SECTION 11610 – BIOFILTER

PART 1 GENERAL

1.01 EXTENT OF WORK

A. The work to be done under this Section consists of furnishing all materials, labor, tools and equipment, and performing all operations necessary to complete the construction of one biofilter and associated air exhaust fan for odor control, the equipment and appurtenances as shown on the Contract Drawings and as specified herein.

B. The work includes furnishing and installing one air exhaust fan with sound proof enclosure, FRP transition ducts and flexible connections at inlet and outlet of fan, exhaust air distribution headers, laterals, located within the biofilter bed, filter media, stone, HDPE geomembrane, filtrate collection and drainage systems, humidification nozzles, water piping and manholes, sprinkler system, including electric controls, valve boxes, pressure gauges and any other materials or equipment as shown on the Contract Drawings and as specified herein.

C. The biofilter media shall be Biosorbens® manufactured by Biorem. The media shall be purchased from Biorem Environmental, Inc., Victor, NY by the Contractor. The purchase price of the media and services furnished by the media manufacturer as described in this Section of the specifications and indicated on the Contract Drawings has been prenegotiated and is included in the Schedule of Prices and Appendix A of Section 01025 – Measurement and Payment. Proposed alternatives will not be accepted. The Contractor shall include all work and costs associated with receiving, storage and installation of this media in the lump sum cost in the Schedule of Prices.

D. The Contractor is required to enter into an agreement with Biorem Environmental, Inc., for the media and services specified herein within 30 days of the Notice to Proceed.

1.02 WORK NOT INCLUDED

A. The following items of work are not included in this Section but, when performed under other Sections, shall conform to applicable requirements stated herein.

1. Concrete is specified in Section 03300 – CAST-IN-PLACE CONCRETE.

2. Finish painting after installation is specified in Section 09900 - PAINTING.

3. The ductwork and appurtenances for the biofilter except as specified under 1.01 B above, are specified in Section 15500 – ODOR CONTROL PIPING, VALVES AND APPURTENANCES.

4. All excavation and backfill required for construction of the biofilter system is specified in Section 02200 – EARTHWORK.

5. All plumbing fixtures, valves, fittings, drains and appurtenances are specified in Section 15412 – PLUMBING.

6. Electrical items are specified in Section 16013 – ELECTRICAL.

1.03 SUBMITTALS

Submittals shall be made as required in Section 01300 – SUBMITTALS. The following specific information shall be provided:

A. Shop Drawings.

1. Shop Fabricated Piping: Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coating, field connection details, and other pertinent information.

2. General Arrangement Drawings: ¼-inch scale drawings showing the layout, general arrangement, and grades for the biofilter. These drawings shall include all irrigation and humidification water piping, odorous air distribution header and piping, moisture control system components, air supply fan, sound proof enclosure, drainage piping and connections, flow meter and pressure gauges.

3. Product literature to provide a complete description of the system.

4. Drawings, catalog information and cut sheets, and performance data.

5. Complete electrical wiring and schematic diagrams, motor and drive details, and pertinent information shall be submitted.

B. Samples. Submit upon delivery sample of stone and biofilter media materials.

C. Quality Control Submittals.

1. Submit gradation and other test results to confirm that media conforms to the requirements of these specifications, including:

a. A letter from the Biofilter Media Supplier certifying that the media has been placed in accordance with the Specifications and the Biofilter Media Supplier's requirements.

b. Sieve analysis of stone.

c. Written description of Geomembrane Manufacturer's and installer's formal programs for manufacturing, fabricating, handling, installing, seaming, testing and repairing geomembrane.

d. Geomembrane installer's Certification of Subsurface Acceptability.

e. Independent Laboratory test results for geomembrane.

2. Pipe Manufacturer's Certificate of Compliance.

3. Submit functional and performance test certificates and reports.

D. Performance Test Submittals:

1. Submit a detailed Performance Testing Plan which includes:

a. Test equipment and apparatus.

b. Calibration and setup procedures.

c. The specific testing methodology to be used.

d. The sampling and analysis procedures.

2. Submit a final report that provides a narrative of the sampling activities, one copy of the original sample log, photographs showing the locations of the velocity and flow measurements, tabular summary of the data, calculated and laboratory results, and conclusions of these results.

1.04 OPERATION AND MAINTENANCE

A. The Contractor/Supplier shall furnish 4 copies of an operation and maintenance manual for equipment supplied. The manuals shall be prepared specifically for this installation and shall include all required catalog cuts, drawings, equipment lists, description etc. that are required to instruct operating and maintenance personnel unfamiliar with such equipment.

1.05 DELIVERY, STORAGE AND HANDLING

A. In accordance with Division 1, and:

1. HDPE Main Air Header: Avoid damage to the welded 12-inch HDPE stub connections.

2. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

3. Media Storage: The BIOSORBENS® biofilter media shall be delivered in bulk (end dump truck) and shall be stored on a clean and level surface. Avoid cross-contamination of foreign materials during handling and placement. Media shall be covered if stored longer than one week.

4. Individually package each sheet of geomembrane and protect from damage during shipment. Mark each package with identification of material type, size and weight.

1.06 GUARANTEE

A. Guarantee for the biofilter system shall be in accordance with the requirements of the General Conditions – Article 38.

B. The odor control equipment shall be guaranteed to perform as follows:

1. Emissions from the biofilter shall conform with all applicable local, state and federal air pollution control regulations, when operated under the design conditions.

2. The concentration of hydrogen sulfide in the outlet air shall not exceed 0.1 ppm when inlet hydrogen sulfide concentrations are between 1 and 10 ppm. At inlet hydrogen sulfide concentrations greater than 10 ppm, the outlet hydrogen sulfide concentration shall not exceed 1% of the inlet concentration. The odor level in the exhaust emissions from the biofilter shall meet the following performance criteria:

3. The concentration of odor threshold shall not exceed 300 D/T using European standards (20 liter per minute sniff rate) when inlet odor concentrations are 3,000 D/T or less. At inlet odor concentrations greater than 3,000 D/T, the outlet odor concentration shall not exceed 10% of the inlet concentration.

4. The performance tests shall be as described in PART 3 of this Section and other parts of these Specifications.

1.07 LICENSES AND FEES

A. The Contractor shall provide to the Owner all necessary licenses and permits to install and operate the biofilter media as specified in this Section of the Specifications. All fees associated with obtaining licenses and permits shall be paid for by the Contractor. The Contractor must show evidence of compliance with all licensing requirements prior to the submittal of shop drawings for the biofilter system.

1.08 WARRANTY

A. The biofilter media supplier shall warranty the useful life of the biofilter media for a period of 10 years from the date of successful completion of the first biofilter performance test that the biofilter media conform to these specifications and are free from defects. The biofilter media supplier warrants that the biofilter media will not compact, degrade or decompose and comply with contaminant removal efficiency as discussed under Paragraph 1.06 of this Section during the 10 year warranty period provided that the system is operated with the media supplier's printed instruction requirements. The media supplier shall repair or replace the media, at the sole option of and at no cost to the Owner, if the media does not perform to the specified requirements of this specification within said Warranty Period. Such repair and replacement shall include the cost of removal and reinstallation.

1.09 DESIGN CRITERIA

A. Odor Control System – In-Ground Biofilter

Air Flow Rate, scfm	10,000 – 30,000 (variable speed)
Inlet Air Temperature	50 - 100EF ±
Ambient Air Temperature	-30 - 120EF ±
Contaminants	Hydrogen sulfide, reduced organic sulfur compounds and Others
Hydrogen Sulfide, ppm	
Avg. Inlet Concentration	1 - 10
Peak Inlet Concentration	20
Removal Efficiency for Hydrogen Sulfide	99% (Also see Section 1.06)
Odor Level, D/T (Outlet)	300
Avg. Inlet Odor Level	2,000 – 3,700
Minimum Odor Removal Efficiency	See Section 1.06
Biofilter Type	In-Ground

Biofilter Dimensions	
Dimensions	40’ x 52’
Media Depth	6’
Media Volume	12,500 ft^3
EBRT	25 seconds
Type of Media	Biosorbens – Supplied by Biorem
Air Plenum	Header/Laterals and stone – as shown on Contract Drawings
Humidification System	
No. of Nozzles	2
Type of Nozzles	Spiral Impingement
Capacity	3.3 gpm each
Sprinkler System	
No. of Nozzles	10
Capacity	42.2 gpm at 90’ head
EXHAUST FAN (including back draft dampers and transition ductwork)	
Type	Centrifugal, variable speed
No.	1
VARIABLE FREQUENCY DRIVE	
No.	1
HP	75
PRESSURE DROP	
Inlet Vacuum, Max. in	5
Discharge Pressure Drop, in	5
Additional Safety, in	2
Total Pressure Drop, w.g., inch	12
Fan Horsepower, hp	75
Maximum Flow Rate, scfm	30,000
Maximum rpm	
ACCESSORIES	
Differential Pressure Gauges – Biofilter	3 @ 0 – 15” WC
Humidification Water Flowmeter	1
Pressure Gauges – Sprinkler Water	1 @ 0 – 100 psi
Pressure Gauges – Humidification Water	1 @ 0 – 100 psi

PART 2 PRODUCTS

2.01 BIOFILTER MEDIA

A. Biofilter media shall be BIOSORBENS® as supplied by Biorem.

1. The BIOSORBENS® media shall consist of inorganic, inert hydrophilic cores uniform in shape. The media size shall be ¼-inch by ¾-inch.

2. The biofilter media shall not shrink or swell with varying moisture contents.

3. The biofilter media shall be formulated with nutrients, buffering agents and adsorbents.

4. The biofilter media pressure drop shall not exceed ½-inch water column per foot of depth upon system startup.

B. Plenum Zone Material:

1. The stone shall be smooth (not broken) washed and non-reactive, conforming to the following gradation:

Sieve Size	Percent Passing by Weight
1 inch	100
¾ inch	90 - 100
½ inch	10 - 50
3/8 inch	0 - 20
No. 4	0 - 5
No. 8	0

2. Materials with an acid solubility greater than 5 percent shall not be acceptable.

C. HDPE Geomembrane:

1. Composition: High density polyethylene (HDPE) containing no plasticizers, fillers, extenders, reclaimed polymers, or chemical additives, except following:

a. Approximately 3 percent by weight of carbon black resin for ultraviolet resistance.

b. Antioxidants and heat stabilizers, not to exceed 1.5 percent total BY WEIGHT, may be added as required for manufacturing.

2. Furnish in rolled single-ply continuous sheets. No field seams other than boots allowed.

3. Sheet Thickness: 24 mils, minimum (average).

4. Roll Length: Longest that will be manageable and reduce field seams.

5. Meet Manufacturer's most recent published specifications and required minimum values in this table.

Property	Required Value	Test Method
Weight per square yard	12 ounces per square yard (± 10%)	ASTM D1910
Smooth-Surface, Minimum Properties, Each Direction		
Tensile Strength (Grab Method)	449 pounds	ASTM D751
Elongation to Break	29%	
Thickness, Nominal, plus or minus 5%	24-mil (average)	
Puncture Resistance	642 pounds	ASTM D751
Tear Strength	74 pounds/inch	ASTM D751
Moisture Vapor Transmission	0.046 grams/meter^2/ 24 hours	ASTM E96B
Permeability	0.00	ASTM D4491

6. Extrudate for Fusion Welding of HDPE Geomembranes: Formulated from same HDPE resin as geomembrane and shall meet applicable physical property requirements.

7. Boots:

a. Fabricated from same material as geomembrane sheets to fit around penetrations, i.e. pipe, without folds, stretching, or unsupported areas.

b. Flanges: Angle shall match the angle of the slope or bottom where the penetration passes through the liner, widths shall be minimum 2 feet plus diameter of penetration.

8. Sealant Caulking:

a. Two-component sealant formulated of 100 percent polyurethane elastomer.

b. Manufacturer: United Coatings; Epoxy Systems, Inc., or equal.

9. Stainless Steel Bands: As manufactured by Breeze Clamp Products, Saltsburg, PA; Band-It IDEX, Inc., Denver, CO; or equal.

10. Neoprene Rubber Pad:

a. 35 to 45 durometer, in accordance with ASTM D2240 hardness.

b. Manufacturer: Aero Rubber Co., Inc., Bridgeview, IL; Chamberlin Rubber Co., Rochester, NY; or equal.

11. Quality Control:

a. Independent Testing Agency certified in the State of New Hampshire and 5 years' experience in the field of geomembrane testing.

b. Test geomembrane actually used as evidence of compliance with specifications herein.

2.02 ODOROUS AIR PIPING

A. Pipe lengths, prefabricated main air header pipes, and fittings shall be supplied by a single manufacturer.

B. Protection shall be provided against ultraviolet light degradation using carbon black, not less than 2 percent, well dispersed in the resin.

C. Main Air Header Pipes:

1. Main air header pipes shall be HDPE pipe meeting all requirements of AASHTO M294, Type S. Contractor to provide transition coupling to FRP ductwork as shown on Drawings.

2. Manufacturer shall weld stubs onto the main air header pipes for the 12-inch HDPE lateral connections. Stubs shall be positioned such that lateral centerline is equal to header centerline.

a. Stubs shall consist of a short length of 12-inch SDR 32.5 HDPE welded flush into the header pipe and a short length of 12-inch corrugated HDPE welded onto the other end.

b. Total length of the stub shall not exceed 18 inches.

c. No stubs shall be welded at a bell and spigot joint.

d. Stub spacing shall be approximately 2'-0" apart, as per the Contract Drawings.

3. The main header shall be 42" inside diameter corrugated HDPE pipe.

D. Air Distribution Laterals and Equalization Header:

1. Laterals shall be 12-inch outside diameter and 10-inch inside diameter corrugated and slotted HDPE pipe meeting all requirements of AASHTO M252, Type CP.

2. Slot size and quantity shall be as shown on the Contract Drawings.

3. Joints: HDPE bell and spigot joints with rubber gaskets per ASTM F477.

E. Main Biofilter Bed Drain:

1. 6-inch diameter smooth and perforated HDPE pipe meeting requirements of AASHTO M252, Type SP.

2. Joints: HDPE bell and spigot joints with rubber gaskets per ASTM F479.

F. Fittings: Snap type or factory welded with HDPE welds per manufacturer's standard procedures and requirements.

G. Manufacturer: Advanced Drainage Systems (ADS), Inc., Spirolite Corporation, or equal.

2.03 SPRINKLER SYSTEM

A. The biofilter system shall include a sprinkler system for moisture control of the activated media using either city water (CW) or plant water (PW). The sprinkler system shall be segregated into independent zones if necessary. Each sprinkler system zone shall include sprinkler nozzles, piping and automatic control valve.

B. The layout and design of the sprinkler system, and the number of sprinkler system zones shall be as shown on the Contract Drawings. The design shall include

components conforming to the requirements specified in this section. The design of the system shall incorporate provisions for cold weather operation. All sprinkler system piping shall be sloped back to a system drain valve as shown on the Contract Drawings.

C. Sprinkler Nozzle: The sprinkler nozzles shall be riser-mounted impact heads with an adjustable coverage from 20 to 340 degrees. Sprinklers shall have distance control diffuser to allow up to 25 percent radius reduction without changing nozzles. Sprinklers shall be Rainbird, Orbit, or approved equal.

D. Control Valve: The sprinkler control valves shall be control type valves, sized as indicated on the Drawings. Valves shall be supplied with 24V ac coil and fail closed on a loss of power. Provide purple flow control handle for nonpotable water service. Rainbird, Orbit, or approved equal.

E. Pipe: PVC pipe conforming to ASTM D2411; 200 psi pressure rated upstream from controls, 160 psi downstream; solvent welded sockets.

F. Water Supply Rotameter: The direct reading rotameter shall be a variable area type with a Teflon float, EPR "O" rings, and PVC fittings. The rotameter shall be of the same size as the pipe in which it is installed. The rotameter shall have a direct reading scale.

G. Pressure Gauges: Pressure gauges for installation on the irrigation system shall be magnehelic differential pressure gauges and shall be housed in a PVC casing; rated for pressures from 0-20" Hg; ambient temperature range of 20° to 140°F; accurate to plus or minus 2% of full scale. Standard accessories to be supplied shall include two NPT plugs for duplicate pressure taps, two pipe thread to rubber tubing adaptors, three flush mounting adaptors with screws and all other required mounting accessories.

2.04 EXHAUST FAN

A. Exhaust Fan: Fan shall have fiberglass reinforced plastic centrifugal backward inclined impeller. The wheel shall be dynamically balanced. Resin shall be suitable for exposure to the specific service conditions. The shaft shall be carbon steel and shall have a FRP sleeve. The shaft seal shall be neoprene suitable for this application. Fan shall be suitable for operation in a Class 1, Division 1 area.

B. Bearings shall be heavy duty, self aligning grease lubricated ball type with minimum of 50,000 hour L10 life. OSHA approved belt guard and shaft guard shall be provided. Motor shall be high-efficiency, TEFC with a 1.15 service factor and suitable for 3/60/460V. The motor shall be inverter duty rated. Fan shall be belt driven.

C. Fan housing shall be constructed of fiberglass and reinforced with rigid bracing to increase structural integrity. Bearing support brackets shall be positioned to directly oppose belt tension forces. Fan housing shall be a curved scroll design with a 1-inch drain connection at the bottom of the fan scroll. The fan inlet and outlet shall have a flanged nozzle.

D. The fan shall be equipped with a variable frequency drive and designed for the following specified requirements:

Exhaust Fan Design Requirements	Max. Speed
Air Flow Rate, cfm	30,000
Max. S.P. up to Biofilter Inlet, in. WC	12.0 ±
Max. Total Pressure Drop, in. WC	12.54 ±
Motor HP	75.0

E. Flexible Connectors

1. Provide flanged expansion joint for outlet of fan to FRP duct transition piece. The flange drilling shall be coordinated with fan and transition.

2. Type: W-design configuration with integral flanges suitable for service with FRP duct.

3. The properties of the flexible connectors shall be as follows: Material shall be EPDM. Material shall be resistant to ultraviolet light degradation and shall be suitable for contact with odorous air as specified herein. The backing rings shall be 1/4-inch thick, 2 in. wide, type 304 stainless steel. The length from flange-to-flange shall be 6 in. unless shown otherwise. The extension shall be 1 inch, compression shall be 2 inches, lateral offset shall be 2.5 inches and the thickness shall be 1/4-inch minimum.

F. The fan shall be anchored to a concrete pad without vibration isolators.

G. The motor shall be manufactured by WEG, Baldor, Reliance or approved equal. Fan motor shall be suitable for operation in a Class 1, Division 2 area.

H. Fan shall be Greenheck, Hartzell, New York Blower or equal. The fan shall have an AMCA seal for Sound and Air Performance.

I. The maximum noise level within 3 feet from the fan operating at its full capacity (maximum flow and maximum head) shall not exceed 85 dBA without the enclosure.

J. Fan shall have bolted fiberglass access door.

2.05 ACCOUSTICAL ENCLOSURE

A. Provide the sound enclosure of materials compatible with the environment in which it is operating and enclosing the entire machinery package.

B. Sound enclosure shall be manufactured by Siemens; Unger Technologies, Inc., or equal.

C. Fabricate the exterior of the enclosure of fiberglass with a gel-coat consisting of polyester resin, a white pigment, and an ultraviolet light inhibitor.

D. Provide an enclosure of unitized welded, bolted or screwed panel construction with wind load, live load, snow load and seismic requirements as described below:

a. Wind load limit anchored - 100 mph.

b. Live load 200 psf.

c. Snow load limit - 35 psf.

d. Seismic zone No. 3.

E. Access Covers and Doors:

1. Provide hinged access to covers or doors on all sides of the enclosure with lockable latches, locks and keys, 2 sets.

2. Checking, changing belts and adding lubricant to be capable of being performed without unmounting or removing enclosure and without the use of tools to open the enclosure.

F. Cooling and Insulation:

1. Interior surface of the enclosure: 2-inch urethane foam with a protective film that is washable and free of perforations and/or materials that would accumulate oil and dust.

2. Provide air circulation fan and reversing acting thermostat.

3. Maximum noise level at 3 feet from enclosure with fan operating at its full capacity (maximum flow and maximum head) shall not exceed: 80 dB(A).

2.06 SYSTEM CONTROLS

A. General:

1. Provide field panels, electrical components and wiring for a complete, functional system.

2. Provide all items which are not specifically specified which are required to implement the specified functions and the functions required for proper system operation.

B. Field Panels:

1. The electrical control panel shall provide electrical control for the air supply fan and sprinkler system. A 480V AC feed shall be supplied to the panel for use to power the system. A 480 to 120 volt fused control transformer shall be provided in the panel for system control power.

2. Provide field panels as described herein.

3. Panel shall contain the local control and monitoring for the odor control system components.

4. Provide Type 316 stainless steel NEMA 3R field panel for fan control.

5. The control panel enclosure for the sprinkler control valves shall be of fiberglass construction and rated Nema 4X. The panel shall be mounted to the assembly and factory tested to full operation with all other components prior to shipment.

6. Operator Controls and Indicators: As a minimum, the following operator interface functions and displays shall be provided on the sprinkler panel:

a. HAND/OFF/AUTO hand switches for each irrigate control valve.

b. System Automatic Operation:

1) Master HAND/OFF/AUTO selector switch in the AUTO position.

2) Irrigation timer controller to start irrigation system based upon preset irrigation cycle program.

7. Power Supply: 120 volts, single-phase.

a. Provide control power transformer as necessary.

C. Control Components:

1. Sprinkler Timer Controller:

a. 120-volt, single-phase input.

b. 24-volt output.

c. Minimum of two independent programs, with eight start times each.

c. 365-day calendar with leap year intelligence.

d. Programmable rain delay.

e. Minimum of four stations.

f. Transformer for operation of solenoids.

g. Surge protection, UL listed.

h. Suitable for outdoor installation.

i. Rainbird, Orbit or equal.

D. Functional Description: When in AUTO mode, timer controller will send a 24-volt signal to sprinkler control valve and open the valve.

E. Pressure Gauges: Pressure gauges shall be provided for the sprinkler system and for measuring the headloss across the biofilter media. Standard accessories to be supplied shall include two NPT plugs for duplicate pressure taps, two pipe thread

to rubber tubing adaptors, three flush mounting adaptors with screws and all other required mounting accessories. Magnehelic pressure gauges shall have a range of 0 – 20" WC. Pressure gauges shall be supplied with diaphragm seals and flushing ports. Gauges shall be 4 ½" face, 0 – 100 PSIG, with stainless diaphragm seals. Gauge process pipe and fittings shall be 1" NPT stainless steel with bleed valve and flushing port.

2.07 MOTOR STARTER

A. A local control panel with a variable frequency drive (VFD) for the fan shall be provided. Fuse protection for all motor circuits shall be included. One spare fuse of each size and type shall be provided.

B. General

1. The drive for the biofilter fan shall be a variable frequency drive, interlocked line and load isolation contactors, line reactors, and harmonic filter. The variable frequency drive shall be an AC pulse width modulated inverter type adjustable frequency variable speed drive or herein identified as AC drive for use with NEMA B design, AC motors.

2. The VFD's shall be Allen Bradley, E-T-N Cutler Hammer, or Siemens.

C. Submittals

1. Complete wiring diagrams and enclosure outline and assembly arrangement drawings shall be furnished for review before assembly of the AC drives shall commence. Drawings shall include front and side views of enclosures with overall dimensions and weights shown, conduit entrance locations and requirements, and nameplate legends.

2. Two each standard operation and maintenance instructions manuals shall be furnished for each horsepower size of AC drive.

3. Standard catalog sheets showing voltage, horsepower and current ratings; dimensions and enclosure details shall be furnished for each AC drive provided. Catalog items proposed shall be flagged on catalog data sheets provided.

4. A detailed list of replacement circuit cards, fuses and power components shall be provided with part numbers and pricing information for each drive horsepower size.

D. Quality assurance

1. Every AC drive unit shall be designed, constructed and tested in accordance with NEMA, UL, NEC, VDE and IEC recommendations.

2. Every AC drive and all supplied options shall be UL approved and listed according to Electric Industrial Control Equipment Specification UL 508C. The controller shall have a UL listed label attached inside the enclosure as verification.

3. Every AC drive shall be tested with an actual motor load and temperature cycled within an environmental chamber at 104º F (40º C). The frequency output and voltage will be varied throughout the test. Documentation shall be furnished to verify successful completion.

E. Variable frequency drive

1. General Description

a. The AC drive shall convert the input AC circuit breaker or motor circuit protector mains power to an adjustable frequency and voltage. The output frequency and voltage of the AC drive shall be adjustable to maintain a constant V/Hz ratio throughout the operating range.

b. The rectifier stage shall convert fixed voltage, fixed frequency, ac line power to fixed dc voltage. The input power section shall utilize a full wave bridge design incorporating diode rectifiers. The dc bus voltage shall be filtered. The rectifier shall be sensitive to the phase rotation of the AC line.

c. The inverter shall change fixed dc voltage to variable frequency AC. The inverter section shall utilize isolated gate bipolar transistors (IGBTs) or intelligent power modules (IPMs) as required by the current rating of the motor.

d. The AC drive shall be capable of operating into an open circuit without damage in order to facilitate start-up/maintenance.

e. The drive shall be provided with a 3% line.

f. The drive shall be provided with NEMA rated interlocked input and output contactors selectable from a selector switch labeled “Variable Frequency Drive – with Bypass”.

g. The output of the assembly shall be provided with motor thermal

overload protection sized to suit the motor provided.

2. Ratings

a. The AC drive shall be designed to operate from an input voltage of 460 + 15% vac.

b. The AC drive shall operate from an input frequency range from 47.5 to 63 hertz.

c. The AC drive unit and not just the fuses shall be rated for installation in a power system capable of delivering up to 65,000 RMS symmetrical amperes.

d. The output frequency shall be from 0.1 to 60 Hz.

e. The output carrier frequency of the drive shall be randomly modulated and selectable at 2 kHz, 4 kHz or 10 kHz depending on the drive rating for low noise operation. No drive with an operable carrier frequency above 10 kHz will be allowed.

f. The minimum displacement power factor shall be .98 lagging under any speed of load condition.

g. The AC drive efficiency shall not be less than 96 percent at full speed and load.

h. Storage temperature range shall be -25º C to +70º C (-13º F to 158º F).

i. The AC drives shall be designed to operate in an ambient temperature 0º C to 40º C (32º F to 104º F).

j. Installation at altitudes less than 3,300 feet above sea level shall not require derating. Locations in higher altitudes will require the AC drives to be rated according to the manufacturers heat rise and test information.

k. Maximum relative humidity shall be 95%, at 40 C, non-condensing.

l. The AC drive shall meet IEC 68-2-6 vibration specification.

4. Adjustments

a. The acceleration and deceleration ramp rates shall be adjustable from 0.2 to 990 seconds.

b. The overload trip shall be adjustable from 0.5 - 115% of rated output current. Set at motor nameplate full load amps.

c. The current limit shall be adjustable from 5 - 110% of rated output current to maximize starting torque.

d. The voltage boost shall be adjustable from 100 to 400% of nominal V/Hz ratio at 1 Hz tapering to 100% at 20 Hz.

e. The AC drive shall be capable of providing a control for adjusting the minimum frequency setting 0 to 60 Hz and a maximum operating frequency adjustable over a range of 25 to 60 Hz.

f. Programmable frequency lockout ranges to prevent the VFD from operating at an unstable speed.

g. Programmable preset speeds.

5. Protection

a. An input circuit breaker or motor circuit protector shall be supplied to provide NEC required branch circuit protection. The breaker shall have a door interlocked external operator.

b. Current limiting fuses shall be installed in the controller input.

c. A non-adjustable instantaneous overcurrent trip shall provide.

d. Protection of the drive shall be capable of being accomplished without the use of fast acting semiconductor output fuses. Subjecting the controller to any of the following conditions shall activate fuseless electronic protective circuits and eliminate component failure or the need for fuse replacement:

1) Short circuit at AC drive output
2) Ground fault at AC drive output
3) Open circuit at AC drive output
4) Short circuits on internal supplies and on logic and analog outputs
5) Input undervoltage

6) Input overvoltage
7) Loss of input phase
8) AC line switching transients
9) Instantaneous overload
10) Sustained overload exceeding 100% of controller rated current
11) Overtemperature

e. Solid state motor overload protection shall be included such that motor speed as well as time and current are included in the protection algorithm.

f. The AC drive shall have a minimum of power loss ride-through of 200 Msec. The drive shall have a user-defined option of frequency fold back to increase the duration of power loss ride-through. It shall also have a selectable ride through function, which will allow the logic to maintain control without faulting.

6. Control Options

a. All operator control options shall be mounted to the front panel, which is integral to the AC drive.

1) Manual speed potentiometer.
2) 3 position Hand-Off-Auto (HOA) selector switch.
3) 3 position VFD-OFF-BYPASS selector switch.
4) The controller shall accept an input signal of 4-20 ma as an automatic speed reference signal.
5) A drive run relay shall provide voltage free Form C output contacts.
6) A drive fault relay shall provide voltage free Form C output contacts.
7) Logic connections shall be furnished on pull apart terminal strips.
8) The drive shall provide a 4-20 ma speed output signal

7. Operation Features

a. The AC drive shall be factory set for manual reset after the first protective circuit trip for a malfunction (loss of power, short circuit, ground fault, memory failure, transistor short circuit, or open transistor). Automatic restart with fault lockout shall provide a reset to allow the controller to restart automatically when configured in two wire start/stop control. The AC drive shall attempt to restart up to 5 programmable restarts after a fixed time delay. If the drive faults

again within 28 seconds, a manual restart will be required.

b. A synchronized restart shall be provided that will catch a spinning motor by sensing the motor frequency and rotational direction and synchronize the AC drive's output prior to restarting.

8. Operator Interface

a. The operator interface terminal shall provide for the modification of AC drive adjustments via a touch keypad. All electrical values, configuration parameters, I/O assignments, parameter adjustments, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics shall be in plain English.

b. The display shall be a high resolution, LCD backlighted screen capable of displaying graphics such as bar graphs as well as six lines of twenty-one alphanumeric characters.

c. The AC drive model number, torque type, software revision number, horsepower, output current, motor frequency and motor voltage shall all be listed on the drive identification display as viewed on the LCD display.

d. The display shall be configured to display one or two bargraphs with numeric data that are selectable and scaleable by the operator. A user defined label function shall be available. As a minimum the selectable outputs shall consist of speed reference, output frequency, output current, motor torque, output power, output voltage, line voltage, DC voltage, motor thermal state, drive thermal state, elapsed time, motor speed, machine speed reference and machine speed.

e. A single keystroke scrolling function shall allow dynamic switching between display variables.

f. The terminal keypad shall consist of programmable function keys. The function shall allow both operating commands and programming options to be present by the operator. A hardware selector switch shall allow the terminal keypad to be locked out from unauthorized personnel.

g. The operator terminal shall offer a general menu consisting of parameter setting, I/O map, fault history and drive configuration. A software lock shall limit access to the main menu. The main menu shall consist of keypad configuration, drive configuration, general configuration, diagnostic mode and drive initialization screens.

h. There shall be arrow keys that will provide the ability to scroll through menus and screens, select or activate functions or increase the value of a selected parameter.

i. A data entry key shall allow the user to confirm a selected menu, numeric value or allow selection between multiple choices.

j. An escape key shall allow a parameter to return the existing value if adjustment is no required and the value is displayed. The escape function shall also return to a previous menu display.

k. A RUN key and a STOP key shall command a normal starting and stopping as programmed when the AC drive is in keypad control mode.

l. The AC drive shall have three LEDs mounted on the front panel to indicate functional status. A green LED will verify the AC drive power is on. A red LED indicator will indicate an AC drive fault. A yellow LED indicator will designate a pending fault condition.

m. Operator control and set-up functions will include the following:

1) Drive Parameters:

- Nominal Current, Motor Full Load Amps
- Nominal Frequency
- Nominal Voltage
- Torque Type
- Profile
- Damping
- Rotation Normalization
- Current Limit

2) Control Parameters:

- Maximum Frequency
- Low Speed Limit
- High Speed Limit
- Acceleration Time
- Deceleration Time
- Acceleration Type
- Deceleration Type
- Skip Frequencies
- Control Type

3) Application Function

- Setpoint Memory
- Speed Reference
- Auto Manual
- Controlled Stop

F. Solid State Reduced Voltage Starter Units.

1. The solid-state reduced voltage starter shall consist of two silicon-controlled rectifiers (SCRs) in a reverse parallel configuration per phase. The power section shall have three clamped semiconductor stacks that are forced air cooled by integral fans. The three power modules shall have individual heatsink assemblies. The controller mounting flange shall have grounding provisions. The power section shall operate at 480 volts, 3 phase, 60 hertz. Metal oxide varistors for transient protection shall be provided on the line terminals. A built-in circuit breaker and isolating contactor shall be included.

2. The starter shall provide ramp starting and stopping of a three-phase induction motor. The controller shall provide the following starting modes:

   a. Current limit.

   b. Full voltage.

3. The microcomputer shall analyze the motor variables and generate control commands that shall control the motor in such a way to reduce the possibility of surges occurring in the system. Starting time shall be adjustable from 1 to 30 seconds; stopping shall be adjustable from 2 to 120 seconds.

4. The controller shall be designed to meet the applicable requirements of UL, NEMA, IEC and IEEE.

5. The power section shall consist of three clamped semiconductor stacks that are forced air cooled by integral fans. Each semiconductor stack shall have individual heat sink assemblies. The controller mounting flange shall have grounding provisions. Metal oxide varistors for transient protection shall be furnished and installed on the line terminals. The power section shall be capable of centrifugal pump duty of 300 percent for 30 seconds. The SCRs shall have a minimum repetitive inverse voltage rating of 1400 volts at 480 volts. The metal oxide varistors shall have a minimum rating of 80 joules. The controller shall be provided with an energy saving feature that shall automatically cause the voltage of the power module to be reduced during times when the motor is unloaded or lightly loaded. The energy saver shall

be defeatable. Line and load terminals shall be provided with a terminal cover.

6. The control module shall be designed for integral mounting on the power section. The control module shall incorporate a microcomputer and shall drive the power semiconductors located in the power section. The logic shall be designed to operate at 85-265 volts, 50 to 60 hertz. A control circuit transformer connected to the incoming line shall be provided. Acceleration ramp time shall be adjustable from 1 to 30 seconds. Initial torque shall be adjustable via a rotary switch with 10 settings from 5 percent to 90 percent of locked rotor torque. Deceleration ramp time shall be rotary digital switch selectable with 9 settings of soft step from 2 to 120 seconds. This feature shall be field defeatable. Protection shall be provided during starting and running modes for start fault, line fault, temperature fault and stalled motor. Dual function LED indicators shall be provided for advisory status and fault annunciation. LEDs shall consist of:

   Control Voltage Present
   Starting
   Running
   Energy Saver
   Stopping
   Fault
   Start Fault
   Stalled Motor
   Temperature Fault
   Line Fault

7. Whenever the device is turned off or a fault condition arises, the power semiconductors shall turn off. The logic section shall contain Form C auxiliary contacts, N.O. and N.C., switch selectable, for customer use. Quantity as required by Contract Drawings.

G. Harmonic Filter

1. General

   a. The harmonic filter shall treat all of the characteristic low frequency harmonics generated by a 3-phase, 6-pulse rectifier load including the 5th, 7th, 11th, 13th, 17th, etc.

   b. The three phase characteristics shall be suppressed without the need for tuning the filter or adjusting capacitors, inductors or other components.

c. Harmonic mitigation shall be a passive, series connected, low pass filter network consisting of inductors and capacitors plus damping resistors to prevent the possibility of filter excitation and resonance.

d. Harmonic attenuation shall be accomplished without the need for phase shifting loads against other harmonic sources.

e. The harmonic filter shall be suitable for use with 6-pulse drives, whether the rectifier consists of diodes or SCR's and whether or not the drives have internal inductance such as line reactors or DC link chokers.

f. The filter shall be suitable for use with variable torque loads.

g. The filter shall suppress characteristic harmonics to guaranteed levels provided that the power supply line voltage unbalance is between 0 percent and 1 percent. If the voltage unbalance is between 1 percent and 3 percent, per ANSI C84.1-1995, the total input harmonic current distortion at any reduced load condition shall not exceed the full load THID by more than 50 percent.

2. Electrical Ratings

a. Voltage (3-phase): 480 volts (+/- 10 percent)
40 HP, 30 KW, 52-Ampere input

b. Power: 75HP, 56KW, 129-Ampere input and
150HP, 112KW, 202-Ampere input

c Frequency: 60 hertz (+/- 0.75 hertz)

3. Applicable Standards

a. The filter shall allow a 6-pulse rectifier load to achieve compliance with both the current and voltage harmonic distortion limits as defined by IEEE-519 based on full load operating conditions.

b. The filter shall be UL listed per UL-508C

c. The filter shall be designed to meet the intent of BS-G5/3, EN61000-3-4, AS-2279 and IEEE-519.

4. Standard Features

a. When applied on a three phase, 6-pulse VFD system the worst case (light load) input harmonic current distortion shall be limited to 8

percent THID. The filter shall meet the guaranteed harmonic distortion levels for all operating conditions from 0 percent load to 100 percent load.

b. When applied on a three phase, 6-pulse VFD system the full load input current harmonic distortion shall be limited to 5 percent THID.

c. True power factor shall be 0.98 lagging to 0.98 leading at the filter full load operating conditions and 0.95 leading at 80 percent load.

d. The harmonic filter shall not cause resonance with the power system.

e. The harmonic filter shall not attract harmonics from other leads which are connected upstream of the filter.

f. The filter shall not cause the DC bus voltage (of a voltage source inverter) to increase by more than 5 percent when operated from nominal supply voltage.

g. To assure that DC bus capacitor life is not reduced by the filter, use of the filter shall result in VFD input current waveform that is consistent with the input current waveform of a drive using a line reactor of 3 percent minimum impedance.

5. Basic Requirements

a. All internal filter wiring shall be copper.

b. Inductive component insulation system shall utilize Class H (200 degree C) insulation.

c. Ambient Temperature: -40 degrees C to +50 degrees C.

d. Temperature Rise: 115 degrees C.

e. Full Load Efficiency: 98 percent minimum

f. Enclosure: Open panel construction for integration into a single cabinet with the VFD. NEMA type 1 general-purpose enclosure for capacitor bank.

g. Filter enclosure shall be fan cooled.

6. Service Conditions

a. Load: 6-pulse variable torque rectifier.

b. Power supply: 480VAC, ± 10 percent, 60 HZ, 3-phase

c. Line voltage unbalance: 1 percent maximum

d. Effective source impedance: 1.5 percent minimum, 6.0 percent maximum

e. Service factor: 1.0 (based on maximum load amps rating).

H. Installation and start-up

1. The services of a qualified manufacturer's technical representative shall supervise the contractor's installation, testing, and start-up and all the AC drives furnished under this specification. The manufacturer's representative shall provide a maximum total of five supervision days.

2. Upon acceptance of the AC drive equipment, training of the operators shall consist of two training days.

I. The enclosure shall be provided with mechanical ventilation or an air conditioner unit to maintain a temperature less than 90º F in a 100º F ambient temperature with the enclosure in direct sunlight. Heater shall be provided in the cabinet to prevent condensation within the cabinet and to maintain minimum temperatures at –10º F ambient temperatures.

PART 3 EXECUTION

3.01 BIOFILTER INSTALLATION

A. General:

1. Do not permit workers to walk or stand directly on gravel, biofilter media or other materials that are less than ½-inch in diameter. Use boards that will sustain workers' weight without displacing gravel.

2. Do not compact layers.

3.02 PLACING MEDIA

A. Inspection: Notify Owner's representative at least 2 full weeks in advance before starting to place biofilter bed.

B. Placement into bed:

1. Before depositing gravel bed, remove debris from material below and level. Measure each elevation.

2. Use placement devices, for example, chutes, pouring spouts, and conveyors, excavator with toothless bucket, as approved by Media Supplier.

3. Vertical Free Fall Drop to Final Placement: Less than 2 feet.

a. For placements where drops are greater than specified, use placement device such that freefall below placement device conforms to required value.

b. Free fall limit to prevent segregation of filter media.

c. Finish top surface to prevent bed irregularities.

C. Conveyor Belts and Chutes:

1. Design and arrange ends of chutes, hopper gates, and other points of media discharge throughout conveying, hoisting, and placing system for media to pass without becoming segregated.

2. Minimum slopes of chutes: Angled to allow media to readily flow without segregation.

3. Conveyor Belts:

a. Approved by Engineer.

b. Cover conveyor belts and chutes.

D. Maximum size of Biofilter Media Placements: Limit size of each placement to allow for uniform placement of media.

E. Bedding, Lateral Zone and Biofilter Media:

1. Place in layers as specified below:

Layer Thickness		
Gravel Layer	**Layer Thickness**	**Size Limits**
Lateral Zone	33-35 inches	1 inch (see specs)
Biofilter Media	6 feet (place to prevent aggregation)	

2. Complete each layer before next layer above is started.

3. Use only clean gravel.

4. Establish correct thickness of each layer as follows:

   a. Level top of each layer.

   b. Top of bed should match berm height.

   c. Provide survey elevations of berm corners.

3.03 ODOROUS AIR PIPING INSTALLATION

A. Examination: Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Preparation:

1. Notify Owner's representative at least 2 weeks prior to field fabrication of pipe or fittings.

2. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

C. Installation – General:

1. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.

2. Remove foreign objects prior to assembly and installation.

3. Take care to install pipe in cool weather to minimize pipe contraction once pipe cools when buried. Follow manufacturer's recommendations.

D. Flanges Joints:

1. Install perpendicular to pipe centerline.

2. HDPE flange with no bolt holes.

3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.

4. Use flat-face flange when joining with flat-faced FRP flange.

3.04 INSTALLATION – BIOFILTER PIPE

A. Placement:

1. Keep trench dry until pipe laying and joining are completed.

2. Exercise care when lowering pipe into trench to prevent twisting or damage to the pipe and stubs.

3. Measure for grade at pipe centerline, not at crown.

4. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.

5. Prevent foreign material from entering pipe during placement.

6. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.

7. Lay pipe upgrade with bell ends pointing in direction of laying.

8. After joint has been made, check pipe elevation at pipe ends and corners of biofilter piping network.

9. Slope piping as indicated on drawing.

3.05 DRAINS

A. Install drains on low points of pipelines. Drains at low points in piping required for completed system may or may not be shown on the Drawings.

3.06 GEOMEMBRANE INSTALLATION

A. Geomembrane Inspection: During unwrapping visually inspect, mark each imperfection for repair.

B. Complete Installer's Certification of Subgrade Acceptability prior to installation per attached.

C. Protection:

1. Do not use geomembrane surfaces as work area for preparing patches, storing tools and supplies, or other uses. Use protective cover as work surface, if necessary.

2. Instruct workers about requirements for protection of geomembrane such as handling geomembrane material in high winds, handling of equipment, and walking on geomembrane surfaces. Shoes of personnel walking on geomembrane shall be smooth bonded sole or be covered with smooth type of overboot. Prohibit smoking, eating, or drinking in vicinity of geomembrane, or other activities that may damage geomembrane.

3. Do not operate equipment without spark arrestors in vicinity of geomembrane material nor place generators or containers of flammable liquid on geomembranes.

4. Protect from vehicle traffic or other hazards.

5. Keep clean and free of debris during placement.

6. Prevent uplift, displacement, and damage by wind.

D. General:

1. Each miscellaneous product required for completion of geomembrane installation shall be of types, sizes, and installed in strict accordance with this specification and the geomembrane manufacturer's recommendations.

2. Reduce field seaming to minimum. Horizontal seams on slopes will not be acceptable. Seams parallel to toe shall be at least 5 feet from toe. Align rough-sided sheets in manner that maximizes their frictional capabilities along slope.

3. Prevent wrinkles, folds, or other distress that can result in damage or prevent satisfactory alignment or seaming. Provide for factors such as

expansion, contraction, overlap at seams, anchorage requirements, seaming progress, and drainage.

4. Temporarily weight sheets with sandbags as necessary to anchor or hold them in position during installation. Use continuous holddowns along edges to prevent wind flow under sheet.

   a. Sandbag fabric shall be sufficiently close knit to preclude fines from working through bags.

   b. Bags shall contain not less than 40 nor more than 60 pounds of sand having 100 percent passing No. 8 screen and shall be securely closed after filling to prevent sand loss.

   c. Do not use tires or paper bags, whether or not lined with plastic. Burlap bags, if used, shall be lined with plastic.

   d. Immediately remove damaged or improperly sealed bags from work area, and immediately clean up spills.

5. Anchor perimeter of geomembrane via anchor trench as shown.

6. Place overlying core materials immediately following completion of geomembrane installation and field testing as acceptable to Engineer.

F. Field Seams:

1. General:

   a. Wipe sheet contact surfaces clean to remove dirt, dust, moisture, and other foreign materials and prepare contact surfaces in accordance with seaming method accepted by Engineer.

   b. Lap sheet edges to form seams to seam geomembrane sheets together. Adjust edges to be seamed and temporarily anchor to prevent wrinkling and shrinkage.

   c. Seams shall not go through a boot. Locate seams a minimum of 2 feet from boot.

   d. Avoid seam intersections involving more than three thicknesses of geomembrane material. Offset seam intersections at least 2 feet. Extend seams through anchor trench to sheet edges.

e. Seal seam “T” intersections by removing excess material and extrusion welding lap joint.

2. HDPE:

a. For boots and seams that cannot be otherwise tested, insert copper wire for spark test at edge of overlapping sheet in extrudate of weld prior to filet welding. Position to within 1/8-inch of sheet edge.

b. Seam sheets together, using fusion-extrusion or hot-wedge welding system, equipment and techniques.

G. Boot Seals:

1. Preparation: Thoroughly clean contact surfaces.

2. Place boot around penetrations so flange is supported everywhere in full contact with the subgrade, and is free of wrinkles.

3. Seal boot to surrounding geomembrane as specified for field seams using extrusion welding methods.

4. Tighten seal clamping bands until neoprene rubber pads are compressed 12 to 15 percent of total pad thickness.

H. In-Place Observation and Testing:

1. Visually inspect geomembrane sheets, seams, anchors, seals, and repairs for defects as installation progresses and again on completion.

2. Test each seam and repair using vacuum testing device and/or air channel pressure test for double wedge welded seams.

3. Clearly mark defective and questionable areas, and repair them to Engineer’s satisfaction.

4. Each area showing injury due to scuffing, penetration by foreign objects, or distress from rough subsurface shall be replaced or covered with an additional layer of geomembrane material.

5. Perform testing in presence of Engineer.

6. Conform to ASTM D6392 and this specification for vacuum box testing and air channel pressure testing.

7. Vacuum Box Testing of Geomembrane Welds:

   a. Vacuum box each of these types of welds: fillet, extrusion, lap, and single hot-wedge fusion lap.

   b. Testing Procedures: Conforming to ASTM D5641.

8. Air Channel Pressure Testing of Double Hot-Wedge Seam:

   a. Insert a needle with gauge in air space between welds. Pump air into space to 30 psi and hold for 5 minutes.

   b. At end of 5 minutes, depressurize seam by placing needle hole in air space between welds at opposite end of seam and observe gauge.

   c. Seam is acceptable if seam maintains a minimum pressure of 27 psi. If pressure drops below 27 psi during test period, or does not drop during 30-second depressurization period, repair needle holes and retest seam by same procedure or vacuum box test along entire length of seam.

   d. Vacuum box test entire length of seam if second air pressure test fails.

      1) If no bubbles appear in vacuum box, lower weld will be considered defective and upper seam is acceptable.

      2) If bubbles appear in vacuum box, repair each defective area by extrusion welding and test again by vacuum box.

   e. As alternative to vacuum box testing, apply soap solution to exposed seam edge while maintaining required air channel test pressure.

      1) If bubbles appear, mark, trim unbonded edge, and extrusion weld defective areas.

      2) If no bubbles appear and test pressure cannot be maintained, leak is judged to be in bottom or second seam.

   f. Mark and repair needle holes.

I. Repairing Geomembrane:

1. Repair damage or rejected seams with pieces of flat and unwrinkled geomembrane material free from defects and seams. Patches shall be tightly bonded on completion of repair Work.

2. Patch shall be neat in appearance and of size 6 inches larger in all directions than areas to be repaired. Round corners of each patch to minimum1-inch radius.

3. Prepare contact surfaces and seam patch in accordance with paragraph 3.06 E.

a. Pull and hold flat receiving surface in area to be patched.

b. Seal each patch by extrusion welding continuous bead along edge, with no free edge remaining.

J. Placing Products Over Geomembrane:

1. Prior to placing material over geomembrane, notify Owner's representative. Do not cover geomembrane until after Engineer provides authorization to proceed.

2. If tears, punctures, or other geomembrane damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged membrane, and repair damage as specified in paragraph 3.06 F.

3. Geomembrane installer shall remain available during placement of overlying products or repair geomembrane if damaged.

K. The geomembrane manufacturer shall provide a minimum one day (8-hr) on-site supervision services during the installation of the geomembrane.

3.07 BIOFILTER TESTING

A. Functional Testing:

1. Test all system components for proper adjustment and operation in both the manual and automatic operating modes.

2. Sprinkler System: Allow the biofilter to operate for a 24-hour period with the humidification system operating and sprinkler nozzle operation in

AUTO mode. Make adjustment to the humidifier flowrate and sprinklers as necessary for proper moisture system operation.

a. Adjust sprinkler coverage to prevent excessive overspray.

3. Provide certification of functional acceptance prior to commencing performance testing.

B. Biofilter Installation Supervision, Commissioning and Training:

1. The Media Manufacturer shall provide, at a minimum, two days (16 hrs) of on-site services for instructing the Contractor during construction, commissioning of the system and operator training. The cost for these services is included within the media purchase price as indicated in the Bid Sheet. If additional days of on-site services are required, the cost for these services shall be the sole responsibility of the Contractor.

C. Performance Testing:

1. It is the intent of these specifications that the Contractor shall be responsible for the successful operation of all the biofilter equipment.

a. Tests of the biofilter shall be made by the Contractor.

b. Testing shall be performed at a time and in accordance with procedures to be approved by the Engineer and shall be in accordance with the requirements of Section 01650 – SHAKEDOWN/TURNOVER/STARTUP OF SYSTEMS.

c. Smoke tests will be performed on the biofilter for joint integrity and to prove proper air distribution throughout the biofilter. Any broken or damaged pipe and fittings shall be replaced at no additional cost to the Owner. Any pipe or fittings that are plugged shall be cleaned and retested if necessary. The smoke must be uniformly distributed over the entire biofilter.

At least two smoke tests will be performed: (1) after placing the laterals and (2) after placing the filter media.

d. Test for odor and specific compounds.

1) Two performance tests shall be conducted for the biofilter. The first test shall be performed 1-2 months after the startup operation of the biofilter or at a time when, in the opinion of the biofilter media manufacturer, the media is

ready for performance testing. The second test shall be performed 6-12 months after the first test. At least one test shall be conducted during the summer operating season (June through September).

2) At least one month prior to conducting the performance test, the testing company shall submit a detailed test protocol to the Engineer to Engineer's and NH DES's approval. The tests shall be conducted after the protocol is approved by the Engineer and DES.

3) Airflow Measurement. Airflow and temperature in the inlet and outlet of the biofilters shall be measured. The airflow in the outlet shall be measured using a specially constructed hood. At least 32 points in the bed surface throughout each biofilter shall be measured.

4) Analysis for odor and specific compounds shall include three replicate tests, each test consisting of one inlet and two outlet samples, collected simultaneously within one hour span.

5) Samples will be tested by an odor/chemical testing laboratory approved by the Engineer. The air sample collection shall be in accordance with EPA approved method. Tedlar bags shall be used for sample collection.

6) Inlet and outlet samples shall be analyzed for dilution to threshold (D/T) for odor concentration, intensity and character. The sniffer flow rate for D/T odor panel test shall be 20 liters per minute.

7) Air samples for odor analysis shall be analyzed within 24 hours of sample collection.

8) Inlet and outlet samples shall also be analyzed for total reduced sulfur compounds (TRS) including hydrogen sulfide (H_2S), methyl mercaptan (MM), dimethyl sulfide (DMS) and dimethyl disulfide (DMDS).

e. All costs associated with performance testing, including possible modifications of equipment, sampling, testing and laboratory fees, chemical use, etc., shall be the responsibility of the Contractor without any cost to the Owner. The analytical laboratory shall be approved by the Engineer.

3.08 BIOFILTER MEDIA MANUFACTURER'S CERTIFICATION

A. The biofilter media manufacturer shall submit a letter stating that he has inspected the design and installation of the biofilter and checked its performance and certifies that the design and installation are satisfactory, that the system is operating correctly, and that the system meets all of the requirements of the Drawings and Specifications.

** END OF SECTION **