SECTION 11374 - BLOWERS, TURBINE

City of San Diego, CWP Guidelines

PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

A. The WORK of this Section includes providing single stage turbine type blowers for aeration service as indicated. The blowers shall be complete with all necessary accessories, drives, silencers, valves, connectors, safety devices, controls, spare parts and tools.

B. The WORK also requires that one manufacturer accept responsibility for furnishing the WORK as indicated, but without altering or modifying the CONTRACTOR'S responsibilities under the Contract Documents.

C The WORK also includes coordination of design, assembly, testing, and installation of the complete blower unit.

1.2 RELATED SECTIONS

A. The WORK of the following Section applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 11370 Blowers, Compressors, and Vacuum Pumps, General

1.3 SPECIFICATIONS AND STANDARDS

A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section:

1.	AGMA 2000-A88	Practice for High Speed Helical and Herringbone Gear Units
2.	AGMA 6001-C88	Shafting - Allowable Torsional and Bending Stresses
3.	AGMA 6025-C90	Standard Specification of Measurement of Sound on High Speed Helical and Herringbone Gear Units
4.	ASTM A 278	Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650EF

1.4 SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in compliance with Section 01300:

1. Blower base dimensions and details.

2. A complete test piping and instrumentation diagram per ASME PTC-10, for approval, showing location, type, and quantity of all instruments for air, water, and lube oil.

3. A statement of the torsional and lateral critical speeds of each blower system on a common baseplate.

4. Speed-torque curve for the blower with vanes and/or diffusers in starting position, computed for specified minimum inlet temperature.

5. A description of the compressor operation from the local panel and the main control panel, covering in detail all logic and sequences of operation.

6. Detailed information on structural, mechanical, electrical, and other changes necessary to adapt to the arrangement indicated.

7. Response curves for temperature sensor.

8. Information on at least one successfully performing installation of comparable size and complexity constructed in the recent past including contact name, address, and telephone number.

1.5 FACTORY TESTING

A. The CONTRACTOR shall be responsible for all costs associated with inspection and testing of materials, products, or equipment at the place of manufacture. This shall include costs for travel, meals, lodging, and car rental for [two] OWNER-designated inspectors for [ ] days required to complete such inspections or observations exclusive of travel days, if the place of manufacture, fabrication and factory testing is more than fifty (50) miles outside the geographical limit of the City. The CONTRACTOR shall not be responsible for salary or salary-related costs of the inspectors. The CONTRACTOR shall comply with the requirements of Section 01400.

B. In addition to the requirements of Section 11370, the factory testing shall include the following:

1. Each motor shall be tested in compliance with IEEE test procedures, including testing for vibration. Results shall be included in the OWNER'S MANUAL.

2. Blower tests shall include testing for vibration, sound, and mechanical integrity. Calibrated torque meter shall measure the shaft input horsepower directly off the motor drive shaft. After testing the blower, internals shall be coated with a long-term rust preventive coating.

3. The completed blower assembly, including the blower, oil lubrication system, controls and instrumentation shall be factory operated and tested along with simulated start of the blower and motor. All start and stop sequences and all safety and alarm systems shall be functionally tested with the control panels connected to the blower skid, instrumentation, electric blow-off, and discharge valves.

4. Vibration levels shall be recorded at various frequencies. Blower air capacity, pressures and temperatures shall be measured and recorded. Horsepower shall be determined using

ASME Test Code procedures. Blower surge point and stonewall condition shall be demonstrated during the test.

5. The shop test for each blower shall include a pressure test for the casings furnished and an impeller overspeed test in excess of 120 percent of design speed. The casing shall be hydrostatically tested to 50 psig.

6. Test reports shall be prepared by the blower manufacturer including necessary calculations and complete performance curves showing capacity, pressure, and horsepower inputs. The CONSTRUCTION MANAGER'S representative shall sign each copy of the test data log sheet and shall also certify that the required tests were performed. Blowers shall not be shipped until the CONSTRUCTION MANAGER has approved the test report.

7. The blower ASME PTC-10 tests and the complete assembly tests shall be witnessed by two representatives of the OWNER/CONSTRUCTION MANAGER.

1.6 FIELD TESTING

A. All blowers shall be field-tested for compliance with the indicated requirements. (See Section 11370 and Part 3 of this Section.)

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All equipment shall be skid mounted or crated and delivered to protect against damage during shipment. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the units and equipment are ready for operation.

B. The motor for each blower shall be supplied with a space heater installed inside the motor enclosure. In order to maintain the temperature of the motors well above the dew point and thus prevent condensation of moisture within the motor enclosure, the CONTRACTOR shall energize the space heaters as soon as the motors are delivered. These heaters shall remain energized until the motors are electrically connected in place and the heaters are energized by the control circuit.

C. Factory assembled parts and components shall not be dismantled for shipment or installation unless permission is received in writing from the CONSTRUCTION MANAGER.

1. Finished surfaces of all exposed flanges shall be protected by wooden or fiberboard blank flanges strongly built and securely bolted thereto. Finished iron and steel surfaces not painted shall be properly protected to prevent rust and corrosion.

1.8 QUALIFICATIONS

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NTS: In the paragraph below, define the terms "comparable size and complexity" for the equipment or system specified. Requiring experience of more than one successful project requires sound justification and prior written approval from the City Project Manager.

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A. **Manufacturer**: A company specializing in the manufacture of single stage centrifugal (turbine) blowers with minimum one successfully performing installation of comparable size and complexity constructed in the recent past. Equipment of comparable size and complexity shall have the following characteristics: [ ].

1.9 SERVICES OF MANUFACTURER

A. **Inspection, Startup, and Field Adjustment**: An authorized service representative of the manufacturer shall visit the site for not less than [ ] days to furnish the indicated services.

B. **Instruction of OWNER'S Personnel**: The authorized service representative shall also furnish the indicated services for instruction of the OWNER'S personnel in the operation and maintenance of the equipment including step-by-step troubleshooting procedures with necessary test equipment for not less than [ ] days.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **General:** The following centrifugal single stage blowers shall be provided for the WORK:

1.	Name of equipment	-	[ ]
2.	Identification numbers	-	[ ]
3.	Quantity	-	[ ]
4.	Location	-	[ ]
5.	Service	-	[ ]
6.	Elevation above sea level (ft)	-	[ ]

B. **Design Criteria**: The blowers shall conform to the following conditions:

1.	Flow rate at 14.7 psia 68 deg F, and 36 percent RH (scfm)	-	[ ]

2.	Design flow rate at site conditions (acfm)	-	[ ]
3.	Design inlet temperature (deg F), min	-	[ ]
4.	Inlet temperature (deg F), max	-	[ ]
5.	Suction pressure	-	[atm minus 0.2 psi]
6.	Design discharge pressure (psig), max	-	[ ]
7.	Discharge pressure (psig), (min)	-	[ ]
8.	Design inlet relative humidity, max (percent)	-	[ ]
9.	Inlet relative humidity, min (percent)	-	[ ]
10.	Motor size, min (hp)	-	[ ]
11.	Motor speed, max (rpm)	-	[ ]
12.	Suction flange size (in)	-	[ ]
13.	Discharge flange size (in)	-	[ ]
14.	Flange rating (psi)	-	[ ]
15.	Guaranteed power consumption at design condition (Blower gearbox shaft consumption times motor efficiency plus oil pump power consumption) (hp)	-	[ ]
16.	Sound pressure level at 3 feet (dBA max)	-	[ ]
17.	Surge point:		
	Flow (cfm)	-	[ ]
	Discharge pressure (psig)	-	[ ]

2.2 BLOWER CONSTRUCTION

A. **General**: The blowers shall be motor driven, single-stage centrifugal type complete with accessories as indicated. Each blower shall be end suction, side discharge with discharge adjustable radially in 15 degree increments. Each blower shall be equipped with an integral intake filter, modulating inlet guide vanes and/or discharge variable diffusers, integral speed-increasing gear, discharge cone/silencer, inlet and outlet silencers, direct coupled motor, coupling and guard, inlet and discharge flexible connectors, motorized discharge shut-off valve, discharge check valve, motorized blow-off valve, lube oil system and instrumentation and control system. Blower motor starters shall include all appurtenances indicated below with local control panels for each blower and the master sequence controller housed in a separate control panel.

1. The equipment is intended to be standard equipment for compressing ambient air for use in diffusers in the aeration tanks.

2. The blowers will receive filtered air, and shall discharge to the main air header. The capacity of each blower shall be automatically controlled to provide the air flow rate through the blower as required by the process. The bypass valve shall open upon blower startup to allow unloaded starting.

B. **Blower and Integral Gearbox Construction**:

1. Blower Body: Casing, backplate, nozzles and flanges shall be made of close-grained cast iron ASTM A 278, Class 30B and have a minimum design pressure of 50 psig. The blower inlet shall be connected directly to the inlet filter/silencer by a flexible connection. Discharge flange shall be faced and drilled to ANSI 16.1, 125 pound. All joints in the casing and backplate shall be machined. A 3/4-inch pipe tap shall be provided at the lowest point of the casing for drainage. The blower shall be provided with lifting lugs capable of supporting the complete unit.

2. Impeller: The impeller shall be of the radial flow type, with backward leaning blades. It shall be machined from forged aluminum alloy or made of welded steel. The impeller shall be suitable for pressure ratios up to 3. All surfaces shall be finished. Cast aluminum or cast steel impellers shall not be acceptable. The impeller shall be attached to the shaft by shrinkfit and locknut arrangement, it shall be statically and dynamically balanced, and subjected to an overspeed test of not less than 20 percent above the operating speed, after which it shall be carefully inspected for defects.

3. Pre-Rotation Assembly: An adjustable variable pre-rotation assembly (if used) shall be mounted integral with each process air blower. Vanes shall be multi-leaf and pivoted, mounted in a cast iron housing. Sleeve bearings shall be of the permanently lubricated type or accessible for lubrication. Pre-rotation blades shall be made of bronze or aluminum alloy. At least 4 vanes shall be provided. The adjustable inlet guide vanes may be used for capacity control or for maximizing efficiency. Each guide vane assembly shall be installed complete with an electric actuator to operate from a 4-20 mA DC signal. Two adjustable limit switches shall be mounted on each guide vane actuator and lights on the blower control panel shall indicate when the vanes are fully open or closed. The position of the vane from fully open to fully closed shall be transmitted via a 4-20 mA signal and indicated by a meter mounted on the local control panel. Position shall also be indicated by an adjustable manual lever arm and calibrated dial.

4. Variable Diffusers: Variable diffusers (if used) shall be provided for capacity control. The assembly shall be mounted integral with each blower with the diffusers multi-leaf and pivoted. The cast iron housings shall have permanently lubricated sleeve bearings. Blades shall be bronze or aluminum alloy construction for maximizing efficiency. At least 12 vanes shall be provided, arranged in a radial fashion around the periphery of the impeller. Each variable diffuser assembly shall be installed complete with an electric actuator to operate from a 4-20 mA DC signal. Two adjustable limit switches shall be mounted on each variable diffuser actuator and lights on the air blower control panel shall indicated when the vanes are fully opened or fully closed. The position of the diffuser vane from fully open to fully closed shall be transmitted via a 4-20 mA signal and indicated via a meter mounted on the blower local control panel. Position shall also be indicated by an adjustable manual lever arm and calibrated dial.

5. Volume Control: The purpose of the inlet guide vane and/or variable diffuser system shall be to facilitate turndown of each blower from 100 to 45 percent of capacity, while maximizing efficiency over this entire turndown range. It is intended that the blowers be supplied with the blower manufacturer's standard variable control system. The inlet guide vane and/or variable diffuser operators shall be equipped with open-close pushbuttons, an auto-manual selector switch and indicating lights located in the blower control panel. In the automatic setting, the operator shall respond to a 4-20 mA DC position control signal, and shall position the vanes in proportion to the control signal from the programmable controller located in the blower local control panel. The programmable controller in each blower local control panel shall adjust the inlet guide vanes and/or variable diffuser vanes. Peak efficiency of the blower shall be achieved while supplying the required flow to the aeration system at actual operating conditions within the range indicated. In manual/service mode, the vanes may be controlled manually.

6. Blower and Gear Shafts: Blower and gear shafts shall be machined from heat-treated, forged steel and suitably ground. The first responsive critical speed of the rotating assembly shall be at least 15 percent from the normal operating speed. All rotating elements shall be dynamically balanced and conform with AGMA 6001-C88.

7. Gear: Speed increasing gear shall be of the helical parallel shaft type, manufactured in accordance with AGMA 6025-C90, to a minimum AGMA quality number of 12, as specified in AGMA 2000-A88. The gears shall be made of case-hardened alloy steel forgings with the gear teeth precision ground. Service factor used to size the gearbox shall be at least 1.8. The gears shall be of ample size and rated to transmit the maximum torque and horsepower input requirements to the blower under all operating conditions. The service factor shall be minimum 1.5 and rated for continuous duty with ambient temperatures ranging from 10 degrees F to 100 degrees F. All exposed machined surfaces shall be coated with a corrosion resisting compound before shipment.

8. Gear Housing: The gear drive housing shall be of high grade cast iron sufficiently rigid to maintain the shaft positions under maximum loads. The gear housing assemblies shall be machined to close tolerances for bearing fit, gear alignment and oil tightness.

9. Shaft Seals: The shaft seals shall be of the multi-point type with sufficient touch points and with small clearances to minimize air leakage out of or into the casing along the shaft over the specified range of operating conditions and during periods of shutdown. The seals shall

be operated dry and suitable for variations in suction conditions that may prevail during startup and shutdown. Shaft seals shall be accessible for inspection or replacement. The seals shall be designed such that in the event of a seal rub, no damage will occur to the blower.

10. Bearings: Drive shaft radial bearings shall be cylindrical journal bronze bearings with adequate provision for lubrication. Drive shaft thrust bearings shall be multiple segment, double acting, bronze bearings designed for thrust in both directions. Pinion shaft bearings shall be tilted pad type babbitted bronze bearings and double acting thrust bearings, designed for thrust in both directions. Steel backed bearings shall not be allowed. Radial and thrust bearings shall be pressure lubricated and designed for fully hydrodynamic lubrication with sufficient oil film thickness under all operating conditions. All bearings shall be rated for an L-10 bearing life of minimum 100,000 hours. Ball bearings shall not be used for the high speed pinion shaft.

C. **Oil Lubrication System**:

1. General: A complete lube oil system shall be provided with each blower. The system shall be capable of supplying clean oil at a suitable pressure and temperature to lubricate the speed increasing gears and bearings. All components of the lubrication system shall be installed and/or integral with the blower base plate and arranged to permit ease of accessibility for operation, maintenance, inspection and cleaning.

2. Components: The lube oil system shall consist of a reservoir in the base plate, two electrically driven, semi-submerged positive displacement pumps with strainer, an [oil-to-air] [oil-to-water] heat exchanger, one oil filter and miscellaneous appurtenances. The gearbox shall be supplied with high level reservoir (incorporated in the gearbox cover) or a bladder accumulator to supply a sufficient amount of oil during run down of blower in case of power failure. A pressure gauge, thermometer, adjustable high temperature switches and adjustable low oil pressure switches shall be installed on each lube oil system.

3. Oil Pumps: Two electrical motor driven oil pumps shall be provided. The pumps shall be of the positive displacement type, each of adequate capacity to supply the lubricating requirements for the air blower and speed increasing gears when operating at normal speed and during start. The motors shall be minimum 3 hp, 460V, 3-phase, 60 Hz, totally enclosed. One of the pumps shall operate as stand-by, activated by the control system upon low oil pressure. Starters for the oil pumps shall be located in the local control panel. A main motor or gearbox shaft driven primary oil pump and standby electric motor driven oil pump shall be a suitable alternative to two motor drive oil pumps.

4. Oil Reservoir: The interior of each oil reservoir shall be descaled and rustproofed by the application of a permanent coating of the manufacturer's standard. The equipment, attached to the top of the reservoir, shall be mounted by means of pads. All cover openings shall be gasketed. Reservoirs shall be baffled and isolated to minimize air entrainment. The reservoir shall be equipped with a suitably sized vent and breather filter and have a minimum working capacity of 3 min. retention time based on normal flow. The reservoir shall have a minimum 6-inch flanged cleanout with blind flange.

5. Oil Filter: The oil filter shall be of the full flow, replaceable cartridge, duplex type, or one oversized single filter suitable for at least two years' undisturbed operation, capable of removing particles over 10 microns with a clean oil filter pressure drop not exceeding 5 psi at design temperature and flow. Filter cases shall be suitable for operation at a pressure not less than the relief valve setting. A visual gauge shall indicate when a filter is dirty and requires changing.

6. Oil Strainers: Strainers shall be manually cleaned and equipped with a magnetic trap. Design and installation shall permit ready access for cleaning.

7. Oil Cooler: An oil cooler for each blower shall be furnished and shall be of the [air-to-oil] [water-to-oil] type, mounted on each blower skid. Cooler shall be capable of maintaining required cooling rate at all ambient temperatures up to 100 degrees. Each cooler shall be rated to dissipate the total BTUs emitted from the blower gear box. Each cooler shall be suitable for installation in the location indicated. Cooler shall be furnished with [an electric 460 volt, 3-phase, 60 Hz motor driven fan] [a cooling water flow control valve and on-off water solenoid valve].

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NTS: Ambient temperature at oil cooler can be no greater than 105 degrees F if an air cooled aftercooler is used. If ambient temperatures exceed 105 degrees F, a water cooled aftercooler must be used.

An oil heating system as indicated below shall be provided if the ambient temperature is expected to drop below 50 degrees F.

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[8. Oil Heating System: The equipment supplier's standard provisions for oil heating shall be provided to heat the oil if the ambient temperature in the blower room is expected to drop below 50 degrees F. If a Chromalox (or equal) type of oil heater is used, it must be specifically designed to heat lightweight oils with no more than 15 watts per square inch. The heater and thermostat shall be mounted on the oil reservoir with the contactor located in the local control panel. The blower shall not start unless the oil is above 50 degrees F. A low oil temperature warning light shall be provided on each local control panel.]

D. **Couplings**:

1. General: Flexible, forged steel spacer couplings shall be furnished for connecting the blower and motor. Couplings shall be of the proper size to transmit the power required to drive the blower under all conditions of operation. Coupling and spacer shall be dynamically balanced, independently, to tolerance suitable for maximum continuous speed.

2. Coupling Design: Couplings shall be dry type and designed for long periods of continuous operation. The coupling design shall absorb inaccuracies of the alignment and permit axial adjustment. The coupling shall ensure that the motor shaft does not exert a thrust on the blower bearing. Coupling construction shall be such that either shaft of the unit may be

removed without disturbing adjustment of the other. An OSHA approved steel guard shall be provided and installed over the coupling.

3. Torsional Analysis: A complete torsional critical speed analysis shall be conducted in order to ensure that the blower, motor and coupling are properly designed. Data shall be included in the submittal to confirm that there are no torsional critical speeds within the operating range of the unit.

4. Unit Mounting: Each blower and motor, coupled together, shall be factory mounted on a common steel base, properly braced to form a rigid support for the entire unit. The units shall be factory aligned on the base prior to shipment.

E. **Base Plates and Mountings**:

1. Base Plate: Each blower shall be furnished with a base plate of adequate size to support the blower, speed increasing gear, motor, lubricating system and accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting (using a four-point lift), with all equipment mounted, without distortion or other damage to the base plate or to component parts of the machinery. The base plate shall contain the oil reservoir.

2. Mountings: The base plate shall mount on machine mounts provided by the blower manufacturer, suitable to absorb the weight and vibration of the blower assembly without undue stress or distortion.

2.3 BLOWER DRIVE

A. **Electric Motor**: Each blower shall be provided with a horizontal, open, drip-proof, constant speed, squirrel cage, heavy duty motor in accordance with Section 16040, with a service factor of 1.15. The motors shall be provided with corrosion-resistant hardware, and they shall be of the high-efficiency design.

B. **Power Supply**: All motors shall be suitable for operation on [480] [4160] [ ] volt, 3-phase, 60 Hz power supply, at the indicated location.

C. **Motor Bearings**: Bearings shall be of ample size to carry all imposed loads with a design safety factor of 2.0. Bearings and housings shall be designed so that they can be removed for examination or replacement without removing the rotating element.

D. **Motor Safety Devices**: Each bearing housing shall be provided with a 100 ohm platinum temperature detector located in the lower half of each bearing. Each detector shall be utilized to indicate high temperature conditions. The impending high temperature condition shall actuate an alarm on the blower control panel. The high-high temperature condition shall shut the motor down at the motor control center.

Each motor shall have two velocity seismoprobes, Bentley-Nevada 16699, or equal, on each end of the motor above the bearing housings. Probes shall not be mounted using epoxy glue. Each velocity seismoprobe shall be mounted in a Bentley-Nevada 21128 housing.

2.4 ACCESSORIES

A. **Inlet Filter/Silencer**: Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet flange of the blower to reduce pressure drop across the inlet appurtenances. The frame shall be constructed of steel tubing, welded and hot-dipped galvanized, after fabrication. Walls shall consist of sandwiched galvanized steel outer skin and acoustical sound deadening material on the inside of the housing. The filter elements shall be square or rectangular replaceable elements mounted on a flat, vertical mounting frame, secured by hold-down clips, for easy removal and replacement of elements. Suitable gasket material shall be permanently affixed to the mounting frame to prevent bypass of air around filters. If the filter/silencer is located outside, a weatherproof cover shall protect the filter elements from rain. The air filter elements supplied shall filter the ambient air to a level of 90 to 95 percent removal of 0.3 micron particle size when tested according to the DOP Test Method. The filters shall be sized for a normal face velocity of 750 fpm at peak air flow, with an initial resistance of 0.45 inches water column (w.c.) across the element.

The integral inlet silencer shall consist of a lamella, mounted in the filter/silencer, between the filter elements and the blower inlet, suitably wrapped with sound deadening material. The lamella internals shall serve to dissipate incoming noise levels via the sound absorbing material. Maximum clean filter pressure drop of the inlet filer/silencer with the elements installed shall be 1.2 in. w.c. Maximum pressure drop with dirty inlet filters shall be 2 in. w.c.

The entire filter/silencer housing shall be designed for maximum air flow at minimum pressure drop. Legs shall be adjustable for vertical positioning and leveling. The filter/silencer shall connect directly to the blower inlet with a flexible connector.

B. **Discharge Flexible Connector**: Each blower shall be provided with a discharge expansion joint as indicated. The expansion joint shall alleviate stresses caused by thermal expansion and contraction in the piping system and the vibration imposed on the piping by the blowers. The expansion joints shall consist of fabric and various rubber compounds reinforced with a steel back-up ring for strength. The expansion joints shall be capable of withstanding the vacuum and pressure under all operating conditions and a temperature range of at least 0 to 300 degrees F. a temperature range of at least 0 to 300 degrees F. Expansion joints shall be equipped with 150 lb ANSI standard flanges with control rods. The expansion joint shall be of the filled-arch type, that results in a smooth, cylindrical inner surface to minimize air turbulence.

C. **Discharge Cone/Silencer**: Each blower shall be supplied with a discharge cone/silencer to increase the discharge from the blower outlet size to the discharge pipe size as indicated. The length of the discharge cone/silencer shall be aerodynamically designed to minimize pressure drop and minimize discharge turbulence. The discharge cone/silencer shall have ANSI 125 lb discharge and bypass flanges, size as indicated. Suitable instrument connections shall be provided, as required. The discharge cone/silencer shall be constructed of a minimum 10 gauge carbon steel. The inside wall of the discharge cone/silencer shall be lined with deep layers of sound absorbing material, resistant to high temperatures. This sound absorbing material shall be covered by perforated galvanized steel plate, minimum 10 gauge thickness.

D. **Blow-Off (Bypass) Valve**: Each blower shall be provided with a blow-off valve to allow unloaded startup. The valve shall be a butterfly valve, as indicated in Section 15104 for air service. The valve operator shall be motorized, 460/60/3, equipped with open/close limit switches, and shall

be suitable for air service at 300 degrees F operating temperature. The operator shall provide open-close modulating operation of the valve, based on remote contact closures from the blower control panel while in the automatic mode of operation. Opening or closing shall be controlled by the open/close pushbuttons while in the manual mode of operation. Controls for the valve shall be mounted in each local blower control panel with indicating lights to indicate fully open or closed.

E. **Discharge Valves**: Each blower shall be furnished with a discharge butterfly valve sized as indicated. Maximum pressure drop at maximum rated flow shall not exceed 1 in. w.c. Discharge valve shall be equipped with motorized operator with position indicator and limit switches as indicated in Section 15101. Valves shall be suitable for hot air service at 300 degrees F and identical to the blow-off valves, except for size. Controls and lights shall be mounted on each control panel, identical to the blow-off valve.

F. **Check Valve**: Each blower shall be provided with a discharge check valve, as indicated. Check valves shall be dual flat plate type with center hinge and spring closure, and shall have cast iron body and aluminum plates, Type 316 stainless steel hinge pin and springs, and silicone or Viton seal. The valves shall have flat sealing surfaces with the resilient seat facing on the body. The two plates shall be independently supported on the hinge pin and have separate closure springs. Valves shall have 125 lb. ANSI flanges and shall handle the blower rated discharge flow with a headloss not to exceed 1.6 in. w.c. at temperatures up to 300 degrees F. Check valves shall be MissionDuo-Chek, APCO, or equal.

G. **Discharge Silencer**: Each blower shall be provided with a silencer on the discharge for high frequency noise attenuation. Discharge silencers shall be high temperature type, rated for a minimum temperature of 300 degrees F, constructed of welded carbon steel, and consisting of an annular air flow passage lined inside and outside with acoustically perforated tubes backed by deep layers of sound absorbing material. Silencers shall provide maximum attenuation with minimum pressure drop, with a blocked line-of-sight, full flow area configuration, to attenuate noise in the high frequency range. Minimum attenuation shall be as follows:

Octave Band Center Frequency (Hz)	125	250	500	1000	2000	4000
Attenuation (dB)	10	18	30	30	44	40

Silencers shall have 125 lb ANSI flanged connections and shall be as manufactured by Universal Silencer, Burgess Manning, or equal.

H. **Blow-Off Silencers**: A blow-off silencer shall be provided for each blower and mounted on the discharge line, as indicated. The blow-off valve silencer shall be constructed of carbon steel and contain 6 annular acoustically transparent tubes, surrounded by sound absorption material encased in an outer shell. The silencer shall have one ANSI 125 lb. flange inlet connection for bolting onto the end of the bypass line.

2.5 INSTRUMENTATION

A. **General**: Instrumentation components shall be provided by the blower manufacturer. These components shall be mounted on the blower skid insofar as possible with all electrical connections brought to common junction boxes located on the blower skid. Two separate junction boxes shall be provided. One for low voltage and analog signals, and a second box for 120/60/1 controls and wiring.

B. **Instruments**: Instrumentation shall include, as a minimum, the following instruments and functions:

1. Inlet High Air Temperature Switch (recirculation surge)
2. Outlet High Air Temperature Switch (surge and malfunction)
3. High Oil Temperature Switch
4. Low Oil Temperature Switch
5. Air/Oil Cooler Temperature Switch (to start air cooled aftercooler)
6. Inlet and Outlet Temperature Transmitters, 4-20 mA
7. Inlet and Outlet Air Temperature Gauges
8. Oil Thermometer
9. Inlet and Outlet Water Thermometers
10. Inlet High Air Pressure Switch (surge monitor)
11. Standby Oil Pump and Low-Low Oil Pressure Switches
12. Inlet Air Filter Differential Vacuum Manometer
13. Inlet Air Filter Differential Pressure Switch
14. Discharge Air Pressure Transmitter, 4-20 mA
15. Oil Pressure Gauge
16. Discharge Air Pressure Gauge
17. Oil Filter Differential Pressure Indicator
18. Variable Diffuser Position Transmitter 4-20 mA
19. Inlet Guide Vane Position Transmitter, 4-20 mA

C. **Temperature Sensing**: The RTD monitor system shall include platinum, 100 ohm RTDs embedded in the motor windings (each phase) and in each bearing of both the motor and blower gearbox. The system shall continuously monitor the temperature of the three-wire bearing RTDs and include a display and switch to permit monitoring of actual bearing temperature. The temperature monitoring system shall include an adjustable alarm feature that permits the operator to select an "alarm" temperature. When bearings reach
shall be illuminated until reset, and a set of form C contacts, rated not less than 5 amps at 120 VAC. Monitors shall be Bentley-Nevada 3300/35, or equal.

The system shall have a temperature range as recommended by the blower manufacturer; trip point repeatability of not more than 1.8 degrees F; detection circuit response time of 5 milliseconds, maximum; deadband, 2 percent maximum; calibration accuracy of 1 degree F. Motor and blower bearings shall be similarly protected by this monitoring system. The monitors shall mount on the local control panel door and contain all the appurtenances necessary for a complete temperature monitoring system.

D. **Vibration Monitors**: A shaft vibration monitoring system shall be furnished for each blower and motor. The system shall include the following probes:

1. Blower gearbox fast shaft shall have X-Y configuration vibration detectors, Bentley-Nevada 21500, or equal, with proper cable for five meter proximeters.

2. Blower gearbox fast shaft thrust bearing (axial) detector, Bentley-Nevada 21500, or equal, with proper cable for five meter proximeters.

3. Blower gearbox accelerometer, Bentley-Nevada 23732, or equal.

4. Motor velocity transducer, two supplied, one for each bearing, Bentley-Nevada 16699, or equal.

The skid-mounted vibration detectors shall be factory wired to the blower skid analog terminal box. The necessary relays and switches to provide complete vibration protection shall be mounted in the blower control panel. Vibration monitors for compressor ad gearbox shall measure the displacement of the rotating shafts with respect to the bearing housing. Vibration transducers shall be compatible with Bentley-Nevada 3300 series, or equal. The monitoring system shall consist of dual channel vibration and thrust monitors, as required, to receive and monitor signals generated by the various probes on the blower and motor. The monitors shall mount on the local control panel door and contain all appurtenances necessary for a complete vibration monitoring system.

2.6 LOCAL CONTROL PANELS (LCP)

A. **General Function**: Each blower shall be furnished with a separate local control panel (LCP). Each LCP shall include all controls to operate the blowers, provide detection of malfunctions and shut down the blower should malfunctions occur. The control philosophy shall be failsafe operation, by which all controls and instruments shall fail into an alarm condition. The blower shall not be able to operate unless the controls are energized, and there are no defective controls. The controls shall be housed in a freestanding cabinet to be mounted as indicated.

B. **Construction**: The panel shall be fabricated from formed sheet steel of not less than No. 14 gauge thickness, braced and reinforced. The enclosure shall be freestanding, NEMA 12, with hinged door front access only. All wiring within the panel shall be grouped together in harnesses, secured to the structure, and terminate in a master terminal board. The panel shall be finished with light grey enamel over a rust-resistant primer. The control panel shall be completely factory assembled and wired such that field wiring shall consist only of connection to terminals. The panel shall have an internal fluorescent light and two-plug receptacle.

C. **Power Supply and Identification**: Power supply to the LCP will be 480 volt, 3-phase, 60 Hz. All switches, indicators, pilot lights, etc., shall be located on the front door of the panel and labelled with white-on-black laminated plastic nameplates, except for the touchplate, which shall have universal symbols for identification.

D. **Circuit Breakers and Starters**: Each LCP shall contain a flange mounted circuit breaker main power disconnect on the front door. A circuit breaker panel shall be mounted inside the panel for power distribution to oil pumps, control valves, etc. Starters for motor operated valves and oil pumps shall be mounted inside the panel. A voltage regulating line isolation transformer with 120 volt secondary shall be provided for control power. A separate 24 volt transformer shall also be supplied.

E. **Controls**: Each blower LCP shall contain controls for blower motor starting, surge and overload detection, shutdown control and sequencing, alarm and emergency shutdown systems, inlet guide vanes, variable diffusers, discharge valve, bypass valve and the oil pressure lubrication system.

F. **Additional Features**: The following additional items shall be supplied in each LCP:

1. Fuses: All starters shall be fused, as well as the instrumentation power, the (120/60/1) two plug receptacle, the temperature/vibration monitor system, and the programmable controller.

2. A programmable logic controller shall perform the following functions:

   a. Starts or shuts down blower in a permissive sequence. Shutdown shall occur in three different sequences: normal, soft or emergency stop.

   b. Receives input from operating variables that signal malfunction.

   c. Monitors operating variables and controls inlet guide vanes to maximize efficiency.

3. Control relays shall provide digital (dry contact) process signals external to the LCP and for other control functions external to the programmable controller (PC).

4. Timers, external or internal to the PC shall provide interlocks, time delays and pulse signals for blower control.

5. Varistors shall be provided for "noise" protection and to remove transient peaks across the control relays.

6. Motor overload protection controller shall be provided to control the maximum vane setting on the blower so motor current does not exceed a preset level.

7. Isolation amplifiers, R/I converters, RTD relays and other controls shall be supplied, as required, for complete system control.

8. A keypad/touchplate mounted in the front panel shall be supplied, incorporating the latest solid state keypad technology. On-off and open-close control shall be affected by touching the various keypad functions. A colored LED light in the right, upper corner of each keypad signals various functions. The keypad shall include the following functions and lights:

   a. Start Compressor: Light On (Light flash until feedback signal received)
   b. Stop Compressor: Light On
   c. Local Control: Light On
   d. Remote/Auto Control: Light On
   e. Open Blow-off Valve: (Light On-Open)
   f. Close Blow-off Valve: (Light On-Closed)
   g. Open Variable Diffuser: (Light On-Maximum Open)
   h. Close Variable Diffuser: (Light On-Minimum Closed)
   i. Open Inlet Guide Vane: (Light On-Maximum Open)
   j. Close Inlet Guide Vane: (Light On-Minimum Closed)

k. Lead Oil Pump Start (Service Only): (Light On-Oil Pump Run)
l. Lead Oil Pump Stop (Service Only): (Light On-Oil Pump Stop)
m. Reset Low Oil Pressure (Lights On Low-Low Oil Pressure)
n. Reset High Oil Temperature (Lights On High Oil Temperature)
o. Reset Surge Control (Lights On Surging)
p. Reset Recirculation Surge (Lights On Recirculation Surge)
q. Reset High RTD Temperature (Lights On High Motor Temperature)
r. Reset General Alarm (Lights On General Alarm)

Alternatively conventional pushbutton or selector switch controls and lights may be provided in lieu of a keypad/touchplate.

9. Additional Switches and Lights: Additional selector switches, pushbuttons, and lights shall include:

a. Normal/Service: located inside the panel which allows for permissive start of the blower components in the service mode.
b. Service Start-Stop Oil Cooler Fan (and run light)
c. Lamp and Horn Test
d. Alarm Horn Silence
e. High Discharge Air Temperature Reset and Light
f. High Discharge Air Pressure Reset and Light
g. Inlet Air Filter high Differential Pressure Light
h. Oil Pump 1 Selected/Running Light
i. Oil Pump 2 Selected/Running Light
j. Emergency Stop Mushroom Button (keyed)
k. Open-Close Discharge Valve (with Open and Close Lights)

10. Light Colors: Light colors (except for Bentley-Nevada monitors) shall be:

White - Status
Yellow - Warning
Red - Alarm

11. Monitor Location: The temperature/vibration machine monitor shall be located on the front of the panel door.

12. Meters: Panel mounted meters shall be rectangular, approximately 4 x 4 inches with a black pointer indicating position on an appropriate scale. Meters shall include:

a. Motor Amps
b. Inlet Guide Vane Position
c. Variable Diffuser Position (45 to 100 percent capacity)
d. Inlet Temperature
e. Discharge Temperature
f. Discharge Pressure

13. Alarm Horn: An alarm horn shall be mounted on top of the blower panel and be energized upon any alarm condition. Horn silence button shall be located on the panel door.

14. Hourmeter: A non-resettable hourmeter shall be located on the panel door.

G. **Start/Stop Controls**: Start/stop blower sequence controls shall be furnished in the LCP. In addition, all shutdown conditions shall activate the stop control

The blowers shall start under an automatic sequence initiated by the local start signal or the remote start signal when in remote/auto control. Upon signal to start, dry contacts (rated 5 amperes at 120 VAC) shall signal that the inlet guide vanes and variable diffusers are at minimum, the bypass valve is opened, and the discharge valve is closed. All vanes and valves shall be equipped with limit switches on both the open and closed position to indicate position. If components are not properly positioned, they shall move to their respective start positions. The oil prelubrication system shall energize and run for a minimum 2 min., prelubrication time. Once position is confirmed and all other start/safety functions are also confirmed, the blower motor shall be started. A feedback signal from the MCC shall confirm the starter being energized. When the blower reaches operating speed, as determined by the motor start sequence, the contacts shall operate to open inlet guide vanes, open discharge valve, close blow-off (bypass) valve, and release control of the inlet guide vanes and variable diffusers to the control on the LCP. Interlocks shall be provided to prevent blower operation after the delay time during startup, if the vanes are closed, or if the bypass valve is not fully closed. Provide sequence fail alarm and shutdown if any portion of the start, run or stop sequence is not properly executed.

H. **Surge/Overload Control**: The surge/overload system shall sense unbalanced/surge conditions by means of pressure sensing devices, high temperature, or motor current draw. These devices shall be of the manufacturer's standard, and their purpose shall be to prevent an unbalanced surge condition from damaging the blower. Detection of surge conditions shall shut-down the blower.

I. **Blower Shutdown**: There shall be three means of shutting down the blower:

1. Normal Stop - initiated by pushing the stop button or remote stop. Machine normally stopped to avoid surge.

2. Soft stop (accompanied by mild surge) initiated by:
   a. High Oil Temperature
   b. High Inlet Air Temperature (recirculation surge)
   c. Surge
   d. High Motor Temperature
   e. No Feedback Signal from MCC during Start Sequence
   f. Loss of Feedback Signal from MCC during Normal Operation
   g. Sequence Failure
   h. Discharge valve is not fully open within 2 min after receiving feedback signal from MCC.
   i. Blowoff valve has not closed within 5 min. after receiving feedback signal from MCC.
   j. High Discharge Pressure

3. Emergency stop (accompanied by surge) initiated by:

   a. Pushing Emergency Stop button
   b. Low Oil Pressure

c. Vibration - Danger
d. Bearing Temperature - Danger
e. PC Failure

J. **Frequency of Starts**: The PC shall not allow more than four starts per hour in order to protect the motor.

K. **High Inlet Air Temperature**: The high inlet air temperature (recirculation surge) shall be active at all times, regardless of whether or not the blower is operating. The purpose being to detect a discharge air check valve failure by reverse air flow.

L. **External Contacts**: External contacts in the LCP shall be as follows:

1. To plant process control (for blower monitoring purposes):

a. Blower on
b. Blower off
c. Common alarm
d. Control status - Local or Remote/Auto

2. To Master Blower Control Panel (MBCP):

a. Blower on
b. Blower ready for start
c. Maximum air flow
d. Minimum air flow
e. Common alarm
f. Blower in Remote/Auto

3. From MBCP:

a. Blower Start/Stop Signal
b. Increase air flow
c. Decrease air flow

4. To and From MCC:

a. Motor start signal to MCC
b. Run confirmation signal (feedback from MCC)

2.7 MASTER BLOWER CONTROL PANEL

$# _____

NTS: The Specifier shall choose the method of blower control and cross out the other type of control.

_____ #$

A. **General**: A programmable controller based sequencing panel shall be provided for starting and stopping blowers automatically and to facilitate [discharge air header pressure control] [dissolved oxygen control].

B. **Design Conditions**: The sequencing system shall provide [discharge header pressure control] [dissolved oxygen control] over a range of [to] [psig] [dissolved oxygen] with any or all of the blowers in service. The discharge pressure set point shall be adjustable from the MBCP or from a remote analog input provided by others. The remote set point input shall be a 4-20 mA DC signal corresponding to the [to] [psig] [dissolved oxygen] control range.

C. **Construction**: The control panel shall be freestanding, NEMA 12 enclosure with a front opening door and similar in construction to the LCP. Electrical equipment and wiring shall meet the requirements of Section 16050.

D. **Panel Front**: The panel front shall have a [ ] position selector switch that shall select the start sequence of the blowers. The local [pressure] [dissolved oxygen] set point adjustment knob and the local/remote switch for local or remote [pressure] [dissolved oxygen] control shall also be located on the panel door.

The MBCP shall have status lights as follows for each blower:

1. Blower in remote (white)
2. Blower on (white)
3. Common alarm (red)

E. **Sequence Control**: The master sequence controller, via the internal programmable controller, shall receive the main air header pressure 4-20 mA signal that calls for more or less air. The controller shall bring blowers on and off line and increase/decrease on-line blower capacity based on the manufacturer's standard control logic. The result being gradual increase/decrease of air throughout the entire range of one to [ ] blowers on-line. In the event of a blower failure, the next blower in the preselected start sequence shall come on-line.

F. **External Contacts**: External dry contacts from the MBCP to each LCP shall be as follows:

1. Blower Start/Stop Signal
2. Increase Air Flow
3. Decrease Air Flow

2.8 SURFACE PREPARATION AND SHOP PAINTING

A. All surfaces shall be prepared, shop primed, and shop finish painted with two coats of manufacturer's standard paint system as part of the WORK under this Section.

B. Machine surfaces that are not painted shall be protected by coating with a corrosive-protective compound.

2.9 TOOLS AND SPARE PARTS

A. **Tools**: The WORK includes special tools necessary for maintenance and repair; tools shall be stored in tool boxes, and identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.

B. **Spare Parts**: The WORK includes the following spare parts:

1. Two complete sets of all bearings for the blower.
2. Two complete sets of all bearings for air blower motors.
3. Two complete sets of "O" rings and gaskets for the blowers and motors.
4. Five sets of oil filter cartridges
5. One main and one auxiliary oil pump (or one, only, if duplicate main and auxiliary oil pumps are provided)
6. Five sets of inlet air filters

Spare parts shall be identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.

2.10 MANUFACTURERS

A. The blower units indicated shall be manufactured by one of the following (or equal):

1. Turblex Inc.
2. Roots

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **General**: The blowers and motors shall be installed in accordance with the instructions of the manufacturer and as indicated. All piping shall be supported to preclude the possibility of exerting undue forces and moments on the blower flanges. Each blower unit shall be mounted on a flat and level concrete pad.

B. **Lubricants**: Installation shall include furnishing the required oil and grease for initial operation. The grades of oil and grease shall be in accordance with the manufacturer's recommendations.

3.2 STARTUP AND COMMISSIONING

A. **Services of Manufacturer**: The CONTRACTOR shall furnish the services of a factory representative of the blower manufacturer who has complete knowledge and experience in the proper installation, startup and operation of the blower and drive equipment to inspect the final installation and supervise the field acceptance tests of the equipment. The services of the representative shall be provided as indicated in Part 1, above. If there are difficulties in operation of the equipment due to the manufacturer's fabrication or CONTRACTOR'S installation, additional service shall be provided at no cost to the OWNER.

B. **Field Acceptance Tests**: After the installation of the blowers, motors, controls and all appurtenances, each complete unit shall be subject to field acceptance tests under actual operating

conditions. The field acceptance tests shall be made by the CONTRACTOR under the direct supervision of a qualified representative of the blower manufacturer, in the presence of and as directed by the CONSTRUCTION MANAGER.

C. The field acceptance tests shall demonstrate that, under all conditions of operation, each unit:

1. Has not been damaged by transportation or installation.
2. Has been properly installed.
3. Has no mechanical defects.
4. Is in proper alignment.
5. Has been properly connected.
6. Is free of overheating of any parts.
7. Is free of objectionable vibration and noise.
8. Is free of overloading of any parts.

D. Field acceptance testing shall be conducted after the installation of all equipment has been completed and the equipment operated for a sufficient period to make all desirable corrections and adjustments.

E. Field acceptance tests and testing procedures shall be mutually arranged and coordinated with the OWNER'S plant personnel and representatives. The CONTRACTOR shall schedule his testing procedures with the full knowledge and consent of the OWNER, and shall not adversely affect the operation of plant facilities.

F. A factory representative, who has complete knowledge of proper operation and maintenance and experience in conducting training sessions, shall be provided, as indicated in Part 1, to instruct the OWNER'S personnel on proper operation and maintenance, including startup and shutdown procedures, proper lubrication practices, and troubleshooting of all equipment. A resume of the instructors' background shall be submitted for the approval of the CONSTRUCTION MANAGER, inasmuch as the training sessions may be videotaped. This work may be conducted in conjunction with the inspection of the installation and field tests. If there are any difficulties with the training or in the operation of the equipment due to the manufacturer's design, fabrication, or the CONTRACTOR'S installation, additional startup and training services shall be provided at no cost to the OWNER.

** END OF SECTION **