City of San Angelo – Water Utilities

Request for Bid

Wastewater Treatment Plant/Blower Replacement Specifications

City of San Angelo

72 West College Avenue

San Angelo, Texas 76903

TURBOCOMPRESSOR BLOWERS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes furnishing and placing into successful operation two (2) turbocompressor blowers complete with accessories. The existing facilities and blowers are shown in drawings following this specification. The two (2) blowers provided per this specification shall be capable of being installed in the same location/building and be able to connect to existing piping inlet and outlet piping.

B. Installation will be performed by the OWNER, City of San Angelo. Each blower shall be provided with an inlet filter, inlet silencer, outlet flexible joint, outlet silencers, back flow barrier, manual isolation valve, blow-off valve and silencers, motor cooling air outlet silencer, acoustic sound enclosure, VFD, local panel, magnetic bearings and other appurtenances as described in this specification section needed for a complete system. The same supplier shall furnish the turbocompressors and accessories.
   1. Each single-stage radial centrifugal turbocompressor is to be designed to provide absolutely oil-free air to the aeration system.
   2. The turbocompressor and control cabinet shall be mounted on a common base plate.
   3. A UL listed VFD shall vary the turbocompressor speed to provide continuous flow control and power optimization according to the changes in the process (air flow and differential pressure) and ambient conditions (ambient temperature and relative humidity) automatically without operator interface when the controls are in the remote mode.
   4. The speed of the blowers shall be varied using either the local Touchpad to assure the turbocompressor(s) are operating at maximum efficiency.
   5. Accessories shall be as described in this specification.

1.02 REFERENCES

A. The turbocompressor and accessories shall be in accordance with the referenced standards listed below.
   1. American Iron and Steel Institute (AISI).
   2. American National Standards Institute (ANSI).
   4. International Standards Organization (ISO) 5389: 1992 – Turbocompressors.
   4. VDI 2045: 1993 – Acceptance and Performance Tests on Turbo Compressors and Displacement Compressors
   5. ASME PTC 10 – 1974, reaffirmed 1986 Compressors & Exhausters

1.03 SYSTEM DESCRIPTION

A. Design Requirements:

1.	Site conditions:	
	a. Elevation:	1,783 feet (above sea level)
	b. Inlet air temperature range:	10^{o}F to 100^{o}F
	c. Relative humidity range:	30% to 90%
2.	Quantity of turbocompressors:	2
3.	Air flow rate per turbocompressor:	3,000+ scfm
4.	Total design air flow rate:	6,000+ scfm
5.	Differential pressure:	11.5 psi
6.	Motor horsepower per turbocompressor:	200 hp
7.	Maximum design speed:	28,620 rpm maximum

B. Motor Design Requirements:

1.	The high-speed permanent magnet type motor shall be as follows:	
	a. Motor horsepower per turbocompressor:	200 hp maximum
	b. Volts/Phase/Hertz:	480 volts/3 phase/60 hertz
	c. Motor speed:	28,620 rpm maximum
	d. Enclosure:	IP33D

1.04 DEFINITIONS

A. Continuous operation shall be defined as 24 hour per day 7 days per week operation

B. Intermittent operation shall be defined as periodic operation, including unlimited starts and stops or be out of operation for extended periods of time. Stops are defined as zero (0) RPM of rotor and shaft.

C. Turbocompressor system shall be defined as a single-stage high-speed centrifugal turbocompressor with an integral high speed unit, internal inlet silencer, internal outlet silencer variable frequency controller, blow off valve and internal silencer, control cabinet, non contacting magnetic bearing system all mounted on a common skid.

1.05 SUBMITTALS

A. Product Data: Submit data completely describing products and listings of all components and accessories with materials of construction including but not limited to the following.
   1. Turbocompressor operating characteristics and specifications.
   2. Motor characteristics and specifications.
   3. Installation instructions including leveling, alignment, connections with existing piping and foundation, pre-startup checklist and initial startup procedures.
   4. Proposed surface preparation and factory paint.
   5. Weight of turbocompressor assembly including turbocompressor, motor and control cabinet as well as the individual weights of all accessories.
   6. Other information as required or specified elsewhere in this specification.
   7. Materials of Construction for all major turbocompressor components and accessories.

B. Shop Drawings:
   1. Certified dimensional drawings of the turbocompressor unit assembly, including accessories shall be provided
   2. Certified anchor bolt layout drawings.
   3. Instrumentation, control system schematic, all electrical and control components wiring diagrams.
   4. All dimensional drawings necessary to coordinate with existing piping and new piping layout with structural, architectural, and/or other mechanical work.
   5. Certified turbocompressor wiring diagrams including the local control panel located in the turbocompressor door and the VFD.

C. Quality Assurance Submittals:
   1. Performance Test Reports signed by the manufacturer's test engineer shall be submitted after fabrication of complete package unit, but prior to shipment of the turbocompressors. Test shall be performed on complete package only, as testing of core units only will not be acceptable. Tests shall be conducted on each turbocompressor package as testing of other then all turbocompressors shall not be acceptable.
      a. Results of each test shall be summarized in a separate, certified, standard factory written test report.
      b. Reports shall be organized and clearly present testing methods and procedures, testing equipment used as well as the test data. A copy of the report shall be placed in a metal holder that is part of the electrical cabinet door for reference.
      c. One copy of each certified written test report shall be submitted to the engineer for review and acceptance. Test reports shall be reviewed and accepted by the Engineer prior shipment unless the engineer or owner waives this requirement.
      d. Certified test report(s) should include the following:
         1) Performance curves that includes air flow rate in scfm versus kw input/ horsepower and air flow rate in scfm versus rpm curves for each turbocompressor
         2) Hydrostatic test results.
         3) Dynamic balancing test results for each turbocompressor.

D. Additional Submittal Data
   1. Operation and Maintenance Manuals:
      a. Prepare five (5) hardcopy sets and one (1) PDF copy of operation and maintenance manuals for the entire centrifugal turbocompressor system, including accessories called out in this specification section.
      b. Provide Project Record Documents showing as-built dimensions, as-built wiring and control diagrams, as-built logic diagrams and design information for the turbocompressor(s) and accessories supplied being supplied.
      c. Provide a description of the internal turbocompressor control system.
      d. Provide panel drawings, wiring diagrams, specifications, and a detailed description of the internal turbocompressor control panels.

1.06 QUALITY ASSURANCE

A. General:
   1. Turbocompressor manufacturer shall have a minimum of ten (10) years experience in design and manufacture of turbocompressors using magnetic bearing technology.
   2. Provide a list of references (name, location and contact information) of at least five (5) installations currently using the same or similar model and drive configuration as is being proposed.
   3. Conduct certified performance testing on each turbocompressor as outlined in this specification.
   4. Tests shall be conducted using the actual turbocompressors being supplied. Test results from previous models or similar sized turbocompressor shall are not acceptable.
   5. All tests shall be conducted at the manufacture's factory on a complete package. Testing of cores separately from the package shall not be acceptable.
   6. If the certified factory tests indicate noncompliance with the requirements of this specification, the turbocompressors shall be reworked and retested at the manufacturer's expense until complacence with the specification is attained.

1.07 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping:
   1. Protect equipment during shipment in accordance with manufacturer's recommendations.

B. Storage and Protection:

   1. Protect the turbocompressor system components and accessories at the project site and during installation prior to project completion per manufacturer's instructions.
   2. If the compressor is to be stored prior to installation the following conditions must be observed.
      1) Ambient temperature: +14°F to +140°F
      2) For a maximum of 72 hours -40°F to +140°F
      3) Store the battery pack of the magnetic bearing controller in a fully charged condition, in a cool but frost free room.
      4) Maximum relative humidity < 95 %, non-condensing, non-corrosive, no dripping water.
      5) Maximum storage time is 6 months, if longer contact Sulzer Pumps.

1.08 WARRANTY

A. Provide manufacturers' standard warranty. The warranty period shall be for twenty-four (24) month after shipment.

1.09 MAINTENANCE

A. Special Tools:
   1. If needed, provide one (1) set of special tools required for complete assembly or disassembly of the turbocompressor system and accessories.
   2. Special tools shall be defined as any tool not typically necessary for general plant maintenance.

B. Spare Parts:
   1. Each turbocompressor shall be furnished with the following spare parts labeled and packed for warehouse storage as recommended by the turbocompressor supplier. Spare parts shall be as follows.
      a. One (1) complete set of main process air filters per blower.
      b. One (1) complete set of cooling air filters per blower.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The turbocompressor shall be the ABS Turbocompressor HST 20 as manufactured by Sulzer Aeration Solutions a company owned by Sulzer Pump Solutions, Inc. or equal pre-approved five (5) days prior to the bid date.

2.02 GENERAL

A. Turbocompressors shall be of single-stage centrifugal design utilizing oil free non-contacting magnetic bearing technology with the following design characteristics.
   1. Turbocompressors shall be designed for heavy, continuous, industrial service, be capable of providing a minimum of sixty (60) starts per hour and have a minimum design life of twenty (20) years before any major rebuild will be needed.
   2. Operate within specified vibration levels without overloading the drive motor.
   3. The rotor shall remain levitated at all times while power is being supplied to the turbocompressor. Turbocompressors with rotors that rest on bearings while in the stand by mode with power supplied to the turbocompressor shall not be considered as an equal.
   4. Operate without sign of distress when operating at specified operating point and at off design conditions.
   5. Have a pressure-volume curve, which extends from the design system pressure to the upper system surge pressure with a continuously rising pressure characteristic.
   6. Will not surge at or above specified flow rates corresponding to specified differential pressure.
   7. The maximum input motor horsepower should not exceed specified nameplate horsepower when operating at design flows at forty degrees Celsius (40°C).
   8. The turbocompressor must deliver oil-free and non-pulsation air at all times to the aeration process.

9. The motor and control cabinet components are to be air cooled using ambient air only. Systems that use water cooling are not acceptable or equal.
10. Wire to water power must include all motor, thermal, mechanical and electrical losses of the turbocompressor as well as losses of all auxiliary equipment such as all lubrication systems, cooling systems etc.

B. Minimum flow of each turbocompressor must be no greater than forty-five percent (45%) of the maximum flow rate over the entire temperature range.

C. Rotor critical speed must be a minimum of twenty percent (20%) above the operating design speed.

D. Maximum unfiltered peak-to-peak radial or axial displacement of the rotor shaft shall not exceed 1.25 mils at all operating speeds when measured at on the motor or the turbocompressor base.

E. Free field (R=infinity) sound pressure level without accessories shall not exceed seventy decibels (70 dBA) at any point three feet (3') from the turbocompressor assembly when operating at specified air flow rates and differential pressure.

F. Local control panel (LCP)
1. The local control panel (touchpad and display) shall be located on the turbocompressor control cabinet door. This LCP is connected to the internal high speed controller and functions only as an interface using a touchpad and display unit that allows the turbocompressor to be operated manually and displays all information needed to operate the turbocompressor. In addition the LCP will be intuitive, user friendly, allowing customization of monitoring as process control.
2. A mode control switch to select the turbocompressor operating mode (fieldbus, touchpad, start and stop) shall be included as part of the LCP.

G. Variable Frequency Drive
1. A UL approved VFD shall be used to control the speed of the turbocompressor. It will communicate with the internal controller that has surveillance and control software that controls the turbocompressor(s) operation in accordance with signals received from the plant upper automation controls, Master Control Unit if multiple units are installed or the local control panel.

2.03 MATERIALS

A. Major Turbocompressor components shall be manufactured from the following materials.
1. Casings and Inlet Inducer: High-strength aluminum alloy, A1Si7Mg-T6.
2. Impellers: High-strength forged aluminum alloy.
3. Rotor Shafts: Alloy steel with permanent magnets.
4. Turbocompressor and Motor Frame: Welded steel.
5. Inlet and outlet accessories: Hot dipped galvanized steel.
6. Expansion Joints: AISI 316SS.

7. Check Valve : AISI 316SS/EPDM

2.04 TURBOCOMPRESSOR BLOWER

A. High-Speed Unit

High-speed unit shall consist of an integrated turbocompressor – permanent magnet electric motor assembly, with the following components:

6. Impeller and Spiral Valute Casing
   a. 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 three-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 and O-ring 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. Special impellers designed for a specific duty point shall not be considered acceptable or equal.
   b. 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.
   c. The turbocompressor inlet inducer shall be integral to the turbocompressor volute.
7. High-Speed Electric Motor
   a. An air-cooled, VFD compatible, high speed, special duty electric permanent magnet motor specifically designed for high-speed service shall be provided.
   b. The motor shall have Class F winding insulation (with Class H on critical components) with thermal sensors that are tied into the thermal protection surveillance software built into the blower control system.
   c. The motor rotor shaft shall be supported by magnetic bearings at all times while power is supplied to the turbocompressor providing a smooth vibration free rotation over the entire speed range. Blowers that use bearing systems that contact stationary parts during start up or if power is lost are not an acceptable alternate.
   d. The motor shall be air cooled by a cooling fan that is mounted directly to the end of the motor rotor shaft. Units that are cooled by anything other then ambient air shall be not be considered as and equal.
   e. The motor and high speed unit shall be mounted to a welded steel base/frame separated by rubber mounts.
8. Magnetic Bearing System
   a. The motor rotor shaft shall be continuously levitated in a magnetic field by the digitally controlled magnetic bearing system when power is on. This system shall consist of two (2) radial and two (2) axial active magnetic bearings, two (2) rotor position sensors and a magnetic bearing controller (MBC). The position sensors shall continuously 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 turbocompressor

operation eliminating friction and wearing of all moving parts. The magnetic bearing system shall not require any oil lubrication.

b. The magnetic bearing controller shall be an MBC-12 having a maximum input power of 1.3 hp (1 kW).

4. Noise Enclosure
   a. The high speed unit shall be enclosed in a noise reduction system that reduces the noise levels to less than seventy decibels (70 dBA). This enclosure shall be easily removable for inspection of the high speed unit using socket head screws.

B. Blower Enclosure
   1. Access to the VFD and MBC and Control components shall be through panels on the side of the turbocompressor. The enclosure shall be a minimum twelve (12) gauge steel with locking bolts but still allowing quick access. The enclosure shall have at a minimum IP33D rating.
   2. The cabinet shall be painted using a phosphate treatment system with a zinc chromate iron oxide primer with a baked rust-inhibiting enamel topcoat.
   3. Louvers on the enclosure shall be used to provide cooling air to the control cabinet and high speed unit.
   4. The equipment mounted within the control side of the enclosure shall be mounted on the enclosure back panel and neatly organized.
   5. Blower systems having separate control cabinets are not acceptable.

C. Variable Frequency Drive
   1. A UL rated variable frequency drive shall be installed in the control cabinet to vary the speed of the turbocompressor providing optimal turbocompressor efficiency at all plant operational demands. The VFD along with the internal controllers software shall automatically control the turbocompressor performance based a 4-20mA signal from either an air header pressure transducer, D.O. probes or if in local mode, directly from the local control panel (keypad on the turbocompressor door).
   2. The VFD shall be a VACON NXP High Performance model; six (6) pulse variable speed drive adequately sized for the turbocompressor motor and mounted inside the integral control cabinet.

D. Local Control Panel

A Local Control Panel is mounted on the turbocompressor front panel and consists of a touchpad with display that shall perform the following functions:

1. Display the Turbocompressor Operating Parameters

   The turbocompressor functions shall be monitored continuously during operation and communicated to the LCP where the following values are displayed.

Group Name	Parameter	Symbol
Basic Monitoring Values	Inlet Mass Flow	SCFM
	Inlet Pressure	P1
	Pressure Rise	ΔP
	Pressure Ratio	*(decimal or fraction)*
	Inlet Temperature	°F
	Outlet Temperature	°F
	Inlet Relative Humidity	%
	Rotational Speed	RPM
	Input Power	HP
	Motor Torque	ft lb
Fixed Values	Maximum Speed *	RPM
	Maximum Power *	HP

*The maximum and minimum values depend on the compressor model.

2. Fault and Alarm

   The turbocompressor system is continuously monitored to assure the turbocompressor and its control systems are functioning correctly. If the monitoring system detects something that is not functioning properly either an alarm or a fault message appears in the control panel display. If the fault is not critical to the safe operation of the turbocompressor an alarm message will be displayed and the turbocompressor will continue to operate. If the fault is critical to the safe operation of the turbocompressor a fault message will be displayed and the turbocompressor will be automatically taken out of service until the reason for the fault is acknowledged and/or corrected.

   The detection system shall automatically monitor the following conditions:

   a. Power Supply Status:
      1) Over voltage in main power supply
      2) Under voltage in main power supply
      3) One phase missing
      4) Over/under voltage in auxiliary power supply
   b. Process Air Inlet and Outlet:
      1) Blockage in the inlet or outlet air piping
      2) Overpressure
      3) Inlet air temperature too high (surge)

c. Cooling Air Inlet and Outlet:
    1) Blockage in the inlet or outlet air piping
    2) Cooling air over temperature via motor/VFD over temperature monitoring.
    3) Motor temperature
    4) VFD temperature
    5) Magnetic bearing controller temperature

3. Flow Control
   The local control system shall allow adjustments of the turbocompressor flow while either operating or stopped when in local mode and the "flow set" light is illuminated. If the turbocompressor is in operation adjustments can be made at any time. Change in the reference flow volume setting shall take effect immediately. If the turbocompressor is stopped adjustments can be made at any time. Changes in the reference flow volume setting shall take effect the next time the turbocompressor is put into service.

   The turbo compressor's volume flow control shall be based on an indirect flow volume measurement via 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 inlet air temperature effects shall be considered when determining these limits.

   The 100% reference flow (20 mA) shown on the Keypad corresponds to turbo compressor's maximum specified volume flow at existing plant ambient conditions.

   Speed and power limits shall be selected for protection of the turbocompressor motor and frequency converter.

E. Blow Off Valve
   1. A blow off valve shall be an integral part of the turbocompressor system protecting it during start up and shut down conditions. It shall be a pneumatically controlled plug type valve that is controlled by each turbocompressors internal control system.
      a. The blow off valve and silencer shall be an integral part of the turbocompressor, be mounted on the inside of the enclosure and adequately sized to handle the flow and pressures seen during start up and shut down.

2.05 ACCESSORIES

A. General:
   1. All accessories listed in this specification section are to be supplied by the turbocompressor manufacturer as part of the turbocompressor system to ensure system compatibility. Each specified accessory should be furnished as completely assembled as possible and installed as indicated on the plan drawings for each turbocompressor.

B. Expansion Joints:
   1. An inlet expansion joint is not required on the turbocompressor.

2. An outlet expansion joint shall be installed as close as possible to the turbocompressor outlet flange. It shall have galvanized steel flanges and 304 stainless steel bellows. It shall have a minimum axial movement of ±0.79 in (±20mm) and lateral movement of ±0.16 in (±4mm) and a maximum axial force of 225 lbf (1000N).

C. Main Air Inlet Filter:
   1. An external filtration system shall be provided for each turbocompressor. Each filter system shall be adequately sized for the airflow rate of each turbocompressor. The filter system shall either be internal to the blower enclosure or a separate filter housing containing all filter elements with door for easy access. The access door shall be sealed to prevent air infiltration and sufficiently sized to allow easy access to the filters.
   2. The filters for external air inlet filter shall be pocket Camfil Hi-Cap having a high density microfine glass fiber filter medium suitable for high efficiency filtration that has a EN779:2002:G4 standards filter class that is mounted on a galvanized steel frame with a hook and lever arrangement for easy replacement.

D. Inlet Silencer:
   1. An inlet silencer shall be provided for each turbocompressor and be internal to the blower enclosure. Each inlet silencer shall be adequately sized for each turbocompressor.

E. Outlet Silencer:
   1. A flanged outlet silencer shall be provided for each turbocompressor inside the blower enclosure. Each outlet silencer shall be adequately sized for each turbocompressor.

F. Check Valves:
   1. A check valve shall be provided with each turbocompressor as indicated on the plan drawings. It shall prevent back flow into the turbocompressor and be installed directly after the expansion joint as indicated on the plan drawings.
   2. The check valve shall be a high performance wafer type non-slam single flapper check valve with a cast CF8M body, a cast CF8M clam type plate, a CF8M hinge pin, a metal to metal sealing surface, a minimum temperature rating of 302^{o}F (150^{o}C) and have a maximum pressure loss of 0.077 psi (534 Pa). Dual flap check valves shall not be considered equal.

G. Shut Off Valve
   1. A flanged manual short body lug type butterfly shut off valve shall be provided for each turbocompressor as indicated on the plan drawings. The shutoff valve shall be geared for ease of operation. It shall be installed in the discharge pipe to isolate the turbocompressor from the process.
   2. The manual butterfly shut off valves shall have a cast iron body, a 316 SS disc, 420SS pivot shaft and an EPDM seal, a minimum 248^{o}F (120^{o}C) temperature rating and a maximum 0.006 psi (41 Pa) pressure loss.

H. Air Pressure and Temperature Sensors:
   1. Provide pressure sensors on the inlet and outlet piping of each turbocompressor internal to the blower enclosure.
   2. Provide temperature sensors in the inlet and outlet piping and a temperature sensor on the motor for each turbocompressor, internal to the blower enclosure.
   3. Provide a mass flow meter internal to each blower.

I. Uninterruptible Power Supply (UPS) for MBC:
   1. Each turbocompressor is supplied 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 turbocompressor 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.

2.06 NAMEPLATE DATA

A. A nameplate shall be provided on each turbocompressor. The nameplate shall be mounted easily visible and contain the following information.
   1. Vendor's Name.
   2. Model Type and Serial Number
   3. Year Manufactured
   4. Weight
   5. Main Power Supply
   6. Auxiliary Power Supply
   7. Enclosure

2.07 SOURCE QUALITY

A. Certified Factory Tests:
   1. General:
      a. Conduct performance testing on each turbocompressor as outlined below. Testing must be done on the complete package. No testing of cores outside the blower package will be acceptable.
      b. Tests shall be conducted using the contract turbocompressor.
      c. All tests shall be conducted at the turbocompressor manufacturer's factory.

d. If the certified factory tests indicate noncompliance with the requirements of this Contract Documents, the turbocompressors shall be reworked and retested at the manufacturer's full expense until compliance with the specifications is attained.

2 Impeller Balancing/Vibration Test:
   a. Conduct static balancing of impeller units prior to turbocompressor shaft assembly.
   b. Conduct dynamic balancing of complete turbocompressor rotary assembly
   c. Impeller and rotor shall be balanced to provide a maximum rotor shaft deflection of less than 20μm. Provide certified test report for each unit.
   d. Maximum vibration amplitude when operating at maximum design speed.
   e. Submit certified static and dynamic balancing test results for each turbocompressor.

3. Performance Tests:
   a. Performance tests will be conducted in accordance with ISO 5389 ("Turbocompressor's performance test code") and VDI 2045 ("Acceptance and Performance Tests on Turbo Compressors and Displacement Compressors"), Part 1 and Part 2. Measuring of mass flow is made according to VDI 2041 ("Orifice Plates and Nozzles for Special Applications"), chapter 5.2 with a ISA 1932 nozzle, made according to DIN 1952 and ISO 5167 standard ("Measurement of fluid flow by means of orifice plates, nozzles and venturi tubes inserted in circular cross-section conduits running full").
   b. A written statement that the turbocompressor meets the specified performance requirements shall be included as a part of the submitted certified test report.
   c. Conduct performance testing in conformance with the above standards and as supplemented by the requirements specified herein:
      1) Conduct performance tests at nine (9) test points on each turbocompressor. Two (2) of these points shall bracket the rated point.
      2) Conduct performance tests at additional points at test conditions equivalent to the full range between specified turbocompressor operating limits.
   d. In addition to the data specified above, each test report shall contain the following:
      1) A copy of certified input power data from 50% to 100% full load.
      2) Data showing performance at rated speed vs. discharge pressure from lowest system pressure to maximum pressure. The performance shall be shown in terms of standard cubic feet per minute and brake horsepower required at the input shaft of the turbocompressor. The data shall be for the inlet conditions specified in the Performance Requirements section of this specification and corresponding to operation at rated inlet conditions. Surge points shall be indicated.
   e. Prior to conducting the tests, submit the proposed test procedure for review.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation of the turbocompressor and accessories will be performed by the OWNER in accordance with manufacturer's recommendations found in the Installation Manual and any addendums including alignment of components, mounting level and connections.
B. Turbocompressors will be installed one at a time. The installation of the second turbocompressor will not commence until the first turbocompressor has been installed, fully operational, and passed all performance testing.
C. Inspection, Start-Up, and Field Quality Control will be performed by Manufacturer/Respondent of the Request for Bid.

3.02 INSPECTION

A. Inspect the turbocompressor and accessories for shipping damage and to ensure that all accessories arrived undamaged and are in conformance with the specifications.

B. The following inspection of the installation shall be completed before the turbocompressor is started.
   1. Piping and accessories are properly aligned.
   2. All accessories are adequately supported per the specification and drawings.
   3. The turbocompressor is adequately grounded per the manufacturer's installation instructions.
   4. The turbocompressor anchor bolt and all accessory fasteners are properly torqued.

C. Assure that all electrical systems are proper connected and terminals are tight.

3.03 FIELD QUALITY CONTROL

A. Inspection and Check-out
   1. Prior to operating the turbocompressor, complete the inspection as outlined in paragraph 3.01, test all support systems, including but not limited to power systems, control systems, piping systems, safety systems, etc..
   2. Complete electrical system shall be tested to ensure proper function.
   3. Instrumentation and Controls:
      a. A complete functional test of the internal instrumentation and control systems shall be completed to assure they have not been damaged during shipment.
      b. Set operational limits (start/stop, etc.) and alarm and shutdown limits as needed.
   4. Inspect piping to assure it is clean and free of any contaminants that may harm the turbocompressor.

B. Equipment Performance Test
   1. Run each turbocompressor from minimum to maximum specified flows at the differential pressure of the plant system to assure that no damage has occurred during shipment that may affect the performance of the turbocompressor.
   2. Record temperature, pressure, and flow.

C. Vibration Test: The turbocompressor shall be operated from minimum to maximum speed and the rotor shaft shall demonstrate that the deflection shall not exceed 20μm throughout this operating speed range and shown graphically on computer printout if required.

D. Operational Testing:
   1. Testing of each turbocompressor shall be deemed successful if it has been demonstrated that it operates as intended and meets specification requirements.
   2. The turbocompressor tests shall be deemed failed if an unintended shutdown occurs, the control system does not respond as it should and vibration is in excess of the specified value. Minor on-line adjustments and tuning of instrumentation are not considered a failure.
   3. If during the testing the turbocompressor fails any of the tests the cause of the failure will be corrected and the testing repeated until no failures occur.

E. Manufacturer's Field Service:
   1. A factory authorized representative shall check out and inspect the turbocompressor and installed accessories before the initial start-up and certify that the system has been correctly installed and prepared for start-up. Factory representative shall insure proper operation of turbocompressor protection devices including vibration, temperature, and current alarms as well as interlocks with pre-surge. The allotted time for this work shall be one (1) day per turbocompressor.
   2. The factory authorized representative shall also provide training for owner's personnel in the operation and maintenance of the turbocompressor system. The allotted time for the training shall be one (1) day and occur after the turbocompressors inspection and start up have been completed.

End of Specification Section