted into and out of the membrane tank.

E. Membrane Supports:
   1. All membrane supports shall be fabricated of 304L stainless steel.
   2. Supports shall be designed to carry the load of wet membrane racks.
   3. Each support shall have a guide and locking mechanism to secure and assure alignment of each membrane tank.

F. Filtrate System:
   1. Provide two suction headers per membrane tank for filtrate collection.
   2. Each rack in the tank shall be connected to the suction header.
   3. The pipe connections between the membrane modules and the manifold header shall be capable of operating at the positive and negative pressures expected of the system.

G. Mixed Liquor Feed System:
   1. Mixed liquor shall be fed into the membrane tanks through jet nozzles beneath the base of each module for two-phase fluid transfer.

H. Air Scour System:
   1. Membrane system shall supply air to the bottom of the membrane modules in order to allow agitation of the membrane surface. Air nozzles shall be constructed of PVC.

I. Membrane Integrity Test System:
   1. Membrane system shall be capable of testing for leaks in the membrane equipment when a turbidity excursion occurs. On-line turbidity analyzers to monitor effluent quality and membrane integrity are specified in Section 11018.

J. Piping:
   1. The membrane bioreactor system Supplier shall furnish all piping within the internal limits of the membrane tanks.
      a. Piping for the mixed liquor header, filtrate header, and air header shall be 304L SS conforming to the requirements of Section 15063.
      b. Nozzle laterals and filtrate piping from the membrane racks to the filtrate headers shall be Schedule 80 PVC conforming to the requirements of Section 15067.
      c. Air connections from the membrane rack to the air header shall be industrial grade hose.
   2. Terminate all piping with ANSI standard flanges.
   3. Design all piping for flow velocities less than 10 feet per second under pressurized conditions, and less than 5 fps under vacuum conditions.
   4. All piping that conveys chemicals shall be chemically resistant.

K. Vacuum Eductor System:
   1. Provide a vacuum eductor system for each filtrate header system to prime the filtrate suction header and piping. Each vacuum eductor system shall include a priming eductor, a high level switch, and a compressed air solenoid valve.
   2. The priming system shall operate at the start of each relaxation, clean-in-place, and maintenance clean sequence before filtration recommences.
   3. Required pressure feed shall be 87 psi with an air consumption of 16.1 scfm.
   4. The eductor system shall be resistant to chemical corrosion with stainless steel wetted parts for the solenoid valve, level switch, and priming eductor.
   5. Priming eductor construction:
      a. NBR vacuum seals.
      b. Push on connector for compressed air, through-flow silencer, and mounting brackets.
      c. Temperature range: -4 to 176 degrees F.
      d. Stainless steel wetted parts.
      e. Manufacturer: PIAB.
   6. Maximum noise level for the system shall be 65 dBA.

7. Solenoid valves shall be Type 1 as specified in Section 11017.
8. Level switches shall be Vibrating Fork Type as specified in Section 11018.

L. Compressed Air System: The compressed air system for the membrane bioreactor system shall be furnished by the membrane Supplier and is specified in Section 11015, Compressed Air System.

M. Filtrate Pumps: The filtrate pumps for the membrane bioreactor system shall be furnished by the membrane Supplier and is specified in Section 11016, Filtrate Pumps.

N. Valves: Valves for the membrane bioreactor system that shall be furnished by the membrane Supplier are specified in Section 11017, Biological Treatment System – Valves.

2.4 CHEMICAL CLEANING SYSTEMS

A. The Supplier shall integrate a complete and automatic membrane cleaning system designed to restore and maintain the membrane bioreactor system performance by reducing and controlling the transmembrane pressure. The system shall be designed to clean the membrane modules in place without requiring their disconnection or removal from the tanks. The chemical cleaning system shall be made up of the following cleaning procedures and systems.
   1. Clean-In-Place Chemical Cleaning System:
      a. Cleaning shall be fully automatic. Initiation of the clean-in-place cleaning process shall be either by a scheduled event from the PLC system, or by an operator initiated command. Upon completion of the cleaning process, the system shall automatically return to normal operation.
      b. The required frequency for clean-in-place cleaning shall be no more often than as specified in Article 2.1 of this Section.
      c. Clean-in-place cleanings shall be performed with the following chemical solutions:
         1) Sodium hypochlorite at 1,500 ppm.
         2) Citric acid at 2 percent w/w.
   2. Maintenance Clean Chemical Cleaning System:
      a. Cleaning shall be fully automatic. Initiation of the maintenance cleaning process shall be by an operator initiated command when prompted. Upon completion of the cleaning process, the system shall automatically return to normal operation.
      b. The required frequency for maintenance cleaning shall be no more often than as specified in Article 2.1 of this Section.
      c. Maintenance cleanings shall be performed with 300 ppm sodium hypochlorite and shall require no more than 2.5 gpm per module.
   3. Storage-In-Place System:
      a. Membrane storage shall be fully automatic. Initiation of the storage cleaning process shall be by an operator initiated command. The system

shall automatically return to normal operation upon completion of the storage process by an operator initiated command.

b. Storage-in-place cleanings shall be performed with 5 to 10 ppm sodium hypochlorite solution.

B. The chemical feed system for membrane cleaning are specified in Section 11014, Sodium Hypochlorite and Citric Acid Feed Equipment.

2.5 ANCHORS BOLTS

A. Furnish anchor bolts, adhesive anchors, and nuts of ample size and strength for the purpose intended, sized by the equipment Supplier. Anchors for the filtrate header, air header, mixed liquor header, nozzle lateral assemblies, and membrane supports shall be furnished by the equipment Supplier. Anchor bolt materials shall be of stainless steel conforming to the requirements of Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.

2.6 PROCESS CONTROLS AND INSTRUMENTATION

A. The operating strategy of the membrane bioreactor system shall be as specified in Section 11020 and include the following operating modes as a minimum:
   1. Filtration (normal operation).
   2. Filtration Standby.
   3. Filtration Recirculation.
   4. Membrane Relaxation.
   5. Maintenance Clean.
   6. Clean-In-Place.
   7. Storage-In-Place.

B. Process instrumentation for the membrane bioreactor system is specified in Sections 11018, Biological Treatment System – Instrumentation.

C. Process control system for the membrane bioreactor system is specified in Section 11019, Biological Treatment System – Controls, Interface, and Hardware.

2.7 TOOLS AND SPARE PARTS

A. Furnish and deliver the following spare parts boxed and labeled.
   1. Spreader Bar- for rack assembly removal.
   2. Rack Maintenance Stand.
   3. Rack Release Tool-for unlocking rack hold-down nut.
   4. Pin/Leak Repair Tube-for module pin repair.

B. Spare parts shall be packed in clearly identified sturdy containers and shall be stored in a dry, warm location until transferred to the Owner at the conclusion of the Project.

C. The Supplier shall provide all special tools required for the routine operation or maintenance of the membrane system including all hand tools required for membrane removal.

2.8 SHOP PAINTING

A. Surface preparation and painting shall conform to the requirements of Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSPECTON

A. Inspect and verify that structures or surfaces on which the equipment shall be installed have no defects which shall adversely affect installation.

B. Inspect all equipment prior to installation.

C. Promptly report defects, which may affect the Work to the Engineer.

3.2 INSTALLATION

A. Install equipment in accordance with the details shown on the Drawings, Shop Drawings, and the Supplier's instructions.

B. Provide piping and coordinate equipment drains with floor penetrations.

C. Supplier's representative shall check and approve the installation prior to operation. Check shall include verifying dimensions and ensuring that anchorage devices and reinforcing required are correctly installed and located. Supplier's representative shall certify the proper installation of all components. Supplier's representative shall field test and calibrate the equipment to assure that the system operates to the Owner's satisfaction.

3.3 FIELD PAINTING

A. Field painting shall conform to the requirements of Section 09900, Painting. Do not paint stainless steel surfaces.

3.4 FIELD QUALITY CONTROL

A. All equipment will be given running tests by Contractor at the job Site following installation of the equipment and controls. Should the tests indicate any malfunction, Contractor shall make any necessary repairs and adjustments. Such tests and adjustments shall be repeated until, in the opinion of the Engineer, the installation is complete and the equipment is functioning properly and accurately, and is ready for permanent operation.

B. A factory trained representative of the Supplier shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services as specified in Section 11010, Biological Treatment System – General Provisions. Supplier's representative shall test operate the system in the presence of the Engineer and verify that the equipment conforms to the requirements.
   1. Field test all modes of operation to ensure a complete, acceptable system. Include all operating modes and all failure modes to verify that associated equipment will shutdown and alarm as required.
   2. System Conformance Test:
      a. Prior to startup, the Contractor under the direction of the Supplier shall conduct a comprehensive System Conformance Test for the membrane bioreactor system and controls.
      b. Test shall demonstrate that the membrane bioreactor system and controls are properly installed and functioning and verify all interfaces with control alarms and monitoring devices.
      c. Supplier shall direct tests, analyze all data, and certify the System Conformance Test has been completed and is acceptable.
      d. Test shall be conducted for 24 consecutive hours.
      e. Supplier shall develop and submit test procedures for review and approval. Test shall not begin until the test procedures have been approved by the Engineer.
      f. Owner and Engineer may observe all tests and shall be given 10 days notice of tests prior to test date.

++ END OF SECTION ++