SECTION 11489

DUAL MEMBRANE DIGESTER GAS STORAGE SYSTEM

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, and test one (1) dual membrane gas storage system on a ground-mounted, concrete pad near the anaerobic digester complex as specified herein and shown on the Drawings.

B. Equipment shall be provided in accordance with the requirements of Section 11000, Equipment General Provisions.

C. The storage system shall be furnished and installed complete with outer air supported sealing membrane, inner floating gas membrane, bottom protection membrane, air supply system, air pressure control system with safety devices, mounting hardware, and electrical controls. The membranes shall be sealed to the concrete equipment curb at the gas storage pad.

D. This specification sets forth the minimum essential characteristics and requirements for the dual membrane air pressurized digester gas storage system for this project. Included in this specification are the structural, material, component performance and installation requirements.

E. The Contractor shall be responsible for coordinating work in this Section with related work specified elsewhere in this Contract so as to provide all assemblies, hardware, appurtenances, transition pieces and accessories for complete and fully functional installation.

1.02 DESIGN REQUIREMENTS

A. The gas storage system shall be designed for mounting on a new 30 foot internal dia. concrete, ground-mounted, pad as indicated on the plans.

B. The minimum usable gas storage volume for each gas storage system shall be at least 7,000 cubic ft. in a half-sphere configuration.

C. The storage system shall be designed to permit digester gas to be stored and maintained automatically at a preset constant operating pressure, as the stored gas volume varies on demand. The system will accommodate gas inflow rates of up to 250 cfm and gas withdrawal rates of up to 250 cfm.

D. The operating pressure for the system shall be adjustable from a minimum of 8-inches w.c. to a maximum of 12-inches w.c. Adjustment shall merely involve setting the air system pressure control system to the desired operating pressure.

E. The gas storage system shall be designed to withstand a maximum pressure of 14-inches w.c., or a pressure increase of up to 2.0-inches w.c. above the selected operating pressure, to allow proper operation of waste gas and emergency relief systems.

F. The gas storage system shall be designed to withstand wind loads of up to 120 mph at the across the full operating pressure range as described herein.

G. All components of the system in contact with digester gas shall either be made of materials which are not significantly affected by the normal constituents of this gas or shall be given a protective coating resistant to these constituents.

1.03 SUBMITTALS

A. Shop Drawings shall be submitted in accordance with Section 01300, Submittals; and Section 11000, Equipment General Provisions. In addition to the requirements of the above sections, the following information shall be provided:

1. Complete design data and calculations for each digester gas storage system including air supply calculations for system headloss and pipe sizing.

2. Drawings and details of the gas storage system including detailed mounting and anchor bolt size and materials.

3. Documentation that the equipment manufacturer meets the experience requirements detailed herein.

1.04 WARRANTY AND GUARANTEE

A. Warranty and Guarantee shall be as specified in Section 11000 with the exception that the warranty period for the mechanical equipment specified within this section shall be for two (2) years. The warranty period for the inner and outer membrane as specified within this section shall be for five (5) years.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. The gas storage system shall be as manufactured by Evoqua (Dystor) Water Technologies LLC of Waukesha, Wisconsin; WesTech Engineering Inc. Model DMT (DuoSphere), of Salt Lake City, or approved equal.

B. The equipment manufacturer shall have not less than ten (10) years of experience in the application, design, and manufacture of dual membrane anaerobic digester storage systems for wastewater treatment plants and submit a list of not less than twenty-five (25) operating installations as evidence of meeting the experience requirement.

C. The manufacturer of the dual membrane anaerobic digester gas storage system shall assume sole responsibility for the design and shall provide the services of a qualified manufacturer's technical representative for installation and testing of the system.

2.02 DESCRIPTION

A. Each membrane style gas holder system shall consist of an outer, air supported sealing membrane, an inner floating gas membrane, floor membrane, air supply system, air pressure control system with safety devices, and electrical controls. The membranes shall be sealed to the top of a gas storage concrete pad.

B. An air chamber shall be formed between the outer air membrane and the floating gas membrane. A gas storage chamber shall be formed between the floating gas membrane and floor mounted membrane on the surface of concrete storage pad.

C. A small fan shall be used to pressurize the air chamber. An air pressure control valve in the fan discharge line shall maintain the air chamber pressure at the required operating pressure, as set by the operator of the system. The force of the air chamber pressure on the gas membrane shall keep the gas operating pressure essentially the same as air pressure until the gas storage chamber is either full or empty.

D. The system shall include controls to either continue to run the fan (continuous purge systems) or cycle the fan (non-continuous purge systems) to maintain the air chamber at operational pressure even when the system is empty. Alarms shall be provided to warn of differential pressure or vacuum conditions that could damage the gas holder or could let air into the digester gas system. A gas detector shall be provided to monitor the air chamber or air outlet for the presence of methane.

E. Flame traps with thermal shut-off valves, shall be provided in accordance with the requirements of Section 11486, Digester Gas Safety Equipment and shall be installed in the air supply and air purge ducting to protect against flame propagation from an external source in the event of a gas membrane failure as noted on the Contract Drawings.

2.03 MEMBRANE SYSTEM AND APPURTENANCES

A. Air Membrane

1. The outer air/sealing membrane shall be fabricated from a high strength vinyl coated polyester fabric specifically designed for air supported structures, tension structures, and other high stress membrane applications. The PVC coating shall be specially compounded to provide long fabric life through high resistance to abrasion, weathering and ultraviolet rays.

2. The base fabric shall have a weave structure of tire cord strength polyester yarns. The finished coated fabric shall have a nominal weight of not less than 31 oz./sq. yd.

3. The air membrane material shall have a minimum warp/fill tongue tear strength of 214/180 pounds and a minimum strip tensile strength of 646/562 lbs/inch. The minimum adhesion shall be 11 lbs/inch.

4. The fabric shall be furnished with a polymer alloy top finish to prevent plasticizer migration and to provide improved weatherability, abrasion resistance and cleanability.

5. The air membrane shall be specially fabricated, using proven techniques for air supported structures, so that the fabric stress will not exceed 50 lbs/inch at the maximum design pressure, including wind loads and for the operation of waste gas burners and other excess gas handling systems.

6. All seams shall be made by heat, induction welding or high frequency welding. Sewing in this area will not be acceptable.

7. The air membrane color shall be sandstone or white.

8. One (1) inspection window made from lexan shall be installed on the external membrane. The opening and clamping shall be supported by a cord edge.

B. Gas Membrane

1. The gas membrane shall be fabricated from a material that is highly resistant to the normal constituents of digester gas. Furthermore, the material shall be specifically produced for biogas applications by the manufacturer. The material shall consist of a polyester base fabric with a PVC coating.

2. The base fabric shall have a weave structure of tire cord strength polyester yarns. The finished coated fabric shall have a nominal weight of not less than 31 oz./sq. yd.

3. The gas membrane material shall have a minimum warp/fill tongue tear strength of 213/180 pounds and a minimum strip tensile strength of 730/640 lbs/inch. The minimum adhesion shall be 20 lbs/inch.

4. The fabric shall be furnished with a polymer alloy top finish to prevent plasticizer migration and to provide improved weatherability, abrasion resistance and cleanability.

5. The gas membrane shall be specially fabricated using proven techniques for air supported structures, so that the fabric stress will not exceed 50 lbs/inch at the maximum design pressure, including wind loads and for the operation of waste gas burners and other excess gas handling systems.

6. Membrane Fabrication shall be conducted using Radio Frequency (RF) Welding. Localized hot-air welding, or induction welding, are acceptable where RF Welding is not possible.

C. Floor Mounted Membrane

1. The floor mounted membrane shall meet all requirements of the gas membrane as described above.

D. Membrane Seals

1. At the mounting wall, the membranes shall be sealed by a common seal arrangement, using layers of neoprene on either side of each membrane.

2. The seal shall be held in place on top of the mounting wall by 4 inch wide Type 304 stainless steel **or aluminum** clamping bars. Clamping bar anchors shall be Type 304 stainless steel adhesive type with Type 304 stainless steel washers and nuts.

3. The seal shall be designed to provide a minimum compression load of 30 psi over the entire seal area.

E. Membrane Anchorages

1. All steel design, for the membrane anchorages, shall be in accordance with the AISC Manual of Steel Construction, latest edition, and the International Building Code (IBC), latest edition.

2. The air (outer), gas (inner) and floor membranes shall have common anchorage and seal arrangements, as indicated on the drawings.

3. Manufacturer shall provide the anchor bolt spacing, bolt size, and embedment depth. The Contractor shall be responsible for providing and installing the anchor bolts per the Manufacturer's instructions.

F. Metal Materials

1. All steel plates shall conform to ASTM A36. All structural steel shapes with shape series of M, MT, S, ST, C, MC, and L shall conform to ASTM A36. Structural shapes W, WT, and HP shall conform to ASTM A992/ A572. All pipe to be ASTM A53, grade B. All stainless steel shall be type 304. Steel members in contact with liquids, either continuously or intermittently, shall have a minimum thickness of 1/4". All aluminum shall be type 5052, 6061, or 6063 alloy unless noted.

2. Steel fabrication and welding shall be in accordance with the latest edition of the Structural Welding Code, AWS D1.1, D1.6, and D1.2, of the American Welding Society (AWS). All welded connections shall develop the full strength of the connected elements and all joined or lapped surfaces shall be completely seal welded with a minimum 3/16 inch fillet weld. Intermittent welding shall not be allowed.

3. Sharp projections of cut or sheared edges of ferrous metals shall be ground to a radius by multiple passes of a power grinder as required to eliminate sharp edges that may damage the membranes and to ensure satisfactory coating adherence.

G. Stored Gas Volume Detection

1. The gasholder system shall be provided with the capability to provide operating personnel with an approximate reading of the amount of gas stored. The amount of gas stored is defined as the difference between; a.) the gas below the gas (inner) membrane and b.) the concrete pad floor elevation.

2. The volume of gas stored shall be determined by the use of a laser level sensor, ultrasonic or rope length transmitter mounted in the top of the air supported membrane.

3. The signals from the laser level transmitters will be correlated to provide a reading of the gas storage volume which can be called up on the graphical user interface.

4. Membrane level detection – Laser, ultrasonic or rope length transmitter shall be located on the air (outer) membrane in a location as recommended by the Manufacturer for optimum instrument performance. The transducer shall be aimed at the gas (inner) membrane as recommended by the Manufacturer. The transmitter shall produce a 4-20 mA output signal to the system control panel based upon the position of the membrane. The signal shall be correlated to an approximate volume of gas stored. The transmitter shall be suitable for operation in a classified (Class 1, Division 1, group D) space.

2.04 AIR SYSTEM COMPONENTS

A. Fans

1. Two air fans per membrane cover shall be furnished for providing system pressure. Each fan shall be rated to deliver 290 cfm at a 16-inches w.c. discharge pressure, based on standard inlet conditions**.**

2. Each fan shall include a TEFC, 3.0 hp (maximum), 3500 rpm, 230/460 volt, 3 phase, 60 Hertz motor.

3. Fan construction shall include an all welded steel housing and mounting frame with manufacturer's standard finish inside and out. Fans shall be provided with AMCA "B" spark resistant construction, including a riveted or welded aluminum alloy wheel and non-ferrous through plate.

4. Flexible connectors shall be installed between the fan and the air piping.

5. All fans and motors shall be painted as specified in Section 09900 - Coatings.

6. Air supply line to the gas holder shall be equipped with a check valve or other means to prevent deflation of the air chamber during a loss of power event. Valve material shall be Type 304 stainless steel.

B. Inlet Filter

1. A filter shall be provided on the fan inlet. The filter shall be provided with a washable, interchangeable, polyurethane pre-filter and polyester element having a nominal removal efficiency of 99% for 10 micron particles.

2. The filter housing shall be carbon steel with manufacturer's standard finish inside and out.

C. Air Pressure Control and Safety Relief Valve

1. A pressure relief valve shall be furnished for controlling the air membrane operating pressure and protect the membranes against over-pressurization. Valve type, size and location shall be as recommended by the manufacturer. Valve material shall be Type 304 or Type 316 stainless steel.

2. The valve shall be adjustable in 0.25-inch w.c. increments through a minimum operating range from 6-inches w.c. to 12-inches w.c.

3. If a diaphragm-type valve is used, the lower side of the diaphragm housing shall be provided with a connection (including a flame check) for ½-inch OD Type 316 stainless steel tubing that shall be connected to the air chamber. The upper side of the diaphragm housing shall have a connection for venting to atmosphere.

D. Pressure Gauges

1. Pressure gauges shall be provided at the discharge of each fan and at the air pressure control valve. The gauges shall be in accordance with the requirements of Section 17650, Pressure Gauges.

2. Gauges at the fan discharge shall have a range of 0-20-inches w.c. The gauge at the control valve shall have a range of 0-15-inches w.c.

E. Air System Piping

1. All rigid air system piping shall be as noted in Section 15390, Schedules and shall be furnished and installed by the Contractor per the manufacturer's recommendations.

2. Pressure control tubing, if required for manufacturer's system, shall be ½-inch Type 316 stainless steel and shall be provided by the Contractor.

F. Air Purge System

1. For non-continuous purge systems, a purge line shall be connected to the air membrane and be controlled by an actuated butterfly valve. The control panel will cause this valve to be opened and closed, as necessary should the following conditions arise:

   a. Digester gas is detected in levels exceeding the % LEL limit within the air space, based on signals from the Gas Detection System as provided by the Manufacturer.

   b. Differential pressures inside the digester put the inner membrane or supports at risk due to a high or low differential.

2. If, after purging, the high % LEL condition remains, the system will enter high alarm status.

3. The butterfly valve shall be sized by the manufacturer and installed in the air discharge piping of each gas holder to serve as a pressure purge valve. The valve shall be provided with a motorized operator (El-o-matic series EL, or equal)

in an enclosure suitable for the classification of the area in which the motorized operator is installed.

4. A 1-inch bypass line shall be installed around the air purge valve to allow a small amount of air to continually vent from the air chamber so that it can be monitored for the presence of methane gas. The bypass line shall be provided with a solenoid valve and isolation ball valves.

5. If the system is continuously purged via blowing excess air through the air chamber, then additional air purge (including automated valve and bypass) is not required. Methane detection shall be as specified elsewhere in this section. Air pressure within the membrane shall be controlled via a weighted check valve. Valve shall be of the weighted check type and shall be made of Type 304 stainless steel. Valve shall be sized and located as recommended by the manufacturer.

G. Flame Traps

1. The inlet and discharge piping to the air chamber shall be provided with 4-inch flame trap assemblies.

2. Flame traps shall be provided in accordance with Section 11486, Digester Gas Safety Equipment.

H. Pressure/Vacuum Relief Assembly

1. Two (2) combination pressure/vacuum relief valves with flame arrestors shall be provided with a safety selector valve on the gas supply piping as shown on the Drawings. Components shall be provided in accordance with Section 11486, Digester Gas Safety Equipment

2.05 AIR SYSTEM CONTROLS

A. Pressure Transmitters

1. Pressure transmitters, rated for installation in a Class I Division 1 hazardous location, shall be provided for monitoring air and gas chamber pressures. Pressure transmitters shall conform to the requirements of Section 17760, Pressure Indicating Transmitters.

2. Each transmitter shall provide a 4-20 mA output signal to the PLC in the air system control panel.

B. Methane Sensor and Transmitter

1. A methane sensor shall be provided to detect the presence of methane in the air leaving the air chamber. The sensing head and transmitter shall be mounted in the air purge valve by pass line or at the pressure regulating valve and shall be provided in accordance with the requirements of Section 17851, Gas Monitoring Systems.

2. The transmitter shall provide a 4-20 mA signal to the PLC in the air system control panel, based on a methane concentration range of 0-100% LEL.

2.06 AIR SYSTEM CONTROL PANEL

A. A complete air system control panel in a NEMA 4X enclosure shall be furnished by the manufacturer of the membrane gas holder system, for installation by the Contractor. The panel shall include motor starters for the fans and all other hardware, wiring and appurtenances to facilitate a complete and working system. The panel shall be installed in a non-hazardous area as shown on the Drawings. The control panel shall be UL-508 listed and shall also be in accordance with specification Section 16902, Electric Controls and Relays.

B. The panel shall incorporate an Allen Bradley ControlLogix or CompactLogix Programmable Logic Controller (PLC) to control the system. The PLC shall have an Ethernet/IP communication port and shall transmit all system data to the Owner's SCADA system.

C. A panel-mounted graphical Operator Interface shall be provided for entering operator selectable functions and operating variables, such as fan or purge valve status, timer settings and gas detector alarm levels. The Operator Interface shall also provide a continuous display of the gas and air chamber pressures, plus the concentration of gas (in percent LEL) detected by the gas sensor and transmitter. Operator interface shall be Allen-Bradley PanelView Plus 6 terminal.

D. The PLC shall provide the following minimum control logic.

1. For non-continuously purged systems, the selected lead fan for the gas holder system in the automatic mode shall operate and the purge valve shall be closed. The selected standby fan shall remain idle unless the lead fan motor overload is tripped. If a fan motor overload is tripped, an indicator on the face of the panel shall be activated The air chamber shall be inflated to the operating pressure set by the pressure control valve, pressurizing the gas chamber to the same pressure. The purge valve bypass line solenoid valve shall be open when either fan is running. For continuously purged systems, the selected lead fan in the automatic mode shall operate to maintain air pressure within the system.

2. Until gas storage is depleted during normal operation, gas pressure will be slightly higher than air pressure due to the added distributed weight of the gas membrane. As gas storage reaches depletion, gas pressure will begin to drop until it is below the air chamber pressure. When gas pressure drops to the same level as air pressure, or the gas membrane sensing instruments indicates that no gas is stored, a "STORAGE EMPTY" signal shall cause an indicator on the face of the panel to be activated. When gas pressure reaches a level of 0.5-inches w.c. below the air chamber pressure, the signal shall also stop the fan and open the purge valve to relieve air chamber pressure.

3. For non-continuously purged system, once the air chamber pressure has been relieved to a level of 0.35-inches w.c. above gas pressure, the purge valve shall close and a fan restart delay timer, adjustable from 0 to 9 minutes, shall be

energized. After the restart delay timer has timed out, the fan shall restart, again pressurizing the air and gas chambers.

4. Should gas pressure drop to 0.75-inches w.c. below the air chamber pressure, a "DIFFERENTIAL PRESSURE ALARM" signal shall activate an indicating light on the face of the panel and energize a remote alarm strobe mounted on the north exterior wall of the associated building. The alarm shall be provided with a manual reset. NEMA 4X alarm strobe shall be provided by the manufacturer.

5. When the air chamber has been depleted (maximum gas storage), gas pressure will rise above the air chamber pressure. When gas pressure reaches a point approximately 0.75-inches w.c. above the air chamber pressure, or the gas membrane sensing instruments indicates that the gas membrane is full, a "STORAGE FULL" signal shall light an indicator on the face of the control panel.

6. When air pressure rises above a setpoint in the control system, an “AIR PRESSURE HIGH” signal shall be generated and displayed on the operator interface.

7. When air pressure drops below a setpoint in the control system, an “AIR PRESSURE LOW” signal shall be generated and displayed on the operator interface.

8. For non-continuously purged systems, if at any time the concentration of methane in the air discharge line of the gas holder reaches a preset point of approximately 35% of the lower explosive limit (LEL), the purge valve shall be opened without stopping the fan. A timer shall keep the purge valve open for a period, adjustable up to 99 minutes, allowing the fan to purge the air chamber. If, after this period, the methane concentration has not dropped below the set point, an indicating light on the panel shall be activated and the remote alarm strobe shall be activated. If, at any time, the methane concentration reaches 60% of the LEL, an indicating light on the panel shall be activated and the remote alarm strobe shall be activated.

9. For continuously purged systems, if the concentration of methane in the air discharge line of the gas holder reaches a preset point of approximately 35% of the lower explosive limit (LEL), for a duration longer than a timer, adjustable up to 99 minutes, an indicating light on the panel shall be activated and the remote alarm strobe shall be activated. If, at any time, the methane concentration reaches 60% of the LEL, an indicating light on the panel shall be activated and the remote alarm strobe shall be activated.

E. Eight sets of isolated contacts shall be provided in the control panel for use by the Owner to interlock equipment of his choice with the operation of the membrane gas holder system. The contacts shall be individually programmable via the operator interface to allow them to be energized by the following conditions: Gas Storage Full, Gas Storage Empty, Gas Alarm, Gas Detector Alarm, and Pressure Transmitter Alarms. The Form C contacts shall be able to be programmed to de-energize either instantaneously or after a period of time (up to 999 minutes) selected by the operator via the operator interface.

PART 3 -- EXECUTION

3.01 MANUFACTURER'S FIELD SERVICES

A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 11000, Equipment General Provisions and shall include the following site visits for each cover:

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	5
Startup and Training	1	2
Services after Startup	1	1

3.02 SHOP TESTING

A. Shop testing shall be in accordance with Section 11000, Equipment General Provisions and with the following additional requirements:

1. Biaxial Tests: Perform biaxial tests on the membranes under load. This involves tensioning a standard fabric piece in both the warp and weft (fill) directions and ascertaining the permanent stretching under various loads. This information must then be used to guide out patterning data to avoid wrinkles or blemishes in the membrane structure.

2. Weld Strength Test: Test a welded test strip to destruction to ensure the weld is stronger than the fabric itself. Manufacturer must submit a report to document this testing.

3. Weld Inflation Test (If Required by Manufacturer): Inflate every welded panel seam to at least 85 psi along a central test air channel (designed into each weld) to ensure that there are no faults in the weld. Manufacturer must submit a report to document this testing.

3.03 INSTALLATION AND FIELD TESTING

A. The dual membrane digester cover shall be installed by the equipment manufacturer in accordance with the plans and specifications and the manufacturers recommendations.

B. Leak testing of the membrane seals shall be performed by the system installer and witnessed by the Owner or their representative.

C. With the gas line closed, the air system fan shall be used to blow air into the gas storage chamber through the test connection provided on the gas takeoff piping. After the unit has been inflated, the test connection shall be capped and the fan connected to the air chamber.

D. Once the cables have been properly aligned, the gas and air chambers shall then be pressurized to the maximum design operating pressure by installing the proper weights on the air pressure control valve and pressure/vacuum relief valve.

E. A soapsuds solution shall then be applied to the membrane seals around the foundation walls. Any area of the seals observed to be leaking shall be resealed.

F. Functional testing of each equipment component and the entire gas storage system shall be completed as required in Section 01650, Start-Up and Field Testing.

- END OF SECTION –