

Roane County Purchasing Department
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**ADDENDUM #1
BID 2015-39/204
BLOWER BUILDING**

TO: All Potential Bidders

This addendum forms part of the Bid Documents. It supplements and modifies them as follows:

ITEM #1 – ADDITIONAL INFORMATION

- Technical Specifications

Please return this addendum to the Purchasing Department in the bid envelope. If your bid has already been sent and this addendum does not pertain to bid pricing, you may return it via facsimile.

ACKNOWLEDGMENT OF ADDENDUM

The undersigned acknowledges receipt of Addendum #1 – Bid #2015-39/204.

Name

Title

SECTION 11370

HIGH SPEED TURBO BLOWER

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Included: Furnish, and test, Quantity two (2) UL Listed, factory assembled high speed, air foil bearing single core turbo blower systems. The packaged blower systems shall be complete, including sound enclosure, motors, variable frequency drives, control panels, programmable logic controllers, inlet air filter/silencers, blow-off valves, check valves, discharge valves, flexible connectors and other appurtenances as shown on the Drawings, as specified herein, and as needed for a complete and operational blower system. Nuts, bolts, pipe spools & elbows, washers, lock-washers and gaskets needed to install the loose appurtenances are not part of the scope of supply.
- B. Blowers shall be complete pre-packaged units consisting of Permanent Magnet Synchronous Motors, integrated air filters, variable speed drive, and PLC (programmable logic controller) based Local Control Panel.
- C. The equipment shall be furnished by a single MANUFACTURER.

1.2 SYSTEM DESCRIPTION

- A. The system shall include factory assembled single core high speed turbo blowers with integral variable frequency drives and programmable logic controllers in a complete package that does not require lubrication of the bearings for operation.
- B. All equipment including controls and drives specified herein shall be specifically designed for this service and the environment encountered in this installation.
- C. Equipment shall be designed and capable of either continuous or intermittent operation.
- D. All equipment, supports, anchors and fasteners shall be of adequate strength to withstand loads associated with starting, turbulence, thrusts, thermal expansion and contraction and other loads encountered under normal operating conditions.
- E. The equipment, sizes, materials and arrangements described in this specification section are based on recommendations by equipment manufacturers and shall be considered minimum limits of acceptability. The equipment manufacturer shall be responsible for design, arrangement and performance of all equipment supplied under this section. Arrangements other than those shown on Drawings shall be subject to the ENGINEER'S approval.

1.3 SUBMITTALS

- A. Product Data: Provide construction details, material descriptions, dimensions of individual components and profiles and finishes for each component.
- B. Shop Drawings: Provide plans, elevations, sections, details and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and location and size of each field connection.
 - 2. Manufacturer and model number of all equipment within this specification and an itemized list of components being furnished.
 - 3. Layout drawings and equipment cut sheets showing dimensions, clearances, sizes, arrangement and size of connections, supports, anchors and total weights of the product.
 - 4. Detailed specifications and data describing the materials of construction.
 - 5. Wiring Diagrams: For power, signal and control wiring diagrams, including terminals and numbers.
 - 6. Motor requirements in accordance with applicable motor specification section.
 - 7. Equipment weights and lifting points.
- C. Information Submittals:
 - 1. Factory functional and motor performance test reports.
 - 2. Special shipping, storage and protection and handling instructions.
 - 3. Manufacturer's instructions for installation.
 - 4. Manufacturer's equipment installation report.
 - 5. Location of nearest stocking distributor for spare parts.
 - 6. Recommended spare parts list to maintain the equipment in service for a period of three years. Include a list of special tools required for checking, testing, parts replacement and maintenance with current pricing information.
 - 7. List special tools, materials and supplies furnished with equipment for use prior to and during start-up and for future maintenance.
 - 8. Warranty certificate.
- D. Performance Data: Blower certified past performance test reports for each blower (as outlined later in this specification) and including, but not limited to, certified blower curves showing pressure, capacity, horsepower demand and blower efficiency over the entire operating range of the blower. The equipment manufacturer shall also indicate separately the pressure, capacity, horsepower demand and efficiency required at the design point(s).
- E. Submit complete instruction manual for operation and maintenance of the equipment in accordance with this section. Include the following data:
 - 1. Alignment, adjustment, and repair instructions.
 - 2. MANUFACTURER'S installation and operation instructions.
 - 3. Assembly diagrams.
 - 4. Troubleshooting guide.
 - 5. Recommended spare parts lists and predicted life of parts subject to wear.
 - 6. Scheduled maintenance intervals.
 - 7. Manufacturer's service plans.

1.4 QUALITY ASSURANCE

- A. The packaged blower systems, including blower, motors, controls and all appurtenances to form an integrated system, shall be supplied by one manufacturer who shall provide all the equipment and appurtenances regardless of manufacturer.
- B. Manufacturer Qualifications:
 - 1. MANUFACTURER shall be experienced in manufacturing high speed turbo blowers similar to those indicated for this Project and have a record of over Seven (7) years successful in-service performance in Canada and/or USA for similar municipal wastewater treatment applications.
 - 2. MANUFACTURER must have similar blowers permanently installed and operational in at least sixty (60) wastewater treatment facilities in North America. Twenty (20) of these facilities must be similar in design to what is specified.
 - 3. MANUFACTURER shall have a history of manufacturing, providing and servicing this equipment for at least five (5) years in North America.
 - 4. A list of similar installations shall be furnished, to show conformance with article 1.4 B.1 to B.3, with the manufacturer's bid as well as with the shop drawing submittal, including names and telephone numbers of contacts.
 - 5. MANUFACTURER shall have a domestic service facility and factory personnel located within four hours of driving time.
- C. Installer Qualifications: A MANUFACTURER authorized representative who is trained and approved for installation of units is required for this Project.
- D. Acceptable manufacturers:
 - 1. Basis of Bid
 - a. APG-Neuros
 - b. or Engineer Approved Equal
 - 2. Not Used

- E. Work shown on the drawings is based on APG-Neuros blowers. If an alternate manufacturer is allowed, it shall be the responsibility of the Contractor to perform any required redesign and coordination associated with, but not limited to, mechanical equipment layout, electrical wiring, conduit and controls and structural/architectural work at no additional cost to the Owner. The proposed redesign shall be subject to review and approval of the Engineer.

1.5 DELIVERY, STORAGE AND HANDLING

- A. The equipment, material and spare parts shall be shipped complete except where partial disassembly is required by transportation regulations or for the protection of components.
- B. Spare parts shall be packed in containers bearing labels clearly designating contents and pieces of equipment for which they are intended.
- C. The CONTRACTOR shall unload, store and safeguard equipment, materials and spare parts in accordance with the MANUFACTURER's instructions.

1.6 WARRANTY

- A. Provide an equipment warranty in the Owner's name for a three (3) years period from substantial completion of the blower equipment, not to exceed forty-two (42) months from delivery, whichever occurs first.
- B. Provide an equipment warranty in the contractors' name to cover the period during construction, through substantial completion. The duration of this warranty period will be determined based on the construction schedule and confirmed with the contractor.
- C. Blower manufacturer's warranty shall be void if the following occur:
 - 1. Unauthorized modifications, including tampering with or drilling any holes in the blower enclosure or improper sealing of cable conduits.
 - 2. Exposure to or entry of direct rain or mist to the enclosure during storage or blower operation.
 - 3. Opening the blower control section by other than the manufacturers authorized Field Service representative before start-up.
 - 4. Excessive corrosive fluids, dirt or dust found in or around the blower.
- D. Each Blower shall have built in provisions for remote access via VPN or cellular communication for MANUFACTURER to remotely monitor blower operation, troubleshoot and apply upgrades. The owner shall enroll the equipment in the blower manufacturers remote technical support program during the warranty period.

1.7 SPARE PARTS

- A. Furnish the following recommended spare parts with the blowers:
 - 1. One (1) set of inlet air filters per blower
- B. Furnish one set of special tools required for complete assembly or disassembly of blower system components for each type or size of blower specified, together with a storage box (or boxes) for the same. This tool kit shall be sufficiently complete to permit normal repair and maintenance of all equipment furnished under this project.

PART 2 - EQUIPMENT

2.1 EQUIPMENT PERFORMANCE

A. Aeration Blowers shall meet the following design conditions.

Total Number of Blowers	Two(2)
Method of Operation	In parallel, continuous, alternating start
Bearing Type	double-layer bump foil air bearing
Drive Type	Direct
Design Ambient Barometric Pressure (PSIA)	14.165
Design Site Elevation (FASL)	100
Design Maximum Inlet Air Temperature (°F) and Relative Humidity (%)	100°F / 75%
Design Minimum Inlet Air Temperature (°F) and Relative Humidity (%)	28°F / 60%
Design Discharge Pressure (PSIG)	8.4
System Design Maximum Flow at Maximum Inlet Air Temperature and Design Discharge Pressure (SCFM)	2,000
Design Blower Flow Rate (SCFM)	1,000
Discharge Flange Size (ANSI 150 lb.) (in)	8
VFD-Rated Maximum Motor Horsepower (bhp)	75
Available Power Voltage	480
Available Power Phase	3 phase
Maximum Noise at 3 Feet	80 ± 2 dBa
Allowable vibration level	< 4 mm/sec

2.2 GENERAL

- A. Blowers shall have a double-layer type bump foil air bearing and shall not require oils or lubricants for adequate operation. Magnetic bearings, single-layer or leaf type air bearings are unacceptable and are cause for immediate rejection.
- B. Blowers shall be capable of variable speed operation with a minimum turndown of fifty five percent (55 %) from its maximum flow capacity and shall use integral variable frequency drives. Each blower shall be capable of operating continuously and satisfactorily at any point between the minimum and maximum flows without any surge, vibration, hunting, or excessive heating of bearings or motor.
- C. Complete blower packages shall be UL-Listed, with no exception. UL Listing nameplate to be on package exterior. UL-listing must be for the complete package.
- D. Blowers shall be factory tested per ASME PTC-10 Type 2 Performance test to verify flow and wire power at design conditions as well as blower maximum conditions. The acceptance criteria are 4% tolerances on flow.
- E. Neither special foundations nor anchoring shall be required for installation.
- F. All elastomeric materials for couplings, valves, etc., shall be rated for a minimum 250° F temperature.

2.3 HIGH SPEED BLOWERS

- A. Each blower shall be designed to maintain a minimum rise-to-surge of 3.0 psig at the maximum flow point and design pressure.
- B. Blower impellers shall be a single-stage backswept blade high efficiency configuration designed using Computational Fluid Dynamics (CFD) milled from forged aluminum alloy Type 7075 (cast impellers are not permitted), with first 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 dynamically balanced. The use of dual impellers is not permitted.
- C. Bearings shall be sized for a minimum of expected ten (10) years between scheduled overhauls or inspections.
- D. Each blower shall be supplied with a sound enclosure covering the entire blower package. The sound enclosure shall be designed for easy inspection and maintenance of all blower package components. Quick release panels shall provide easy and quick access for routine maintenance of the blower and the package components.
- E. The currently designed blower system layout is based on blowers that do not require separate exhaust connections for ventilation of cooling air. Blowers 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 such as cooling fans, ducting, or external glycol cooling.
- F. Integrated blower instrumentation and PLC programming shall enable measurement and display of shaft vibration, and temperatures in the motor windings and bearings.
- G. Each blower shall be supplied with blower core built in vibration isolating mounts. The blower manufacturer shall be responsible for demonstrating the vibration of the blower core below the 4 mm/s design limit.

- H. Each blower shall be supplied with a discharge cone that will be designed to reduce discharge flow speeds below 82 feet/sec, to minimize discharge piping noise and losses, and increase overall efficiency.

2.4 APPURTENANCES

- A. Each blower shall be supplied with one (1) 8" EPDM expansion joints to be installed on the discharge piping prior to the main air header to mitigate the transmission of vibration to the discharge piping and allow for thermal expansion of the discharge components. The flexible connector shall be suitable for the maximum operating discharge flow temperature and pressure.
- B. Each blower shall be supplied with one (1) 8" wafer style, dual plate check valves that shall be installed on the discharge cones. Check valves shall be of iron body with aluminum internals and silicon seat.
- C. Each blower shall be supplied with one (1) 8" manually operated discharge isolation valves. Valve shall be lug type with iron body, 316 stainless steel disc, 416 stainless steel stem, and viton seat.
- D. Each blower shall be equipped with an integrated electro-pneumatic blow-off valve actuated by blower pressure, and a signal of open/closed status available through the blower PLC.
- E. The blow-off valve discharge shall be supplied with a properly sized blow-off for discharge noise levels not to exceed 90 dBA at 5 feet from blower at HMI height.
- F. Each blower shall be provided with an integrated combination intake 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.
- G. Integrated blower dual filtration shall be comprised of a core pre-filter and a fine filter media with 90% by weight per ASHRAE 52-76 with an 98% efficiency @ 10 microns (nom). Filter element shall be removable without disconnecting the inlet duct and shall be cleanable by maintenance personnel as a preventative maintenance procedure.
- H. Each blower shall be equipped with the following manufacturer's integrated instrumentation and display on blower HMI.
 - 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. Ambient temperature sensor
 - 7. Ambient pressure transducer
 - 8. Vibration sensor (if applicable)

2.5 MOTORS

- A. Each blower shall be supplied with a high speed Permanent Magnet Synchronous Motor (PMSM) operating on 460/480 Volts, 3 Phase, 60 Hertz input power to the VFD. Induction or Permanent Magnet Brushless DC Motors shall not be acceptable.

- B. The maximum allowable motor horsepower shall be as specified in paragraph 2.1 Equipment Performance.
- C. The motor shall have a 1.15 service factor.

2.6 INVERTER/VFD

- A. Each blower shall be equipped with a high efficiency UL listed VFD (Variable Frequency Drive) with 97% efficiency at full rated motor speed and power. VFD Manufacturer shall be KEB America. No other VFD manufacturer shall be approved. Proprietary or Non UL listed VFDs shall not be accepted.
- B. Each VFD shall have an operation in the USA for manufacturing, support and provision of replacement parts.
- C. Each VFD shall have a sinusoidal filter on its output consisting of an L (inductor) and C (capacitor) filter.

2.7 CONTROLS AND INSTRUMENTATION

A. General

1. All components in the control panel shall be completely factory wired and shall include all necessary controls for both the manual/local and automatic/remote operation as indicated on the Drawings and Specifications.
2. The incoming power provided to the panel shall be 480 volt, 3 phases. A suitable thermal-magnetic main circuit breaker sized no less than 125% greater than the connected load 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 (PLC controller box). The SPD locations shall be strategically selected to have surge immunity and the MCOV shall be not less than 115% of nominal voltage.
3. Wiring shall comply with UL/CSA and the Canadian National Electrical Code.
4. All electrical connections to external devices and equipment shall be provided by the Contractor.
5. Equipment and controls furnished by other manufacturers shall be provided in accordance with their instructions, where applicable.
6. The blower shall have an Allen Bradley MicroLogix 1400 PLC for operation, adjustment and monitoring. No similar or equal shall be accepted.
7. The system shall have an Allen-Bradley Panelview 600 HMI touchscreen

B. Miscellaneous electrical devices

1. A 120 VAC to 24 VDC power supply shall be provided to power the programmable controller inputs and other 24 VDC powered devices. The power supply shall be properly sized for the LCP (local control panel) total load.
2. Provide noise filter to provide clean, noise-free power to programmable controllers.

C. Operator Interface: Provide the following indicators on the operator interface:

1. Blower Status (RUN/STOPPED)
2. Operator Mode Selection
3. System pressure display
4. Blower Local / Remote Control

5. Blower Speed Indication Status
 6. Blower Run Times (hours)
 7. Blower Amp Draw (amps)
 8. System Pressure
 9. System Flow
- D. Operator interface device
1. The device shall include the following displays:
 - a. History: displays history of sequential alarms with date and time of occurrence.
 - b. Status: One-touch access to display current system operating status. When the system is running, the display shall show the set point pressure, actual pressure, flow and speed (0-100%).
 - c. Alarm Information: Last alarms recorded in memory are displayed with related detailed information on the alarm including time of occurrence, date, and blower's main operating parameters at the time of alarm and how to correct the alarm condition. Each log shall include individual blower run status, VFD mode, flow and alarm type.
 - d. Alarm List: One-touch access to an Alarm List of all possible alarms and their current status.
 - e. Daily Log/Total: Displays the individual equipment run times and run times since last reset.
 - f. Scroll Key: Used to scroll up and down through data.
 2. Provide Setup Menu system for adjusting all alarm set points, dead band, delays, etc. Display and adjust flow and pressure set points and time delays. Set equipment alternation to manual or automatic. Set the hour of the day for automatic alternation. Restore all factory defaults. Protect adjustable settings with a password.
- E. Alarm systems
1. Local indication of alarm conditions shall be provided on the face of the control panel via a general amber alarm light. Specific alarm messages shall be provided on the operator interface screen.
 2. All alarm conditions shall be displayed at the operator Panelview 600 HMI terminal and shall provide output capability to display all alarm conditions at future SCADA system. No other similar or equal HMI will be acceptable.
- F. SCADA System
1. The following outputs shall be provided to the plant PLC and SCADA system via Ethernet/IP communication.
 - a. All alarms
 - b. All equipment status (On/Off, In Remote/Not in Remote, Off)
 - c. All parameters displayed at the operator interface (blower PLC)
 - d. Motor speed
 - e. Airflow
 - f. Discharge pressure
 - g. Blower run: output
 - h. Blower stop: output
 - i. Blower fault: output
 - j. Remote on: output, enabled when touch screen is placed in remote
 2. The following inputs shall be provided from the plant PLC and SCADA system
 - a. Remote Command: 4-20 mA input for remote control of blower speed
 - b. Remote start: input

- c. Remote stop: input

G. System Function

1. Each blower LCP shall consist of a PLC-based control system physically located inside the blower enclosure with the following:
 - a. True Programmable Logic Controller:
 - 1) Allen Bradley MicroLogix 1400 PLC with Multifunctional Panelview 600 touch screen display capability.
 - 2) The PLC shall provide local and remote control, monitoring, and diagnostic capability.
 - b. Blower controls shall provide real time monitoring of discharge pressure vs. suction air flow graph indicating current operating point and boundaries.
 - c. Each blower shall have the ability to be controlled in four different modes.
 - 1) Speed (blower functions independently on speed control)
 - 2) Pressure
 - 3) Flow
 - 4) Dissolved Oxygen
 - d. The blower PLC shall have a minimum of 4 operating methods.
 - 1) Local control
 - 2) TCP/IP control
 - 3) Remote Terminal Block control
 - 4) Remote Terminal Block start/stop & Touch screen mode
 - e. Each blower PLC shall allow the blower to automatically restart, when operating in Terminal Block Mode, in the event of a power failure. The blower PLC shall automatically reset all faults and alarms in the PLC and restart the blower.
 - f. Each blower LCP shall automatically perform dynamic adjustments to the blower operating range during seasonal ambient temperature variations such that attainable maximum and minimum flow is always optimized. Dynamic adjustments shall not expose the blower to surge. For micro-communicator CPU's, setting input current for flow and pressure shall not be permitted as an alternative to dynamic adjustment.
 - g. Each Blower PLC shall be capable of time control blower synchronization based on pre-set, user defined settings for flow and speed. The user shall define pre-set operating schedule in the blower PLC. The blower PLC shall allow for a minimum of 6 daily set points for time control ability.
 - h. Each Blower shall have built in provisions for remote access via VPN or cellular communication for the blower manufacturer to monitor operation and troubleshoot remotely.
 - i. The blower PLC shall allow for alternating operating schedules such that the service hours per blower is either 2:1, 3:1, 4:1 or 5:1 with respect to the standby unit. Ratio Alternation function permits the owner to balance the run time of all blowers or stagger the hours of use to facilitate maintenance scheduling.
 - j. Blower PLC controls shall include intuitive, user friendly fault menus for ease of monitoring diagnostics and troubleshooting.
 - k. Each blower shall include built in automatic surge protection.

- l. Blower controls shall include built in measurement or calculation for the following parameters:
 - 1) Flow (calculated)
 - 2) Speed (calculated)
 - 3) Vibration
 - 4) Temperature (inlet and discharge air, motor, bearing)
 - 5) Pressure
- m. The blower PLC shall be accessible through a touch screen control panel and shall control the blow-off valve for each blower.
- n. All integrated controls shall be enclosed in a sub-panel located inside the blower enclosure.
- o. Turbo Blower PLC shall be capable for communication through Ethernet /IP communication protocol.

2.8 SHOP PAINTING

- A. The blower enclosure shall be painted in manufacturer's standard color. Painted carbon steel enclosures shall be Zinc primed and dual powder coated with a total dry film thickness of 4 mils dft.

2.9 FACTORY ACCEPTANCE TESTS

- A. All equipment shall be factory tested in accordance with a pre-approved Test Procedure by the Engineer during submittals approval.
- B. Tests shall be performed on the actual assembled unit being supplied for this project. Prototype model tests and calculated values based on previous model testing will not be acceptable.
 - 1. Functional Package 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. Unless otherwise specified, 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 and vibration level.
 - 2. Performance Test: A certified report of a performance test of the blowers furnished shall be submitted to the Engineer for review. 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 the durability with the applicable performance criteria specified.
- C. In the event the 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.
- D. Any subsequent tests as may be necessary to ensure compliance with these Specifications shall be performed at no additional cost to the Owner.
- E. Performance tests shall cover the design points contained in this specification. Any additional test points requested beyond these points can be provided at the additional cost of \$1300 USD per test point, for a maximum of three additional test points.

- F. The Manufacturer/Contractor shall notify the Engineer and Owner at least 30 days prior to conducting the factory acceptance tests. The contractor, owner, and engineer shall confirm their decision and/or acceptance of the proposed date within five (5) days of receipt of the manufacturer's notification.
- G. The manufacturer shall complete production and acceptance testing of the product on a schedule pre-agreed to with the owner and contractor. Should there be a delay of more than fifteen (15) days for the owner and/or contractor to take delivery, the manufacturer shall invoice the amount allocated for delivery on the order and store the product on their premises until delivery is approved.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install and adjust equipment in accordance with the Drawings, approved shop drawings and the manufacturer's instructions. Do not operate the equipment until the installation is approved by the manufacturer's representative.
- B. ASSEMBLY AND INSTALLATION
 - 1. Do not drill, cut or weld any component to the blower enclosure or accessories. Only bolted connections will be allowed in the field.
 - 2. Manufacturer to certify installation readiness prior to start-up for conformance to manufacturer's instructions.
- C. MANUFACTURER'S SERVICES:
 - 1. Provide the services of a qualified, factory-trained representative of the manufacturer for review of each part of the installation before approval. The contractor shall provide a firm date for the required services with a minimum of four (4) weeks advanced notice. Any changes to this date will result in a penalty of \$1500 USD and the negotiation of a new date.
 - 2. Hold a Pre-Start-Up meeting with the manufacturer to verify proper blower installation, Start-Up procedure and operating conditions.
 - 3. Each day shall consist of eight (8) hours at the project site excluding travel time and breaks. Provide services at no additional cost to the OWNER.
 - a. Equipment installation review and training of OWNER's personnel – three (3) days in one (1) trip
 - 4. Prior to equipment start-up, the CONTRACTOR, with the assistance of the manufacturer's representative, shall re-inspect all equipment for proper assembly, installation, and calibration:
 - a. All components shall operate without alarms or shut downs, except as intended, for eight consecutive hours.
 - b. Equipment shall operate through the design performance range consistent with available flows. Adjust, balance, calibrate and verify that the equipment, safety devices, controls and process system operate within the design conditions.

END OF SECTION