



**Harrisonburg-Rockingham Regional  
Sewer Authority**

North River WWTF  
Bioreactor Blower Equipment Procurement

Technical Specifications

HRRSA RFP No. HRRSA-2015-03  
Wiley|Wilson Comm. No. 214256.00

December 15, 2014



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SECTION 114251 – HIGH SPEED TURBO BLOWERS – AIR FOIL BEARING

Relevant Equipment and Component Numbers	
<u>Tag Number</u>	<u>Equipment Name</u>
TB-1	Bioreactor Turbo Blower No. 1
TB-2	Bioreactor Turbo Blower No. 2
TB-3	Bioreactor Turbo Blower No. 3 (HRRSA Option)

PART 1 - GENERAL

1.01 SCOPE OF WORK:

A. The Manufacturer shall:

1. Provide high speed turbo blower unit(s) with air foil bearings and appurtenances as specified herein. Each blower unit shall include blowers, motors, variable frequency drives, local blower control panel, sound attenuation enclosure, inlet air filter/silencer, blow-off valves with silencer, discharge check valve, discharge isolation valve, inlet and discharge flexible connectors and other appurtenances as shown on the drawings, as specified herein, and as needed for a complete and operational blower system.
2. Provide a master control panel (MCP) with programmable logic controller (PLC) as specified herein to control the blower unit(s) and appurtenances provided under this specification, existing Spencer Blower No. 8 and the Bioreactor Dissolved Oxygen (DO) Control System.

B. General:

1. The Manufacturer shall be responsible for providing a complete, fully functional blower system to include blower units and MCP. All equipment provided under this section shall be the end products of one Manufacturer who shall be responsible for the suitability and compatibility of all included equipment in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.
2. Each blower unit provided under this Specification shall be factory- and field-tested for compliance to the requirements specified herein. The blower system(s) shall be shipped completely assembled except that the appurtenances will be shipped loose for field installation.
3. The equipment provided under this section will be installed by a General Contractor under a separate contract. The Manufacturer shall commission the blowers and provide start-up support to HRRSA and the General Contractor as specified herein.
4. The blower system(s) shall be designed to be supplied with 480-volt, 60-hertz, 3-phase power.
5. All equipment shall be designed for continuous or intermittent operation and long operating life in a high humidity atmosphere.

## 1.02 DEFINITIONS

- A. Standard cubic feet per minute (scfm) is defined as air at 68 degrees F, 14.7 psia, and 36 percent relative humidity flowing at a rate of 1 cubic foot per minute.
- B. Surge volume is defined as the air flow rate at which the blower exhibits the first indication of pressure pulsation or flow reversal.
- C. Continuous operation shall be defined as 24 hour per day 7 days per week operation
- D. Intermittent operation shall be defined as periodic operation, including up to 2 starts per hour or extended periods off-line.

## 1.03 REFERENCES

- A. ASME PTC – 10 Test Code on Compressors and Exhausters
- B. International Standards Organization (ISO) 5389: 1992 – Turbocompressors.
- C. VDI 2045: 1993 – Acceptance and Performance Tests on Turbo Compressors and Displacement Compressors
- D. NEC: National Electric Code

## 1.04 SUBMITTALS

- A. Shop Drawings shall be approved by Engineer prior to fabrication of blower units or master control units.
- B. Shop Drawings for Blower Units
  - 1. Product Data for Blower Units
    - a. Complete list of all system components to be provided.
    - b. Make, model, weight, and horsepower of each equipment assembly.
    - c. Detail specifications for equipment assemblies indicating component drawings, dimensions, weights, loads, required clearances, method of field assembly, components, anchor bolt locations and location and size of each field connection.
    - d. Detail component drawings and specifications for air foil bearings.
    - e. Performance data for each type of equipment that will show compliance with specification requirements stated herein. Performance data shall include the maximum air flow rate, total system horsepower demand, wire-to-air efficiency, rise-to-surge, and maximum turndown at the design conditions and shall include the maximum discharge pressure and corresponding air flow rate.

- f. Performance blower curves showing air flow rate in SCFM versus discharge pressure (PSI), total system horsepower demand and total system efficiency (wire-to-air), surge boundary lines including surge lower limit (SLL) and surge control line (SCL) over the entire operating range of the blower.
  - g. Identification of outside utility requirements for each component such as air, water, power, etc. Include operating parameters for all required utilities.
  - h. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
  - i. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
  - j. Special shipping, storage and protection, and handling instructions.
  - k. Routine maintenance requirements prior to installation and start-up.
2. Submittal Drawings for Blower Units
- a. Detailed Mechanical, Structural, and Electrical Drawings showing the equipment fabrications and interface with other items.
    - 1) Include dimensions, size, and locations of connections to other work.
    - 2) Include information on weights of all major equipment.
  - b. System layout, installation, and placing drawings for blower units and appurtenances.
- C. Shop Drawings for Master Control Unit
1. Detail drawings and specifications for master control unit including dimensioned drawings, weights, required clearances, method of field assembly, components, anchor bolt locations and location and size of each field connection.
  2. Instrumentation, control system schematic, all electrical and control components wiring diagrams.
  3. Source code for blower control system to allow HRRSA to integrate local/custom DO Control System programming into the PLC program
  4. Special shipping, storage and protection, and handling instructions.
  5. Routine maintenance requirements prior to installation and start-up.
- D. Shop Drawings for Sound Attenuation Enclosure:
1. Detail drawings, technical information and specifications for noise enclosure to be provided with each blower to reduce noise level such that blower noise level shall not exceed 80 dBA in any direction at one meter from the blower noise

- attenuating enclosure in free field conditions.
  2. Submit performance data for noise enclosures that will show compliance with noise reduction specifications stated herein.
  3. Provide manufacturer's guarantees that the noise enclosures will meet noise reduction specifications stated herein.
  4. Special shipping, storage and protection, and handling instructions.
  5. Routine maintenance requirements prior to installation and start-up.
- E. Certified Factory Performance Test
1. Submit Certified Factory Performance Test Report for approval. Certified Factory Performance Test Report shall be approved by Engineer prior to shipment of blower units or master control units.
  2. A Certified Factory Performance Test Report shall be provided for each fully assembled blower unit to include the VFD, motor, blower blower supplied for this project. The Report shall include certified blower test curves showing air flow rate in SCFM versus discharge pressure (PSI), total system horsepower demand and total system efficiency (wire-to-air), surge boundary lines including surge lower limit (SLL) and surge control line (SCL) over the entire operating range of the blower (minimum 10 points of operation). The Report shall also indicate separately the pressure, capacity, horsepower demand and efficiency at the design conditions.
- F. Field Test results and Vibration Report.
- G. Manufacturers Operation and Maintenance Manuals customized for this project.
- H. Manufacturer's Certificates of of Proper Installation and Proper Operation.
- I. Manufacturer's Written Warranty.

#### 1.05 DELIVERY, STORAGE, AND HANDLING

- A. Shipping:
1. Ship equipment, material, and spare parts complete, except where partial disassembly is required by transportation regulations or for protection of components.
  2. Pack all spare parts in containers bearing labels clearly designating the contents.
  3. Deliver spare parts at the same time as pertaining equipment.
- B. Receiving:
1. Owner will inspect and inventory items immediately upon delivery to site and is responsible for storing and safeguarding equipment, material, instructions, and spare parts in accordance with Manufacturer's written instructions.

## 1.06 WARRANTY

- A. The Manufacturer shall provide a full written warranty for all equipment under this section. The warranty period shall be 24 months from delivery of equipment or 18 months from substantial completion, whichever is shorter. If a defect is found during the warranty period, the Manufacturer shall remedy said defect at no cost to Owner.

## 1.07 SPARE PARTS AND SPECIAL TOOLS.

- A. Four replacement filters for each filter system supplied.
- B. Complete set of special tools.

## PART 2 - PRODUCTS

## 2.01 MANUFACTURERS

- A. Basis of Design Alternative 1:
1. APG-Neuros NX350-C070
- B. Basis of Design Alternative 2:
2. APG-Neuros NX400-C060

## 2.02 PERFORMANCE REQUIREMENTS

- A. This RFP includes two basis of design alternatives that may require different equipment. The following design conditions are applicable to each design alternative unless otherwise specified.
- B. The following environmental conditions shall be applicable to all design alternatives.
1. Maximum Inlet air Temp = 100 F;
  2. Relative humidity = 100 percent;
  3. Site elevation = 1,164 ft msl
- C. Basis of Design Alternative 1

<b>Parameter</b>	<b>Design Value per Blower Unit</b>
Blower Bearing	Air Foil
Number of Blower Cores	1

Intake Size (inch)	16"
Discharge Size (inch)	16"
Design Air Flow Rate (SCFM)	7,200
Design Discharge Pressure (PSI)	8.0
Turn Down Capability	50%
Minimum Air Flow Rate (SCFM)	3,600
Minimum Rise-to-Surge at Design Conditions (PSI)	3.0
Maximum Operating Pressure (PSI)	10.0
Performance Test Requirement	ASME PTC-10-1997 (Type 2)
Allowable Vibration Level	0.15 in/sec (4 mm/sec)
Minimum Motor HP	350
Motor Rating	Permanent Magnet / Class F Insulation
Primary Power	480V / 3 PH / 60 Hz
Auxiliary Power	120V / 1 PH / 60 Hz
Control Power	24VDC
VFD Rating	UL Listed
Harmonic Filter Rating	IEEE 519 Compliant
Sound Attenuation Enclosure 3-ft Free Field Rating at Design Conditions	80 dBA
Installation Location	Indoors
Minimum Ambient Temperature	0 deg F
Maximum Ambient Temperature	120 deg F

## D. Basis of Design Alternative 2

<b>Parameter</b>	<b>Design Value per Blower Unit</b>
Blower Bearing	Air Foil



Number of Blower Cores	2
Intake Size (inch)	16"
Discharge Size (inch)	12"
Design Air Flow Rate (SCFM)	8,300
Design Discharge Pressure (PSI)	8.0
Turn Down Capability	50%
Minimum Air Flow Rate (SCFM)	4,150
Minimum Rise-to-Surge at Design Conditions (PSI)	3.0
Maximum Operating Pressure (PSI)	10.0
Performance Test Requirement	ASME PTC-10-1997 (Type 2)
Allowable Vibration Level	0.15 in/sec (4 mm/sec)
Minimum Motor HP	400
Motor Rating	Permanent Magnet / Class F Insulation
Primary Power	480V / 3 PH / 60 Hz
Auxiliary Power	120V / 1 PH / 60 Hz
Control Power	24VDC
VFD Rating	UL Listed
Harmonic Filter Rating	IEEE 519 Compliant
Sound Attenuation Enclosure 3-ft Free Field Rating at Design Conditions	80 dBA
Installation Location	Indoors
Minimum Ambient Temperature	0 deg F
Maximum Ambient Temperature	120 deg F

### 2.03 GENERAL REQUIREMENTS

A. Safety Devices: The completed Work shall include all necessary permanent safety

devices, such as machinery guards, emergency stops and similar items required by OSHA, and other federal, state, and local health and safety regulations.

- B. Flanges and Pipe Threads: Flanges on equipment shall comply with 125LB ANSI B16.1 unless otherwise indicated. Threaded flanges and fittings shall be NPT or ASTM A182.
- C. Blowers units shall not allow heat caused by motor or electrical cooling to be exhausted into the blower room. Blower and integral VFD shall not require any external cooling devices.
- D. Lifting Lugs: Equipment weighing over 100 pounds shall be provided with lifting lugs.

## 2.04 BLOWER EQUIPMENT

- A. High Speed Blowers
  - 1. Materials of Construction
    - a. Casings and Inlet Inducer: High-strength aluminum alloy, A1Si7Mg-T6.
    - b. Impellers: High-strength forged aluminum alloy.
    - c. Rotor Shafts: Alloy steel with copper cladding.
    - d. Blower and Motor Frame: Welded carbon steel.
  - 2. Blower impellers shall be of the backswept three dimensional high efficiency configuration milled from forged aluminum alloy Type 7075. The first lateral critical speed at least 120 percent of the maximum allowable operating speed. The impeller shall be mounted directly to the motor shaft and shall be statically and dynamically balanced. The use of dual impellers is not permitted.
  - 3. Bearings shall be sized for a minimum of expected twenty (20) years between major overhauls.
  - 4. Each blower shall be supplied with integrated instrumentation allowing for direct measurement of vibration and temperatures of the motor and air bearing.
  - 5. Each blower shall be supplied with built in vibration isolating mounts. The blower manufacturer shall be responsible for attenuating noise and vibration in the blower package such that no special installation base shall be required nor shall any vibration from the blower package be transmitted to the floor or intake and discharge base or the piping.
  - 6. Blowers shall be designed to be placed on a concrete housekeeping equipment pad provided by the installing Contractor (6" thick, 3,000 PSI concrete with #5@12" O.C. E.W. reinforcing) and anchored to the pad using 316 SS anchor bolts. Manufacturer shall provide the specification for anchor bolts to be supplied and installed by Owner.
  - 7. The blower intake shall originate outside the sound attenuating enclosure.
  - 8. Provide flanged connections exterior to the sound attenuating enclosure for blower intake and blower discharge.

**B. Sound Attenuation Enclosure**

1. Provide each blower unit with a steel sound enclosure covering the entire blower unit. The sound enclosure shall be designed for easy inspection and maintenance of all blower package components. Provide quick release panels to allow access for routine maintenance of the blower and all internal components. The blower unit enclosure shall protect against falling water, condensation and dust.
2. At the design conditions specified herein, blower noise level shall not exceed 80 dBA in any direction at one meter from the blower noise attenuating enclosure in free field conditions.

**C. Motors**

1. Provide each blower unit with a high speed Permanent Magnet Synchronous Motor (PMSM) driven by a variable frequency drive operating on 480 Volts, 3 Phase, 60 Hertz input power.
2. Designed for ambient temperature conditions indicated.
3. Motor shall have thermal sensors (RTDs) in the winding for each phase reporting the motor temperature monitoring instrumentation.
4. The motor shall have a 1.15 service factor. Blower manufacturer shall be responsible for coordinating the starting torque requirement of the blower and the motor.
5. Each blower motor shall be of the PMSM type that has no physical connection between stator and shaft, therefore eliminating brushes, slip rings or break resistors. The PMSM shall be combined with a Sine Wave Filter (Sinus Filter) and Input Line Reactor.

**D. Variable Frequency Drive**

1. Provide each blower unit with a high efficiency UL listed Variable Frequency Drive (VFD) with 97% efficiency at full rated motor speed and power.
2. Provide each VFD with a passive harmonic filter that reduces the THD (Total Harmonic Distortion) to achieve compliance IEEE 519. Harmonic filters shall be mounted internal to the blower enclosure.
3. Provide each VFD with a sinusoidal filter on its output consisting of an L (inductor) and C (capacitor) filter.

**2.05 APPURTENANCES****A. Intake Filter/Silencer**

1. Provide each blower unit with an integrated combination intake/inlet filter/silencer system. Intake, filter and silencer performance losses shall be included by the blower vendor in the blower performance calculation. The intake/inlet filter/silencer system shall be integrated into the overall blower and enclosure design and shall fit within the enclosure.
2. The inlet silencer shall have a dual wall construction with a minimum 3.94 in

(100 mm) thick fiberglass or mineral wool insulation between the walls, have a maximum pressure loss of 0.005 psi (37 Pa), and be constructed of AISI 304 SST. Each inlet silencer shall attain the following minimum attenuation characteristics at design conditions.

<b>Inlet Silencer</b>								
Octave Band								
Mid Frequency (Hertz)	63	125	250	500	1,000	2,000	4,000	8,000
Attenuation, db	2	5	15	24	39	32	21	12

3. The inlet filter media shall have an efficiency of 90% by weight per ASHRAE 52-76 with synthetic dust equivalent to separation > 95% @ 10 microns. Filter element shall be removable without disconnecting the inlet flange connection and shall be cleanable by maintenance personnel as a preventative maintenance procedure.

**B. Blow Off Valve**

1. Provide each blower unit with electro-pneumatic blow-off valve actuated by blower pressure integral to the discharge cone silencer.
2. The blow-off valve discharge shall be supplied with a blow-off silencer. Each blow off silencer shall attain the following minimum attenuation characteristics at design conditions.

<b>Blow Off Silencer</b>								
Octave Band								
Mid Frequency (Hertz)	63	125	250	500	1,000	2,000	4,000	8,000
Attenuation, db	4	9	17	29	41	28	25	28

3. The blow off valve and silencer shall be 316 SST construction with PTFE or viton seals and shall have 125LB ANSI B16.1 flange connections.

**C. Discharge Cone Silencer**

1. Provide each blower unit with a flanged outlet silencer. Each outlet silencer shall attain the following minimum attenuation characteristics at design conditions.
2. The outlet silencer shall have a dual wall construction with a minimum 3.94 (100 mm) thick fiberglass or mineral wool insulation between the walls, have a maximum pressure loss of 0.063 psi (432 Pa), and be constructed of AISI 304 SST. The silencer shall have 125LB ANSI B16.1 flange connections.

<b>Discharge Silencer</b>								
Octave Band								

Mid Frequency (Hertz)	63	125	250	500	1,000	2,000	4,000	8,000
Attenuation, db	4	9	17	29	41	28	25	28

D. Intake Weather Hood

1. Provide a weather hood for each blower unit with a flanged connection to be mounted by the Contractor on the blower unit intake piping exterior to the blower building. Weather hood shall have an effective minimum intake area of 400% of the intake connection to the blower unit. Provide a minimum 48-inch diameter mushroom type intake or minimum 36-inch by 36-inch square hood with AISI 304 SST construction. Provide No. 24 AISI 304 SST insect screen over opening.

E. Isolation Butterfly Valve, BFV (air service).

1. Provide each blower unit with a 16-inch discharge BFV and a line size BFV to isolate the blow off valve.
2. Lug style, two-piece ASTM A 126 Class B
3. Materials of construction: Cast or ductile iron ASTM A 536 body, one piece type 316 SST thin-profile disc and stem, heavy-duty stem bushing, NBR stem seal, FKM (viton) replaceable resilient seat
4. Pressure rating: 75 psi pressure bi-directional bubble-tight
5. Temperature rating: 300 degrees F
6. Process connections: 125LB ANSI B16.1 flanges
7. Supply reduced disc diameter, if available
8. Hand actuators shall be 10 position locking type
9. Manufacturers and Products:
  - a. Bray Controls Series 21.
  - b. Dezurik Style BOS.

F. Check Valve, CV (air service)

1. Provide each blower unit with a 16-inch discharge check valve.
2. Wafer-style, dual plate check valve with spring
3. Materials of construction: 316 SST body, 316 SST internals and disc, 316 SS spring and silicone seal.
4. Temperature rating: 500 degrees F
5. Manufacturers and Products:
  - a. Flexi-Hinge Series 504.

G. Flexible Connectors (air service)

1. Provide each blower unit with two 16" flexible connectors to be installed on the discharge aeration piping prior to the main air header and the intake aeration piping prior to exiting the blower building.
2. Connections shall be the single arch, 12-inch neutral length, reinforced rubber expansion joint type with control rods.
3. Flexible connection material of construction shall be EPDM suitable for 300 F air source.
4. Process connections: 125LB ANSI B16.1 flanges
5. Manufacturers and Products:

## a. Proco Series FA 231 EE

- H. Provide the following instrumentation for each blower unit:
1. Inlet differential pressure sensors for filter monitoring
  2. Discharge differential pressure sensor
  3. Inlet and discharge temperature sensors
  4. Bearing temperature sensor
  5. Motor temperature sensor
  6. Vibration sensor

## 2.06 CONTROLS

## A. General

1. All components in the Local Control Panels (LCP) and Master Control Panel (MCP) shall be completely factory wired and shall include all necessary controls for both the manual/local and automatic/remote operation of the blower units.
2. All electrical and control connections that are not factory assembled and shipped complete shall only require the installing Contractor to connect wires between junction boxes installed on the blower unit by the Manufacturer.
3. The incoming power provided to the LCP shall be a 480VAC, 3 PH, 60 Hz circuit to power the blower unit VFD and an auxiliary 120/208VAC, 1 PH 60 Hz circuit to power the LCP. Main circuit breakers for both circuits sized per NEC shall be provided along with all transformers, relays, etc. necessary to make the panel fully functional. Surge protective devices (SPD) shall be provided to protect the electrical and control components from excessive voltage and current: Type 1 SPD to protect the 480V loads (VFD) and Type 2 SPD to protect the 120V loads (LCP).
4. The incoming power provided to the MCP shall be a 120/208VAC, 1 PH 60 Hz circuit. Main circuit breakers for both circuits sized per NEC shall be provided along with all transformers, relays, etc. necessary to make the panel fully functional. Surge protective devices (SPD) shall be provided to protect the electrical and control components from excessive voltage and current: Type 2 SPD to protect the 120VAC loads.
5. Wiring and all electrical components shall comply with UL/CSA and NEC.

## B. Miscellaneous electrical devices

1. A 120 VAC to 24 VDC power supply shall be provided to power the PLC inputs and other 24 VDC powered devices. The power supply shall be properly sized for the LCP total load.
2. Provide noise filter to provide clean, noise-free power to the PLC.

## C. Local Control Panel (LCP)

1. Provide an LCP on each Blower Unit with all components contained in a NEMA 12 enclosure segregated from the main blower enclosure.
2. The LCP shall include a PLC and HMI. PLC shall be Schneider Electric Modicon Premium or Allen Bradley CompactLogix. HMI shall be Schneider Electric Magelis or Allen Bradley PanelView 600.

3. The LCP shall be configured for Ethernet TCP/IP or Profibus communication protocol with the MCP.
  4. The LCP shall have sufficient I/O slots to accommodate all blower instrumentation with 25% spare installed I/O terminal capacity.
  5. The LCP program/functionality shall:
    - a. Display system status, system alarms and allow local reset of alarm conditions. At a minimum, provide the following indicators for each blower unit. All indicators shall be available for communication to the MCP via Ethernet communication.
      - 1) Status (RUN/STOPPED)
      - 2) Local / Remote Control Selection
      - 3) Local / Remote Control Indication
      - 4) Start / Stop (Local Control Only)
      - 5) Speed Select (Local Control Only)
      - 6) Speed Indication Status (RPM)
      - 7) Run Times (hours)
      - 8) Amp Draw (amps)
      - 9) System Pressure (PSI)
      - 10) Flow Rate (SCFM)
      - 11) Vibration Level (in/sec)
      - 12) Alarm Condition (Indicate Alarm Code/Condition)
      - 13) Alarm Local Reset
    - b. Provide a local / remote operation mode selector for the blower unit. In remote mode, the blower unit shall be controlled by the MCP. In local mode, the blower unit shall be controlled from the LCP.
    - c. Provide dynamic flow control monitoring and adjustment in both remote and local modes of operation. Automatically perform dynamic adjustments to the blower operating limits (surge limit, maximum pressure limit, power limit and speed limit) to reflect measured temperature and environmental conditions such that attainable maximum and minimum flow is always optimized. Such dynamic adjustments shall include adjustments to the surge boundary / SCL so as not to expose the blower to surge.
    - d. Provide the blower unit with automatic surge protection.
    - e. Control the blow-off valve.
- D. Main Control Panel (MCP)
1. Provide an MCP to control the blower system, to include up to four turbo blower units and the existing Spencer 8 blower with all components contained in a NEMA 12 enclosure.
  2. The MCP shall control multiple turbo blowers using a standalone PLC based system to control the air flow rate from the turbo blower system. The MCP shall control the turbo blowers to maintain operation at their optimal efficiency point based on either a flow (SCFM) or pressure (PSI) input from the Dissolved Oxygen Control System.
  3. Dissolved Oxygen Control System (DOCS): The Owner will self-perform development of a DOCS to control dissolved oxygen in the 12 Bioreactor Basins. The Manufacturer shall make the source code for the MCP PLC available to

allow the Owner to integrate the DOCS program into the MCP PLC program.

The MCP shall include I/O capacity to monitor and control multiple DO sensors, flow meters and flow control valves required to implement the DOCS.

4. The Manufacturer shall provide programming support to the Owner to support integration of the Owner developed DOCS program. The Manufacturer shall perform a final system test of the MCP PLC program to ensure that the Manufacturers blower control program is properly integrated with the DOCS program.
5. The MCP shall include a PLC and HMI. PLC shall be Schneider Electric Modicon Premium with Unity Software. HMI shall be Schneider Electric Magelis.
6. The PLC shall be configured for Ethernet TCP/IP communication protocol with up to four blower unit LCPs and the Plant SCADA system.
7. The PLC shall have sufficient I/O slots to accommodate all DOCS instrumentation. Provide the following minimum terminal capacity with spare PLC chassis capacity to install up to 4 additional I/O cards: 80 Analog Inputs (4-20 mA); 32 Analog Outputs (4-20 mA); 8 Digital Inputs (24 VDC); 8 Digital Outputs (24 VDC).

## 2.07 FINISHING

- A. The blower enclosure shall be painted in manufacturer's standard color. Sound enclosure shall be powder coated polyester base total dry film thickness 4 MDFT.
- B. All other exposed metal shall be surface preparation shall be SSPC 10, rust-inhibitive epoxy primer for ferrous metal with a total dry film thickness of 2.5 MDFT and an alkyd enamel or polyurethane enamel final coat with a total dry film thickness of 4 MDFT.
- C. Field finish in accordance with Manufacturer's directions with the same type of paint system applied in the factory.

## PART 3 - EXECUTION

### 3.01 GENERAL

- A. Packaged Equipment: When any system is provided as pre-packaged equipment, coordination shall include space and structural requirements, clearances, utility connections, signals, outputs, and features required by the manufacturer including safety interlocks.

### 3.02 INSTALLATION

- A. Manufacturer shall be responsible for supervising installation of blowers by the installing Contractor and issuing a Certificate of Proper Installation prior to start-up.
- B. Manufacturer shall adjust blower assemblies such that the driving units are properly



aligned, plumb, and level within Manufacturer's tolerances with the driven units and all interconnecting shafts and couplings so that a proper alignment results.

- C. It shall be the responsibility of the Manufacturer to note strain from attached piping, blower or driver misalignment, noisy operation, or other signs of improper setting for correction by the installing Contractor.
- D. Filter Startup: Prior to startup, the Manufacturer shall be responsible for cleaning filter housings of any trash, loose dirt or dust by vacuuming and hand wiping. The inside walls of the intake pipe shall be thoroughly cleaned of dust and dirt.

### 3.03 FACTORY TESTS

- A. All equipment shall be factory tested in accordance with the following tests for compliance with the operational requirements specified herein. Tests shall be performed on the actual assembled unit being supplied for this project. \
- B. The Manufacturer shall notify the Engineer and Owner at least 14 days prior to conducting the factory performance tests.
- C. Blower Unit Test:
  - 1. Mechanical Test: Blower(s) shall be given a factory mechanical test to assure mechanical integrity. If the test indicates that adjustments are necessary to ensure conformance with specifications, such adjustments shall be made prior to shipment. A certified report of a mechanical test of each blower furnished shall be provided. The mechanical test shall consist of operating the units at or near design conditions for a minimum of one (1) hour. Test data shall include duration of the test, bearing temperatures, speed, brake horsepower, pressure and temperature rise, vibration level, wire-to-air power (HP) and air flow rate (SCFM) over the entire range of operation.
  - 2. Certified Factory Performance Test: A certified report of a performance test of the blower units furnished shall be submitted to the Engineer for review as described hereinbefore. The performance test shall be performed in accordance with the American Society of Mechanical Engineers (ASME-PTC10-1997 (TYPE 2) Power Test Code for Displacement Compressors, Vacuum Pumps and Blowers and shall demonstrate each blower unit's ability to meet the performance criteria specified herein and shall note the following:
    - a. Relative humidity
    - b. Inlet pressure and temperature
    - c. Discharge pressure and temperature
    - d. Capacity
    - e. Speed
    - f. Power impact (line voltage and current)
    - g. Efficiency

- h. Surge point
  - i. Bearing inspection
  - j. Vibration check
  - k. Noise level
3. Impeller Balancing/Vibration Test:
- a. Conduct static balancing of impeller units prior to blower shaft assembly.
  - b. Conduct dynamic balancing of complete blower rotary assembly
  - c. Impeller and rotor shall be balanced to provide a maximum rotor shaft deflection of less than 20 um.
  - d. Measure maximum vibration amplitude when operating at maximum design speed.
  - e. Submit certified static and dynamic balancing test results for each blower unit as part of the Certified Factory Performance Test Report.
- D. In the event any blower fails to meet the performance requirements specified, the Engineer shall have the right to require the manufacturer to modify or replace the blower to meet the performance requirements specified.
- E. Additional tests shall be conducted as required to ensure compliance with these Specifications and shall be performed at no additional cost to the Owner.
- F. Blower Package Testing: On completion of final assembly of the blower package and prior to shipment, each packaged blower shall be mechanically run for a minimum of 30 minutes to ensure functionality and operability of the blower system and it's LCP (local control panel).

#### 3.04 FIELD TESTS AND INSPECTIONS

- A. Prior to equipment start-up, the Manufacturer shall inspect all equipment for proper assembly, installation, and alignment, for quiet and proper operation. The Manufacturer shall issue a Certificate of Proper Installation prior to beginning functional test.
- 1. Functional Test: The Manufacturer shall operate each blower unit and MCP without alarms or shut downs, except as intended, for 7 consecutive days.
  - 2. During the functional test, the Manufacturer shall operate blower units through the design performance range. Adjust, balance, calibrate and verify that the equipment, safety devices, controls and process system operate within the design conditions. Response shall be checked for each equipment item and alarm.
- B. Promptly correct or replace all defective equipment revealed by or noted during tests at no additional cost to the Owner and repeat tests until specified results acceptable to Engineer are obtained.
- C. In the event the blower equipment fails to meet the performance requirements specified,

the Engineer shall have the right to require the Manufacturer to modify or replace the blower equipment to enable said system to meet the performance requirements specified.

- D. Additional tests shall be conducted as required to ensure compliance with these Specifications and shall be performed at no additional cost to the Owner.
- E. A copy of all information from functional tests, including data, worksheets, and other materials shall be turned over to the OWNER at the completion of the testing program.

### 3.05 MANUFACTURERS REPRESENTATIVE

- A. Provide manufacturer's representative for a minimum of five (5) days per blower unit to perform installation inspection and field testing.
- A. Provide manufacturer's technical support for a minimum of twenty-four (24) hours to provide programming support to Owner for implementing the dissolved oxygen control system program into the MCP.
- B. Provide manufacturer's representative for a minimum of two (2) days total to perform operations and maintenance training.
- C. Provide a manufacturer's signed certificates of proper installation and proper operation for each blower unit under this Section.

END OF SECTION

## SECTION 114251 – HIGH SPEED TURBO BLOWERS – MAGNETIC BEARING

Relevant Equipment and Component Numbers	
<u>Tag Number</u>	<u>Equipment Name</u>
TB-1	Bioreactor Turbo Blower No. 1
TB-2	Bioreactor Turbo Blower No. 2
TB-3	Bioreactor Turbo Blower No. 3 (HRRSA Option)

## PART 1 - GENERAL

## 1.01 SCOPE OF WORK:

## A. The Manufacturer shall:

1. Provide high speed turbo blower unit(s) with magnetic bearings and appurtenances as specified herein. Each blower unit shall include blowers, motors, variable frequency drives, local blower control panel, sound attenuation enclosure, inlet air filter/silencer, blow-off valves with silencer, motor exhaust air silencer, discharge check valve, discharge isolation valve, inlet and discharge flexible connectors and other appurtenances as shown on the drawings, as specified herein, and as needed for a complete and operational blower system.
2. Provide a master control panel (MCP) with programmable logic controller (PLC) as specified herein to control the blower unit(s) and appurtenances provided under this specification, existing Spencer Blower No. 8 and the Bioreactor Dissolved Oxygen (DO) Control System.

## B. General:

1. The Manufacturer shall be responsible for providing a complete, fully functional blower system to include blower units and MCP. All equipment provided under this section shall be the end products of one Manufacturer who shall be responsible for the suitability and compatibility of all included equipment in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.
2. Each blower unit provided under this Specification shall be factory- and field-tested for compliance to the requirements specified herein. The blower system(s) shall be shipped completely assembled except that the appurtenances will be shipped loose for field installation.
3. The equipment provided under this section will be installed by a General Contractor under a separate contract. The Manufacturer shall commission the blowers and provide start-up support to HRRSA and the General Contractor as specified herein.
4. The blower system(s) shall be designed to be supplied with 480-volt, 60-hertz, 3-phase power.
5. All equipment shall be designed for continuous or intermittent operation and long operating life in a high humidity atmosphere.

## 1.02 DEFINITIONS

- A. Standard cubic feet per minute (scfm) is defined as air at 68 degrees F, 14.7 psia, and 36 percent relative humidity flowing at a rate of 1 cubic foot per minute.
- B. Surge volume is defined as the air flow rate at which the blower exhibits the first indication of pressure pulsation or flow reversal.
- C. Continuous operation shall be defined as 24 hour per day 7 days per week operation
- D. Intermittent operation shall be defined as periodic operation, including up to 2 starts per hour or extended periods off-line.

## 1.03 REFERENCES

- A. ASME PTC – 10 Test Code on Compressors and Exhausters
- B. International Standards Organization (ISO) 5389: 1992 – Turbocompressors.
- C. VDI 2045: 1993 – Acceptance and Performance Tests on Turbo Compressors and Displacement Compressors

## 1.04 SUBMITTALS

- A. Shop Drawings shall be approved by Engineer prior to fabrication of blower units or master control units.
- B. Shop Drawings for Blower Units
  - 1. Product Data for Blower Units
    - a. Complete list of all system components to be provided.
    - b. Make, model, weight, and horsepower of each equipment assembly.
    - c. Detail specifications for equipment assemblies indicating component drawings, dimensions, weights, loads, required clearances, method of field assembly, components, anchor bolt locations and location and size of each field connection.
    - d. Detail component drawings and specifications for magnetic bearings.
    - e. Performance data for each type of equipment that will show compliance with specification requirements stated herein. Performance data shall include the maximum air flow rate, total system horsepower demand, wire-to-air efficiency, rise-to-surge, and maximum turndown at the design conditions and shall include the maximum discharge pressure and corresponding air flow rate.
    - f. Performance blower curves showing air flow rate in SCFM versus discharge pressure (PSI), total system horsepower demand and total system efficiency (wire-to-air), surge boundary lines including surge

- lower limit (SLL) and surge control line (SCL) over the entire operating range of the blower.
- g. Identification of outside utility requirements for each component such as air, water, power, etc. Include operating parameters for all required utilities.
  - h. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
  - i. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
  - j. Special shipping, storage and protection, and handling instructions.
  - k. Routine maintenance requirements prior to installation and start-up.
2. Submittal Drawings for Blower Units
- a. Detailed Mechanical, Structural, and Electrical Drawings showing the equipment fabrications and interface with other items.
    - 1) Include dimensions, size, and locations of connections to other work.
    - 2) Include information on weights of all major equipment.
  - b. System layout, installation, and placing drawings for blower units and appurtenances.
- C. Shop Drawings for Master Control Unit
1. Detail drawings and specifications for master control unit including dimensioned drawings, weights, required clearances, method of field assembly, components, anchor bolt locations and location and size of each field connection.
  2. Instrumentation, control system schematic, all electrical and control components wiring diagrams.
  3. Source code for blower control system to allow HRRSA to integrate local/custom DO Control System programming into the PLC program
  4. Special shipping, storage and protection, and handling instructions.
  5. Routine maintenance requirements prior to installation and start-up.
- D. Shop Drawings for Sound Attenuation Enclosure:
1. Detail drawings, technical information and specifications for noise enclosure to be provided with each blower to reduce noise level such that blower noise level shall not exceed 80 dBA in any direction at one meter from the blower noise attenuating enclosure in free field conditions.
  2. Submit performance data for noise enclosures that will show compliance with

- noise reduction specifications stated herein.
  3. Provide manufacturer's guarantees that the noise enclosures will meet noise reduction specifications stated herein.
  4. Special shipping, storage and protection, and handling instructions.
  5. Routine maintenance requirements prior to installation and start-up.
- E. Certified Factory Performance Test
1. Submit Certified Factory Performance Test Report for approval. Certified Factory Performance Test Report shall be approved by Engineer prior to shipment of blower units or master control units.
  2. A Certified Factory Performance Test Report shall be provided for each fully assembled blower unit to include the VFD, motor, blower blower supplied for this project. The Report shall include certified blower test curves showing air flow rate in SCFM versus discharge pressure (PSI), total system horsepower demand and total system efficiency (wire-to-air), surge boundary lines including surge lower limit (SLL) and surge control line (SCL) over the entire operating range of the blower (minimum 10 points of operation). The Report shall also indicate separately the pressure, capacity, horsepower demand and efficiency at the design conditions.
- F. Field Test results and Vibration Report.
- G. Manufacturers Operation and Maintenance Manuals customized for this project.
- H. Manufacturer's Certificates of of Proper Installation and Proper Operation.
- I. Manufacturer's Written Warranty.

#### 1.05 DELIVERY, STORAGE, AND HANDLING

- A. Shipping:
1. Ship equipment, material, and spare parts complete, except where partial disassembly is required by transportation regulations or for protection of components.
  2. Pack all spare parts in containers bearing labels clearly designating the contents.
  3. Deliver spare parts at the same time as pertaining equipment.
- B. Receiving:
1. Owner will inspect and inventory items immediately upon delivery to site and is responsible for storing and safeguarding equipment, material, instructions, and spare parts in accordance with Manufacturer's written instructions.

#### 1.06 WARRANTY

- A. The Manufacturer shall provide a full written warranty for all equipment under this section. The warranty period shall be 24 months from delivery of equipment or 18 months from substantial completion, whichever is shorter. If a defect is found during the warranty period, the Manufacturer shall remedy said defect at no cost to Owner.

#### 1.07 SPARE PARTS AND SPECIAL TOOLS.

- A. Four replacement filters for each filter system supplied.
- B. Complete set of special tools.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. Basis of Design Alternative 1:
1. ABS Sulzer HST 40-U400-1-L-48
- B. Basis of Design Alternative 2:
1. ABS Sulzer HST 40-U400-1-L-48

#### 2.02 PERFORMANCE REQUIREMENTS

- A. This RFP includes two basis of design alternatives that may require different equipment. The following design conditions are applicable to each basis of design alternative unless otherwise specified.
- B. The following environmental conditions shall be applicable to all design alternatives.
1. Maximum Inlet air Temp = 100 F;
  2. Relative humidity = 100 percent;
  3. Site elevation = 1,164 ft msl
- C. Basis of Design Alternative 1

<b>Parameter</b>	<b>Design Value per Blower Unit</b>
Blower Bearing	Magnetic
Intake Size (inch)	24"
Discharge Size (inch)	10" (w/ 10" x 20" Silencing Cone)



Design Air Flow Rate (SCFM)	7,200
Design Discharge Pressure (PSI)	8.0
Turn Down Capability	50%
Minimum Air Flow Rate at Design Conditions (SCFM)	3,600
Minimum Rise-to-Surge at Design Conditions (PSI)	2.0
Maximum Operating Pressure (PSI)	10.0
Performance Test Requirement	ISO 5389 and VDI 2045 (Part 1 and Part 2)
Allowable Vibration Level	0.15 in/sec (4 mm/sec)
Minimum Motor HP	400
Motor Rating	Permanent Magnet / Class F Insulation
Primary Power	480V / 3 PH / 60 Hz
Auxiliary Power	480V / 3 PH / 60 Hz
Control Power	24VDC
VFD Rating	UL Listed
Harmonic Filter Rating	IEEE 519 Compliant
Sound Attenuation Enclosure 3-ft Free Field Rating at Design Conditions	80 dBA
Installation Location	Indoors
Minimum Ambient Temperature	0 deg F
Maximum Ambient Temperature	120 deg F

## D. Basis of Design Alternative 2

<b>Parameter</b>	<b>Design Value per Blower Unit</b>
Blower Bearing	Magnetic
Intake Size (inch)	24"
Discharge Size (inch)	10" (with 10" x 20" Silencing Cone)

Design Air Flow Rate (SCFM)	8,300
Design Discharge Pressure (PSI)	8.0
Turn Down Capability	50%
Minimum Air Flow Rate at Design Conditions (SCFM)	3,600
Minimum Rise-to-Surge at Design Conditions (PSI)	2.0
Maximum Operating Pressure (PSI)	10.0
Performance Test Requirement	ISO 5389 and VDI 2045 (Part 1 and Part 2)
Allowable Vibration Level	0.15 in/sec (4 mm/sec)
Minimum Motor HP	400
Motor Rating	Permanent Magnet / Class F Insulation
Primary Power	480V / 3 PH / 60 Hz
Auxiliary Power	480V / 3 PH / 60 Hz
Control Power	24VDC
VFD Rating	UL Listed
Harmonic Filter Rating	IEEE 519 Compliant
Sound Attenuation Enclosure 3-ft Free Field Rating at Design Conditions	80 dBA
Installation Location	Indoors
Minimum Ambient Temperature	0 deg F
Maximum Ambient Temperature	120 deg F

### 2.03 GENERAL REQUIREMENTS

- A. Safety Devices: The completed Work shall include all necessary permanent safety devices, such as machinery guards, emergency stops and similar items required by OSHA, and other federal, state, and local health and safety regulations.
- B. Flanges and Pipe Threads: Flanges on equipment shall comply with 125LB ANSI B16.1 unless otherwise indicated. Threaded flanges and fittings shall be NPT or ASTM A182.

- C. Lifting Lugs: Equipment weighing over 100 pounds shall be provided with lifting lugs.

## 2.04 BLOWER EQUIPMENT

### A. High Speed Blowers

1. Materials of Construction
  - a. Casings and Inlet Inducer: High-strength aluminum alloy, A1Si7Mg-T6.
  - b. Impellers: High-strength forged aluminum alloy.
  - c. Rotor Shafts: Alloy steel with copper cladding.
  - d. Blower and Motor Frame: Welded carbon steel.
2. The impeller shall be shaped from a solid forging on a numerical machining center using CAM technology to ensure consistent efficiency. Semi-open impeller design with 3 dimensional shaped blades optimized for the design range of each turbocompressor. The impeller shall be attached directly to the motor shaft using an aircraft technology fastener system without a coupling or keyway. A labyrinth seal arrangement on the bottom of the impeller shall provide a non contact seal between the volute and motor. The impeller shall be a standard design configuration.
3. The spiral valute casing with horizontal intake and vertical discharge connection shall be provided with intake and discharge flanges in accordance with and manufactured to DIN 2576, PN 10 standards.
4. The blower inlet inducer shall be integral to the blower volute.
5. Bearings shall be sized for a minimum of expected twenty (20) years between major overhauls.
6. Each blower shall be supplied with integrated instrumentation allowing for direct measurement of vibration and temperatures of the motor and air bearing.
7. Each blower shall be supplied with built in vibration isolating mounts. The blower manufacturer shall be responsible for attenuating noise and vibration in the blower package such that no special installation base shall be required nor shall any vibration from the blower package be transmitted to the floor or intake and discharge base or the piping.
8. Blowers shall be designed to be placed on a concrete housekeeping equipment pad provided by the installing Contractor (6" thick, 3,000 PSI concrete with #5@12" O.C. E.W. reinforcing) and anchored to the pad using 316 SS anchor bolts. Manufacturer shall provide the specification for anchor bolts to be supplied and installed by Owner.
9. The blower intake shall originate outside the sound attenuating enclosure.
10. Provide flanged connections exterior to the sound attenuating enclosure for blower intake, blower discharge and motor cooling air.

### B. Sound Attenuation Enclosure

1. Provide each blower unit with a steel sound enclosure covering the entire blower unit. The sound enclosure shall be designed for easy inspection and maintenance of all blower package components. Provide quick release panels to allow access for routine maintenance of the blower and all internal components. The blower unit enclosure shall protect against falling water, condensation and dust.
2. At the design conditions specified herein, blower noise level shall not exceed 80 dBA in any direction at one meter from the blower noise attenuating enclosure in free field conditions.

C. Motors

1. Provide each blower unit with a high speed Permanent Magnet Synchronous Motor (PMSM) driven by a variable frequency drive operating on 480 Volts, 3 Phase, 60 Hertz input power.
2. Designed for ambient temperature conditions indicated.
3. Motor shall have thermal sensors (RTDs) in the winding for each phase reporting the motor temperature monitoring instrumentation.
4. The motor rotor shaft shall be supported by magnetic bearings at all times while power is supplied to the blower unit providing a smooth vibration free rotation over the entire speed range.
5. The motor shall be air cooled by a cooling fan that is mounted directly to the end of the motor rotor shaft.
6. The motor shall have a 1.15 service factor. Blower manufacturer shall be responsible for coordinating the starting torque requirement of the blower and the motor.
7. Each blower motor shall be of the PMSM type that has no physical connection between stator and shaft, therefore eliminating brushes, slip rings or break resistors. The PMSM shall be combined with a an Input Line Reactor.

D. Magnetic Bearing System

1. The motor rotor shaft shall be continuously levitated in a magnetic field by the magnetic bearing system. This system shall consist of two radial and two axial active magnetic bearings, two rotor position sensors and a magnetic bearing controller (MBC). The position sensors shall continuous measure the shaft position and send a signal to the MBC controlling the energy in the active magnetic bearings keeping the motor rotor shaft levitated and centered. There shall be no mechanical contact at any time between any moving and stationary surfaces during the blower operation eliminating friction and wearing of all moving parts. The magnetic bearing system shall not require any oil lubrication.
2. The magnetic bearing controller shall be an MBC-12 having a maximum input power of 1.3 hp (1 kW) and be powered by a 3 phase, 60 Hz with a power supply that has the same voltage as the main power supply.

- E. Variable Frequency Drive
  - 1. Provide each blower unit with a high efficiency UL listed Variable Frequency Drive (VFD) with 97% efficiency at full rated motor speed and power.
  - 2. Provide each VFD with a passive harmonic filter that reduces the THD (Total Harmonic Distortion) to achieve compliance IEEE 519. Harmonic filters shall be provided in NEMA 1 free standing cabinets for external mounting adjacent to the blower enclosure.

2.05 APPURTENANCES

- A. Intake Filter
  - 1. Provide each blower unit with an inlet single stage filtration system. Intake and filter performance losses shall be included by the blower vendor in the blower performance calculation. Each filter system shall be adequately sized for the airflow rate of each blower unit. The filter system shall include filter element(s), filter housing filter access door with quick release door handle and gasket, filter to flanged inlet pipe adapter and be constructed using single wall 304 SST. The access door shall be sealed to prevent air infiltration and sufficiently sized to allow easy access to the filters. The filter system shall have 24-inch 125LB ANSI B16.1 flange connections.
  - 2. The filters shall be pocket Camfil Hi-Cap having a high density microfibre glass fiber filter medium suitable for high efficiency filtration that has a EN779:2002:G4 standards filter class that is mounted on a 304 SST frame with a hook and lever arrangement for easy replacement.
- B. Intake Silencer
  - 3. Provide each blower unit with an inlet silencer. Silencer performance losses shall be included by the blower vendor in the blower performance calculation. The silencer shall have 24-inch 125LB ANSI B16.1 flange connections.
  - 4. The inlet silencer shall have a dual wall construction with a minimum 3.94 in (100 mm) thick fiberglass or mineral wool insulation between the walls, have a maximum pressure loss of 0.005 psi (37 Pa), and be constructed of AISI 304 SST. Each inlet silencer shall attain the following minimum attenuation characteristics at design conditions.

<b>Inlet Silencer</b>								
Octave Band								
Mid Frequency (Hertz)	63	125	250	500	1,000	2,000	4,000	8,000
Attenuation, db	2	5	15	24	39	32	21	12

- C. Blow Off Valve
  - 1. Provide each blower unit with electro-pneumatic blow-off valve actuated by blower pressure integral to the discharge cone silencer.

2. The blow-off valve discharge shall be supplied with a blow-off silencer. Each blow off silencer shall attain the following minimum attenuation characteristics at design conditions.

<b>Blow Off Silencer</b>								
Octave Band								
Mid Frequency (Hertz)	63	125	250	500	1,000	2,000	4,000	8,000
Attenuation, db	4	9	17	29	41	28	25	28

3. The blow off valve and silencer shall be 316 SST construction with PTFE or viton seals and shall have 125LB ANSI B16.1 flange connections.

D. Discharge Silencer and Motor Cooling Air Silencer

1. Provide each blower unit with flanged outlet silencers for discharge and motor cooling air. Each silencer shall attain the following minimum attenuation characteristics at design conditions.
2. The outlet silencer shall have a dual wall construction with a minimum 3.94 in (100 mm) thick fiberglass or mineral wool insulation between the walls, have a maximum pressure loss of 0.063 psi (432 Pa), and be constructed of AISI 304 SST. The silencer shall have 125LB ANSI B16.1 flange connections.

<b>Discharge Silencer</b>								
Octave Band								
Mid Frequency (Hertz)	63	125	250	500	1,000	2,000	4,000	8,000
Attenuation, db	4	9	17	29	41	28	25	28

E. Intake Weather Hood

1. Provide a weather hood for each blower unit with a flanged connection to be mounted by the Contractor on the blower unit intake piping exterior to the blower building. Weather hood shall have an effective minimum intake area of 400% of the intake connection to the blower unit. Provide a minimum 48-inch diameter mushroom type intake or minimum 36-inch by 36-inch square hood with AISI 304 SST construction. Provide No. 24 AISI 304 SST insect screen over opening.

F. Inlet Scrap Trap

1. Provide each blower unit with a 316SS inlet scrap trap to be installed by the installing Contractor in the inlet pipe to prevent particles larger than 0.08 inches (2 mm) by 0.08 inches (2 mm) from entering the blower unit. The inlet scrap trap shall be located between two flanges as close to the blower unit inlet flange as possible.

- G. Isolation Butterfly Valve, BFV (air service).
1. Provide each blower unit with a 20-inch discharge BFV and a line size BFV to isolate the blow off valve.
  2. Lug style, two-piece ASTM A 126 Class B
  3. Materials of construction: Cast or ductile iron ASTM A 536 body, one piece type 316 SST thin-profile disc and stem, heavy-duty stem bushing, NBR stem seal, FKM (viton) replaceable resilient seat
  4. Pressure rating: 75 psi pressure bi-directional bubble-tight
  5. Temperature rating: 300 degrees F
  6. Process connections: 125LB ANSI B16.1 flanges
  7. Supply reduced disc diameter, if available
  8. Hand actuators shall be 10 position locking type
  9. Manufacturers and Products:
    - a. Bray Controls Series 21.
    - b. Dezurik Style BOS.
- H. Check Valve, CV (air service)
1. Provide each blower unit with a 20-inch discharge check valve.
  2. Wafer-style, dual plate check valve with spring or single flap non spring loaded
  3. Materials of construction: 316 SST body, 316 SST internals and disc, 316 SS spring and silicone seal.
  4. Temperature rating: 500 degrees F
  5. Manufacturers and Products:
    - a. Flexi-Hinge Series 504.
- I. Flexible Connectors (air service)
1. Provide each blower unit with two flexible connectors to be installed on the discharge aeration piping prior to the main air header and the intake aeration piping prior to exiting the blower building and one line size flexible connector to be installed on the blower exhaust connection.
  2. Connections shall be the single arch, 12-inch neutral length, reinforced rubber expansion joint type with control rods.
  3. Flexible connection material of construction shall be EPDM suitable for 300 F air source.
  4. Process connections: 125LB ANSI B16.1 flanges
  5. Manufacturers and Products:
    - a. Proco Series FA 231 EE
- J. Uninterruptible Power Supply (UPS) for MBC:
1. Provide each blower unit with an uninterruptible power supply (UPS) system that provides a secondary source of power for the magnetic bearings and MBC. This system is a back up to the power generation mode feature that is the first line of safety if a power outage occurs assuring that the blower unit will spin down without damaging the high speed unit.
  2. The UPS shall have batteries sufficiently sized to provide a safe spin down and a monitoring panel that will indicate the condition of the batteries.
- K. Provide the following instrumentation for each blower unit:

1. Inlet differential pressure sensors for filter monitoring
2. Discharge differential pressure sensor
3. Inlet and discharge temperature sensors
4. Motor temperature sensor
5. Vibration sensor

## 2.06 CONTROLS

### A. General

1. All components in the Local Control Panels (LCP) and Master Control Panel (MCP) shall be completely factory wired and shall include all necessary controls for both the manual/local and automatic/remote operation of the blower units.
2. All electrical and control connections that are not factory assembled and shipped complete shall only require the installing Contractor to connect wires between junction boxes installed on the blower unit by the Manufacturer.
3. The incoming power provided to the LCP shall be a 480VAC, 3 PH, 60 Hz circuit to power the blower unit VFD and an auxiliary 120/208VAC, 1 PH 60 Hz circuit to power the LCP. Main circuit breakers for both circuits sized per NEC shall be provided along with all transformers, relays, etc. necessary to make the panel fully functional. Surge protective devices (SPD) shall be provided to protect the electrical and control components from excessive voltage and current: Type 1 SPD to protect the 480V loads (VFD) and Type 2 SPD to protect the 120V loads (LCP).
4. The incoming power provided to the MCP shall be a 480, 3 PH 60 Hz circuit. Main circuit breakers for both circuits sized per NEC shall be provided along with all transformers, relays, etc. necessary to make the panel fully functional. Surge protective devices (SPD) shall be provided to protect the electrical and control components from excessive voltage and current: Type 2 SPD to protect the 120VAC loads.
5. Wiring and all electrical components shall comply with UL/CSA and NEC.

### B. Miscellaneous electrical devices

1. A 120 VAC to 24 VDC power supply shall be provided to power the PLC inputs and other 24 VDC powered devices. The power supply shall be properly sized for the LCP total load.
2. Provide noise filter to provide clean, noise-free power to the PLC.

### C. Local Control Panel (LCP)

1. Provide an LCP on each Blower Unit with all components contained in a NEMA 3/IP33 enclosure segregated from the main blower enclosure.
2. The LCP shall be configured for Ethernet TCP/IP or Profibus communication protocol with the MCP.
3. The LCP shall have sufficient I/O slots to accommodate all blower instrumentation with 25% spare installed I/O terminal capacity.
4. The LCP program/functionality shall:
  - a. Display system status, system alarms and allow local reset of alarm conditions. At a minimum, provide the following indicators for each



blower unit. All indicators shall be available for communication to the MCP via Ethernet communication.

- 1) Status (RUN/STOPPED)
  - 2) Local / Remote Control Selection
  - 3) Local / Remote Control Indication
  - 4) Start / Stop (Local Control Only)
  - 5) Speed Select (Local Control Only)
  - 6) Speed Indication Status (RPM)
  - 7) Run Times (hours)
  - 8) Amp Draw (amps)
  - 9) System Pressure (PSI)
  - 10) Flow Rate (SCFM)
  - 11) Vibration Level (in/sec)
  - 12) Alarm Condition (Indicate Alarm Code/Condition)
  - 13) Alarm Local Reset
- b. Provide a local / remote operation mode selector for the blower unit. In remote mode, the blower unit shall be controlled by the MCP. In local mode, the blower unit shall be controlled from the LCP.
  - c. Provide flow control monitoring and adjustment in both remote and local modes of operation. Perform adjustments using an internal load-proportional signal in the control card located in the VFD. The limits (surge limit, max pressure ratio limit, power limit and speed limit) for these signals shall be programmed into the application software. The limits shall be based on the most stringent and restrictive inlet air temperature and environmental conditions.
  - d. Provide the blower unit with automatic surge protection.
  - e. Control the blow-off valve.
- D. Main Control Panel (MCP)
1. Provide an MCP to control the blower system, to include up to four turbo blower units and the existing Spencer 8 blower with all components contained in a NEMA 12 enclosure.
  2. The MCP shall control multiple turbo blowers using a standalone PLC based system to control the air flow rate from the turbo blower system. The MCP shall control the turbo blowers to maintain operation at their optimal efficiency point based on either a flow (SCFM) or pressure (PSI) input from the Dissolved Oxygen Control System.
  3. Dissolved Oxygen Control System (DOCS): The Owner will self-perform development of a DOCS to control dissolved oxygen in the 12 Bioreactor Basins. The Manufacturer shall make the source code for the MCP PLC available to allow the Owner to integrate the DOCS program into the MCP PLC program. The MCP shall include I/O capacity to monitor and control multiple DO sensors, flow meters and flow control valves required to implement the DOCS.
  4. The Manufacturer shall provide programming support to the Owner to support integration of the Owner developed DOCS program. The Manufacturer shall perform a final system test of the MCP PLC program to ensure that the Manufacturers blower control program is properly integrated with the DOCS program.

5. The MCP shall include a PLC and HMI. PLC shall be Schneider Electric Modicon Premium with Unity Software. HMI shall be Schneider Electric Magelis.
6. The PLC shall be configured for Ethernet TCP/IP communication protocol with up to four blower unit LCPs and the Plant SCADA system.
7. The PLC shall have sufficient I/O slots to accommodate all DOCS instrumentation. Provide the following minimum terminal capacity with spare PLC chassis capacity to install up to 4 additional I/O cards: 80 Analog Inputs (4-20 mA); 32 Analog Outputs (4-20 mA); 8 Digital Inputs (24 VDC); 8 Digital Outputs (24 VDC).

## 2.07 FINISHING

- A. The blower enclosure shall be painted in manufacturer's standard color. Sound enclosure shall be powder coated polyester base total dry film thickness 4 MDFT.
- B. All other exposed metal shall be surface preparation shall be SSPC 10, rust-inhibitive epoxy primer for ferrous metal with a total dry film thickness of 2.5 MDFT and an alkyd enamel or polyurethane enamel final coat with a total dry film thickness of 4 MDFT.
- C. Field finish in accordance with Manufacturer's directions with the same type of paint system applied in the factory.

## PART 3 - EXECUTION

### 3.01 GENERAL

- A. Packaged Equipment: When any system is provided as pre-packaged equipment, coordination shall include space and structural requirements, clearances, utility connections, signals, outputs, and features required by the manufacturer including safety interlocks.

### 3.02 INSTALLATION

- A. Manufacturer shall be responsible for supervising installation of blowers by the installing Contractor and issuing a Certificate of Proper Installation prior to start-up.
- B. Manufacturer shall adjust blower assemblies such that the driving units are properly aligned, plumb, and level within Manufacturer's tolerances with the driven units and all interconnecting shafts and couplings so that a proper alignment results.
- C. It shall be the responsibility of the Manufacturer to note strain from attached piping, blower or driver misalignment, noisy operation, or other signs of improper setting for correction by the installing Contractor.

- D. Filter Startup: Prior to startup, the Manufacturer shall be responsible for cleaning filter housings of any trash, loose dirt or dust by vacuuming and hand wiping. The inside walls of the intake pipe shall be thoroughly cleaned of dust and dirt.

### 3.03 FACTORY TESTS

- A. All equipment shall be factory tested in accordance with the following tests for compliance with the operational requirements specified herein. Tests shall be performed on the actual assembled unit being supplied for this project. \
- B. The Manufacturer shall notify the Engineer and Owner at least 14 days prior to conducting the factory performance tests.
- C. Blower Unit Test:
1. Mechanical Test: Blower(s) shall be given a factory mechanical test to assure mechanical integrity. If the test indicates that adjustments are necessary to ensure conformance with specifications, such adjustments shall be made prior to shipment. A certified report of a mechanical test of each blower furnished shall be provided. The mechanical test shall consist of operating the units at or near design conditions for a minimum of one (1) hour. Test data shall include duration of the test, bearing temperatures, speed, brake horsepower, pressure and temperature rise, vibration level, wire-to-air power (HP) and air flow rate (SCFM) over the entire range of operation.
  2. Certified Factory Performance Test: A certified report of a performance test of the blower units furnished shall be submitted to the Engineer for review as described hereinbefore. The performance test shall be performed in accordance with the Performance tests will be conducted in accordance with ISO 5389 and VDI 2045 (Part 1 and Part 2) and shall demonstrate each blower unit's ability to meet the performance criteria specified herein and shall note the following:
    - a. Relative humidity
    - b. Inlet pressure and temperature
    - c. Discharge pressure and temperature
    - d. Capacity
    - e. Speed
    - f. Power impact (line voltage and current)
    - g. Efficiency
    - h. Surge point
    - i. Bearing inspection
    - j. Vibration check
    - k. Noise level
  3. Impeller Balancing/Vibration Test:
    - a. Conduct static balancing of impeller units prior to blower shaft assembly.
    - b. Conduct dynamic balancing of complete blower rotary assembly

- c. Impeller and rotor shall be balanced to provide a maximum rotor shaft deflection of less than 20 um.
  - d. Measure maximum vibration amplitude when operating at maximum design speed.
  - e. Submit certified static and dynamic balancing test results for each blower unit as part of the Certified Factory Performance Test Report.
- D. In the event any blower fails to meet the performance requirements specified, the Engineer shall have the right to require the manufacturer to modify or replace the blower to meet the performance requirements specified.
- E. Additional tests shall be conducted as required to ensure compliance with these Specifications and shall be performed at no additional cost to the Owner.
- F. Blower Package Testing: On completion of final assembly of the blower package and prior to shipment, each packaged blower shall be mechanically run for a minimum of 30 minutes to ensure functionality and operability of the blower system and it's LCP (local control panel).

#### 3.04 FIELD TESTS AND INSPECTIONS

- A. Prior to equipment start-up, the Manufacturer shall inspect all equipment for proper assembly, installation, and alignment, for quiet and proper operation. The Manufacturer shall issue a Certificate of Proper Installation prior to beginning functional test.
- 1. Functional Test: The Manufacturer shall operate each blower unit and MCP without alarms or shut downs, except as intended, for 7 consecutive days.
  - 2. During the functional test, the Manufacturer shall operate blower units through the design performance range. Adjust, balance, calibrate and verify that the equipment, safety devices, controls and process system operate within the design conditions. Response shall be checked for each equipment item and alarm.
- B. Promptly correct or replace all defective equipment revealed by or noted during tests at no additional cost to the Owner and repeat tests until specified results acceptable to Engineer are obtained.
- C. In the event the blower equipment fails to meet the performance requirements specified, the Engineer shall have the right to require the Manufacturer to modify or replace the blower equipment to enable said system to meet the performance requirements specified.
- D. Additional tests shall be conducted as required to ensure compliance with these Specifications and shall be performed at no additional cost to the Owner.
- E. A copy of all information from functional tests, including data, worksheets, and other

materials shall be turned over to the OWNER at the completion of the testing program.

3.05 MANUFACTURERS REPRESENTATIVE

- A. Provide manufacturer's representative for a minimum of five (5) days per blower unit to perform installation inspection and field testing.
- B. Provide manufacturer's representative for a minimum of two (2) days total to perform operations and maintenance training.
- C. Provide a manufacturer's signed certificates of proper installation and proper operation for each blower unit under this Section.

END OF SECTION



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