REQUEST FOR PROPOSAL

Felix C. Davis Wastewater Treatment Plant

North Charleston Sewer District

BLOWER EQUIPMENT PRESELECTION

PREPARED FOR

North Charleston Sewer District

PREPARED BY

Hazen and Sawyer

TABLE OF CONTENTS

APPENDICES

NOTICE OF REQUEST FOR PROPOSALS

The North Charleston Sewer District (NCSD) will preselect a blower equipment supplier as part of the Aeration Upgrade and Rehabilitation Project. Blower suppliers who intend to submit a price and offer to provide equipment to NCSD, via the General Contractor for the project, must provide all materials requested herein and be preselected by NCSD via this RFP process. The preselected blower equipment supplier will be listed in the specifications and the equipment price will be included in the bid form. The General Contractor will be required to contract with the preselected blower equipment manufacturer at the previously negotiated equipment price with provisions for cost escalation dependent on delivery date as specified herein.

Proposals for Blower Equipment shall be received electronically by **North Charleston Sewer District** by **2:00 p.m.** local time on **November 30, 2023.**

Only blower manufacturers herein referred to as "suppliers" and the specific blower equipment conforming to the enclosed specifications and determined to be acceptable will be preselected for the project.

NCSD reserves the right to modify the technical specifications for the equipment described in this request prior to issuing the final Construction Documents. Such modification will not impact the outcome of this preselection process but will require the supplier to comply with the modifications. If the modification is a material change, a revised price negotiation will be considered.

Although an equipment manufacturer will be preselected, neither the preselection nor any preselection rating will relieve any bidder or supplier from meeting the requirements of the final Construction Documents.

The anticipated Selection Schedule is summarized below:

Milestone	**Date**
Issue Request for Proposals	November 3, 2023
Questions Due By	November 20, 2023 by 2 PM local time
Supplier Proposals Due	November 30, 2023 by 2 PM local time

REQUEST FOR PROPOSAL

INTRODUCTION

The Felix C. Davis Wastewater Treatment Plant (WWTP) is a 32-mgd design annual average flow activated sludge facility. Aging infrastructure and inefficient equipment require replacement of the existing process aeration blowers. There are currently five operating multistage centrifugal blowers and one inoperable single-stage integral-gear blower installed in the blower building at the Felix C. Davis WWTP. All existing blowers will be removed and replaced with new blowers. All blowers are currently fed from an existing 4,160V power distribution. Preliminary analysis indicates significant additional electrical cost will be incurred, and facility footprint will be lost for blower packages requiring low-voltage (480V) electrical feed compared to those that can accommodate the existing 4,160V service.

Two blower technologies are being considered for this project: single-stage integral-gear centrifugal blowers and high-speed direct drive centrifugal (turbo) blowers. NCSD intends to pre-select a single blower technology and equipment supplier. The blower package will be purchased and installed by a General Contractor under a contract with NCSD.

The anticipated bid and construction milestone dates are as follows:

Anticipated Milestone	**Estimated Date**
Anticipated Bid Advertisement	September 2024
Anticipated Contractor NTP	October 2024
Anticipated Delivery of Blowers	October 2025

INTERPRETATIONS AND ADDENDA

All questions regarding the RFP are to be submitted to the Engineer via email. Interpretations or clarifications considered necessary by the Engineer in response to such questions will be issued by addenda and emailed to all Suppliers. Questions received less than 10 days prior to the date for opening of proposals will not be answered.

PREPARATION OF PROPOSALS

1. Submit proposals directly to NCSD via email to purchasing@ncsd.sc.gov.
2. A complete and responsive proposal must include the following:
   a. Complete and executed Cost Proposal Form.
   b. Supplemental Information requested in Appendix A.
3. The proposal as originally submitted shall be complete to allow for a full analysis without the need for additional information. No supplementary explanation is assumed or intended. However, the Engineer reserves the right to clarify or request further information after opening of proposals.

EVALUATION OF PROPOSALS

1. Competitive proposals are being solicited which include capital cost information as well as guaranteed minimum performance criteria to be used for the evaluation and selection process.
2. The selection of the Equipment Supplier will follow a value-based process that includes a weighted evaluation based on the following criteria:
    a. Life-Cycle Costs (Capital and O&M)
    b. Performance
    c. Operation & Maintenance
    d. Constructability
    e. Supplier Experience with Similar Blowers
    f. Electrical Requirements
3. NCSD reserves the right to accept or reject any or all proposals submitted and waive minor defects, informalities, and technicalities. NCSD will evaluate each proposal and will select the Supplier, which in NCSD's opinion, has submitted the proposal best suited to the needs and goals of the Project and deemed to be in compliance with the requirements of the RFP including the attached specifications.
4. NCSD will select an Equipment Supplier to provide blowers as part of the Aeration Upgrade and Rehabilitation Project. The selected blowers will be included in the design and named in the final Construction Documents.
5. NCSD intends to negotiate with the preselected manufacturer. If a negotiated price can be reached, the preselected manufacturer will be listed in the technical specification and the negotiated price will be included in the bid form.
6. The preselected Equipment Supplier will contract directly with the General Contractor and be bound by its required schedule and contract.

COST PROPOSAL FORM

1. In submitting this proposal, Supplier represents that supplier has examined and carefully studied the documents provided in this RFP and the following Addenda, receipt of which is hereby acknowledged:

Addendum No.	Addendum Date
_____	_____
_____	_____

2. The proposed price shall include all products, delivered to the site, and services required for a complete and fully functional system, as further defined in the technical specifications. The Supplier shall attach a list of all blower package components and accessories and all Supplier services included in their cost.

3. Complete the cost table below based on compliance with the Appendix B technical specifications.

Base Cost Proposal	**No.**	**Unit**	**Unit Price**	**Total Price**
Shop Drawings	1	LS		
Blowers		EA		
Field and Start-Up Services	1	LS		
			Total Base Cost (USD)	

4. As described in Appendix A, the Supplier is allowed to suggest deviations from the technical specifications. For these deviations list cost adjustments, if any, relative to these deviations in the table below. Add additional line items as needed.

Deviations from Technical Specification	**No.**	**Unit**	**Unit Price**	**Total Price**
Item 1:				
Item 2:				
Item 3:				

5. The cost shall remain valid from the date of anticipated equipment delivery for one hundred eighty (180) days. For time extending beyond this period, the cost will be adjusted once through Change Order by the ratio of the Producer Price Index (PPI) and will be coordinated directly with the Contractor with written confirmation of the proposed change based on PPI provided to NCSD. Baseline PPI shall be the date of submittal of the proposal, and adjusted based on the average PPI for the 12 months immediately prior to the date of advertisement for bid.
6. Payment may be requested by Supplier via the Construction Contractor upon delivery of the full equipment package, acceptance by Engineer, and suitable storage at or near the site in order for NCSD to establish title to such materials and equipment or otherwise protect NCSD's interest.

This Proposal is submitted by:

Printed Name and Title: _____

Supplier Name: _____

Signature: _____

Date: _____

APPENDIX A

SUPPLEMENTAL INFORMATION REQUIREMENTS

GENERAL

In addition to the Cost Proposal Form, proposals shall include the information requested herein, at a minimum. Each Supplier shall review the requirements of this Request for Proposal document and provide additional information the supplier deems necessary.

The response information shall be provided in the forms provided below, or a reasonable facsimile of the provided forms. Suppliers choosing to use reasonable facsimiles of the forms should maintain both the format and the content of the provided forms. Copies of the forms in MS Word format will be provided by email upon request.

Failure to submit all required information, back-up documentation, and completed forms may be cause for rejection.

PROCUREMENT, FABRICATION AND INSTALLATION HISTORY

A. Provide the information requested in the following table:

Parameter	Units	Value	Submittal Requirements
Equipment Lead Time			
Purchase Order to Shop Drawing Submittal	Weeks		
Shop Drawing Approval to Delivery	Weeks		
Number of North American Installations of the Proposed Blower model	-		Provide List
Year of First Installation of the Proposed Blower model	-		Provide Description
State and/or Country of Primary Blower Manufacturing	-		

TECHNICAL DATA

A. Provide information requested in the following table related to the proposed equipment.

Parameter	Units	Value
Total No. of Duty Blowers to Meet Design Point [1]	-	
Min. Turndown Flow at Min. Temperature [2]	scfm[4]	
Power Consumption at Design Conditions [3]	kW	
Rated Noise Level (at 3ft from any point of the blower or ancillary equipment)	dB	

Parameter	Units	Value
Max Dimensions of Blower Skid in inches	L x W x H	
Max Dimension of Largest Component in inches	L x W x H	
Total Weight of Blower Skid	Lbs	
Weight of Largest Component	Lbs	
Clearance Required Around Blower Skid	Inches	
Electrical Voltage at Blower Package Connection	V	
Full Load Amperage at Blower Package Conditions	A	
Heat Emission of Individual Blower at Design Point	BTU/hr	

1. Duty blowers need to provide a total capacity of 36,000 scfm at the site elevation and design inlet conditions stipulated in the specifications.
2. Refer to Section 43 11 11 and 43 11 12 for design inlet and ambient conditions.
3. Total power consumption of all blowers operating in order to provide design capacity of 36,000 scfm.
4. Standard cubic feet per minute (scfm) is defined airflow rate in terms of standard conditions (68°F, 14.7 psia and 36% relative humidity)

B. Suppliers shall review the technical specifications included within this RFP. Indicate whether the proposed equipment will conform to the requirements of the applicable technical specifications below.

Specification	Conformance? (Circle One)
Section 43 11 11 – Direct-Drive Single-Stage Centrifugal Blowers	YES/NO
Section 43 11 12 – Integral-Gear Single Stage Centrifugal Blowers	YES/NO

C. The Supplier can request deviations from the specification for consideration by the Engineer. Where the Supplier's proposal does not meet the requirements of the technical specifications, provide a detailed list of all deviations from the specified requirements and explain why the Supplier believes the deviations are advantageous to the District. If there is a cost adjustment associated with the deviation, list in the cost proposal form.

D. For each exception, describe the reason for the exception and describe the alternative proposed by the Supplier with supporting documentation. For each exception taken, provide evidence that the proposed alternative has been successfully used at other similar installations.

E. All blowers are currently fed from an existing 4,160V power distribution. Preliminary analysis indicates significant additional electrical cost will be incurred, and facility footprint will be lost for blower packages requiring low-voltage (480V) electrical feed compared to those that can accommodate the existing 4,160V service. The Supplier shall confirm whether the proposed blower packages can be served by 4,160V power. If the blowers cannot be served directly from the 4,160V service, the Supplier is encouraged to propose on ancillary equipment (i.e. step-down transformers integrated into the blower

packages) that can be included under their scope of supply to integrate the existing 4160V electrical feed to serve their proposed blowers. The ancillary equipment shall be provided as a cost adder to the manufacturer's base blower bid.

PERFORMANCE

Complete the following Blower Performance Tables and provide performance curves for the blowers. Performance curves shall be developed in terms of standard conditions of 14.7 psia, 68°F, and 36% relative humidity as well as the design criteria specified in Paragraph 2.02 of the technical specifications.

Criteria	Units	Design Operating Points				
		No. 1	**No. 2**	**No. 3**	**No. 4**	**No. 5**
Inlet Air Flow	scfm	9,100	12,000	13,700	16,200	19,900
Discharge Pressure	psig	7.00	7.05	7.10	7.15	7.25
Inlet Air Temperature	°F	70	70	70	70	70
Inlet Air Relative Humidity	%	70	70	70	70	70
Barometric Pressure	psia	14.69	14.69	14.69	14.69	14.69
Inlet Pressure	psia	0.1	0.1	0.1	0.1	0.1
No. of Blowers Operating						
Inlet Air Flow per blower	scfm					
Maximum Wire Power	kW					
Usage Factor	%	20%	20%	20%	20%	20%
Wire Power Draw * Usage Factor	kW					
Total Maximum Wire Power	kW					

1. For blowers with external harmonic filters, an assumed harmonic filter efficiency of 95% shall be used to convert wire power at the blower enclosure to wire power at the harmonic filter as follows: Wire Power Draw at Blower/0.95 * Usage Factor.

Note: The blowers shall not exceed the maximum wire horsepower consumption for the operating points and inlet conditions given above. Maximum wire power draw specified for each design point shall be wire to air power and include all power demands and losses associated with the blower package, including but not limited to the motor, variable frequency drive, harmonic filter (if internal to the blower enclosure), cooling system losses (including those associated with pre-heating of inlet air due to recycling of cooling air to the blower inlet within the package), and any additional electrical requirements. Wire power shall be as measured at the electrical connection to the blower package and shall be based on fully closed blower packages if blowers are housed within an enclosure. **Performance data based on or assuming a blower package with an open enclosure is not acceptable for blower technologies installed in enclosures**.

The total maximum wire power shall be calculated as the sum of the maximum wire power for each operating blower at the design operating points multiplied by the usage factor for the operating points given above. The maximum wire power draw for each design point shall be submitted with the shop drawings (at a later date, through the Contractor) **with no tolerances and shall be confirmed during the PTC-13 factory performance tests.**

MAINTENANCE AND SPARE PARTS

A. Provide the following data related to vendor-supplied service.

Item	Units	Value	Submittal Requirements
Location of closest service center to North Charleston, SC	-		
5-Year Service Contract Cost (not part of base bid)	USD		Provide a description of service contract scope

B. Spare Parts

Item	Units	Value	Submittal Requirements
5-Year Cost of Spare Parts			List of recommended spare parts

C. Provide maintenance information requested in the following table for the proposed equipment as applicable. Supplier shall expand the table as needed to include all other items that will typically require replacement over the 20-year service life of the blowers. The table shall include cost of each replacement part, repair and replacement intervals, and indicate if part must be replaced by a certified technician.

Parameter	Units	Value	Certified Technician Service Required?
Expected Oil Change Interval	Months		YES/NO
Oil Change Volume, per blower	Gallons		YES/NO
Cost of recommended oil, per gallon	USD		YES/NO
Is oil only available through manufacturer?	Yes/No		YES/NO
Expected Coolant Change Interval	Months		YES/NO
VFD Fan Replacement Interval	Months		YES/NO
VFD Fan Replacement Cost	USD		YES/NO
VFD Replacement Interval	Months		YES/NO
VFD Replacement Cost	USD		YES/NO
UPS Replacement Interval	Months		YES/NO
UPS Replacement Cost	USD		YES/NO
Harmonic Filter Replacement Interval	Months		YES/NO

Parameter	Units	Value	Certified Technician Service Required?
Harmonic Filter Replacement Cost	USD		YES/NO
Mag Bearing Controller Replacement Interval	Months		YES/NO
Mag Bearing Controller Replacement Cost	USD		YES/NO
Mag Bearing Cooling Fan Replacement Interval	Months		YES/NO
Mag Bearing Cooling Fan Replacement Cost	USD		YES/NO

D. In addition, provide the following data related to estimated life of wearing parts, cost of replacement, and indicate if part must be replaced by a certified technician (as applicable).

Parameter	Units	Estimated Life	Estimated Cost of Parts	Certified Technician Service Required?
Replacement Bearings	Hours of Operation			YES/NO
Replacement Seals	Hours of Operation			
Replacement Filters	Hours of Operation			

DRAWINGS AND PERFORMANCE CURVES

Proposals are to be accompanied by the following Drawings:

1. Dimensional drawings, plans and details showing general construction and assembly, dimensions, materials of construction, and finishes.
2. Dimensional drawing showing clearance required around each side of equipment for regular servicing and maintenance.
3. Provide performance curves for the blowers.
4. Provide .STP or .RVT files compatible with Revit of proposed blowers.

APPENDIX B

TECHNICAL SPECIFICATIONS

SECTION 43 11 11

DIRECT-DRIVE SINGLE-STAGE CENTRIFUGAL BLOWER PACKAGES

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation electric motor-driven, high speed direct-drive single-stage centrifugal blower packages including electric motors, variable frequency drives (VFDs), acoustical enclosures, check valves, blow-off valves, discharge butterfly valves, inlet filters, individual blower control panels, a Master Blower Control panel if required by the manufacturer, harmonic filters and all necessary auxiliary equipment as specified herein and shown on the Drawings or as required for a complete installation of the system.

B. All equipment specified in this Section shall be designed and furnished by the blower manufacturer, who shall be responsible for the suitability and compatibility of all included equipment. Aeration blowers shall be manufactured by APG-Neuros, Sulzer-ABS, or Aerzen.

C. The layout and design of the aeration blower system including blower discharge piping and supports in the contract drawings are based on equipment manufactured by TBD. Any changes in design including but not limited to structural supports, piping systems, electrical systems, or HVAC systems resulting from the use of equipment from other manufacturers (named or unnamed) shall be the sole responsibility of the Contractor. Any redesign for substitute equipment shall be submitted for the Engineer's review prior to fabrication or installation.

1.02 SUBMITTALS

A. The Contractor shall submit complete Shop Drawings, Operation and Maintenance Instructions and other information for the blower systems and all equipment specified herein in accordance with Section 01 33 00 – Submittal Procedures.

B. Shop Drawings shall include full descriptive information of materials used, method of fabrication, sizes, enclosures, ratings and layout dimensions, etc. to demonstrate full compliance with the Contract Documents.

C. Shop Drawings shall include weights of all system components and total weight of the operating blower packages.

D. The performance characteristic curves for the blowers shall be submitted with the shop drawings. Performance curves shall be developed in terms of standard conditions of 14.7 psia, 68°F, and 36% relative humidity as well as the design criteria specified in

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Paragraph 2.02. The curves shall show horsepower draw over the range of SCFM flow rates. Curves that show horsepower as % of 100% horsepower are unacceptable. The standard inlet conditions above shall be at the inlet to the blower package and do not include the impacts of recycling cooling air to the blower inlet within the package. Additional operational data for the blowers shall be submitted including recommended alarm settings and operational limits.

E. A complete description of the protective coating system to be used for all components, prior to shipment and after installation, shall be submitted with the shop drawings.

F. A listing of spare parts furnished shall be submitted with the shop drawings.

G. The blower manufacturer shall submit installation instructions in accordance with Section 01 33 00 – Submittal Procedures. Installation instructions shall be complete including unloading, check-out following shipment, storage, handling, assembly, anchorage, and start-up instructions and shall be submitted prior to delivery of the blowers.

H. Certified test reports including all details of apparatus, procedure, and results and all required calculations shall be submitted for each shop test conducted. Reports for shop tests shall be approved by the Engineer prior to shipment.

I. Computations showing the Manufacturer’s maximum power input at the design points specified for each blower unit.

J. Motor, VFD, and harmonic filter literature, illustrations, specifications and engineering data.

K. Instruments including product data sheets, manufacturer’s catalog information, and performance/operation criteria and requirements.

L. Panel, console, and cabinet layout drawings, component product information, wiring diagrams, field wiring requirements, and operator interface graphic layouts specific to the project.

M. Blower control system block diagram, input/output information, hardware layout drawings, interconnection diagrams, and point-to-point interconnection wiring diagrams for field wiring.

N. Blower package current draw at full load and power factor data.

O. Each blower package shall be CSA/UL name plate certified. The blower manufacturer shall submit proof of UL/CSA Certification on the same model and size proposed. Any exceptions to this requirement shall be listed on the blower manufacturer’s proposal and shall be furnished by the Contractor to the Engineer prior to acceptance.

1.03 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall arrange for the manufacturer to furnish the services of a qualified service person, with at least three years of experience, who is regularly involved in the inspection, operation, and maintenance of blowers and blower systems of the size and type being furnished. The service persons shall:

1. Inspect the installed equipment to verify that installation is in accordance with the blower manufacturer’s requirements

2. Verify proper connection of piping and installation of accessories

3. Witness and check final adjustments and alignment

4. Confirm proper wiring of all instruments and field wired items

5. Witness and check start-up of each blower system

6. Assist the Contractor in performing field testing and prepare a written report as specified below.

7. Troubleshoot and correct any mechanical, electrical, or control problems with the system that are noted during initial operation.

8. Submit written certification signed by the service person that the system has been properly installed, tested, and adjusted; that the system operates as specified or as required, including date of field test, as well as a listing of all persons present during the tests.

9. Investigate and supervise correction of any operating problems which may arise during the guarantee period of the equipment.

10. Instruct representatives of the Owner on proper operation and maintenance, including start-up and shut-down procedures and troubleshooting of all equipment.

B. Such services shall be furnished at no additional cost to the Owner and shall entail a period of not less than eight (8) days and a minimum of four (4) site visits. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

C. The manufacturer’s service person shall sign in and out every day on-site and shall comply with all Owner requirements for visiting the site.

1.04 QUALITY ASSURANCE

A. The materials covered by the Specifications are intended to be standard equipment of proven reliability and as manufactured by reputable manufacturers having experience in

the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Drawings and operated per the manufacturers' recommendations.

B. All materials shall be new and both workmanship and materials shall be of the very best quality, entirely suitable for the service to which the units are to be subjected and shall conform to all applicable Sections of these Specifications. All parts of duplicate machines shall be interchangeable without modification. The construction of the blowers shall be such that the blowers will not be damaged during continuous operation and will not have undue vibration above the blower's surge volume limit. The design and construction of the blowers shall not cause any unbalanced floor loadings.

C. The blower manufacturer shall warrant the centrifugal blower packages including all accessories furnished with the package (either inside or external to the enclosure) for materials and workmanship for a period of two (2) years starting on the date of substantial completion. Warranty and Guarantee shall be as specified in Section 46 00 00 – Equipment General Provisions with the exception that the warranty period shall be for two (2) years. The warranty shall be submitted with the shop drawings.

1.05 COORDINATION OF DELIVERIES AND RESPONSIBILITY FOR STORAGE

A. The Contractor shall protect blower system components at the project site and during installation. The Contractor shall be required to place blowers onto their pads within 24 hours after arrival of the blowers at the site. The Contractor shall be responsible for scheduling and coordinating deliveries of blowers with the manufacturer to minimize the time that blowers are on-site and not installed. The Contractor shall be responsible for any additional cost incurred for storage of blowers. The Contractor shall connect space/strip heaters and manually rotate shafts if necessary as recommended by the manufacturer.

PART 2 – PRODUCTS

2.01 GENERAL

A. The aeration blowers shall be high speed, direct-drive centrifugal type. Blowers shall be complete pre-packaged units. Blower packages shall be of single-core or dual-core design. High efficiency, high speed motors shall be furnished as an integral part of the blower core assembly. Units shall have integrated cooling, variable speed drive and controls.

B. The Contractor shall make all alterations required to structures, equipment, piping, controls, or other work shown in the Contract Drawings that may be required for the blower systems ultimately furnished.

C. The blowers shall be designed for heavy, continuous industrial service and shall be capable of starting a minimum of 4 times per hour.

2.02 PERFORMANCE REQUIREMENTS

A. The proposed blowers shall satisfy the conditions of service and requirements listed below. Standard cubic feet per minute (SCFM) is defined as the delivered airflow rate at the blower discharge in terms of standard conditions (68°F, 14.7 psia and 36% relative humidity).

B. The blowers shall be capable of delivering the specified design flow rate per blower (in scfm) at the specified discharge pressure at the minimum inlet pressure, design maximum air temperature and relative humidity at the design maximum temperature as specified for the blower primary design point below. The design air temperatures and relative humidity listed shall be at the inlet to the blower package and do not include the impacts of recycling cooling air to the blower inlet within the package. Motor horsepower shall not exceed the maximum rated motor horsepower specified. The blowers shall be capable of turndown to the minimum flow rate at the design minimum temperature and relative humidity at design minimum temperature specified below.

Ambient Conditions	
Site Elevation, ft	20
Ambient Barometric Pressure, psia	14.69
Ambient Temperature Range, °F	20 - 104
Ambient Relative Humidity Range, %	10 - 100

1. Alternative 1 – Single Core

Design Inlet Conditions	
Minimum Inlet Pressure, psia	14.39
Design Maximum Air Temperature, °F	98
Relative Humidity at Design Max. Temperature, %	50
Design Minimum Air Temperature, °F	30
Relative Humidity at Design Min. Temperature, %	45
Capacity Requirements	
Number of Blowers	5
Mass Flow Rate/Blower at Design Max Inlet, SCFM	9,000
Volumetric Flow Rate/Blower at Design Max Inlet, ICFM	9,940
Discharge Pressure, psig	8.50
Discharge Pressure (absolute), psia	23.19
Maximum Wire Power at Design Point, HP	TBD
Minimum Flow Rate/Blower at Design Min. Inlet, SCFM	5,400
Motor Requirements	
Blower Package Supply Voltage, V	480 (4160[1])
Maximum Rated Power, HP	TBD

[1]Blower manufacturer is encouraged to provide alternative proposal with integrated transformer to accept existing site 4160 V power

2. Alternative 2 – Dual Core

Design Inlet Conditions	
Minimum Inlet Pressure, psia	14.39
Design Maximum Air Temperature, °F	98
Relative Humidity at Design Max. Temperature, %	50
Design Minimum Air Temperature, °F	30
Relative Humidity at Design Min. Temperature, %	45
Capacity Requirements	
Number of Blowers	4
Mass Flow Rate/Blower at Design Max Inlet, SCFM	12,000
Volumetric Flow Rate/Blower at Design Max Inlet, ICFM	13,250
Discharge Pressure, psig	8.50
Discharge Pressure (absolute), psia	23.19
Maximum Wire Power at Design Point, HP	TBD
Minimum Flow Rate/Blower at Design Min. Inlet, SCFM	5,400
Motor Requirements	
Blower Package Supply Voltage, V	480 (4160[1])
Maximum Rated Horsepower, HP	TBD

[1]Blower manufacturer is encouraged to provide alternative proposal with integrated transformer to accept existing site 4160 V power

C. The blowers shall not exceed the maximum wire horsepower consumption for the operating points and inlet conditions given below. Maximum wire power draw specified for each design point shall be wire to air power and include all power demands and losses associated with the blower package, including but not limited to the motor, variable frequency drive, harmonic filter (if internal to the blower enclosure), cooling system losses (including those associated with pre-heating of inlet air due to recycling of cooling air to the blower inlet within the package) and any additional electrical requirements. Wire power shall be as measured at the electrical connection to the blower package and shall be based on fully closed blower packages. Performance testing on a blower package with an open enclosure is not acceptable. Inlet air temperatures and relative humidity listed shall be at the inlet to the blower package and do not include the impacts of recycling cooling air to the blower inlet within the package. The total maximum wire power shall be calculated as the sum of the maximum wire power at the design operating points multiplied by the usage factor for the operating points given below. The maximum wire power draw for each design point shall be submitted with the shop drawings with no tolerances and shall be confirmed during the factory performance tests.

1. Blower Design Operating Points

Criteria	Units	Design Operating Points				
		No. 1	No. 2	No. 3	No. 4	No. 5
Inlet Air Flow	scfm	9,100	12,000	13,700	16,200	19,900
Discharge Pressure	psig	7.00	7.05	7.10	7.15	7.25
Inlet Air Temperature	°F	70	70	70	70	70
Inlet Air Relative Humidity	%	70	70	70	70	70
Barometric Pressure	psia	14.69	14.69	14.69	14.69	14.69
Inlet Pressure	psia	0.1	0.1	0.1	0.1	0.1
No. of Blowers Operating						
Inlet Air Flow per blower	scfm					
Maximum Wire Power	kW					
Usage Factor	%	20%	20%	20%	20%	20%
Wire Power Draw * Usage Factor	kW					
Total Maximum Wire Power	kW					

D. 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. Each blower shall be designed to maintain a minimum rise to surge margin of 1 psig away from the blower primary design point along the constant speed line under the range of inlet conditions specified. Surge volume is defined herein as the airflow rate at which the blower exhibits the first indication of pressure pulsations or flow reversal.

E. The blower system shall be designed to deliver varying airflow rates through speed control via a variable frequency drive (VFD). Independent increase/decrease control commands will be provided from the Plant Distributed PLC system through the network to the respective blower PLCs as described in Section 40 61 96 – Process Control Descriptions. Control of minimum airflow delivery will be based on blower speed or airflow as specified in Section 40 61 96 – Process Control Descriptions. The Contractor shall coordinate with the blower manufacturer and instrumentation subcontractor to provide any necessary modifications including but not limited to the controls and functional descriptions described in Section 40 61 96 – Process Control Descriptions at no cost to the Owner.

2.03 BLOWER MOTORS

A. Each blower shall be supplied with a Permanent Magnet Synchronous (PMSM) high speed motor that shall operate on 460/480 Volts, 3 Phase, 60 Hertz input power. The

PMSM shall be combined with a Sine Wave Filter (Sinus Filter), if necessary, and Line Input Reactor. Induction Motors shall not be acceptable.

B. The blowers shall have a maximum motor output as specified in Paragraph 2.02B. The Contractor shall be responsible for any and all modifications, including but not limited to electrical modifications, required to accommodate any larger capacity motors should they be required by the selected blower manufacturer.

C. The motor shall have a minimum 1.15 service factor. The motor shall be able to start under the starting conditions required. The blower manufacturer shall be responsible for coordinating the starting torque requirement of the blower and the motor. Certified tests shall be submitted to the Engineer prior to shipment of the equipment.

D. Additional requirements for the blower motors shall be as follows:

1. Insulation: Minimum of Class F rated to 155°C (311° F). However, temperature rise shall be limited to that of Class B insulation.

2. Stator Temperature monitoring: internal thermocouple embedded in each of the three motor windings.

3. As an alternative to requirements 1 and 2 above, 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

4. Ambient temperature ranging from 0°F to 104°F

5. Duty: Continuous

6. Bearings: Bump foil-type air bearings or magnetic bearing

7. Standards: Conform to latest issue of IEEE, ANSI, and NEMA, as applicable

8. High Temperature Shutoff: Control circuit to include high temperature shutoff tied to probe in discharge connection

2.04 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. VFDs shall be liquid or air cooled.

B. Each VFD shall have a manufacturing operation in the USA for manufacturing, support and provision of replacement parts. VFDs shall be KEB Combivert F5 or Cutler-Hammer (Vacon) NX Series.

C. Each VFD shall be supplied with passive harmonic filter that reduces the THD (Total Harmonic Distortion) to less than 5%. The harmonic filters shall be supplied by MTE Corporation, Arteche, Mirus International, TransCoil or approved equal. Harmonic filter shall be located inside the blower electrical room as indicated on the Drawings or integrated into the blower package enclosure.

   1. External harmonic filters shall be provided with a separate contactor to disconnect the capacitor bank when the blower is not running. The VFD shall provide a 120V control signal to the harmonic filter to indicate the blower run status.

D. For the air-foil bearing blowers, each VFD shall have a sinusoidal filter on its output consisting of an L (inductor) and C (capacitor) filter.

E. Each VFD shall have an integrated user interface that includes field bus connection and free available support software.

2.05 ENCLOSURES

A. 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. Hinged doors shall be supplied for all panels heavier than 50 lbs. The blower package enclosure shall protect against falling water, condensation and dust.

B. The blower manufacturer shall be responsible for attenuating noise and vibration in the blower package such that no special installation base shall be required nor shall any vibration from the blower package be transmitted to the floor or intake and discharge base or the piping.

C. Each blower shall be supplied with a closed-loop propylene glycol water-to-air cooling system or full air-cooling system to cool the motor and VFD. Water-to-air cooling system shall consist of an electric pump, radiator, coolant tank, connecting hoses and all associated mechanical and electrical equipment. The air-to-air cooling system shall consist of all fans and filters and associated mechanical and electrical equipment. The cooling system shall be integral within the blower package enclosure and shall not require any external cooling devices such as external cooling fans or external water cooling.

D. Each blower shall be supplied with an anchorage system suitable for mounting the blower to the concrete equipment base as indicated on the Drawings. The manufacturer shall provide all hardware required for installation. The Contractor shall coordinate the anchorage system with the blower manufacturer prior to placing the equipment base.

2.06 BLOWER CORE

A. The blower core shall be of cast iron, alloy steel, or aluminum construction and shall be suitable for temperatures up to 311°F and a minimum design pressure of 50 psig. The blower core shall be mounted to the base using elastomeric vibration isolators.

2.07 SHAFTS AND SEALS

A. The motor/compressor shaft shall be machined from high quality steel or titanium alloy. Shaft seals shall be non-contact, multi-point labyrinth type with small clearances and sufficient touch points to minimize air leakage into or out of the casing while the compressor is operating or during shutdown. The seals shall be operated dry and suitable for any variations in pressure conditions that may occur during startup, operation and shutdown.

2.08 BEARINGS

A. The blowers shall be of the air foil bearing type or magnetic bearing type and shall not require oils or lubricants for adequate operation.

B. The blower manufacturer shall guarantee the bearings for a minimum of 25,000 start/stop cycles between major overhauls. The blower manufacturer shall provide for materials and labor to repair and/or replace the bearings if they shall fail prior to the specified minimum bearing life.

C. Magnetic bearings shall consist of two radial and two axial magnetic bearings with continuous rotor position measurement sensors controlled by an active magnetic bearing controller. The magnetic bearing controller shall be an MBC-12 or equivalent having a maximum input power of 1 kW.

D. The blower supplier shall furnish for each magnetic bearing blower an uninterruptible power supply (UPS) system that provides a secondary source of power for the magnetic bearings and magnetic bearing controller. The UPS shall have batteries sufficiently sized to provide a safe spin down and a monitoring panel that shall indicate the condition of the batteries.

2.09 IMPELLERS

A. Each blower shall have a single impeller, which shall be machined from a solid forging high-strength aluminum alloy, Type 7075 or casted 71-4PH stainless steel. Impellers shall be directly mounted to the end of the motor shaft and shall be statically and dynamically balanced.

B. Each impeller shall be of the single-stage backswept blade high efficiency configuration or of the semi-open impeller design with three-dimensional shaped blades individually

optimized to the design range of the compressor. The first lateral critical speed shall be at least 120% of the maximum allowable operating speed.

2.10 DISCHARGE PRESSURE GAUGES

A. Discharge pressure gauges shall be provided by the Manufacturer for installation on the discharge piping of each blower. Pressure taps shall be provided by the Contractor at locations selected for stable measurement and accurate evaluation of discharge pressure. Gauges shall be liquid-filled.

B. The discharge pressure gauge shall be a 316 stainless steel bourdon type with a range of 0-15 psi. Scale shall be a 270° arc scale with figure interval every 1 psi and minor graduations every 0.1 psi. Dial size shall be 4 1/2 inches with black phenolic case. Gauge tap shall be 1/4 inch minimum.

C. Gauges shall have an accuracy of ±1 percent. All gauges shall be by the same manufacturer.

2.11 INSTRUMENTATION

A. Each blower package shall be equipped with the following integrated instrumentation:

1. Inlet Pressure Sensors
2. Inlet Filter Differential Pressure Measurement or Switch
3. Discharge Pressure Sensor
4. Inlet and Discharge Temperature Sensors
5. Bearing Temperature Sensor
6. Motor Temperature Sensor
7. Air Flow Measurement Indication (measured or calculated)
8. Vibration Sensor (for air-foil bearing blowers)
9. Surge Detection

2.12 BLOWER CONTROL SYSTEM

A. The blower supplier shall furnish an integrated PLC or microprocessor-based control system for each blower that is physically located inside the blower enclosure. Each blower control system shall include a PLC or microprocessor for monitoring, displaying and protecting the blowers. Each blower control system shall also include a touch screen operator interface unit (OIU) located on the blower enclosure.

B. The PLCs in the blower control panels shall be Allen-Bradley CompactLogix 5380. The PLC shall be provided complete with rack, power supply, I/O cards, special function cards, instructions, memory, input/output capacity, and appurtenances to provide all required features and functions. PLC design shall comply with the requirements in Section 40 63 43 – Programmable Logic Controllers of the Specifications.

C. Each blower PLC system shall be provided with an Ethernet network interface card for communications with the existing in-plant Ethernet network. Ethernet network interface module shall be Allen Bradley or Ntron.

D. The blower control panel shall provide the ability to operate each blower in constant discharge pressure or constant flow modes when local control is enabled.

E. Each blower control panel shall contain a main power disconnect which is lockable in the off position.

F. Transformer capacity to provide 120V power to controls or appurtenant equipment shall be provided as required by the manufacturer.

G. All branch circuit protection, as well as protection for the instrumentation power, Operator Interface and the PLC shall be in accordance with the NEC.

H. Each blower control panel shall contain controls for normal blower motor starting and stopping sequence, surge and overload detection and protection, emergency shutdown control and sequencing, alarm systems, blower capacity control, blower flow control and blower discharge pressure control.

I. Each blower control shall be furnished with a touchscreen OIU located on the blower enclosure. The OIU shall be per manufacturer’s standard and provide the following functions at a minimum:

    1. The blower operator interface screens shall provide start-stop and operational mode interface, alarm status, help messages, and diagnostics. The top of the screens shall have lines dedicated to the listing of alarms, and alarm acknowledge. Specific indications of blower control parameters are as listed herein and shall be provided.

    2. Surge protection and motor overload indication with impending warning and trip functions. Note that impending surge and impending overload shall be monitored by the blower control panel. Impending surge and impending overload information shall be sent to the Plant distributed PLC system to prevent increase/decrease control adjustments from the distributed PLC system that could result in surge/overload of the blower.

    3. Blower bearing temperature indication with impending warning and trip functions and levels.

4. Motor temperature indication with impending warning and trip functions and levels.

5. Motor speed indication.

6. Blower flow as percentage of flow capacity indication with manual control functions (increase/decrease).

7. Blower flow indication with manual control functions (increase/decrease).

8. Discharge pressure indication with manual control functions (increase/decrease).

9. Suction and discharge air temperature indication display.

10. Air inlet filter differential pressure display and/or indication of high differential pressure.

11. Wire power draw in kilowatts and horsepower display.

12. Motor current display.

13. Vibration levels (for air-foil bearing blower)

J. Additional selector switches, pushbuttons and indicators shall be provided as listed below.

1. Emergency stop mushroom pushbutton.

2. Blower “Run” indicating light (red).

3. Blower “Stop” indicating light (green).

4. Blower “Fault” indicating light (amber).

K. Adjustable time delays shall be incorporated to allow uninterrupted motor start and to prevent nuisance shutdowns.

L. All trip functions shall be frozen upon a shutdown so that shutdown status can be determined and the values at shutdown preserved. The PLC shall store and display the 30 most recent shutdown alarms including identification of alarms, time and date of occurrence, and value on trip.

M. The control panel shall be completely installed, pre-wired and tested at the factory by the blower system manufacturer.

N. An as-built wiring diagram of the completed panel design shall be encased in plastic inside the panel.

O. Panel layout and wiring diagrams shall be submitted with the submittal drawings.

P. Alarms shall not be annunciated under normal start-up and shut-down conditions.

Q. Vibration detectors shall be provided for each air-foil bearing blower, and a vibration detection system from the MBC from each of the magnetic bearing blowers. A warning alarm shall be activated through the monitor when vibration exceeds a pre-determined set-point provided by the blower manufacturer. An alarm shall be indicated, and the blower shall be shutdown when vibration exceeds a pre-determined set-point provided by the blower manufacturer.

R. RTDs shall be 100-ohm platinum 3-wire units. Initial warning and alarm/shutdown temperature shall be as recommended by the blower supplier.

S. The surge protection system shall, at a minimum, prevent surge conditions by use of blower speed, calculated blower airflow incorporating inlet temperature and pressure, and/or inlet temperature/pressure fluctuations. Adjustable time delays shall be incorporated to prevent nuisance shutdowns. Initial settings for impending surge shall be as recommended by the manufacturer. The blower speed, calculated airflow, inlet pressure, inlet temperature, and other surge protection data shall be monitored by the blower control panel and PLC. Motor overload protection shall be provided so that the motor horsepower does not exceed a preset level.

T. The blower control system shall provide a common failure relay output activated by any of the shutdown conditions.

U. Panel shall be prewired with a master terminal strip to accommodate all inputs and outputs. Each end of each wire shall be identified by a unique wire number printed on a heat shrunk sleeve marker.

V. All wiring external to control components within the panel shall be multi-strand copper no smaller than 16 gauge with each end properly numbered according to the manufacturer’s drawings. Wiring will be done in a workmanlike manner and run in covered trays. All wires that attach to door mounted components shall be neatly bundled and tied. All external connections shall terminate on a common terminal strip with at least 10% spare connection points.

W. The blower control panel shall control the electrically actuated blow-off valve for each blower.

X. The blower package electronics, including but not limited to the VFD and the harmonic filter shall be factory coated with a conformal coating that complies with IEC60721-3-3 3C3 environmental classification conditions.

2.13 REQUIREMENTS FOR INTERFACE WITH THE PLANT DISTRIBUTED PLC SYSTEM

A. The Contractor shall provide coordination required for communication of information between the blower PLCs or microprocessors and the Plant Distributed PLC System as described herein. The blower manufacturer shall make available in contiguous blocks of separate memory registers the required digital and analog information to the Plant Distributed PLC System and the plant SCADA control system through network communication, including blocks for the writing of remote supervisory commands from the plant PLC. The blower manufacturer shall be responsible for protecting the blower and its appurtenant equipment and systems from damage caused by inadvertent or erroneous commands from the plant control system. The Plant Distributed PLC System (by the instrumentation subcontractor under Division 40) is to receive the following information from each blower control panel PLC (or Blower Master Control Panel if furnished by the manufacturer):

1. Log all monitored points for trend analysis
2. View real-time trends
3. View historical information
4. Display graphs and charts
5. Date/time history of alarms including surge
6. View all screens available at the blower LCPs

2.14 BLOWER START-UP AND SHUTDOWN SEQUENCE CONTROL PROGRAMS

A. The blower start-up and shutdown sequence control programs shall be provided by the blower manufacturer in each blower control panel PLC as follows:

1. A blower may be called to start or stop by the following:
    a. Manually at the blower control panels through the touch screen OIU.
    b. Manually through the Plant Distributed PLC System (remote - manual).
    c. Automatically through the Plant Distributed PLC System.
2. The Distributed PLC System or the plant operator through the touch screen OIU at the local control panel shall provide a command to the blower control panel to start its respective blower. The PLC shall confirm that alarm conditions are cleared and the blower is available for starting. In the case of a blower failure or if a blower is locked out by a PLC-based "permissive", the Distributed PLC System (or Master Control Panel if furnished) shall try to start the next available blower according to

the control program in the Distributed PLC System. Indication of the next blower to be started and the next blower to be shut down through the strategy shall be provided on the plant SCADA operator workstation (OWS) graphic displays.

3. When a blower is called to start, a "blower start-up " notification shall be provided on the respective blower control panel display and on the plant SCADA OWS displays and shall remain on the screen until the start-up sequence is completed. Status of delay timers showing countdown time shall be displayed during a start-up and shutdown sequence.

4. Automatic control of the dissolved oxygen control valves and blower operating speed by the Distributed PLC System shall be discontinued by the Distributed PLC System until completion of the start-up sequence.

5. When a blower is called to stop either through the Distributed PLC System or the local touch screen operator interface, a "blower shutdown" notification shall be provided on the respective blower control panel display and on the plant SCADA OWS displays.

6. After the command is received from the Distributed PLC System to shut down the blower (or a blower shutdown is initiated manually through the touch screen), the PLC shall stop the blower and return the blower to the start-up ready condition. A "blower stopped" notification shall be provided on the respective blower control panel display and on the plant SCADA OWS displays.

7. Emergency stop capability shall be provided through a push button located on the blower enclosure. Emergency stop shall de-energize all equipment on the blower base and cannot be reset or reactivated until the maintained emergency stop has been released to restart the blower after an emergency stop.

8. The blower control panel shall include protective shutdown interlocks to protect the blower from abnormal operating conditions including:

    a. Motor High Winding Temperature

    b. High Discharge Air Temperature

    c. High Motor Horsepower

    d. Surge

    e. Sequence Failure

    f. Blower High Vibration

    g. Pushing Emergency Stop Pushbutton

h. PLC Failure

i. VFD Failure

j. Blower Bearing High Temperature (air-foil bearing blower)

2.15 BLOWER MACHINE MONITORING PROGRAMS

A. The Blower monitoring programs shall be provided by the blower manufacturer in each blower control panel (or Master Control Panel if furnished by the blower manufacturer) as follows:

1. Monitoring and protection of the blowers from abnormal operating conditions.

2. Speed, power and current inputs from the respective blower VFD.

3. Provide monitoring of all analog inputs. The blower control panel shall shut down the blower if inputs are not within the acceptable range. Hold-out circuitry shall be provided in the programming to prevent shut-down on alarm condition while the blower is being started.

B. A digital indication of each blower bearing vibration level (for air-foil bearing blowers) displayed in mils shall provide warning and shutdown at operator adjustable vibration levels with initial settings as recommended by the manufacturer.

C. A digital indication of motor winding temperatures, blower inboard and outboard bearing temperature, discharge air temperature, and inlet air temperature shall provide warning and shutdown at operator adjustable temperatures with initial settings as recommended by the manufacturer.

D. The following is a listing of the analog inputs to each blower control panel. Analog inputs shall be monitored/displayed at the blower control panel and monitored/logged/displayed in the plant SCADA control system through the Ethernet network connection.

1. Inlet Filter Differential Pressure

2. Inlet and Discharge Pressure

3. Inlet and Discharge Air Temperature

4. Motor Speed

5. Bearing Temperature

6. Motor Temperature

7. Motor Horsepower

8. Motor Current

9. Blower Vibration (air-foil bearing blowers)

E. The blower control panel shall record and report the order in which alarm conditions are received, such that operators can determine the alarm that caused blower shut-down.

F. The following is a listing of the commands to each blower control panel via the OIU (or via the Master Control Panel if furnished by the Manufacturer) and through the plant SCADA control system via the Ethernet network connection.

1. Local Blower Start

2. Local Blower Stop

3. Local Blower Reset

4. Remote Blower Start

5. Remote Blower Stop

6. Remote Blower Reset

7. Increase Blower Capacity

8. Decrease Blower Capacity

G. Status for remote monitoring purposes in the plant SCADA control system shall include the following.

1. Remote Blower Run Indication

2. Remote Blower Stopped Indication

3. Remote Blower Fault Indication

4. Remote Blower Ready Indication

5. Impending surge indication

6. Impending overload indication

7. VFD Run

8. VFD Enable

9. VFD Reset

2.16 EQUIPMENT IDENTIFICATION

A. Each of the blowers shall be provided with a substantial stainless steel or aluminum nameplate, securely fastened in a conspicuous place and clearly inscribed with the manufacturer's name, year of manufacture, serial number, and principal rating data (including blower design capacity in scfm, design discharge pressure in psig and psia, design minimum inlet pressure in psia, maximum temperature and relative humidity at maximum temperature and motor information).

2.17 EXPANSION AND FLEXIBLE COUPLINGS

A. Each blower package shall include a flexible connector to be installed on the discharge and inlet aeration piping prior to the main air header. The flexible connectors shall be sized for a standard pipe diameter and shall prevent the transmission of noise and vibrations from the blower package into the piping. The flexible connector shall be suitable for the maximum operating temperature and pressure ratings of the equipment provided. The blower manufacturer shall provide stainless steel restraining bolts and hardware. Discharge expansion couplings shall be suitable for a pressure of 25 psig and a temperature of 300°F.

2.18 CHECK VALVES

A. The blower manufacturer shall furnish one discharge check valve for each blower as shown on the Drawings. Check valves shall be a wafer type discharge check valve of the dual, flat-plate type with center hinge, metallic center post, spring or non-spring closure, steel or cast iron body, Viton-B seal, aluminum-bronze or stainless steel plates, Inkonel 600 or stainless steel springs, and rated for temperatures up to 300°F. Check valve shall be Crane Duo Check II, Flexi-Hinge Type 518, or equal. The check valves shall be installed by the Contractor as shown on the Drawings. The Contractor shall perform any piping modifications necessary to incorporate the check valve provided by the blower manufacturer at no cost to the Owner. Check valves shall be suitable for installation in the horizontal or vertical position.

2.19 ISOLATION VALVES

A. The blower manufacturer shall furnish one discharge isolation butterfly valve for each blower as shown on the Drawings. Discharge isolation valves are to be provided with a manual operator and shall provide for tight shut-off. A mechanical dial indicator shall be provided on the operator to continuously indicate valve positions. All components of the discharge isolation valves shall be suitable for operation at temperatures up to 300°F. Valves shall be resilient-seated butterfly valves as specified in Section 40 05 64 – Butterfly Valves. The butterfly valves shall be installed by the Contractor as shown on the Drawings. The Contractor shall perform any piping modifications necessary to

incorporate the butterfly valves provided by the blower manufacturer at no cost to the Owner.

2.20 BLOW-OFF VALVES AND SILENCERS

A. Each blower shall be equipped with an integrated blow-off valve. Blow off valve shall be powered by the single point electrical supply. No external power shall be required for operation of the valve. The valve discharge shall be supplied with a properly sized blow-off silencer directly bolted to the blow-off valve or mounted inside the blower package. Each blow-off valve shall be adequately sized for the specified airflow rate for each compressor. The blow-off valve shall open upon loss of power to the blower.

B. The blower manufacturer shall provide a blow off silencer for each blower. The silencer shall provide the following performance for the application where the air and noise flows are in the same direction.

Octave Band Center Frequency – Hertz	125	250	500	1,000	2,000	4,000	8,000
Insertion Loss – Decibels (dB.)	10	17	29	41	28	25	28

2.21 INLET FILTER AND SILENCER

A. Each blower shall be provided with a combination intake / inlet filter / silencer system. Intake, filter and silencer performance losses shall be included by the blower vendor in the blower performance calculation.

B. The filter media shall have an efficiency of 90% by weight per ASHRE 52-76 with synthetic dust equivalent to separation greater than 95% at 10 microns for air-bearing blowers, or EN779:2002 G4 standard grade for magnetic-bearing blowers. Filter element shall be removable without disconnecting the inlet duct. Inlet filter elements shall have a rigid frame.

C. The inlet silencer shall be designed to minimize noise such that the sound pressure level 3 feet from the blower enclosure or inlet filter does not exceed 85 decibels.

D. Maximum clean filter pressure drop of the inlet filter/silencer with the elements installed shall be 2.5 in. w.c. (0.09 psig).

E. An integrated inlet air filter/silencer shall be provided for the APG-Neuros and Aerzen blowers. The intake / inlet filter / silencer system shall be integrated into the overall blower and enclosure design and shall fit within the physical dimensions of the enclosure.

F. An external inlet filter shall be provided for the Sulzer-ABS blower options as shown on the Drawings. The external inlet filter shall be constructed of galvanized sheet steel. Legs shall be adjustable for vertical positioning and leveling. The filter elements shall be rectangular, replaceable elements mounted on a flat, vertical track of aluminum construction, and removable through galvanized steel doors located on each side of the galvanized steel housing. The manufacturer shall supply a flexible expansion coupling to be mounted between the inlet filter housing and the blower inlet as shown on the Drawings.

    1. An external inlet silencer shall be provided between the external inlet filter and the blower inlet.

2.22 DISCHARGE CONE DISCHARGE SILENCER

A. Each blower shall be provided with a manufacturer-supplied discharge cone and silencer to reduce noise while limiting pressure drop at the blower discharge.

2.23 TOOLS AND SPARE PARTS

A. Spare parts shall be provided in accordance with Section 46 00 00 – Equipment General Provisions.

B. Blower manufacturer is to submit a list of recommended spare parts with long lead items clearly identified.

C. Two (2) sets of replacement inlet air filters shall be provided by the blower manufacturer for each blower furnished. Filters shall be provided for both inlet air and electrical/control panels

D. The blower manufacturer shall furnish one set of special tools as required for complete assembly or disassembly of blower system components for each type or size of blower specified, together with a neat metal box (or boxes) for the same. The tool kit shall be sufficiently complete to permit normal repair and maintenance of all equipment furnished under this project.

PART 3 – EXECUTION

3.01 INSTALLATION

A. All equipment specified herein shall be installed in accordance with the manufacturer's instructions and checked by the respective manufacturers' representative, in conformity with the applicable Sections of this Specification. After installation, the equipment shall be aligned and adjusted as required for proper operation.

3.02 PRELIMINARY PERFORMANCE TESTS

A. Preliminary factory running and performance tests for each of the blower packages shall be performed by the Manufacturer to confirm performance at the design points specified in Paragraph 2.02 prior to factory performance tests. Impellers shall be statically and dynamically balanced and over-sped to 105% of rated speed. Preliminary factory running test results shall be provided to and approved by the Engineer prior to scheduling factory performance tests.

3.03 FACTORY PERFORMANCE TESTS

A. After approval of preliminary performance tests, each of the blower packages is to be factory performance tested in accordance with the ASME Wire-to-Air Performance Test Code for Blower Systems (ASME PTC 13) and as specified herein. Performance testing shall be performed for the entire job-specific blower package including blower core, variable frequency drive, cooling systems, inlet filters/silencers, internal harmonic filters, enclosure, and all appurtenant equipment that will be contained within the complete blower package.

1. Performance testing shall be performed on a fully closed blower package where the blower is to be installed with a permanent enclosure. Performance testing on an enclosed blower package with an open enclosure is not acceptable.

2. Tests shall be conducted using the actual motor and ancillary equipment provided under this section. The use of shop motors, variable frequency drives or any other equipment that will not be contained within the job-specific blower package furnished as specified herein shall be prohibited.

3. The Manufacturer’s representative coordinating the testing shall be experienced in the testing requirements of ASME PTC 13 and shall sign and date the test procedure and results certifying the assembled systems were tested as a complete package system. Test results shall be reported in accordance with the same code and the results shall be submitted and approved by the Engineer prior to shipment.

B. A detailed shop test plan shall be submitted for Engineer approval with the Shop Drawings prior to testing. The shop test plan shall fully describe the manufacturer's test facilities and the test procedure to be used. Discharge piping and instrumentation shall be in accordance with ASME PTC 13.

1. Complete instrumentation layout and Manufacturer's information for all instrumentation used during testing shall be submitted including the arrangement and device for flow measurement, conversion tables/graphs, and accuracies over the specified flow range. Test instrumentation shall conform with the requirements of AME PTC 13 and the ASME PTC 19 series.

2. All test instrumentation shall be calibrated and certified by an independent test agency within the last twelve months. Certificates shall show the stability of calibration over a period of at least one year per ISO 9001, Paragraph 4.11.

3. The Blower Manufacturer, through the Contractor, shall give the Owner/Engineer a minimum of four weeks’ notice prior to factory performance testing.

C. The shop performance tests shall be conducted for each blower to demonstrate compliance with all performance requirements. The test shall include determination of the surge point and verification of the guaranteed points. Performance tests shall include a minimum of seven points including the specified design maximum and minimum flows specified in Paragraph 2.02 B and the design operating points specified in Paragraph 2.03 C. Test points shall be submitted by the blower manufacturer and approved by the Engineer prior to factory performance testing.

1. Operate each blower at each test point for a duration sufficient to demonstrate all readings have stabilized and meet the fluctuation criteria defined in Table 3.5.5-1 of ASME PTC 13.

D. Compressor net delivered flow rate and discharge pressure shall be guaranteed with no negative tolerance. There shall be no other tolerances or measuring uncertainties in reporting test results (i.e., the tests shall be reported with ± zero percent tolerance).

E. Measured power shall be wire-to-air power and include all power demands and losses associated with the blower unit, including but not limited to the motor, variable frequency drive, job filter, harmonic filter (if internal), bearing controller, and cooling system losses. Wire power shall be as measured at the electrical supply to the blower package. Individual power measurements shall be taken where there are multiple electrical supplies to the blower package. Testing using less accurate heat balance or measurement of shaft power shall not be allowed.

1. Wire power shall be measured by a precision power analyzer calibrated to NIST standards. The power analyzer shall instantaneously monitor all electrical legs for voltage and amperage to calculate instantaneous power usage and shall measure the electrical power input to the inlet supply of the blower assembly as described, including all auxiliary systems. The power analyzer shall be capable of handling the distorted voltage and current waveforms and phase relationship of the power factor caused by the harmonics and EMI resulting from an inverter's high-speed switching signals. The precision power analyzer shall meet the Minimum Accuracy and Function Requirements listed in ASME PTC 13, Table 4-2.1.2-1. The power analyzer shall comply with IEC601010-1, IEC61000-3-2 and IEC61000-3-12.

F. Shop test information shall include:

1. Inlet (ambient) and discharge temperature
2. Inlet (ambient) and discharge pressure
3. Inlet filter differential pressure
4. Relative humidity
5. Capacity in inlet cubic feet per minute (icfm) and standard cubic feet per minute (scfm)
6. Speed
7. Blower package input (wire) power in hp and kW
8. Line Voltage
9. Vibration

G. Inlet pressure and inlet temperature shall be considered ambient pressure and temperature at the test facility. Pressure and temperature measurements shall adhere to

paragraphs 4-3 and 4-4, respectively, of ASME PTC 13. Relative humidity shall be measured with a calibrated hygrometer.

H. The inlet volumetric flow rate shall be measured at the blower package discharge to ensure leakage flow is not included in the delivered air measurement. Inlet volumetric flow rate is defined as the delivered mass flow divided by the blower package inlet density.

1. Flow measurement device calibration, readings, and calculations shall be fully documented and conform to ASME PTC 13.

2. Standard cubic feet per minute (scfm) is defined as the delivered airflow rate at the blower discharge in terms of standard conditions (68°F, 14.7 psia and 36% relative humidity).

I. Discharge pressure shall be calculated as the sum of the discharge static pressure and velocity pressures per ASME PTC 13 Part 4-3.11.

J. Discharge temperature shall be the total temperature at the blower package discharge.

K. Blower speed shall be calculated by the Hall effect-based rotation speed sensor or from the power supply frequency, the number of motor poles, and the gear ratio (where applicable). Blower rotational speed shall be measured with instrumentation having an accuracy of greater than or equal to 0.15%

L. Velocity vibration versus frequency levels shall be recorded within 10-1,000 and 10-10,000 Hz frequency range. Vibration shall be reported velocity (in/sec) versus frequency.

M. Raw testing data under factory testing conditions shall be converted to performance at specified conditions per ASME PTC 13 Section 5.

N. In case of failure of any unit to meet the test requirements, the manufacturer, at their own expense, shall make such alterations as are necessary and the tests shall be repeated without additional cost to the Owner until the equipment is passes test requirements.

O. Test results not in verbatim agreement with test results presentation format per the Code shall be cause for rejection of the performance tests. The blower manufacturer’s testing supervisor shall sign each copy of the test report.

P. The Manufacturer shall prepare a blower test report in accordance with the requirements of ASME PTC 13 Section 6. In addition to the requirements of ASME PTC 13 Section 6, performance curves based on the results of the factory performance test shall be developed in terms of standard conditions of 14.7 psia, 68°F, and 36% relative humidity. SCFM shall be plotted against pressure under 14.7 psia, 68°F and 36% relative

humidity, and the curve shall show horsepower draw over the range of SCFM flow rates. Performance curves shall also be provided at the design maximum and minimum inlet conditions specified in Paragraph 2.02B. The blower test reports shall be signed and dated by the authorized performance test technician of the company manufacturing the equipment.

3.04 FACTORY FUNCTIONAL TESTING

A. Upon completion of assembly, each blower, motor, and ancillary components shall be functionally tested with the BCP connected to all skidded instruments, electric valves, and appurtenances. All start/stop sequences and all safety and alarm systems shall be tested.

B. The hardware and software control systems for each blower shall be tested, and all sequences and alarms shall be simulated.

3.05 FIELD TESTS

A. The Contractor and Manufacturer shall perform field running tests at the site following installation of the equipment and controls. Field testing shall be in accordance with Section 46 00 00 – Equipment General Provisions and as specified in this Section. Field running tests shall be conducted by the factory service people with assistance of the Contractor.

B. Running tests shall be conducted under actual operating conditions for a period of not less than 8 hours for each blower. Running tests shall demonstrate that the blower is free from all objectionable vibration and noise and overheating throughout the entire range of specified operation. Initial running tests shall demonstrate that all instruments, controls, and protective shutdown interlocks function properly.

C. Each blower shall be run for 4 hours at full load and for 4 hours at the minimum specified flow. Temperature and vibration readings for all monitored points shall be recorded after 4 hours and at the conclusion of the 8-hour run period for the operating blower(s). Any shutdown of the blower(s) during the test periods shall be recorded and the cause noted. Any defects or operating problems found during running tests shall be promptly corrected.

D. Additional services for improper operation of the Manufacturer’s supplied equipment due to fabrication shall be at no cost to Owner. Manufacturer shall remedy operational issues due to fabrication until satisfactory operation is achieved.

E. Additional services for improper operation of the Manufacturer’s supplied equipment due to installation shall be at no cost to Owner. Contractor shall retain the services of the Manufacturer to remedy operational issues due to installation until satisfactory operation is achieved.

F. Manufacturer shall prepare and submit field quality control reports signed by the Manufacturer for field inspections and field tests in accordance with Section 46 00 00 – Equipment General Provisions and as specified in this Section. Field quality control reports shall include any corrections or adjustments made to the equipment, including instrumentation and controls, during the field tests, including field calibration of equipment instruments. Manufacturer shall prepare and submit certification letter on Manufacturer's letterhead with signature stating the equipment is fully operational and capable of meeting operating requirements.

3.06 PAINTING

A. Blowers, motors and enclosures shall have prime and finish painting done at the factory using the manufacturer's premium grade paint system. Aluminum, stainless steel, and brass shall not be painted. The Contractor shall apply touch-up painting to all scratched, abraded and damaged shop painted surfaces. Touch-up coating type and color shall match the manufacturer's shop paint coating.

END OF SECTION

SECTION 43 11 12

INTEGRAL-GEAR SINGLE-STAGE CENTRIFUGAL BLOWERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation four electric motor-driven, integral-gear single-stage centrifugal blower packages including electric motors, steel bases, discharge expansion joints, discharge cones, discharge valves, check valves, inlet filters/silencers, blow-off valves, valve actuators, control panels and all necessary auxiliary equipment as specified herein and shown on the Drawings or as required for a complete installation of the system.

B. All equipment specified in this section shall be designed and furnished by the blower manufacturer, who shall be responsible for the suitability and compatibility of all included equipment. Integral-gear single-stage centrifugal blowers shall be Model KA22-SV-GL as manufactured by Howden-Turblex, or Model GTB-T40-XY as manufactured by Next Turbo Technologies. No substitutions shall be permitted.

C. The layout and design of the aeration blower system including blower discharge piping and supports in the contract drawings are based on equipment manufactured by TBD. Any changes in design including but not limited to structural supports, piping systems, electrical systems, or HVAC systems resulting from the use of equipment from other manufacturers (named or unnamed) shall be the sole responsibility of the Contractor. Any redesign for substitute equipment shall be submitted for the Engineer's review prior to fabrication or installation.

1.02 SUBMITTALS

A. The Contractor shall submit complete Shop Drawings, Operation and Maintenance Instructions and other information for the blower systems and all equipment specified herein in accordance with Section 01 33 00 – Submittal Procedures.

B. Shop Drawings shall include complete erection, installation, and adjustment instructions and recommendations, electrical characteristics, connection diagrams and schematics identifying all items requiring electrical control and power. Installation instructions shall be complete including unloading, check-out following shipment, storage, handling, assembly, and anchorage and start-up instructions.

C. Shop Drawings shall include weights of all system components and total weight of the operating blowers.

D. The performance characteristic curves for the blower shall be submitted with the shop drawings. Performance curves shall be developed in terms of standard conditions of 14.7 psia, 68°F, and 36% relative humidity, as well as the design criteria specified in Paragraph 2.02, and the curves shall show horsepower draw over the range of SCFM flow rates for various pressure conditions. Additional operational data for the blower shall be submitted including recommended temperature, pressure, and vibration alarm settings and operational limits.

E. A complete description of the protective coating system to be used for all components, prior to shipment and after installation shall be submitted with the shop drawings.

F. A listing of spare parts furnished shall be submitted with the shop drawings.

G. Electronic copies of certified test reports including all details of apparatus, procedure, and results and all required calculations shall be submitted for each shop test conducted. Reports for shop tests shall be approved by the Engineer prior to shipment.

H. The Supplier shall submit a performance guarantee and two-year warranty in accordance with Paragraph 1.04.

1.03 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall arrange for the manufacturer to furnish the services of a qualified service person with at least three years of experience, who is regularly involved in the inspection, operation, and maintenance of blowers of the size and type being furnished. The service persons shall provide, at a minimum the following field services:

1. Inspect the installed equipment to verify that installation is in accordance with the blower manufacturer’s requirements

2. Verify proper connection of piping and installation of accessories

3. Witness and check final adjustments and alignments

4. Verify alignment of the motor, blower, and coupling

5. Check leveling of blower base

6. Confirm proper wiring of all instruments and field wired items

7. Witness and check start-up of each blower system

8. Assist the Contractor in performing field testing and prepare a written report as specified below.

9. Troubleshoot and correct any mechanical, electrical, or control problems with the system that are noted during initial operation.

031319

10. Submit written certification signed by the service person that the system has been properly installed, tested, and adjusted; that the system operates as specified or as required, including date of field test, as well as a listing of all persons present during the tests.

11. Investigate and supervise correction of any operating problems which may arise during the guarantee period of the equipment.

12. Instruct representatives of the Owner on proper operation and maintenance, including start-up and shut-down procedures, proper lubrication practices, and troubleshooting of all equipment.

B. Such services shall be furnished at no additional cost to the Owner and shall entail a period of not less than four (8) days and a minimum of four (4) site visits. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

C. The manufacturer’s service person shall sign in and out every day on-site and shall comply with all Owner requirements for visiting the site.

1.04 QUALITY ASSURANCE

A. The materials covered by the Specifications shall be standard equipment of proven reliability and manufactured by reputable manufacturers having experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Drawings and operated per the manufacturers’ recommendations.

B. All materials shall be new and both workmanship and materials shall be of the very best quality, entirely suitable for the service to which the units are to be subjected and shall conform to all applicable Sections of these Specifications. All parts of duplicate machines shall be interchangeable without modification. The construction of the blowers shall be such that the blowers will not be damaged during continuous operation and will not have undue vibration above the blower's surge limit. The design and construction of the blowers shall not cause any unbalanced floor loadings.

C. The blower manufacturer shall warrant the integral-gear single-stage centrifugal blowers, motors, control panels, valves, and accessories for materials and workmanship for a period of two (2) years starting on the date of substantial completion. Warranty and Guarantee shall be as specified in Section 46 00 00 – Equipment General Provisions with the exception that the warranty period shall be for two (2) years. The warranty shall be submitted with the shop drawings.

D. Equipment and appurtenances shall be designed in conformance with ASTM, ASME, AIEE, and NEMA standards.

1.05 COORDINATION OF DELIVERIES AND RESPONSIBILITY FOR STORAGE

A. The Contractor shall protect blower system components at the project site and during installation. Contractor shall be required to place blowers onto their pads within 24 hours after arrival of the blowers at the site. The Contractor shall be responsible for scheduling and coordinating deliveries of blowers with the manufacturer to minimize the time that blowers are on-site and not installed. The Contractor shall be responsible for any additional cost incurred for storage of blowers. The Contractor shall connect space/strip heaters and manually rotate shafts as recommended by the manufacturer.

PART 2 – PRODUCTS

2.01 GENERAL

A. The aeration blowers shall be single-stage, centrifugal type with integral gear box. The blowers shall be driven at the gearbox input shaft by direct coupled electric motors with flexible couplings and guards as specified herein.

B. The Contractor shall make all alterations required to structures, equipment, piping, controls, or other work shown in the Contract Drawings that may be required for the blower systems ultimately furnished.

C. The blowers shall be designed for heavy, continuous industrial service and shall be capable of starting a minimum of 4 times per hour.

2.02 PERFORMANCE REQUIREMENTS

A. The proposed blowers shall satisfy the conditions of service and requirements listed below. Standard cubic feet per minute (SCFM) is defined as the delivered airflow rate at the blower discharge in terms of standard conditions (68°F, 14.7 psia and 36% relative humidity).

B. The blowers shall be capable of delivering the specified design flow rate per blower (in SCFM) at the specified discharge pressure at the minimum inlet pressure, design maximum air temperature and relative humidity at the design maximum temperature as specified for the blower primary design point below. The design air temperatures and inlet pressure listed shall be at the inlet to the blower. Motor horsepower shall not exceed the maximum rated motor horsepower specified. The blowers shall be capable of turndown to the minimum flow rate at the design minimum temperature and relative humidity at design minimum temperature specified below.

Ambient Conditions	
Site Elevation, ft	20
Ambient Barometric Pressure, psia	14.69
Ambient Temperature Range, °F	20-104
Ambient Relative Humidity Range, %	10-100
Design Inlet Conditions	
Minimum Inlet Pressure, psia	14.39
Design Maximum Air Temperature, °F	98
Relative Humidity at Design Max. Temperature, %	50
Design Minimum Air Temperature, °F	30
Relative Humidity at Design Min. Temperature, %	45
Capacity Requirements	
Number of Blowers	4
Mass Flow Rate/Blower at Design Max Inlet, SCFM	12,000
Volumetric Flow Rate/Blower at Design Max Inlet, ICFM	13,250
Discharge Pressure, psig	8.50
Discharge Pressure (absolute), psia	23.19
Maximum Wire Power at Design Point, HP	TBD
Minimum Flow Rate/Blower at Design Minimum Inlet, SCFM	5,400
Minimum Surge Pressure, psig	9.00
Blower Performance Test Requirement	PTC-13
Motor Requirements	
Voltage, V	4160
Enclosure Type	TBD
Maximum Rated Power, HP	TBD
Blower Gearbox Requirements	
Bearing Type	Ball Bearing or Journal Bearing
Oil Cooling Approach	Oil-to-Air

C. The blowers shall not exceed the maximum wire horsepower consumption for the operating points and inlet conditions given below. Maximum wire power draw specified for each design point shall be wire to air power and include all power demands and losses associated with the blower package, including but not limited to the motor, oil pumping and/or heating, cooling system, and any additional electrical requirements.

Wire power shall be as measured at the electrical connection to the blower package. The total maximum wire power shall be calculated as the sum of the maximum wire power at the design operating points multiplied by the usage factor for the operating points given below. The maximum wire power draw for each design point shall be submitted with the shop drawings with no tolerances and shall be confirmed during the factory performance tests.

1. Blower Design Operating Points

Criteria	Units	Design Operating Points				
		No. 1	No. 2	No. 3	No. 4	No. 5
Inlet Air Flow	scfm	9,100	12,000	13,700	16,200	19,900
Discharge Pressure	psig	7.00	7.05	7.10	7.15	7.25
Inlet Air Temperature	°F	70	70	70	70	70
Inlet Air Relative Humidity	%	70	70	70	70	70
Barometric Pressure	psia	14.69	14.69	14.69	14.69	14.69
Inlet Pressure	psia	0.1	0.1	0.1	0.1	0.1
No. of Blowers Operating						
Inlet Air Flow per blower	scfm					
Maximum Wire Power	kW					
Usage Factor	%	20%	20%	20%	20%	20%
Wire Power Draw * Usage Factor	kW					
Total Maximum Wire Power	kW					

D. Surge is defined herein as the airflow rate at which the blower exhibits the first indication of pressure pulsations or flow reversal. The blowers shall not surge when airflows are at or above the minimum flow rate per blower and the discharge pressure is below the minimum surge pressure specified above for the ambient temperature and humidity ranges provided when throttled using a combination of discharge diffuser and inlet guide vanes.

2.03 BLOWER MOTORS

A. The blower manufacturer shall be responsible for furnishing new electric motors for the blowers. The manufacturer shall be responsible for the proper selection, testing, installation, and operation of the motors and for coordinating the motors with the compressor equipment. Motors shall be premium efficiency motors and meet the requirements of Section 26 05 61 – Medium Voltage Electric Motors.

B. Motor shall be horizontal squirrel cage induction motor designed in accordance with the latest ANSI, NEMA, and IEEE standards. The blower motor voltage, enclosure-type, and maximum motor output shall be as specified in Paragraph 2.02B. The Contractor shall

be responsible for any and all modifications, including but not limited to electrical modifications, required to accommodate any larger capacity motors should they be required by the selected blower manufacturer.

C. Motors shall be designed and manufactured for continuous duty for operation under the following conditions:

1. Altitude below 3300 ft.

2. Ambient temperature ranging from 0°F to 104°F.

3. Voltage variations of plus or minus 10 percent.

4. Frequency variation of plus or minus 5 percent.

5. Combined voltage and frequency variation of plus or minus 10 percent with frequency variation not exceeding plus or minus 5 percent.

D. The motor shall provide a service factor of 1.15. Motor speed shall not exceed 3,600 rpm.

E. Motor torque characteristics shall be at least 20 percent greater than the maximum full load torque requirements over the full range of operating conditions from start-up to full load. Motors shall be suitable for accelerating the blower to full speed using a reduced voltage, autotransformer type starter (starters by others) with inrush limited to acceptable levels.

F. Motors shall be designed for quiet operation. Motor sound pressure shall not exceed 83 db at 3 feet from the motor in unloaded condition.

G. Motors shall provide premium efficiencies and power factors throughout the operating range. The power factors specified shall be achieved without the use of power factor correction capacitors. Motor shall provide minimum efficiencies and power factors as follows:

Percent Full Load	Minimum Efficiency Percent	Minimum Power Factor Percent
100	95.7	88.0
75	96.0	87.0
50	95.9	83.3

1. Efficiencies and power factors for each motor shall be verified by shop testing as specified.

H. Motor insulation shall be Class F or H insulation; however, temperature rise shall be limited to that of Class B insulation. Manufacturer's premium grade insulation shall be used.

I. The stator shall be assembled from high grade electrical sheet steel laminations adequately secured together. Stator windings and end turn connections shall be fully braced to withstand all mechanical, electrical, and thermal stresses. The shaft shall be made of high-grade machine steel or steel forging and of size and design adequate to withstand the load stresses. The rotor shall be fabricated of one-piece die-cast aluminum.

J. The motors shall have spherical anti-friction roller thrust bearings at the non-drive end. All anti-friction thrust bearings shall be designed for an L10 life of 100,000 hours (including blower design thrust and rotor weight). For applications with higher thrust loads (which cannot meet the L10 life) plate-type thrust bearings and oil lubricated sleeve guide bearings shall be used.

K. Each motor shall be provided with an oversized terminal box with space for connections and shall be constructed of cast iron or fabricated steel, neoprene gasketed and bolted. The motor leads shall be permanently marked in agreement with the connection diagram. Motor terminal box shall include lightning arrestors, surge capacitors, and differential current transformers that shall be factory-mounted and prewired. Current transformer leads shall be prewired to terminal strips mounted in a separate low voltage terminal compartment. Arrestors and capacitors shall be rated in accordance with IEEE Std. 141-1993-6.7.3.9.2. The three stator phase leads shall be provided with 2-hole pad connectors for the incoming cables.

L. Motor shall be designed and manufactured for operation in the direction required for the blowers. The phase sequence shall be marked permanently and plainly inside the stator lead junction box or on the outside of the motor.

M. Motor shall be provided with six platinum resistance temperature detectors (RTDs) embedded in the stator winding. RTDs shall be 100-ohm, platinum, 3 wire type having a stability of better than 0.2 percent of maximum exposed temperature for one year of service, or 0.25 degrees Celsius, whichever is greater. Two detectors per phase are required and shall be placed at locations determined to give close approximation of the hottest spot temperatures.

N. Motors shall be supplied with space heaters for 120V operation.

O. Motor bearings shall be provided with vibration detectors and RTDs mounted in 316 stainless steel thermowells. RTDs and vibration monitoring equipment shall be as specified below.

2.04 BASE

A. A welded steel fabricated base shall be provided for mounting each new blower, gear box, electric motor, lubricating system, cooling system and accessories. The base shall be fabricated A36 steel in a rigid box section shape with drip lip, lifting eyelets, and sufficient rigidity to permit lifting with a 4-point lift with all equipment mounted. The box section shall be properly ribbed for stiffness and present large bearing areas for carrying the load on the foundation. The base shall contain the oil reservoir. Machined pads shall be provided as required to properly level the base. The base shall be rigid to prevent deflection during start-up and normal operation that would affect alignment. Spring mount vibration isolation pads shall be provided between the concrete pad and the base of the blower unit.

2.05 IMPELLERS

A. The impellers shall be radial flow type with open and backward leaning blades. Impellers shall be milled or fabricated from forged hiduminimum aluminum alloy (ASTM B247 AA2618). The impeller shall be attached to the shaft by shrinkfit and locknut arrangement. The impeller shall be statically and dynamically balanced.

2.06 VARIABLE VANES

A. The purpose of the inlet guide vane and variable discharge diffuser vanes shall be to facilitate turndown of each blower from 100% to 45% of capacity, while maximizing efficiency over the entire turndown range.

B. An adjustable inlet guide vane assembly shall be provided to pre-rotate incoming air and maximize efficiency. Inlet guide vanes shall be made in an aerodynamic, streamlined design in cross-section and located in radial fashion around the annular inlet. Inlet guide vane position shall be controlled through the PLC in the blower control panel.

C. The inlet guide vanes shall modulate simultaneously with the diffuser vanes to continuously optimize efficiency.

D. Variable discharge diffuser vanes shall be provided for capacity control. Vanes shall be aerodynamically shaped for maximizing efficiency.

E. The inlet guide vane and the variable diffuser assemblies shall be mounted integrally with each blower. All vanes shall be mounted in permanently lubricated sleeve bearings or ball bearings. Operating linkages for inlet guide vanes and variable diffusers shall be housed within the blower.

F. Each variable vane assembly shall include a blower mounted electric actuator and position indication on the blower control panel.

G. The position of each set of vanes, from fully open to fully closed, shall be transmitted to the blower control panel via an analog signal. The inlet guide vane and the diffuser vane position shall be indicated on the display on the blower control panel.

2.07 BLOWER AND INTEGRAL GEARBOX CASING

A. Blower casing shall be made of ductile iron ASTM A536, 60-40-18 or close-grained cast iron ASTM A278, Class 30, have a maximum continuous duty design temperature of 400°F, and a design pressure of 50 psig. Air inlet shall be axial through an annular inlet. The discharge flange shall be faced and drilled to ANSI B16.1, Class 125 pound. A threaded port shall be provided at the lowest point of the casing for drainage. The blower casing shall be provided with lifting lugs capable of supporting the blower/gearbox.

B. The gear drive housing shall be of close-grained cast iron ASTM A48, Class 30B or close-grained cast iron ASTM A278, Class 30, vertically or horizontally split, sufficiently rigid to maintain the shaft positions under maximum loads. Inspection ports, with bolt-on covers, shall be provided in the upper portion of the gearbox housing. The ports shall allow access to the gearbox internals for the purpose of inspection. Adjustment of the vibration proximity probes on the high-speed shaft shall be possible from the outside of the gearbox.

C. Gearbox configuration shall incorporate a single helical gear set in an over/under configuration. The overhung impeller and fast-shaft shall operate between the first and second critical speeds.

D. The blower and gear housing assemblies shall be machined to close tolerances for bearing fit, gear alignment, air, and oil tightness.

E. The gearbox shall be of ample size and rated to transmit the maximum torque and horsepower input requirements to the blower under all operating conditions and continuous duty.

F. All exposed machined surfaces shall be coated with grease prior to shipment.

2.08 SHAFTS, GEARS, AND SEALS

A. The blower gear shafts shall be machined from heat-treated, forged steel and suitably ground. Any responsive lateral critical speed of the rotating assembly shall be at least fifteen (15) percent from the normal operating speed. Any torsional resonances of the package shall be at least ten (10) percent from the normal operating speed. All rotating elements shall be dynamically balanced and conform to "Design and Selection of Components for Enclosed Gear Drives" (AGMA 6001-C88).

B. The speed-increasing, helical, parallel shaft type gears shall be made of case-hardened alloy steel forgings with the gear teeth precision ground. All gears shall be manufactured in accordance with the American Gear Manufacturers Association "Standard

Specification for Measurement of Sound on Enclosed Helical, Herringbone, and Spiral Bevel Gear Drives" (AGMA 6025-C90) to a minimum AGMA quality number no less than twelve (12), as specified in AGMA 2000/A88. Service factor used to size the gearbox shall be a minimum of 1.5 based on full load horsepower rating of the motor.

C. The shaft seals shall be of a non-contact, multi-point, labyrinth type and operated dry. A vented space between air and oil seals shall be provided. Any leakage shall be minimized by having small clearances between female and male parts. The female part shall be made of aluminum or bronze to avoid damage to the shaft in the event of a seal rub. Numerous slinger rings (diameter changes) on the shaft shall be provided in the sealing area to ensure oil is centrifugally slung off the shaft.

2.09 BEARINGS

A. Blower bearing types are specified in Paragraph 2.02B.

B. Where ball bearings are specified, anti-friction roller bearings with pressurized spray lubrication shall be required. Roller bearings shall be non-proprietary and manufactured by SKF or equivalent.

1. Low-speed shaft radial bearings and thrust bearings shall be standard steel construction.

2. High-speed shaft radial bearings and thrust bearings shall be of hybrid silicon-nitride ceramic construction.

C. Where journal bearings are specified, hydrodynamic, oil pressure lubricated bearings shall be required with sufficient oil film thickness under all operating conditions. All bearings shall be of bronze construction.

1. Low-speed shaft radial bearings shall be of the cylindrical, journal type.

2. High-speed shaft radial bearings shall be multi-segment, Babbitt-type, and designed to suppress hydrodynamic instabilities and provide sufficient dampening to limit rotor vibrations.

3. Thrust bearings shall be multi-segment and designed for thrust in both directions.

2.10 OIL LUBRICATION SYSTEM

A. A complete lube oil system shall be provided with each blower, installed integrally with the blower base and arranged to permit ease of accessibility for operation, maintenance, inspection, and cleaning.

B. Where ball bearings are specified, the lube oil system shall consist of an oil sump and an oil pump integral to the blower gearbox.

1. One main gearbox shaft-driven oil pump shall be provided, capable of full capacity and pressure to supply lubrication for the air blower/gearbox when operating. The oil pump shall supply a sufficient amount of oil while the compressor is running down during power failure.

2. The oil filter shall be of the full flow, replaceable cartridge, simplex type with integral transfer valve, and capable of removing particles nine (9) microns in diameter with 98.7% efficiency. The clean oil filter element pressure drop shall not exceed five (5) psi at design temperature and flow. A visual gauge shall indicate when a filter is dirty and requires changing.

C. Where journal bearings are specified, the oil reservoir shall be integral to the blower base with the reservoir interior de-scaled and rust-proofed by the application of a permanent coating of the Manufacturer's standard.

1. Reservoirs shall be baffled to minimize air entrainment, to isolate foam, and shall be equipped with a suitably sized vent and breather filter, and have a minimum working capacity of three (3) minute retention time based on normal flow. The reservoir shall have a minimum 28 square inch clean-out with a blind flange or gasketed cover plate and 1½ inch NPT valve drain at the lower/side of the reservoir.

2. One main gearbox shaft-driven primary oil pump and one electric motor-driven oil pump (as pre-lube and post-lube) shall be provided, each capable of full capacity and pressure to supply lubrication for the air blower/gearbox when operating. The electric motor-driven oil pump shall operate at start/stop of the blower and, at low oil pressure, be activated by the control system located in the blower control panel. The motor shall be minimum 3 Hp, 480 VAC, 3 phase, 60 Hz, TEFC, high efficiency and have adequate power to pump oil at the minimum oil temperature of 50°F. The oil pumps shall supply a sufficient amount of oil while the compressor is running down during power failure.

3. The oil filter shall be of the full flow, replaceable cartridge, duplex type with integral transfer valve, and capable of removing particles nine (9) microns in diameter with 98.7% efficiency. The clean oil filter element pressure drop shall not exceed five (5) psi at design temperature and flow. A visual gauge shall indicate when a filter is dirty and requires changing.

4. Oil heating shall be provided by use of the auxiliary oil pump to maintain oil temperature above 50°F. An RTD shall be provided for measurement and indication of oil temperature. The blower shall not start unless the oil is above 50°F. Low oil temperature warning indication shall be provided on the display on the blower control panel.

D. Oil-to-air heat exchangers shall be provided for each blower and mounted on the blower base. Oil-to-air heat exchanges shall be rated for a design pressure of 250 psig and design temperature of 250 degrees Fahrenheit. The system shall provide fully automatic operation to maintain oil temperature to the bearings to below 140°F.

2.11 COUPLINGS

A. A flexible, forged steel, double-disc, dry type spacer coupling shall be furnished to connect the blower and motor. Couplings requiring grease lubrication shall not be allowed. Coupling and spacer shall be balanced to AGMA, Class 8, or better, and sized with a minimum service factor of 1.5. 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 and painted Safety Yellow.

B. A complete torsional critical speed analysis shall be conducted by the Supplier to ensure that the blower, motor, and coupling are properly designed. Include data in the submittal to confirm that there are no torsional critical speeds within the operating range of the unit.

2.12 PRESSURE GAUGES

A. Inlet and discharge pressure gauges shall be installed by the Contractor on the suction and discharge of each blower.

B. The inlet vacuum gauge shall be a 316 stainless steel bellows gauge with a range of 0-30 inches of mercury/0-15 psi. Scale shall be a 270° arc. Dial size shall be 4-1/2 inches with black phenolic case. Gauge tap shall be 1/4 inch minimum.

C. The discharge pressure gauge shall be a 316 stainless steel bourdon type with a range of 0-15 psi. Scale shall be a 270° arc scale with figure interval every 1 psi and minor graduations every 0.1 psi. Dial size shall be 4 1/2 inches with black phenolic case. Gauge tap shall be 1/4 inch minimum.

D. Gauges shall have an accuracy of plus or minus 1 percent. All gauges shall be by the same manufacturer.

2.13 INSTRUMENTATION

A. Each blower shall be equipped with the following instrumentation:

1. Inlet Filter Differential Pressure Sensor

2. Inlet Pressure Sensor

3. Discharge Pressure Sensor

4. Inlet Air Temperature Sensor

5. Discharge Air Temperature Sensor

6. Motor Windings RTD

7. Motor Bearing RTD

8. Motor shaft vibration

9. Motor bearing vibration

10. Blower Bearing RTD

11. Blower shaft and gearbox vibration

12. Oil temperature (high and low alarm and trip settings)

13. Oil pressure

14. Surge Detection

15. Air Flow Measurement Indication (measured or calculated)

B. The Contractor shall furnish and install new conduit and wiring from junction boxes on the blower skid to the blower LCP and from field-mounted instruments to the LCP as required for a complete system. Skid mounted instruments shall be installed in the factory and shall be factory-terminated in junction boxes (one digital and one analog) on the blower skid and connected by the Contractor to the LCP. Contractor shall provide taps, isolation valves, tubing, and pipe stanchions required for pressure gauge and other new devices for installation as specified.

C. The RTD monitor system shall include 100 ohm platinum RTD's embedded in the motor windings (two per phase; one active, one spare) and in each bearing of both the motor and blower/gearbox. The system shall monitor and display actual winding and bearing temperature at the blower control panel. When the windings or bearings reach the selected temperature, an indicator illuminates until reset and the unit shuts down. The PLC shall receive and the Operator Interface shall graphically display the RTD signals. The Supplier shall provide the necessary hardware for direct communication between RTD's, PLC, and Operator Interface.

D. A shaft vibration monitoring system shall be furnished for each blower and motor. The system shall include:

1. Blower gearbox casing mounted velometer

2. A Keyphasor sensor on the shaft between the motor and blower

3. X-Y configuration vibration detectors at each bearing of the motor, four probes total per motor

E. The PLC in the blower control panel shall receive, and the Operator Interface shall graphically display, the vibration probe signals. The Operator Interface shall include an adjustable alarm feature on the rising vibration levels that first alarms and is followed by unit shutdown. The alarm/shutdown shall be displayed until reset. Provide necessary hardware for direct communication between vibration probes, PLC, and Operator Interface.

2.14 BLOWER CONTROL PANELS

A. The Supplier shall furnish remote mount NEMA 12 blower local control panels (LCPs) for the new blowers. Each blower control panel shall include a touch screen operator interface on the front of the panel, a programmable logic controller (PLC), and network communication hardware to interface with the Plant SCADA system.

B. The PLC control system and I/O subsystem shall all be products of Allen Brandley CompactLogix 5380. The PLC shall utilize TCP/IP Ethernet communication protocol. All PLC inputs/outputs shall be provided in accordance with Section 40 61 23 – Signal Coordination Requirements.

C. The Blower Control Panels shall each include a UPS to provide uninterruptible power to the PLCs. The UPS shall conform to all requirements of Section 40 67 63 – Uninterruptible Power Systems.

D. The blower LCPs shall be connected to the in-plant Ethernet control system network. All data available at the blower LCP shall be available in the Plant SCADA system.

E. Each blower control panel shall contain controls for blower motor normal starting and stopping sequences, surge and overload detection and protection, emergency shutdown control and sequencing, alarm systems, inlet guide vanes, variable diffuser vanes, discharge valve, bypass valve, and the oil lubrication system operation as a minimum.

F. Each blower control panel shall operate from a single 120 VAC or 480 VAC, 3 phase supply and shall contain a main power disconnect which interlocks the enclosure door. Starters for variable vane operators, oil pumps, oil-to-air heat exchangers, and all ancillary equipment shall be furnished and installed by the blower manufacturer in the blower control panel. Power supply for the blow-off valve and discharge isolation valve operators shall be provided by the blower manufacturer in the blower control panel. Low voltage variable power signals entering the blower control panel shall be isolated.

G. All branch circuit protection shall be in accordance with NEC codes, as well as protection for the instrumentation power, the (120/60/1) duplex GFCI protected receptacle, Operator Interface, and the PLC.

H. The PLC shall start and shut down the blower in a permissive sequence, receive input, monitor and control operating variables. The PLC shall also contain a program for continuous optimization of blower efficiency with respect to changes in operating conditions.

I. Lightning arrestors and surge suppressors shall be provided for 120V control power.

J. Surge suppressors shall be provided for "noise" protection and to remove transient peaks across all inductive loads.

K. Signal isolators, PLC rack-mounted RTD input modules, vibration transmitters, and other controls shall be supplied, as required, for complete system control.

L. Identify each end of each wire by a unique wire number printed on a heat shrunk sleeve marker.

M. Provide an Operator Interface with a touch screen active matrix TFT color graphic minimum 10-inch LCD display that incorporates all controls, alarms and meters in easy to interpret color screens. Operator Interface shall be Allen Bradley Panelview Plus.

N. The operator interface screens shall provide start-stop and operational mode interface, alarm status, help messages, and diagnostics. The following operator interface screens shall be provided, generally as described, and incorporating state-of-the-art upgrades available at the time of engineering design and submittal for the Engineer's review. As a minimum, provide the following:

    1. Local Control Panel Menu – The master screen lists all operating screens as touch-sensitive screen points for selection.

    2. Main Blower Operations – Touch-sensitive screen points for blower start, blower stop, increase or decrease capacity, local or remote selection. This screen shall display a bar chart or dial indicator of blower capacity (in percent) and numerical horsepower or amperage draw. A 1 x 3 inch message center shall display appropriate messages, including a troubleshooting guide, upon alarm.

    3. Service Functions Display – When in service mode, touching an identified screen point shall display on-off (open-close) screen points to operate the items listed below. A normal or service/test screen point shall also be displayed to change operation status.

        a. Normal/Service mode selection and status

b. Inlet guide vanes – current position, scale, open, close

c. Discharge guide vanes – current position, scale, open, close

d. Inlet/discharge guide vanes recalibration

e. Discharge valve – current position, open limit (adjustable), open, close

f. Blow-off valve – current position, close limit (adjustable), open, close

g. Blow-off valve start-up settings – setpoint, delay

h. Oil cooler fan – start/stop

4. Blower Transmitter Display – Shall display all blower components, their current value, units of measurement, alarm settings and trip settings including but not limited to:

a. Inlet guide vanes

b. Variable diffuser vanes

c. Inlet air temperature

d. Discharge air temperature

e. Differential pressure

f. Oil reservoir temperature (high and low alarm and trip settings)

g. Oil pressure

h. Blower bearing temperatures

i. Blower shaft and gearbox vibration

j. Discharge valve position

k. Blow-off valve position

5. Motor Transmitter Display – Shall display all motor components, their current value, units of measurement, alarm settings and trip settings including but not limited to:

a. Amperage (from the MCC)

b. Motor bearing temperatures

c. Motor winding temperatures

d. Motor shaft vibration

e. Motor bearing vibration

f. Motor power (in horsepower) draw (from the MCC)

6. Alarm/Trip Display – A flashing warning lamp icon shall be indicated on the display upon detection of an alarm or trip. Pressing the icon shall display the alarm/trip display. The alarm/trip display shall provide a description of the individual alarms or trips detected along with the date and time the alarm or trip occurred. The screen shall display a troubleshooting list to use as a guide to correct the alarm. The operator shall acknowledge the alarm once corrected by pressing an "acknowledge" button. All cleared alarm and trip messages (including date and time) shall continue to be accessible through a legacy alarm screen to monitor alarm trends and facilitate diagnosis/corrective actions. An alarm horn silence button shall also be provided.

7. Configuration Display – Shall allow selection and display of the following:

   a. Test mode button

   b. Powerup default – Normal or service modes

   c. Powerup default – local or remote control mode

8. Transmitter Scaling Set-Up – Lists calibration range of all analog signals. Password access shall be required to change any value.

O. Additional selector switches, pushbuttons, and indicators shall include:

1. Service/Normal/Test – Located on the Operator Interface. This touch sensitive screen point allows permissive start of the blower components only in the Service Mode. When in Test Mode, this diverts MCC start signal to test logic that simulates motor start to facilitate testing of the system without starting the drive motor.

2. Emergency stop mushroom button on panel door

3. Blower "Run" indicating light (red).

4. Blower "Stop" indicating light (green).

5. Blower "Fault" indicating light (amber).

6. Separate, non-resettable hour meter on panel door

P. Monitor and indication of all analog signals shall be displayed on the Operator Interface, including, but not limited to:

1. Motor amperage
2. Motor horsepower
3. Variable diffuser vane position
4. Inlet guide vane position
5. Blow-off valve position
6. Discharge valve position
7. Temperature signals
8. Pressure signals
9. Vibration signals
10. RTD bearing/winding temperatures

Q. The surge detection system shall sense unbalanced/surge conditions by use of inlet pressure, inlet temperature and/or motor horsepower. Detection of surge conditions shall trip the blower off-line. Adjustable time delays shall be incorporated to prevent nuisance shutdowns.

R. Motor overload protection software shall be provided to control the maximum vane setting on the blower, so that motor current does not exceed a pre-set level. Motor overload protection shall be provided such that if motor current exceeds 105% of full load amps the blower shall be shutdown through the PLC in the Blower LCP.

S. The output air flow in scfm shall be displayed on the Operator Interface. The calculation of this flow may utilize dynamic field inputs of differential pressure across the blower, inlet temperature, and shaft power derived from motor wire power or current, in conjunction with performance test stand data. The multi variant algorithm based on test stand data and the defined inputs of air temperature, pressure, and motor power draw may be used to determine flow throughout the operating range of the compressor.

T. The high inlet air temperature (recirculation) alarm and the zero-speed switch shall be active when there is no main motor feedback present at the blower control panel from the MCC (i.e. blower is "off" and not running). The purpose of these sensors is to detect reverse air flow through the compressor and reverse rotation of the impeller.

U. All electrical work associated with the blower panels, instruments, and controls provided by the blower system manufacturer shall be in accordance with the National Electric

Code. Switches and pushbuttons shall be heavy duty, oil-tight, NEMA 4 type. The completed panel shall receive a UL label. Each blower control panel shall be provided with a power disconnect switch. Provide separate 24-volt power supplies as required.

V. The control panel shall be completely pre-wired and tested at the factory by the blower system manufacturer.

W. Terminal blocks shall be 300-volt, 30-amp, barrier type screw terminals with 10% on each block as spares. Each terminal shall be identified. Power and control wiring shall use separate block from analog signal wiring. Analog signal wiring shall be shielded.

X. An as-built diagram of the completed panel shall be encased in plastic inside the panel.

Y. Engraved plastic nameplates shall be mounted on the inside of each blower panel to identify the various devices, instruments, etc. Nameplates shall have white letters on a black background.

Z. Alarms shall not be annunciated under normal start-up and shut-down conditions.

2.15 REQUIREMENTS FOR INTERFACE WITH THE PLANT'S SCADA SYSTEM

A. The Contractor shall provide coordination required for communication of information between the blower control panels and the Plant SCADA system. The blower manufacturer will make available in separate contiguous registers the required digital and analog information to the Plant SCADA system through network communication. The blower manufacturer shall submit copies of the graphic displays for approval. The Contractor shall coordinate with the control system subcontractor under Division 40 to develop the graphic displays in the SCADA display format protocol. The Plant SCADA system shall provide the following for information from the blower control panels (by the control system subcontractor under Division 40):

1. Log all monitored points for trend analysis

2. View realtime trends

3. View historical information

4. Display graphs and charts

5. Date/time history of alarms including surge

2.16 BLOWER START-UP AND SHUTDOWN SEQUENCE CONTROL PROGRAMS

A. The blower start-up and shutdown sequence control programs shall be provided by the blower manufacturer in each blower control panel PLC as follows:

1. A blower may be called to start or stop by the following:

a. Manually at the blower control panel through the touch screen operator interface.

b. Manually through the Plant SCADA System. (remote-manual)

c. Automatically through the Plant SCADA System.

2. The SCADA system or the operator through the touch screen operator interface at the blower control panel shall provide a command to the blower control panel to start its respective blower. The PLC shall confirm that alarm conditions are cleared and the blower is available for starting. In the case of a blower failure or if a blower is locked out by a PLC-based "permissive", the SCADA system shall try to start the next available blower according to the control program in the SCADA system. Indication of the next blower to be started and the next blower to be shut down through the strategy shall be provided on the SCADA system graphic displays.

3. When a blower is called to start, a "blower start-up " notification shall be provided on the respective blower PLC display and on the plant SCADA displays and shall remain on the screen until the start-up sequence is completed. Status of delay timers showing countdown time shall be displayed during a start-up and shutdown sequence.

4. Automatic control of the dissolved oxygen control valves and variable diffuser vanes by the SCADA system shall be discontinued by the SCADA system until completion of the start-up sequence.

5. The blower PLC shall move inlet guide and discharge diffuser vanes on the blower to be started to their "start-up" position. The SCADA system will provide a command to blowers already operating to modulate to their "start-up" position. The PLC will use continuous 4-20 ma position feedback information from the operators to monitor position for start-up. The PLC shall confirm that the discharge valve of the blower to be started is fully closed and that the blow-off valve for the blower to be started is fully open. Indication that the PLC is "positioning valves" shall be provided on the blower control panel operator interface and on the SCADA system display. Failure of any of the valves to move to their required positions within the time required shall initiate a "start-up sequence/valve failure" alarm through the PLC, shall terminate the start-up sequence, and shall provide alarm indication on the blower control panel OIT and on the SCADA system display.

6. After the blow-off valve is closed, the inlet guide vanes shall be positioned by the blower PLC. When the inlet guide vanes are stabilized, the variable diffuser vanes are ready for operational control; and the start sequence is finished. A "blower #___ start-up sequence completed" message shall be provided on the blower control panel operator interface and on the SCADA system display. The SCADA

system shall restore automatic control of the dissolved oxygen, control valves, and blower variable diffuser vanes.

7. When a blower is called to stop, a "blower shutdown " notification shall be provided on the respective blower PLC display and on the plant SCADA displays and shall remain on the screen until the shut-down sequence is completed.

8. After the command is received to shut down the blower (or a blower shutdown is initiated manually through the touch screen) the PLC shall adjust the variable diffuser and inlet guide vanes to their “shutdown” position, open the blow-off valve to its fully opened position, and then close the discharge valve to the fully closed position. When the discharge valve is fully closed, the start/run signal will drop to the MCC to stop the drive motor. A "blower stopped" notification shall be provided on the respective blower PLC display and on the plant SCADA OWS displays.

9. Upon completion of blower shut-down, the PLC shall satisfy the stand-by conditions.

10. Emergency stop capability shall be provided through the local blower control panel, at the skid mounted emergency stop (if equipped), at the motor starter and through the SCADA system through a single-click function. Emergency stop shall de-energize all equipment on the blower base and cannot be reset or reactivated until maintained emergency stop has been released to restart the blower after an emergency stop.

11. The blower control panel shall include protective shutdown interlocks to protect the blower from abnormal operating conditions. A “soft” stop shall be provided through the PLC if initiated by any of the following:

    a. High Oil Temperature

    b. High Inlet Air Temperature

    c. High Compressor Bearing Temperature

    d. High Motor Bearing Temperature

    e. High Motor Winding Temperature

    f. High Motor Amps

    g. Surge

    h. Impending Surge

i. “Soft” stop shall consist of opening the blow-off valve to its full open position and de-energizing the main drive motor 8 seconds after the alarm condition occurs. Normal post-lube and other normal stop functions shall follow.

12. An “emergency” stop shall be provided through the PLC initiated by any of the following:

    a. Low Oil Pressure

    b. No Run Status Contact Feedback from Starter During Starting

    c. Loss of Run Status Contact Feedback from Starter

    d. Start Sequence Failure

    e. Stop Sequence Failure

    f. High Compressor Casing Vibration

    g. High Compressor Shaft Vibration

    h. High Motor Bearing Vibration

    i. Pushing Emergency Stop Pushbutton

    j. PLC Failure

    k. An “Emergency” stop shall consist of opening the blow-off valve to its full open position and de-energizing the main drive immediately. Normal post-lube and other normal stop functions shall follow.

13. The PLC shall move the discharge valve to the fully closed position after the blower is shut down for any reason.

2.17 BLOWER MACHINE MONITORING PROGRAMS

A. The blower monitoring programs shall be provided by the blower manufacturer in each blower control panel as follows:

1. Monitoring and protection of the blowers from abnormal operating conditions shall be provided through the PLC.

2. Horsepower and amperage inputs to each PLC shall be from the respective blower starter.

3. Provide monitoring of all analog inputs. PLC shall shut down the blower if inputs are not within the acceptable range. Hold-out circuitry shall be provided in the PLC

programming to prevent shut-down on alarm condition while the blower is being started. All analog inputs to the PLC shall be re-transmitted to the Plant SCADA system via Ethernet communication.

B. The following is a listing of the analog inputs to the PLC at each blower LCP. Analog inputs shall be monitored/displayed at the PLC and monitored/logged/displayed through the Plant SCADA system.

1. Motor Drive End Bearing Temperature
2. Motor Non-Drive End Bearing Temperature
3. Blower High Speed Drive End Bearing Temperature
4. Blower High Speed Non-Drive End Bearing Temperature
5. Inlet Air Temperature
6. Discharge Air Temperature
7. Oil Reservoir Temperature
8. Motor Drive End Bearing Vibration (2)
9. Motor Non-Drive End Bearing Vibration (2)
10. Blower Gearbox Vibration
11. Blower Motor Power Draw (from the MCC)
12. Inlet Guide Valve Position
13. Variable Diffuser Vane Position
14. Blower Blow-off Valve Position
15. Discharge Isolation Valve Position
16. Motor Windings Temperature (3)
17. Blower Motor Current (from the MCC)
18. Inlet/Discharge Differential Pressure Transmitter

C. The PLC shall include programming to report the order in which alarm conditions are received, such that operators can determine the alarm that caused blower shut-down.

D. Discrete inputs to each PLC shall include:

1. Blower motor run status
2. Electrical malfunction alarm
3. Low oil pressure switch
4. Low/low oil pressure switch
5. Low oil level switch
6. Blow-off valve operator remote/local indication
7. Oil cooler fan run status
8. Oil filter differential pressure switch
9. Zero speed switch
10. Inlet air filter 1st Stage differential pressure switch
11. Inlet air filter 2nd Stage differential pressure switch
12. LCP Emergency Stop Push/Pull
13. Inlet Guide Vane Open Limit Switch
14. Inlet Guide Vane Close Limit Switch
15. Variable Diffuser Vane Open Limit Switch
16. Variable Diffuser Vane Close Limit Switch
17. Blow-off Valve Open Limit Switch
18. Blow-off Valve Close Limit Switch
19. Discharge Valve operator remote/local indication
20. Discharge Valve Open Limit Switch
21. Discharge Valve Close Limit Switch
22. Surge Detection Switch
23. UPS Alarm

24. UPS on Battery

E. Discrete outputs from the PLC shall include:

1. Main motor run (hour meter)
2. Main motor start/stop
3. Open discharge valve
4. Close discharge valve
5. Blow-off valve open
6. Blow-off valve close
7. Inlet guide vane open
8. Inlet guide vane close
9. Variable diffuser vane open
10. Variable diffuser vane close
11. Oil cooling fan start/stop
12. Alarm horn
13. Alarm beacon

2.18 CHECK VALVES

A. The blower manufacturer shall furnish one discharge check valve for each blower as shown on the Drawings. Check valves shall be a wafer type discharge check valve of the dual, flat-plate type with center hinge, metallic center post, spring or non-spring closure, steel or cast iron body, Viton-B seal, aluminum-bronze or stainless steel plates, Inkonel 600 springs, and rated for temperatures up to 300°F. Check valve shall be Crane Duo Check II, Flexi-Hinge Type 518, or equal. The check valves shall be installed by the Contractor as shown on the Drawings. The Contractor shall perform any piping modifications necessary to incorporate the check valve provided by the blower manufacturer at no cost to the Owner. Check valves shall be suitable for installation in the horizontal or vertical position.

2.19 DISCHARGE ISOLATION AND BLOW-OFF (BYPASS) VALVES

A. The blower manufacturer shall provide electrically operated butterfly valves for the blow-off line and discharge line of each blower. Valves shall be resilient-seated butterfly

valves as specified in Section 40 05 64 – Butterfly Valves. All components of the discharge isolation and blow-off valves shall be suitable for operation at temperatures up to 300°F. The butterfly valves shall be installed by the Contractor as shown on the Drawings. The Contractor shall perform any piping modifications necessary to incorporate the valves provided by the blower equipment Supplier at no cost to the Owner.

B. Motor actuators shall be provided for discharge isolation and blow-off valves and shall meet the requirements of specification Section 40 05 57 – Valve Operators and Electric Valve Actuators. Motor actuators for the discharge isolation valves shall be open-close service. Motor actuators for the blow-off valves shall provide for modulating operation. Cycle time from full open to full closed shall be approximately 60 seconds. 4-20 ma position feedback signals shall be provided for each actuator. Contractor shall wire 4-20 ma position signals to the PLC.

2.20 FLEXIBLE COUPLINGS

A. The blower manufacturer shall provide a flexible coupling to be installed on the inlet and discharge piping of each blower. The flexible coupling shall be sized for a standard pipe diameter and shall prevent the transmission of noise and vibrations from the blower package into the piping. The flexible connector shall be suitable for the maximum operating temperature and pressure ratings of the equipment provided. The blower manufacturer shall provide stainless steel restraining bolts and hardware. Discharge expansion couplings shall be suitable for a pressure of 25 psig and a temperature of 300°F.

2.21 DISCHARGE CONE/SILENCER

A. Provide a discharge cone/silencer (Evasè stack) for each blower to increase the blower outlet size to the larger diameter air discharge piping as shown on the Drawings. Maximum sidewall angle increase shall be 7° per side (14° total). Minimum 10-gauge carbon steel shall be used. Instrument connections shall be provided on the cone/silencer.

2.22 INLET FILTER SILENCER

A. Each blower shall be provided with an inlet filter/silencer designed for maximum air flow at absolute minimum pressure drop to be connected directly to inlet piping for the blowers as shown on the Drawings. Walls of the silencer shall consist of sandwiched galvanized steel outer skin and an acoustical sound deadening material of one (1) inch sound insulation containing an inert barrier, on the inside of the housing. The inert barrier on the walls shall have a thin aluminum foil on its exterior, affixed to the barrier with an industrial adhesive. The silencer housing structural frame shall be hot-dipped galvanized. Legs shall be adjustable for vertical positioning and leveling.

B. The integral inlet silencer shall consist of a set of lamella, mounted internally in the filter/silencer between the filter elements and the blower inlet, suitably wrapped with sound deadening material. Lamella construction shall be such that there is no direct line of sight (direct flow) through the lamella, and the lamella so configured such that the line of air flow shall make at least four turns, for maximum attenuation. An air tight seal shall be provided between the filter frame and silencer.

C. The filter elements shall be rectangular, replaceable elements mounted on a flat, vertical track of aluminum construction, and removable through galvanized steel doors located on each side of the galvanized steel housing. A two-stage filter panel system shall be supplied. The coarse pre-filter shall have a minimum ASHRAE 52.2 MERV value of 8. The final filter element shall have a minimum ASHRAE 52.2 MERV value of 13. Filters shall be sized to limit maximum filter face velocity of 500 feet per minute (fpm) or less.

D. Maximum clean filter pressure drop of the inlet filter/silencer with the elements installed shall be 2.5 in. w.c. (0.09 psig). Maximum pressure drop with dirty inlet filters shall be 4.2 inch w.c. (0.15 psig).

E. A removable spool piece shall be provided between the inlet filter/silencer and the blower inlet. The spool piece shall be a minimum 24 inches long and be fabricated of the material as specified for process air piping in Section 40 06 20 – Process Pipe, Valve, and Gate Schedules.

2.23 EQUIPMENT IDENTIFICATION

A. Each blower shall be provided with a substantial stainless steel or aluminum nameplate, securely fastened in a conspicuous place and clearly inscribed with the manufacturer's name, year of manufacture, serial number, and principal rating data (including blower design capacity in scfm, design discharge pressure in psig and psia, design minimum inlet pressure in psia, maximum temperature and relative humidity at maximum temperature).

2.24 TOOLS AND SPARE PARTS

A. Spare parts shall be provided in accordance with Section 46 00 00 – Equipment General Provisions.

B. Blower manufacturer is to submit a list of recommended spare parts with long lead items clearly identified.

C. Two (2) sets of replacement inlet air filters shall be provided by the blower manufacturer for each blower furnished. Filters shall be provided for both inlet air pre-filter and final filter.

D. The blower manufacturer shall furnish one set of special tools as required for complete assembly or disassembly of blower system components for each type or size of blower

specified, together with a neat metal box (or boxes) for the same. The tool kit shall be sufficiently complete to permit normal repair and maintenance of all equipment furnished under this project.

PART 3 – EXECUTION

3.01 INSTALLATION

A. All equipment specified herein shall be installed in accordance with the manufacturer's instructions and checked by the manufacturers' representative, in conformity with the applicable Sections of this Specification. After installation, the equipment shall be aligned and adjusted as required for proper operation.

3.02 PRELIMINARY PERFORMANCE TESTS

A. Preliminary factory running and performance tests for each of the blower packages shall be performed by the Manufacturer to confirm performance at the design points specified in Paragraph 2.02 prior to factory performance tests. Impellers shall be statically and dynamically balanced and over-sped to 105% of rated speed. Preliminary factory running test results shall be provided to and approved by the Engineer prior to scheduling factory performance tests.

3.03 FACTORY PERFORMANCE TESTS (PTC-13)

A. After approval of preliminary performance tests, each of the blower packages is to be factory performance tested in accordance with the ASME Wire-to-Air Performance Test Code for Blower Systems (ASME PTC 13) and as specified herein.

1. Performance testing shall be performed on a fully closed blower package where the blower is to be installed with a permanent enclosure. Performance testing on an enclosed blower package with an open enclosure is not acceptable.

2. Tests shall be conducted using the actual motor and ancillary equipment provided under this section. The use of shop motors, variable frequency drives or any other equipment that will not be contained within the job-specific blower package furnished as specified herein shall be prohibited.

3. The Manufacturer’s representative coordinating the testing shall be experienced in the testing requirements of ASME PTC 13 and shall sign and date the test procedure and results certifying the assembled systems were tested as a complete package system. Test results shall be reported in accordance with the same code and the results shall be submitted and approved by the Engineer prior to shipment.

B. A detailed shop test plan shall be submitted for Engineer approval with the Shop Drawings prior to testing. The shop test plan shall fully describe the manufacturer's test

facilities and the test procedure to be used. Discharge piping and instrumentation shall be in accordance with ASME PTC 13.

1. Complete instrumentation layout and Manufacturer's information for all instrumentation used during testing shall be submitted including the arrangement and device for flow measurement, conversion tables/graphs, and accuracies over the specified flow range. Test instrumentation shall conform with the requirements of AME PTC 13 and the ASME PTC 19 series.

2. All test instrumentation shall be calibrated and certified by an independent test agency within the last twelve months. Certificates shall show the stability of calibration over a period of at least one year per ISO 9001, Paragraph 4.11.

3. The Blower Manufacturer, through the Contractor, shall give the Owner/Engineer a minimum of four weeks' notice prior to factory performance testing.

C. The shop performance tests shall be conducted for each blower to demonstrate compliance with all performance requirements. The test shall include determination of the surge point and verification of the guaranteed points. Performance tests shall include a minimum of seven points including the specified design maximum and minimum flows specified in Paragraph 2.02 B and the design operating points specified in Paragraph 2.03 C. Test points shall be submitted by the blower manufacturer and approved by the Engineer prior to factory performance testing.

1. Operate each blower at each test point for a duration sufficient to demonstrate all readings have stabilized and meet the fluctuation criteria defined in Table 3.5.5-1 of ASME PTC 13.

D. Compressor net delivered flow rate and discharge pressure shall be guaranteed with no negative tolerance. There shall be no other tolerances or measuring uncertainties in reporting test results (i.e., the tests shall be reported with ± zero percent tolerance).

E. Measured power shall be wire-to-air power and include all power demands and losses associated with the blower unit, including but not limited to the motor, variable frequency drive, job filter, harmonic filter, bearing controller, and cooling system losses. Wire power shall be as measured at the electrical supply to the blower package. Individual power measurements shall be taken where there are multiple electrical supplies to the blower package. Testing using less accurate heat balance or measurement of shaft power shall not be allowed.

1. Wire power shall be measured by a precision power analyzer calibrated to NIST standards. The power analyzer shall instantaneously monitor all electrical legs for voltage and amperage to calculate instantaneous power usage and shall measure the electrical power input to the inlet supply of the blower assembly as described, including all auxiliary systems. The power analyzer shall be capable of handling the distorted voltage and current waveforms and phase relationship of the power

factor caused by the harmonics and EMI resulting from an inverter's high-speed switching signals. The precision power analyzer shall meet the Minimum Accuracy and Function Requirements listed in ASME PTC 13, Table 4-2.1.2-1. The power analyzer shall comply with IEC601010-1, IEC61000-3-2 and IEC61000-3-12.

F. Shop test information shall include:

1. Inlet (ambient) and discharge temperature
2. Inlet (ambient) and discharge pressure
3. Inlet filter differential pressure
4. Relative humidity
5. Capacity in inlet cubic feet per minute (icfm) and standard cubic feet per minute (scfm)
6. Speed
7. Blower package input (wire) power in hp and kW
8. Line Voltage
9. Vibration

G. Inlet pressure and inlet temperature shall be considered ambient pressure and temperature at the test facility. Pressure and temperature measurements shall adhere to paragraphs 4-3 and 4-4, respectively, of ASME PTC 13. Relative humidity shall be measured with a calibrated hygrometer.

H. The inlet volumetric flow rate shall be measured at the blower package discharge to ensure leakage flow is not included in the delivered air measurement. Inlet volumetric flow rate is defined as the delivered mass flow divided by the blower package inlet density.

1. Flow measurement device calibration, readings, and calculations shall be fully documented and conform to ASME PTC 13.
2. Standard cubic feet per minute (scfm) is defined as the delivered airflow rate at the blower discharge in terms of standard conditions (68°F, 14.7 psia and 36% relative humidity).

I. Discharge pressure shall be calculated as the sum of the discharge static pressure and velocity pressures per ASME PTC 13 Part 4-3.11.

J. Discharge temperature shall be the total temperature at the blower package discharge.

K. Blower speed shall be calculated from the power supply frequency, the number of motor poles, and the gear ratio (where applicable). Blower rotational speed shall be measured with instrumentation having an accuracy of greater than or equal to 0.15%

L. Velocity vibration versus frequency levels shall be recorded within 10-1,000 and 10-10,000 Hz frequency range. Vibration shall be reported velocity (in/sec) versus frequency.

M. Raw testing data under factory testing conditions shall be converted to performance at specified conditions per ASME PTC 13 Section 5.

N. In case of failure of any unit to meet the test requirements, the manufacturer, at their own expense, shall make such alterations as are necessary and the tests shall be repeated without additional cost to the Owner until the equipment is passes test requirements.

O. Test results not in verbatim agreement with test results presentation format per the Code shall be cause for rejection of the performance tests. The blower manufacturer's testing supervisor shall sign each copy of the test report.

P. The Manufacturer shall prepare a blower test report in accordance with the requirements of ASME PTC 13 Section 6. In addition to the requirements of ASME PTC 13 Section 6, performance curves based on the results of the factory performance test shall be developed in terms of standard conditions of 14.7 psia, 68°F, and 36% relative humidity. SCFM shall be plotted against pressure under 14.7 psia, 68°F and 36% relative humidity, and the curve shall show horsepower draw over the range of SCFM flow rates. Performance curves shall also be provided at the design maximum and minimum inlet conditions specified in Paragraph 2.02B. The blower test reports shall be signed and dated by an officer (Vice President or higher) of the basic corporation, partnership, or company manufacturing the equipment.

3.04 FACTORY FUNCTIONAL TESTING

A. Upon completion of assembly, each blower, motor, and ancillary components shall be functionally tested with the blower control panel connected to all skidded instruments, electric valves, and appurtenances. All start/stop sequences and all safety and alarm systems shall be tested.

B. The hardware and software control systems for each blower shall be tested, and all sequences and alarms shall be simulated.

3.05 FIELD TESTS

A. The Contractor and Manufacturer shall perform field running tests at the site following installation of the equipment and controls. Field testing shall be in accordance with Section 46 00 00 – Equipment General Provisions and as specified in this Section. Field

running tests shall be conducted by the factory service people with assistance of the Contractor.

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

C. Running tests shall be conducted under actual operating conditions for a period of not less than 8 hours for each blower. Running tests shall demonstrate that the blower is free from all objectionable vibration and noise and overheating throughout the entire range of specified operation. Initial running tests shall demonstrate that all instruments, controls, and protective shutdown interlocks function properly. Additional requirements include:

    1. Run motor uncoupled for up to one-half (1/2) hour to verify motor operation and check magnetic center for proper marking/location

    2. Demonstrate that the blower has the proper shutdown sequence of standard stop, soft stop, and emergency stop

    3. Demonstrates the simultaneous and continuous efficiency optimization by altering the inlet guide vane position based on inlet temperature, differential pressure, and capacity

D. Each blower shall be run for 4 hours at full load and for 4 hours at the minimum specified flow. Temperature and vibration readings for all monitored points shall be recorded after 4 hours and at the conclusion of the 8-hour run period for the operating blower(s). Any shutdown of the blower(s) during the test periods shall be recorded and the cause noted. Any defects or operating problems found during running tests shall be promptly corrected.

E. Additional services for improper operation of the Manufacturer’s supplied equipment due to fabrication shall be at no cost to Owner. Manufacturer shall remedy operational issues due to fabrication until satisfactory operation is achieved.

F. Additional services for improper operation of the Manufacturer’s supplied equipment due to installation shall be at no cost to Owner. Contractor shall retain the services of the Manufacturer to remedy operational issues due to installation until satisfactory operation is achieved.

G. Manufacturer shall prepare and submit field quality control reports signed by the Manufacturer for field inspections and field tests in accordance with Section 46 00 00 – Equipment General Provisions and as specified in this Section. Field quality control reports shall include any corrections or adjustments made to the equipment, including instrumentation and controls, during the field tests, including field calibration of equipment instruments. Manufacturer shall prepare and submit certification letter on

Manufacturer’s letterhead with signature stating the equipment is fully operational and capable of meeting operating requirements.

3.06 PAINTING

A. Blowers, base, and motor shall be prime and finish painted at the factory using the manufacturer’s premium grade paint specifications and conforming to Section 09 90 00 – Painting. Paint system shall be submitted for approval with the shop drawings. A color chart shall be submitted with the shop drawings for Owner selection of color for the blower and motor.

B. Aluminum, stainless steel, and brass shall not be painted.

C. The Contractor shall apply touch-up painting to all scratched, abraded, and damaged shop painted surfaces. Touch-up coating type and color shall match the manufacturer’s shop paint coating.

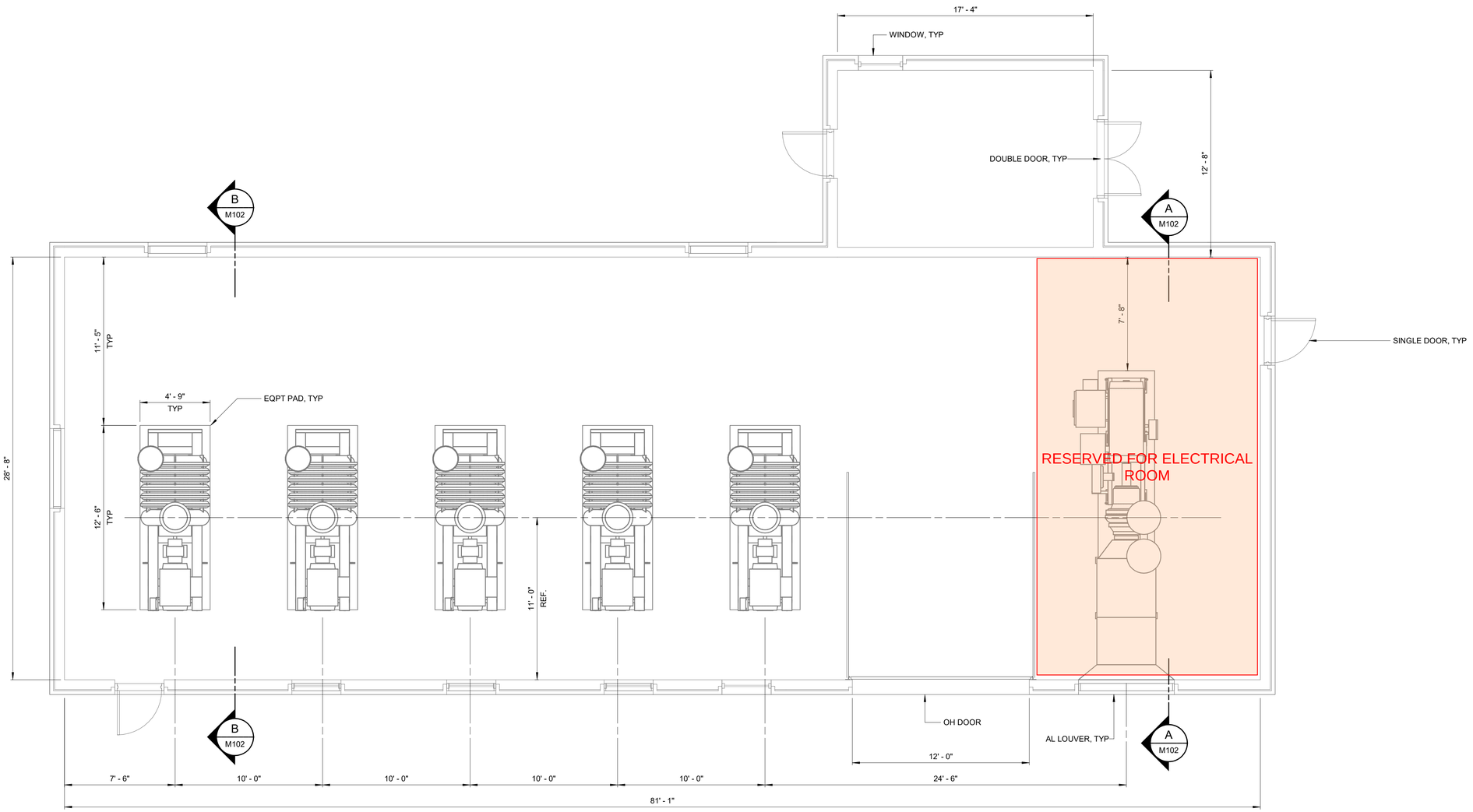
END OF SECTION

APPENDIX C

EXISTING BLOWER ROOM LAYOUT

NOTES:

1. --



INTERMEDIATE PLAN

1/4" = 1'-0"

REV	ISSUED FOR	DATE	BY

PROJECT ENGINEER:	J. HARTWIG
DESIGNED BY:	H&S
DRAWN BY:	H&S
CHECKED BY:	H&S

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE — 0 1/2" 1"

Hazen

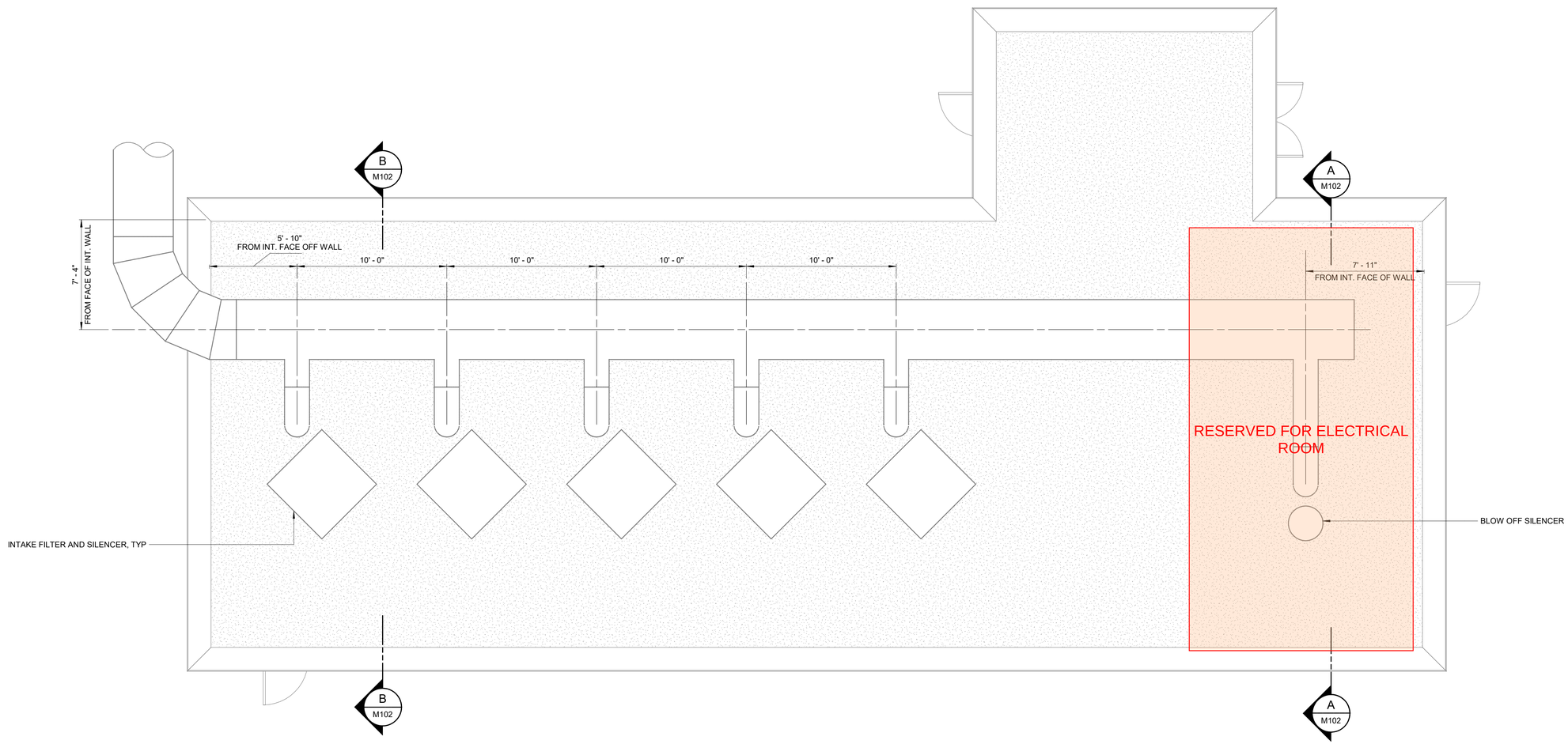
HAZEN AND SAWYER
735 JOHNNIE DODDS BLVD, SUITE 102
MOUNT PLEASANT, SC 29464
LICENSE NO.: C00638

NORTH CHARLESTON SEWER DISTRICT
NORTH CHARLESTON, SOUTH CAROLINA

FELIX C. DAVIS WWTP
AERATION IMPROVEMENTS PROJECT

BLOWER BUILDING
MECHANICAL
INTERMEDIATE PLAN

DATE:	NOVEMBER 2023
HAZEN NO.:	32203-017
CONTRACT NO.:	1
DRAWING NUMBER:	M100



TOP PLAN
1/4" = 1'-0"

REV	ISSUED FOR	DATE	BY

PROJECT ENGINEER:	J. HARTWIG
DESIGNED BY:	H&S
DRAWN BY:	H&S
CHECKED BY:	H&S

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE 0 1/2" 1"

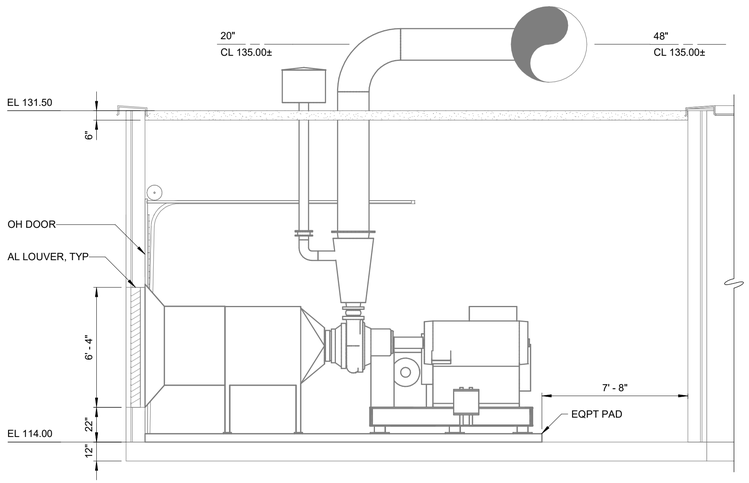
Hazen
HAZEN AND SAWYER
735 JOHNNIE DODDS BLVD, SUITE 102
MOUNT PLEASANT, SC 29464
LICENSE NO.: C00638

NORTH CHARLESTON SEWER DISTRICT
NORTH CHARLESTON, SOUTH CAROLINA

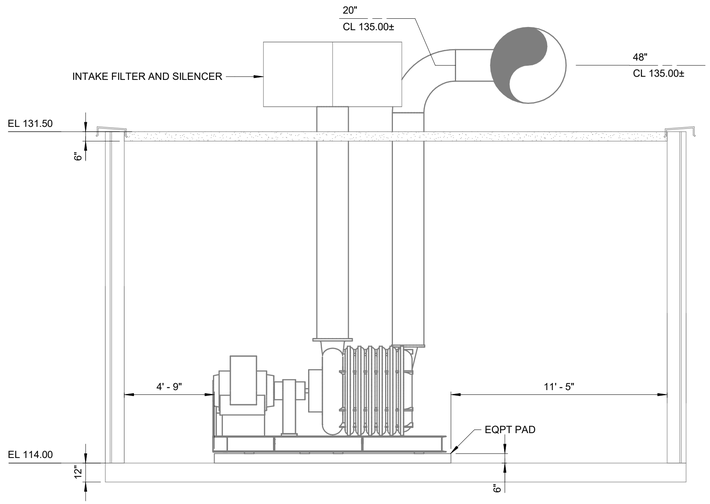
FELIX C. DAVIS WWTP
AERATION IMPROVEMENTS PROJECT

BLOWER BUILDING
MECHANICAL
TOP PLAN

DATE:	NOVEMBER 2023
HAZEN NO.:	32203-017
CONTRACT NO.:	1
DRAWING NUMBER:	M101



SECTION A
1/4" = 1'-0"
M100



SECTION B
1/4" = 1'-0"
M100

REV	ISSUED FOR	DATE	BY

PROJECT ENGINEER:	J. HARTWIG
DESIGNED BY:	H&S
DRAWN BY:	H&S
CHECKED BY:	H&S

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE
0 1/2" 1"

Hazen
HAZEN AND SAWYER
735 JOHNNIE DODDS BLVD, SUITE 102
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LICENSE NO.: C00638

NORTH CHARLESTON SEWER DISTRICT
NORTH CHARLESTON, SOUTH CAROLINA

FELIX C. DAVIS WWTP
AERATION IMPROVEMENTS PROJECT

BLOWER BUILDING
MECHANICAL
SECTIONS

DATE:	NOVEMBER 2023
HAZEN NO.:	32203-017
CONTRACT NO.:	1
DRAWING NUMBER:	M102