Municipal Wastewater Blower True Costs

Overview

- This True Costs Guide is continually evolving. We welcome input to make it more complete and accurate.
- The goal of the True Costs Guide is to help owners and consultants make the best decisions relative to blower selection and integration and to provide specific information by region as to the availability and cost of blowers.
- For example in China there are local suppliers whose prices are lower than international suppliers. How does this affect the decisions for blowers to be used in China?
- How do process changes such as nitrification impact the true cost of various options?
- What are the differences in cost of different options depending on whether it is a replacement or a greenfield installation?
- How important are differences in energy costs between sites being evaluated?
- These are just samples of the many questions addressed.

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Blower and Compressor Applications in Wastewater Plants

Aeration for the purpose of biological treatment is the largest application for blowers and compressors in municipal wastewater plants. There are a number of other uses as well. If sewage sludge is combusted blowers are used for providing the combustion air. Aeration is used in grit collection as well as secondary treatment. If anaerobic digestion is used there is no aeration requirement but there is a move to transport and store the produced gas.

Initially we are focusing on the aeration decisions but will expand later to detailed analysis of the other blower applications.

Material in red indicates areas for which we are seeking further information.

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Blower Options

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McIlvaine Original Analysis

Main Category	Sub Category	PSIG Range	Flow	Efficiency	Cost
Rotary blowers	Rotary blowers	5-30	low	lower	lower
Centrifugal Turbo fans	Centrifugal turbo fans	4-10	high	higher	higher
Centrifugal Compressors	Single stage	5-30	high	higher	higher
	Multi stage	30-65	high	higher	higher
Packaged Turbos	Packaged Turbos	0-30	high	higher	In between
Oil free screw compressors	Oil free screw compressors	Multi stage 52 bar (754 psig)	high	higher	higher

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Xylem Blower Analysis

https://www.xylem.com/siteassets/brand-specific-content-including-catalog/sanitaire/sanitaire-resources/xylem-guide-to-blowers.pdf

	EFFICIENCY	TURN-DOWN CAPABILITY	REPAIR & MAINTENANCE
Positive Displacement Lobe Blowers	POOR	EXCELLENT	MODERATE TO CONSIDERABLE
Positive Displacement Screw Blowers	MODERATE	EXCELLENT	MODERATE TO CONSIDERABLE
Centrifugal Blowers	MODERATE	MODERATE	CONSIDERABLE
Non-Contact Magnetic Bearing Blowers	GOOD	GOOD*	MODERATE
Non-Contact Air Bearing Blowers	GOOD	GOOD*	MINIMAL*

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Aerzen Rotary Lobe vs Screw Compressor

Aerzen compared two types of positive displacement and two types of dynamic blowers:

1. Rotary lobe blowers

2. Low-pressure dry screw compressors

3. Special purpose high speed single-stage centrifugal blowers with inlet guide vanes and outlet diffuser vanes to achieve a wide turndown at constant operating speed. These machines can be operated with a VFD to provide additional flexibility while maintaining highest efficiency.

4. Standardized high speed single-stage turbo blowers. These recently introduced machines are direct-driven by a high-speed permanent magnet motor and always require a VFD to meet varying air density and/or pressure needs. The impellers are precision cast or fully machined depending on the manufacturers. Adjustable diffuser vanes are not used and the machines rely on a well integrated elaborate control system to adapt to changing conditions. They make use of most modern technology with magnetic bearings or air bearings. Magnetic bearings enable continuous vibration monitoring, while air bearings cannot be monitored.

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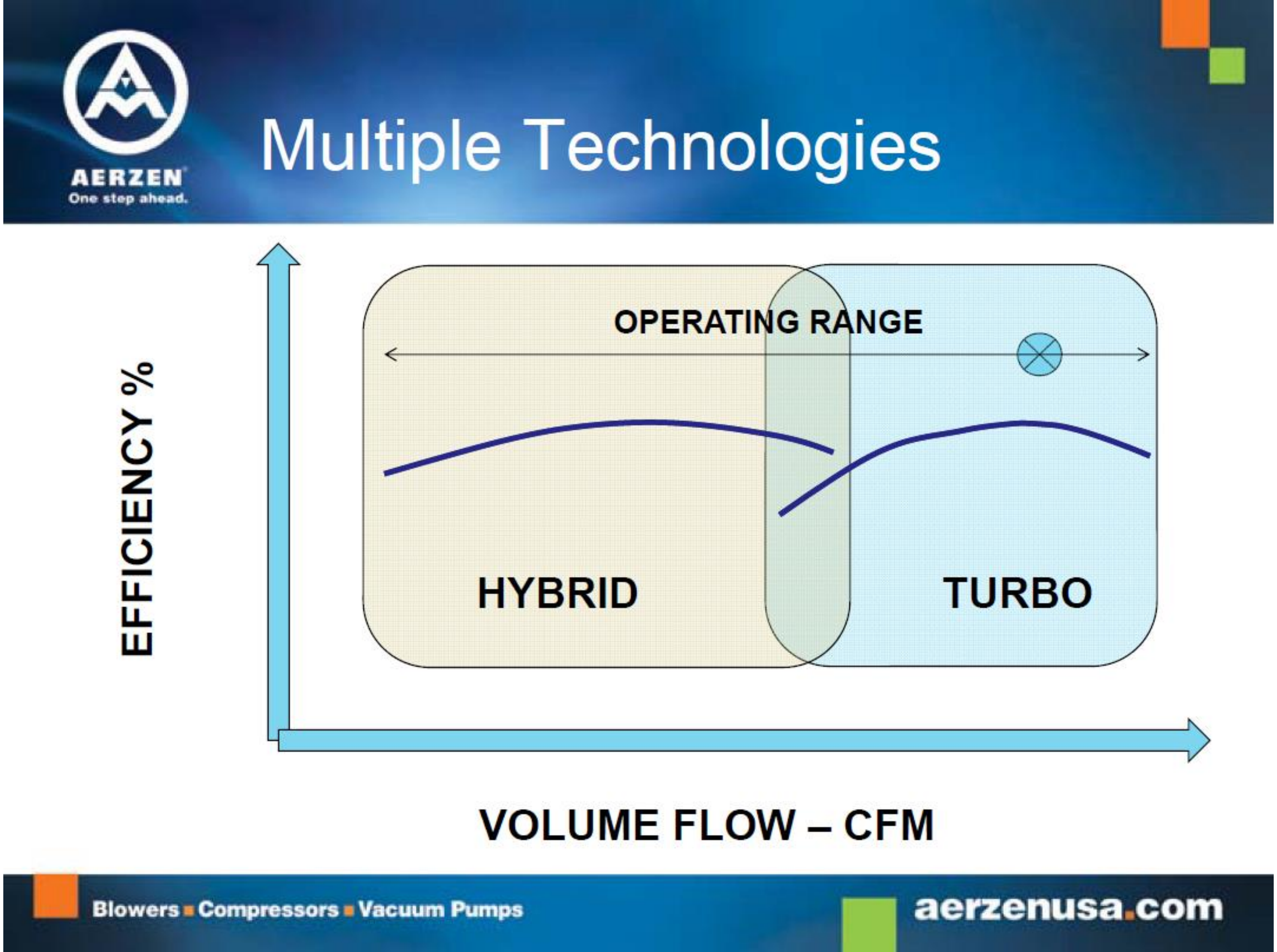
Efficiencies

https://www.acsawater.com/sites/default/files/websitefiles/SVWWTPN/Selecting%20the%20Right%20Blower%20Technology.pdf



Nominal efficiency and turn-down are important. However, in the case of Almonte Springs described in the case histories section. VFD is used with PD blower and provided superior energy efficiency when operating at a normal 50% load.

Multiple blowers are frequently used to provide high efficiency over a wide range of flows. So the nominal efficiency of a single blower is only one of the relevant inputs to determine optimum energy consumptions

We are inviting input on this subject.

Typical Blower Efficiencies

Blower Type	Nominal Blower Efficiency (percent)	Nominal Turndown (percent of rated flow)
Positive Displacement	45-65	50
Multi-Stage Centrifugal (inlet throttled)	50-70	60
Multi-Stage Centrifugal (variable speed)	60-70	50
Single-Stage Centrifugal, Integrally Geared (with inlet guide vanes and variable diffuser vanes)	70-80	45
Single-Stage High Speed Turbo **	70-82	50

**Testing methods are not consistent among different manufacturers

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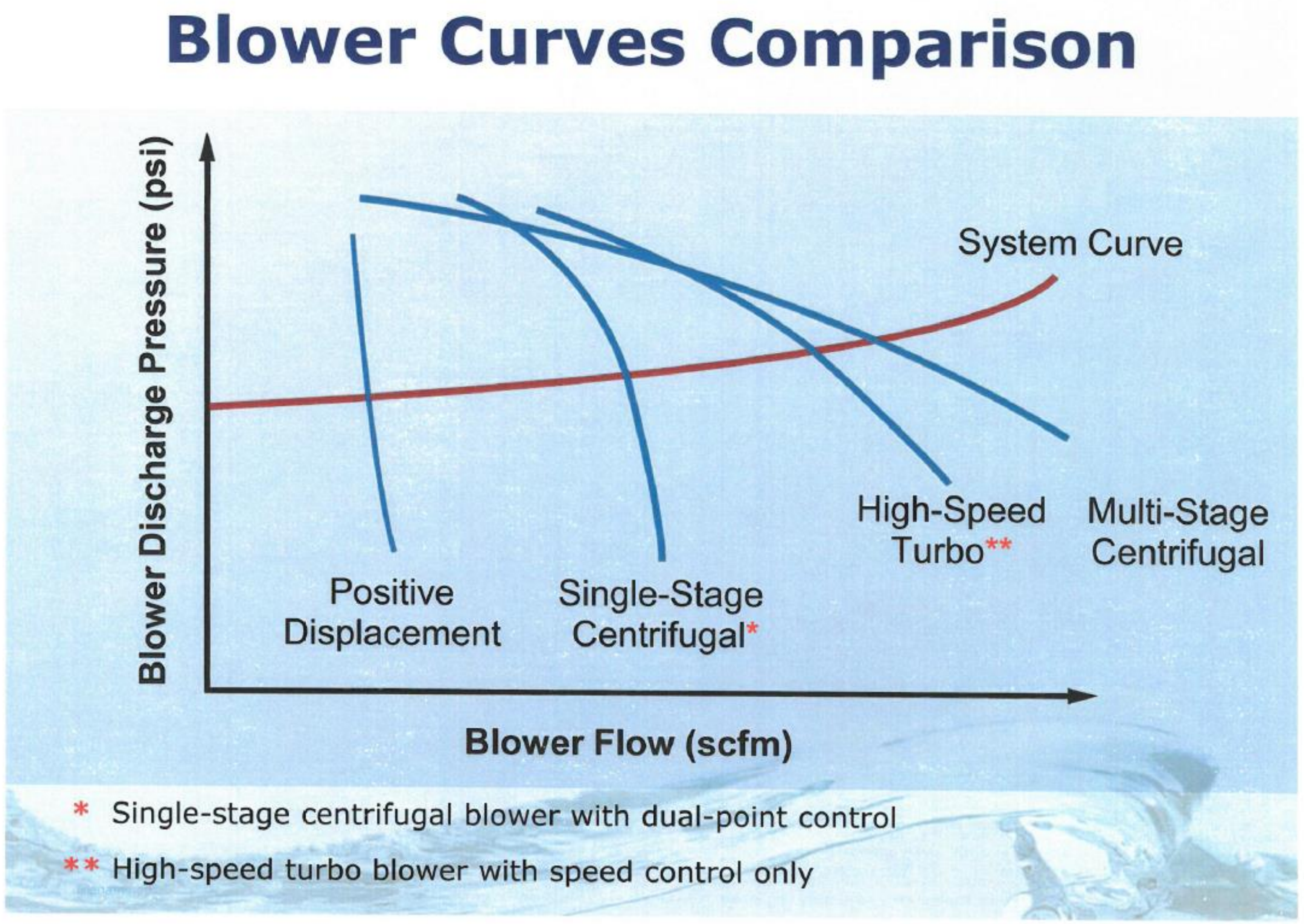
Comments

We will be posting expanded analysis of the performance of different options.



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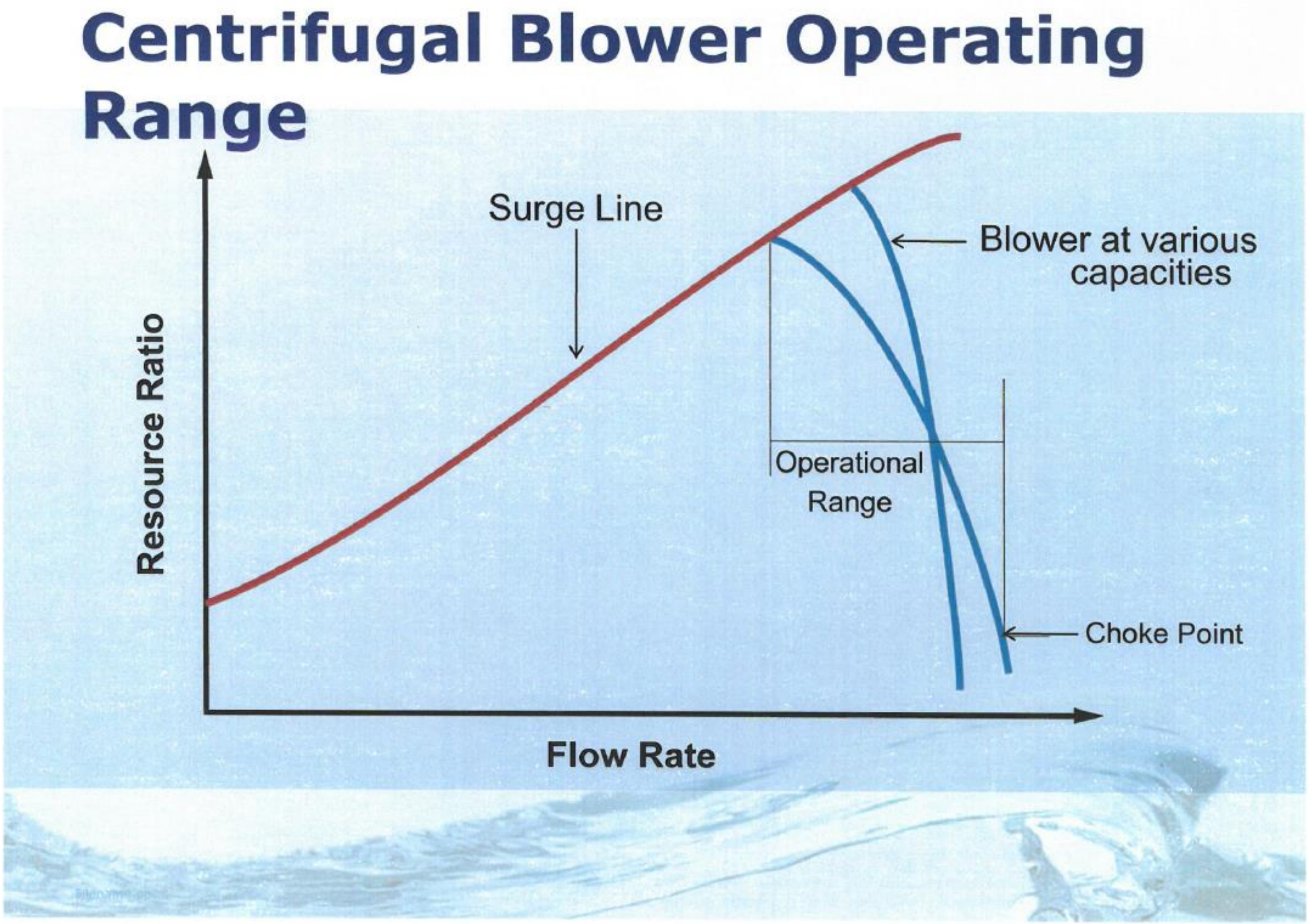
How important is the evaluation of the surge line in blower selection?

This is a chart by Carollo.



Positive Displacement Blowers

Positive Displacement Rotary Blowers - Manufacturers

	Former or Other Names	Corporate Office Country	Americas Availability	EMEA Availability	Asia Pacific Availability
Aerzen					M S
Atlas Copco					
Everest		India		S	M
Gardner Denver					M S
Ingersoll Rand	Hibbon				
Howden	GE, Dresser Roots				
Kaeser					S
K -Turbo		Korea		Sold to Aerzen?	
SWAM		India			
TAIKO		Japan			R- Singapore, Shanghai
tuthill					
Unozawa		Japan			

M = Manufacturing S = Service Center D = Distributor (not direct) R = Representative

We are asking the blower suppliers to validate the availability of their products by continent.

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AERZEN : Robust machines; easy to operate; easy to maintain by plant personnel; mean time between overhauls typically 5 to 10 years; only little instrumentation required and controls are vey simple: no pressure ratio controls required for air density adjustments; the blower adjusts naturally to the system backpressure without any controls; at constant speed, the power required is proportional to the downstream pressure at any moment; flow control range up to 4:18 using a standard constant torque frequency inverter; at constant pressure, the power is proportional to the speed; the drive uses a standard NEMA or IEC motor; wide turndown range; no surge limitation; requires some more space than an equivalent turbo blower; lower initial costs than a turbo; lower repair costs than a turbo; blower and motor bearings are not a limiting factor for number of starts.

Due to their operating principle, rotary lobe blowers rely on pulsation attenuation at the discharge side to reduce piping noise. Packagers are offering acoustic treatment to meet occupational and environmental noise limits.

Positive Displacement Blowers

- Impeller: Two or three lobes
- Controls
  - Constant or variable speed (typically belt-driven)
- Simple instrumentation
- Requires large silencers (intake and discharge)
- Lowest capital cost
- Smaller installations

Positive Displacement

Multi Stage Centrifugals

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Features and Product Availability

We are requesting information from Gardner Denver and other multi stage centrifugal suppliers on their products including availability by continent.

Multi-Stage Centrifugal

- Impeller
  - Series of enclosed impellers
    - Cast or fabricated
    - Various steel alloys
- Controls
  - Inlet throttling
  - Discharge throttling (less efficient)
  - Speed control with VFD
- Bearings
  - Anti-friction roller type
  - Grease or oil lubrication
- Instrumentation
  - Simple
  - Monitor bearing temperature and vibration
- Electric motor (2-pole most often)
  - IC engines (not often)

Multi-Stage Centrifugal

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Multi Stage Centrifugal - Manufacturers

	Former or Other Names	Corporate Office Country	Americas Availability	EMEA Availability	Asia Pacific Availability
Atlas Copco					
Continental Blower					
Gardner Denver					M S
Ingersoll Rand	Hibbon				
Howden	GE, Dresser Roots				
HSI					
National Turbine					
Spencer Turbine					

M = Manufacturing S = Service Center D = Distributor (not direct) R = Representative

We are asking the blower suppliers to validate the availability of their products by continent

Spencer Turbine for Digester Gas Boosting

The Spencer Turbine Company helped a customer find a clean, renewable alternative fuel in an unlikely place—a wastewater treatment plant. When the Hunts Point Water Pollution Control (WPC) in New York City set out to reduce its energy consumption, the New York Power Authority (NYPA)—which operates the facility—investigated using biosolids to generate electricity. With a grant from the New York City Department of Environmental Protection (NYC DEP) energy savings program, the facility realized it had the perfect combination to generate its own power: biosolids and fuel cells. The pairing of methane and fuel cells at the Hunts Point WPC is possible because the methane gas from the wastewater treatment process contains hydrogen, which is what a fuel cell runs on. Tapping the hydrogen, however, requires that the gas pressure be boosted to specific pressure levels. That's where Spencer's digester gas booster capabilities played a vital role.

Spencer provided a skid package specifically designed to help the Hunts Point facility move digester gas from the digester to the fuel cell at the desired pressure levels. But the Hunts Point digester gas includes chemicals, such as hydrogen sulfide (H2S), and other matter that are corrosive. Optimum performance depends on preventing damage from their corrosive effects. So Spencer's Engineering Department recommended stainless steel gas booster construction with anodized aluminum impellers to resist corrosion. Additionally, the hermetically sealed design allows zero leakage of corrosive, explosive and odorous digester gas to the environment. The gas tight, corrosion-resistant gas booster was mounted on a common skid. The skid included a recirculation system, control panel, drip traps and drain lines for condensate removal, temperature and pressure gauges, switches and other components. To ensure that the equipment met customer requirements, Spencer delivered the complete skid to the site pre-assembled, pre-piped, pre-wired and factory tested to the company's standard factory performance test procedures. This turnkey package is truly a plug-and-play design

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Single Stage Centrifugals

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Features and Product Availability

Single-Stage Centrifugal

- Single impeller
  - Open face (most common)
  - Enclosed (Roots)
  - Milled or investment casting
  - Aluminum and SST most common
- Controls
  - Constant speed
  - Inlet guide vanes
  - Discharge variable diffuser vanes
  - Turndown to ~ 45%
- Bearings
  - Journal type bearings
  - Anti-friction roller-type on smaller units
- Instrumentation
  - Complex
  - Vibration, temperature, pressure, power
- Electric motor (2-pole or 4-pole)
  - IC engines

Single-Stage

These blowers have typically been applied to large installations and for pressures up to 30 psig.

We are requesting information from single stage centrifugal suppliers on their products including availability by continent.

Centrifugal Compressor Manufacturers					
	Former or Other Names	Corporate Office Country	Americas Availability	EMEA Availability	Asia Pacific Availability
Aerzen	K-turbo				
Atlas Copco			M S	M S	M S
DMW		Japan			
Ebara Elliot					
Gardner Denver	Hoffman, Lamson, Nash				
GL Turbo		China	S	S	
Howden	GE, Dresser Roots, Siemens KKK				
Ingersol Rand	Hibon				
Man-Turbo					
Sulzer					
M = Manufacturing S = Sales-Direct D = Distributor (not direct)					

High Speed Turbo Blowers

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Carollo Analysis of High Speed Turbos

High-Speed Turbo Blowers

- Instrumentation and electrical components
  - New to municipal wastewater market
  - High speed VFD (may require harmonic filters)
  - High-speed permanent magnet motor
- Blower enclosure
  - Single-source responsibility by blower manufacturer for all components
  - Easy installation
  - Cooling requirements vary by manufacturer
  - Provides sound attenuation

High-Speed Turbo Blower

High-Speed Turbo Blowers

- Single impeller (dual impeller by some manufacturers)
  - Open-face impeller
  - Three-dimensional milling or cast
  - Various material choices (aluminum alloys, stainless steel, etc.)
- Controls
  - Variable speed (single-point control)
  - Discharge variable diffuser vanes (Turblex dual-point control)
  - Turndown to ≈ 50%
- Advance bearing design
  - Allow for higher speeds
  - Two configurations
    - Air bearing (most common)
    - Magnetic bearing
  - Bearings require no lubrication system

High-Speed Turbo Blower

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Direct Drive, Energy Efficient, High-Speed Turbo Blowers

Alvin C. Firmin, PE, BCEE

Presented at:

PNCWA 2009 Annual Conference
Boise, Idaho

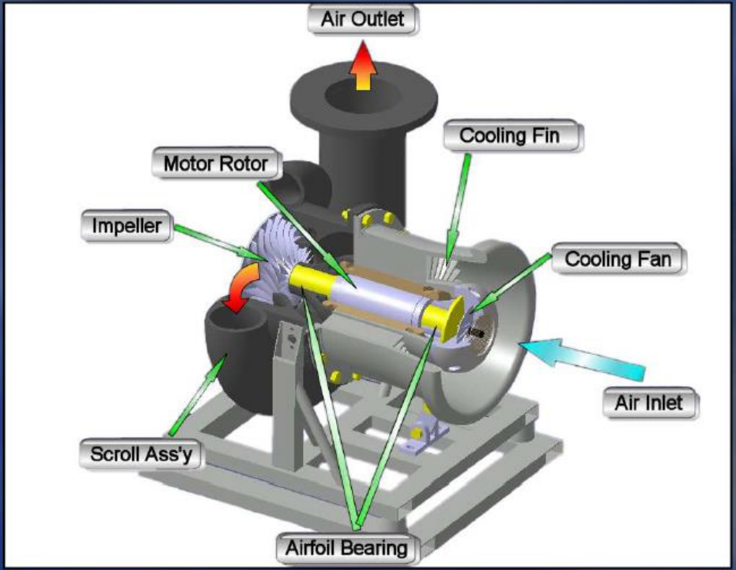
September 16, 2009

CDM

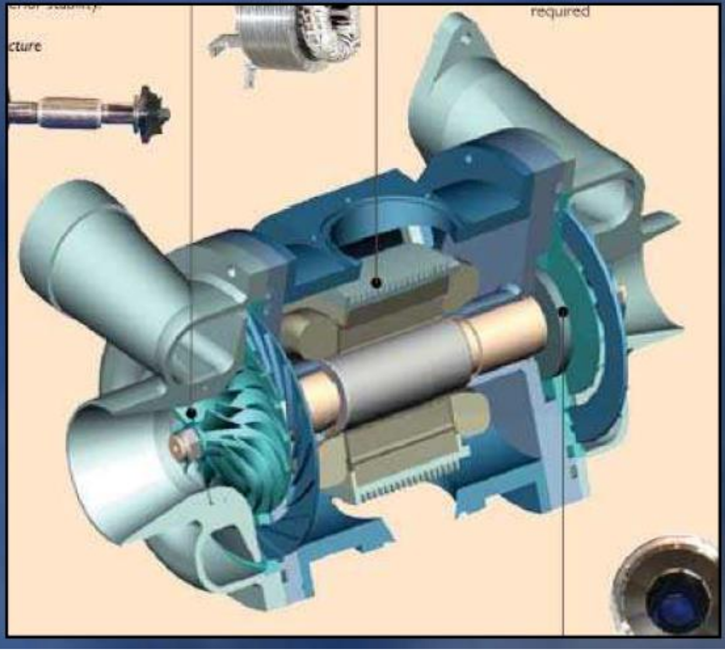
High Speed Blower Technology

- Air Bearings
  - Journal and Thrust Bearing
  - Single or Twin Impellers
  - Originally developed in 1960s for airplane ventilation systems
  - Operate 20,000 to over 40,000 rpm
    - – Efficiency increases with increasing speed
- Magnetic Bearings
  - Journal Bearings and Touch Down Bearing

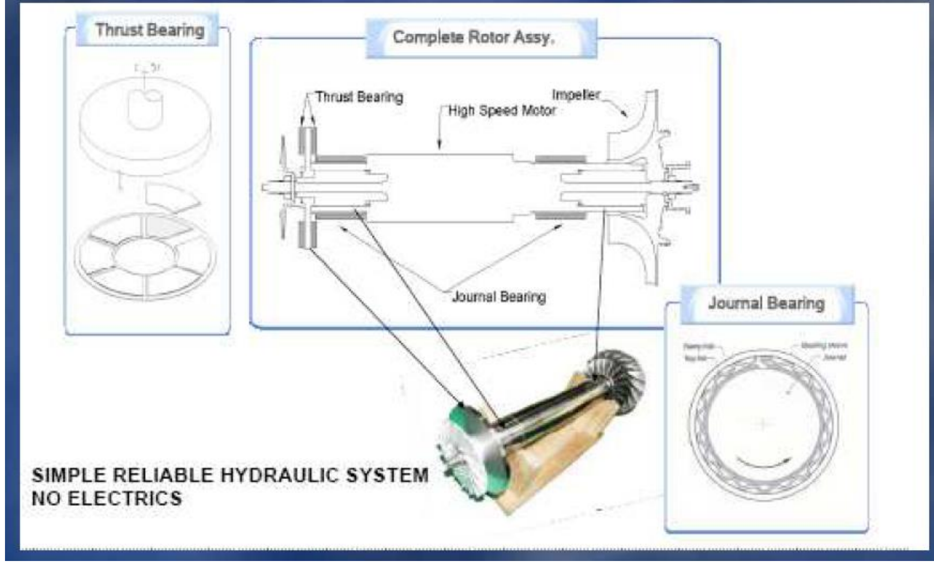
Air Bearing Blowers



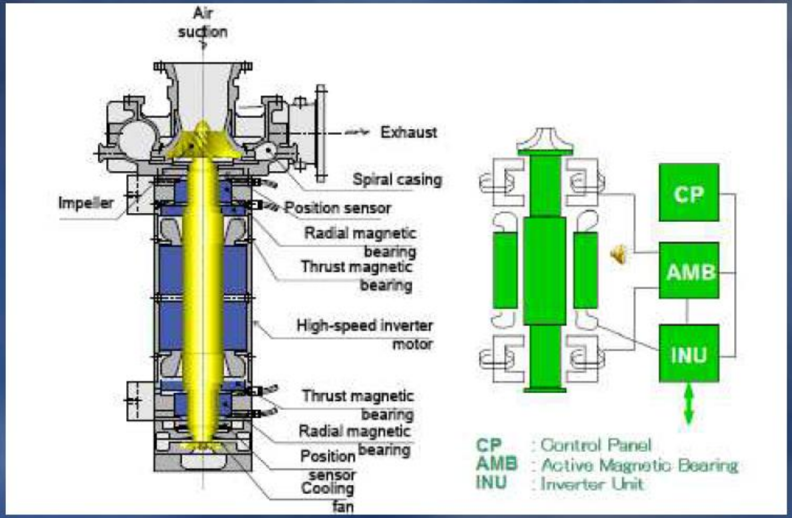
Air Bearing Blowers – Twin Impellers



Rotor Assembly-Air Bearing



Rotor Assembly-Magnetic Bearing



Manufacturers and Available Models Air-foil Bearings

Company	Bearings	Impeller	scfm (6.5 psi)	Max HP	Installations	
					US(9/1/09)	Total (Feb 09)
Nueros	Air	Single	7700	300	86	400
HSI	Air	Twin	8000	300	3	250
Turblex	Air	Single	7700	300	0	0
Kturbo	Air	Twin	8100	300	5	945

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Advantages of Direct Drive, Air-Foil Blowers

- Energy savings
- Higher surge margin
- No lubrication requirements
- Minimum scheduled maintenance
- Easy to install
  - 25% reduction in building footprint
- Compact
- Light weight
- Quiet

MAINTENANCE SCHEDULE

Daily or Before Each Operation	Check the filter pressure drop while the blower is running. Clean or replace the inlet filter before the filter pressure drop reaches 3 kPa.
	Check for unusual noise and vibration.
	Ensure area around the blower is free from debris, flammable or explosive materials.
Monthly *	Inspect inlet filter element. Clean or replace if necessary.

* Inlet filter replacement schedule may vary depending on the running environment.

High Speed Blower "Green" Advantages

Increased Efficiency = Reduces Emissions

Air Lubrication = Oil Free Air

Small Footprint = Reduces Cast Iron Consumption

Integral VFD = Precise Flow Control

Cooling Air Usage = Reduces Heat Rejection

Minor Vibration = Reduces Noise

Carollo Analysis of Bearing Offerings

This older analysis by Carollo is useful but there have been name changes. Turblex is now part of Howden. ABS is part of Sulzer. The Dresser Roots group was sold to GE and is now Howden. Hoffman is part of Gardner Denver

Two Bearing Configurations

Blower Manufacturer	Air Bearing	Magnetic Bearing
Neuros	●	
Turblex	●	
Aerzen	●	
HSi	●	
ABS		●
Dresser Roots	●	
Atlas Copco		●
Piller TSC		●
Hoffman		●
Howden	●	

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Turbo					
	Former or Other Names	Corporate Office Country	Americas Availability	EMEA Availability	Asia Pacific Availability
APG Neuros		Canada M	M		
Atlas Copco					
GL Turbo					
HSI		U.S. M			
Howden	Siemens ,GE, Dresser Roots				
Next Turbo					
Piller					
Spencer					
Sulzer	ABS				
M = Manufacturing S = Sales-Direct D = Distributor (not direct)					

We are requesting input from suppliers relative to product availability by continent.

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Carollo Analysis of Impeller Design and Cooling System

Impeller Design

Blower Manufacturer	Milled Impeller	Cast Impeller
Neuros	●	
Turblex	●	
Aerzen		●
HSi	●	
ABS	●	
Dresser Roots		
Atlas Copco	●	
Piller TSC	●	
Hoffman	●	
Howden	●	

Cooling System

Blower Manufacturer	Use Process Air (Self-Contained within Enclosure)	Separate Cooling System (External Heat Rejection)
Neuros	●	
Turblex		●
Aerzen		●
HSi	●	
ABS		●
Dresser Roots		●
Atlas Copco		●
Piller TSC		●
Howden		●
Hoffman		●

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Atlas Copco New Product ZB 250 High-Speed Turbo Blower for Wastewater Aeration

ZB 100-250 VSD Direct Drive Centrifugal Air Blowers, introduced at WEFTEC 2015; company states a big shift from air-foil to magnetic bearing technology, largely because aeration applications demand safety and reliability above all else. The ZB series of blowers replaces Atlas Copco's legacy HSI units, providing better safety systems with a shaft that is more resistant to large electrical shorts. The ZB blower packages offer a wide capacity range and good efficiency, resulting from the VSD controls. The Elektronikon® system is also worth mentioning, as it allows monitoring for the entire blower installation.

The new ZB 250 high-speed turbo blower provides wastewater aeration basins with high efficiency air, featuring a two-pole permanent magnet motor with rare earth element magnets.
A dedicated bearing controller drives eight radial and two tangential bearing coils, enabling the rotor assembly to spin continually in its geometric center. In the event of a process upset, the bearing controller protects the machine by sensing the change in rotor position and automatically correcting it. If the machine experiences a surge, a shutdown is triggered.
ZB packages come standard in a complete 'ready-to-run' trim level.

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Single Stage Oil Free Compressors

- Single-stage oil-free screw compressors Robust machines; easy to operate; easy to maintain by plant personnel; mean time between overhauls typically 5 to 10 years; only small amount of controls required; no controls required for pressure ratio and air density adjustments; the system backpressure determines automatically the pressure generated by the blower without any controls; at constant speed, less energy than rotary lobe blowers above pressure ratio of 1.7 thanks to internal compression; the power drops and adjusts naturally to the downstream pressure at any moment; flow control using a standard constant torque frequency inverter; at constant pressure, the power is proportional to the speed; the drive uses a NEMA or IEC motor; wide turndown range up to 4:1; no surge limitation; may require more space than an equivalent high-speed turbo blower; compressor bearings are not a limiting factor for number of starts.
- Lower initial and repair costs than a special purpose centrifugal blowers; similar cost to standardized turbo blowers. Due to their operating principle, screw compressors rely on pulsation attenuation at the discharge side to reduce piping noise. Packagers are offering acoustic treatment to meet occupational and environmental noise limits.

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Design Considerations

Aerzen

Matching aeration blowers to plant's demands: A normal operating point should be defined as "the point at which usual operation is expected and optimum efficiency is desired. This point is usually the certified point."1 In other words, if a plant is designed to operate at 80% of its peak, the performance of the aeration blowers should be optimized for that point.

Real plant and operating conditions: The reality of a plant is the result of compromises resulting from the many components combined into a system that needs to perform reliably while subjected to the many interdependent variables that characterize a wastewater treatment operation: quantity and composition of the effluent stream, water and air temperatures, actual vs. future capacity, budget, goals, operator competency, environmental and legal constraints, etc.

Most plants operate with the primary goal of meeting the environmental permit requirements. Managing the plant processes for lowest energy usage and lowest life cycle costs may not be the highest priority, and efforts made to design the most efficient plant could be wasted. Therefore, healthy pragmatism will help prevent spending extra for added complexity that ultimately may become an additional burden to the operations.

Carollo

Specify Site Specific Operating Conditions

- Temperature
  - High Temp used to size blower (volute/impeller)
- Site atmospheric pressure
- Guaranteed power consumption at actual operating conditions
  - Base specified points on estimated operating time under those conditions

Aerzen - Defining the Field of Operation

- The field of operation that the blower system will be subjected to consists of the following parameters: Site conditions: Type of aeration system, Mass flow of air at any moment in time , Other system variables: upstream and downstream
- Type of aeration system; operating pressure The purpose of this section is not a discussion on the most efficient aeration system. Instead, it provides an overview of how components of the aeration system affect the operation of the aeration blowers. 1. Submergence: The depth of submersion of the diffusers determines the hydrostatic head that the blowers must overcome. The submersion ranges typically from 10 ft (3 m) to 26 ft (8m) in municipal wastewater treatment plants, requiring aeration blowers capable of pressures under 15 psig (~1000 mbar), while industrial systems may require 33 ft (10 m) to 66 ft (20 m). For deep aeration applications single stage oil free screw compressors or high-speed centrifugal compressors should be considered.
- Pressure losses must be added to the aeration depth Piping and air distribution system with check valves, isolating valves, elbows other piping components will engender restrictions that, at maximum flow can reach or even exceed 1.0 psi (70 mbar). 3. The head loss across the diffuser system (typically 0.4 to 0.8 psi (30 to 60 mbar)) 4. A safety margin should be added to account for some aging and/or fouling of the diffusers (in the range of 0.5 to 1.0 psi (35 to 70 mbar. When starting up the aeration system, an elevated stagnation pressure needs to be overcome for a short period of time. Moreover, condensate that may have appeared in the pipe must be driven out.
- Variable oxygen need and air flow range The right dosage of the quantity of oxygen at each step of the process and the absorption of the oxygen in the wastewater are the most important parameters that influence the amount of energy used by the plant, since the amount of oxygen is directly proportional to the air flow produced by the aeration blowers. Providing for the correct oxygen level at any moment requires automatic flow adjustments. Blower systems must therefore adapt to these changing conditions in the most efficient and stable way possible, reliably and without surging. This can be accomplished by cycling the blowers, throttling the suction, adjusting outlet diffuser vanes, or using adjustable speed drives. The amount of air required for the aeration will be expressed in units of measure that are independent of the site conditions. These would be scfm (14.7 psia, 70ºF, 36% RH) or Nm3/hr (1.013 bar abs, 0ºC, 0% RH). The sizing of the aeration system will require a calculation of the inlet volume flow: - At maximum temperature and maximum relative humidity - At average temperature and average relative humidity - At minimum temperature and minimum relative humidity
- As an example, if the mass flow of oxygen must vary between 100% and 40% and the ambient conditions vary from a minimum of 14 ºF (-10ºC) / 80% relative humidity and a maximum of 104 ºF (40 ºC) / 65% relative humidity, the turndown capability of the aeration blower system has to be 100% to 32% of the volumetric flow. The turndown capability of the system is determined by the number of blowers, their individual turndown capability, the operating mode (variable flow or on/off cycling operation) and which is largely a function of the blower and drive technology. A wide turndown range is often required to meet the varying oxygen demand: 4:1 to 10:1 are typical.

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Plug and Play Approach and Total Costs

- Plug-and-play approach: An increasing number of manufacturers offer machines in a plug-and-play concept. It is an efficient and attractive proposition to buy industrial equipment as easily as a kitchen appliance. But where one size does not fit all, flexibility is required to meet actual needs. For example, electricians prefer working on motor starters and VFD (if needed) located in a clean and air conditioned electrical room than in the machinery blower room; blowers installed outdoors eliminate the need for a machine room; the control of temperature in a machine room must be achieved without raising the operating costs for air conditioning; in addition to the OSHA limits within the plant, continuous and transient noise emissions may cause problems close in a residential area.
- Total costs: Total costs include the investment costs, energy costs based on anticipated operating conditions over time, maintenance, service, spare parts, and repairs. Unfortunately, costs used to compare proposals are frequently based on hypothetical conditions. Some less obvious aspects are sometimes completely neglected but nonetheless important for the costs of ownership. To mention a few: balanced and stable power supply, unused reserves of pressure or air flow, air filter maintenance/replacement frequency, number of machines, etc.

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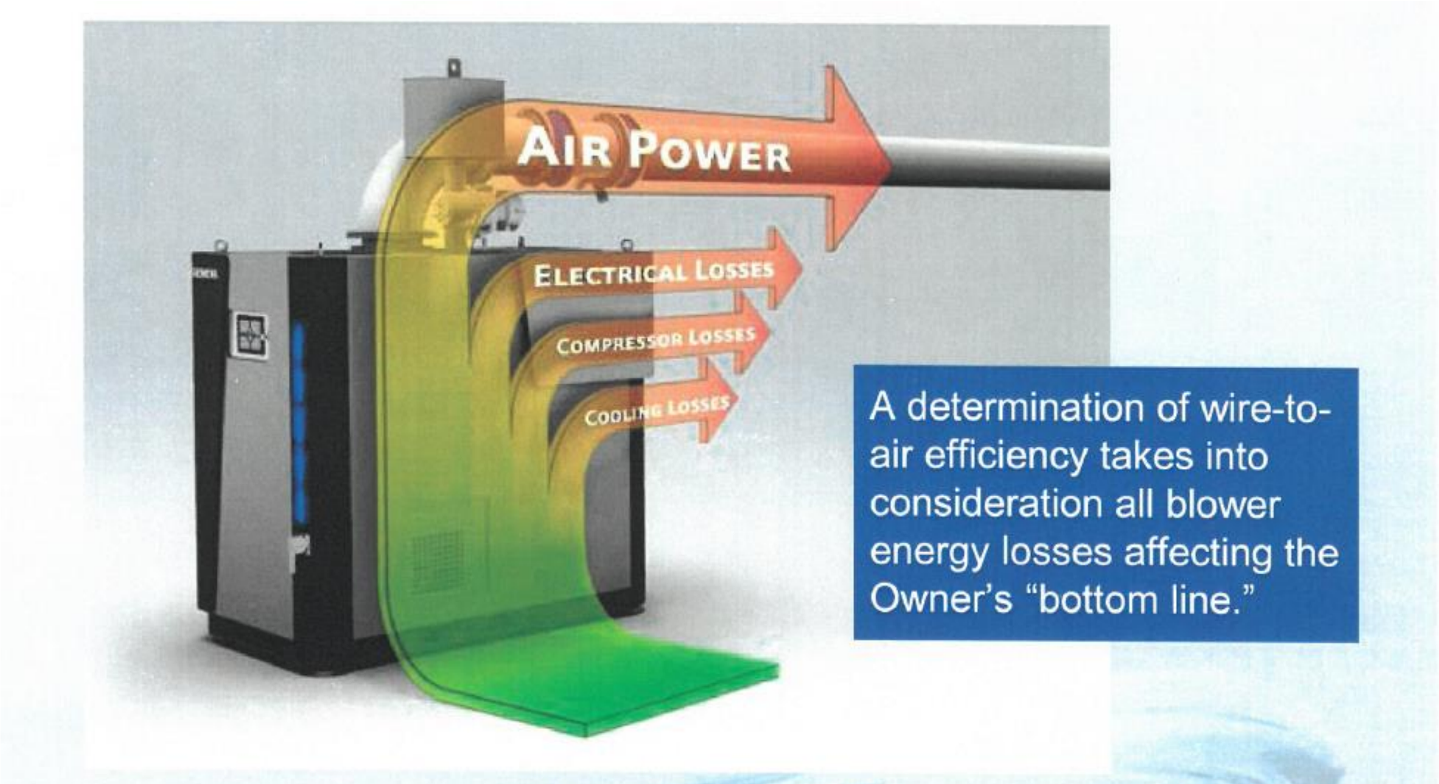
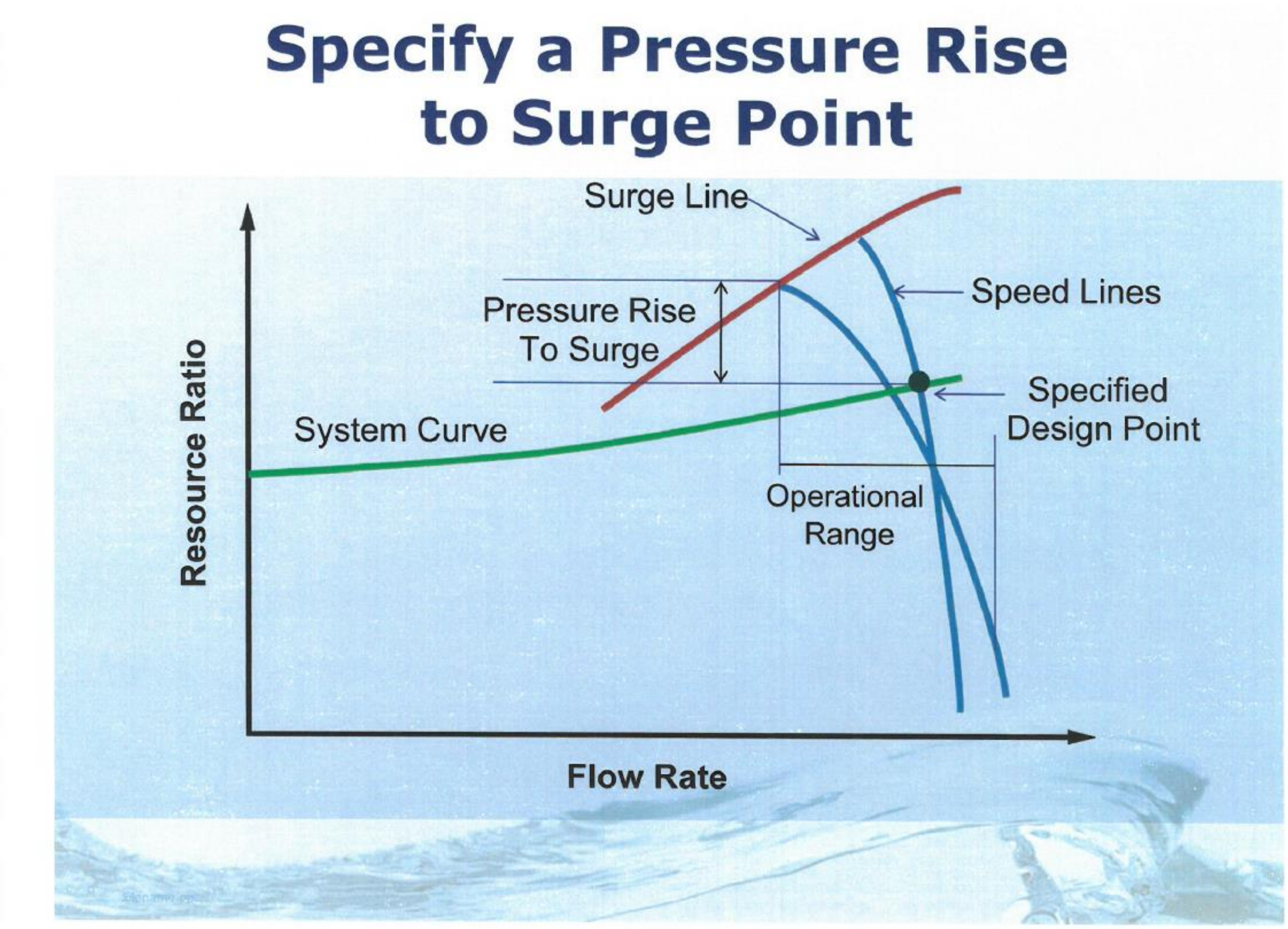
Include all Aspects in Calculating Energy Consumption



* Testing methods are not consistent among different manufacturers

Specify a Pressure Rise to Surge Point



True Cost Evidence

We are requesting additional case histories to cover the variety of applications and approaches which are being used. These will further validate the experience of suppliers and consultants.

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Three Different Blower Types provide Lowest True Cost at CMA

- The Clearfield Municipal Authority (CMA) set out to accomplish a number of key goals when upgrading its regional wastewater treatment plant in Clearfield County, PA, yet few took on more importance than a new aeration blower system capable of efficiently and cost-effectively delivering proper aeration across a wide spectrum of daily and seasonal operating conditions, in addition to meeting the plant's long-term aeration needs. To achieve its goals for aeration, CMA partnered with engineering firm Gwin, Dobson & Foreman, Inc. and blower manufacturer Aerzen USA to design and install a system in that leverages three aeration blower technologies, including turbo blowers, hybrid blowers and positive displacement (PD) blowers. Each fulfills aeration and oxygen demands for separate and distinct applications, while helping CMA continue its strong record of compliance at the lowest possible cost.
- Three BNR reactors. - GD&F opted for turbo blowers rather than PD or Hybrid blowers for the reactors because units are typically more efficient and cost effective in applications with narrow swings in turndown.
- Two digester tanks.- Given the operating conditions of the digester tanks and the need to cost-effectively deliver proper aeration, GD&F specified two 100 HP twisted screw hybrid blowers. The hybrid blowers provide the ability to operate at very high pressure and operate efficiently at those high pressures, yet they also offer tremendous turndown.
- A sludge holding tank.- Given the low operating pressure and lower capital costs, GD&F specified two 50 HP PD blowers for the SH and recycling tanks.
- https://www.blowervacuumbestpractices.com/industries/wastewater/three-blower-technologies-help-pennsylvania-wastewater-plant-meet-wide-range-o

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Kansas City Plant switches from Rotary Lobe to Integrally Geared Blowers

The Sni-A-Bar Municipal Wastewater Plant in Blue Springs, Missouri, partnered with Inovair to replace four fixed-speed rotary lobe blowers on its aeration system with four Variable Frequency Drive (VFD), integrally geared centrifugal blowers.

Measurements indicated that each rotary lobe blower consumed 99.8 kW of electrical input power to deliver 1,875 scfm at 9.5 psig line pressure. By comparison, testing of Inovair's prototype IM blower showed the blower could deliver 1,875 scfm under the same conditions while only consuming 75.2 kW of electrical power, representing a 25 percent savings. Additionally, under worst-case design with ambient conditions of 100 ^{o}F, testing showed the Inovair IM blower could deliver design flow of 1,875 scfm Blue Springs decided to purchase four 100 hp Inovair IM blower units, arranged in 2 stacks of 2 units each. The plan called for Basin 2 to remain aerated by the prototype IM stack. Basin 3 was scheduled for a production IM stack in late spring of 2018. Given IM's configuration and compact footprint, the plant only needed to remove two existing blowers, maintaining three blowers as standby units with one blower dedicated to each basin and a swing blower that could serve either one.

https://www.blowervacuumbestpractices.com/industries/wastewater/sni-bar-wastewater-plant-saves-42000-annually-energy-new-aeration-blowers

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City of Almonte Springs - Aeration Analysis by Tetra Tech

Takeaways

- Older multistage centrifugals replaced with more efficient selections
- Either turbo or rotary blowers recommended for the process
- Concerns about complexity of turning down volume with multi stage centrifugal
- Install centralized aeration control system
- Rotary blower with VFD recommended for aeration in sludge holding tank where load fluctuations offer potential for energy savings

Background

- The City of Altamonte Springs Regional Water Reclamation Facility (RWRF) has a permitted design capacity of 12.5 million gallons per day (MGD) on an average annual daily flow (AADF) basis. The current AADF is approximately half of the permitted value and the facility maintains consistent compliance with regulatory agency permit requirements related to effluent quality.
- The aeration facilities at the plant include six multistage centrifugal blowers, a fine pore diffused aeration system for the treatment process, and a coarse bubble diffused aeration system for the aerated sludge holding tanks. Four of the blowers discharge to a common manifold that serves the process basin and the two remaining blower have a separate manifold that provides air to the sludge holding facilities, however, for reliability purposes, the two manifolds are interconnected The blowers have been in operation for over 20 years and the City is considering replacement of one or two of the units that serve the process basin with newer more efficient machinery that is appropriately sized for current and near-term air demands.
- Also, the City intends to install dedicated blowers adjacent to the sludge holding tanks to simplify process operation and avoid some rather expensive piping replacement that would necessary if the current piping configuration were to remain intact. In view of the above considerations the City retained Tetra Tech to develop and evaluate various blower replacement options. This memorandum presents findings, conclusions, and recommendations resulting from the evaluation of several equipment options; however, it should be noted that this assignment does not address diffused aeration system replacements for the process basin or the aerated sludge holding

Turbo Blower or Rotary Displacement Recommended

- Summary of Improvements and Costs Based on the various analyses described herein, the following improvements are suggested.
- Install two (2) new process aeration blowers with a capacity of 3,500 SCFM each. High efficiency turbo blowers or rotary positive displacement units with axially twisted lobes both represent efficient options; however, the positive displacement machinery has a more extensive track record. Selection of two blowers can be completed after visiting several plants with similar machinery.
- Install one (1) submersible mixer in Zone 3 of each aeration basin to provide efficient mixing and to allow reduced air delivery. Replace the existing 24-inch air header within the aeration basin structure with two (2) separate 20-inch stainless steel air headers.
- Replace the existing 10-inch droplegs and submerged manifold pipes for each diffuser grid. Each new dropleg should include an electrically actuated butterfly valve and air flow meter for precise control of air delivery.
- Install processes monitoring probes within the anoxic and aerobic basins to measure nitrite + nitrate, ammonia, and dissolved oxygen concentrations at selected locations.
- Provide centralized aeration system control via the existing plant control system or with a new PLC-based system. The controls should automatically start and stop the blowers and adjust their speed in response to signals from the process monitoring probes. Also, the control system should automatically adjust the air delivery to each aeration grid based on process feedback.
- Install one (1) new rotary positive displacement blower adjacent to the sludge holding tanks which should be used exclusively for the holding tanks. The blower should include a VFD for adjustment of air delivery to the tanks.

Oxygen Requirements

Air is required for the biological treatment process for CBOD5 removal and nitrification. The Modified Ludzack-Ettinger (MLE) process provides some level of nitrogen removal and the reactions involved in the process result in an “oxygen credit” that mitigates the overall oxygen demand to a modest degree. In order to properly evaluate aeration alternatives, it is first necessary to estimate oxygen demands under current, near-term, and “permitted capacity” conditions. Water Environment Federation Manual of Practice No. 8 (WEF MOP-8) presents relatively straight-forward methodologies to estimate oxygen requirements which are applicable to the MLE process. The table below presents the estimated oxygen requires for current, near-term, and permitted flows using the WEF MOP-8 methodology.

SUMMARY OF PROJECTED OXYGEN REQUIREMENTS

	Time/Condition		
Parameter	Current (2013)	10 Years (2022)	Permitted Capacity
Flows • AADF • MMF • MDF	6.0 MGD 7.8 MGD 10.2 MGD	8.0 MGD 10.4 MGD 13.6 MGD	12.5 MGD 10.4 MGD 13.6 MGD
Oxygen Requirements • AADF • MMF • MDF	16,653 lbs/day 21,445 lbs/day 27,595 lbs/day	22,116 lbs/day 28,387 lbs/day 36,422 lbs/day	34,013 lbs/day 43,355 lbs/day 55,145 lbs/day

Notes:
1. MMF:AADF Peaking Factor = 1.30.
2. MDF:AADF Peaking Factor = 1.70.
3. Flows and loadings for intermediate years may be found by linear interpolation.

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Air Requirements

In order to achieve more economical aeration, the City would like to replace some of the existing blowers with new, more efficient machinery that has the ability to meet wide variations in air demands. Further, the City desires to maintain the current permitted capacity of 12.5 MGD; therefore, the system must be capable of delivering approximately 15,500 SCFM with the largest unit out of service. To meet these goals it is suggested that the City consider replacing two of the existing multistage centrifugal units with blowers rated for 3,500 SCFM each. Under this concept the smaller more efficient machines would provide sufficient air for AADFs for the next 10 years and a "firm capacity" of 21,400 SCFM will be provided, which is more than adequate to address the process aeration needs at the plant's permitted capacity. In fact the firm capacity provided under this scenario is such that only one new dedicated blower would need to be installed at the aerated sludge holding basin if the interconnecting piping between the two systems remains intact.

SUMMARY OF PROJECTED AIR REQUIREMENTS

Parameter	Time/Condition		
	Current (2013)	10 Years (2022)	Permitted Capacity
Air Requirements			
• AADF	5,206 SCFM	6,928 SCFM	10,633 SCFM
• MMF	6,730 SCFM	8,925 SCFM	13,606 SCFM
• MDF	7,737 SCFM	10,288 SCFM	15,461 SCFM

Notes:

1. Air requirements are based on the follow conditions and constants:
   - $\alpha = 0.55$
   - $\beta = 0.95$
   - Barometric Pressure = 14.7 psi
   - Tank Liquid Depth = 15.9 feet
   - Temperature = 20° C
   - Standard Oxygen Transfer Efficiency = 30%
   - Operating DO @ AADF & MMF = 2.0 mg/L
   - Operating DO @ MDF = 1.0 mg/L
2. Air requirements for intermediate years may be found by linear interpolation.

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Three Options Available

- Process Aeration Blower Options There appear to be three basic equipment options that merit consideration for the new process aeration blowers. Each option is described below.
- Multistage Centrifugal Blowers: Replacing two of the existing 300 horsepower blowers with smaller more efficient multi-stage units would provide energy savings by providing a greater range of efficient operation or better “turndown” and improved compression efficiency. The units supplied under this option would be very similar to the existing units; however, they would be smaller and have 200 horsepower drive motors.
- High-Efficiency Turbo Blowers: The latest high efficiency blower technology involves high-speed blowers with air bearings that accommodate rotational speeds of 20,000 to 30,000 RPM. These machines are very small in physical size when compared to multi-stage centrifugal or rotary positive displacement units and they feature a unitized package that includes the blower, variable frequency drives, and controls. As is the case with smaller multistage units, replacing two of the existing 300 horsepower blowers with smaller more efficient turbo units would provide energy savings by providing a better turndown and improved compression efficiency.
- The third option for provision of smaller more efficient blowers involves the installation of two rotary positive displacement blowers. This type of blower feature pairs of rotating lobes that provide air delivery in direct proportion to blower speed at efficiencies that are slightly less than those published for multi-stage centrifugal or turbo blowers. The lobes are usually straight; however, an axially twisted configuration is available that improves compression efficiency and lowers noise emissions. These blowers are usually furnished in a unitized package that includes the blower, variable frequency drive, and controls. Once again, replacing two of the existing 300 horsepower blowers with smaller more efficient units would provide energy savings by providing a better turndown and improved compression efficiency. Plotting the power requirements and allowable range of air delivery for the existing machinery and potential blower options provides a useful “initial comparison” of alternatives.

1. All of the replacement blower options are considerably more efficient than the existing blowers when air flow is in the range of approximately 2,500 to 3,500 SCFM.

2. All three blower replacement options have similar efficiencies when air deliveries are in range of 2,500 to 3,500 SCFM.

3. The rotary positive displacement blower option has better turndown than the other two replacement options.

TABLE 8

ESTIMATED CAPITAL, OPERATING, & PRESENT WORTH COSTS FOR PROCESS BLOWERS

		New Multi-Stage Centrifugal Blowers			High Efficiency Turbo Blowers			Rotary Positive Displacement Blowers		
CAPITAL COSTS										
Blower Equipment				$164,000			$240,000			$200,000
Piping Modifications				$31,000			$31,000			$31,000
Tax, Overhead, Profit, & Installation				$65,600			$96,000			$80,000
Sub-Total				$260,600			$367,000			$311,000
Engineering & Contingency				$52,120			$73,400			$62,200
Total Capital Cost				**$312,720**			**$440,400**			**$373,200**
POWER COSTS										
Year	Air Required @ AADF (SCFM)	Total Operating Power (HP)	Annual Power Cost, $/year	Present Worth of Power Cost	Total Operating Power (HP)	Annual Power Cost ($/year)	Present Worth of Power Cost	Total Operating Power (HP)	Annual Power Cost, $/year	Present Worth of Power Cost
1	5,210	257	167,845	157,601	234	$152,774	$143,450	273	$178,597	$167,697
2	5,401	274	178,852	157,686	241	$157,473	$138,838	279	$182,480	$160,885
3	5,592	284	185,730	153,757	248	$162,350	$134,401	294	$192,186	$159,101
4	5,783	291	189,858	147,581	255	$166,949	$129,773	300	$196,069	$152,409
5	5,974	291	189,858	138,574	264	$172,220	$125,700	342	$223,247	$162,943
6	6,166	295	192,609	132,002	272	$177,506	$121,651	321	$209,658	$143,686
7	6,357	305	199,488	128,372	280	$182,747	$117,599	330	$215,481	$138,664
8	6,548	326	213,246	128,850	288	$187,975	$113,580	339	$221,305	$133,720
9	6,739	337	220,125	124,889	296	$193,458	$109,759	351	$229,070	$129,964
10	6,930	341	222,877	118,732	305	$199,220	$106,130	359	$234,894	$125,134
10-Year PW of Power Costs				**$1,388,043**			**$1,240,880**			**$1,474,202**
TOTAL PRESENT WORTH				**$1,700,763**			**$1,681,280**			**$1,847,402**

Notes:
1. Two blowers are operating at all time; however, air deliver is matched to demand. Inlet throttling is assumed for muti-stage centrifugal blowers while speed adjustment is assumed for turbo and rotary positive displacement blowers.
2. The total operating horsepower values presented reflect total power draw and include applicable allowances to address motor and VFD efficiencies.
3. Power costs are based on a unit cost for energy of $0.10/kWh.
4. Present worth costs are based on a discount rate of 6.5%.

Concerns about Complexity of Turndown with Multi Stage Centrifugal

- When evaluating blower options it is important to carefully consider turndown in the overall analysis. In the case of the Altamonte Springs WRF, it is assumed that a low flow condition occurs from about midnight to 6:00 am which results in a fairly steady flow of about 3 MGD. During this period the air demand for treatment is about 2,600 SCFM; however, properly mixing the basin necessitates an air flow of approximately 3,000 SCFM. If one of the existing multistage blowers is used to deliver 3,000 SCFM the resulting power draw equals approximately 191 horsepower if inlet throttling is practiced.
- In contrast, the smaller replacement blowers would draw between 130 and 150 horsepower during the 6-hour low-flow period depending upon which type of equipment is selected. On an annual basis, the replacement blowers could result in a savings ranging from about $7,000 to $10,000/year. Without inlet throttling, an existing multistage blower will draw about 240 horsepower and annual cost savings associated with the replacement machinery would range from $15,000 to $18,000/year.
- Based on these values, it is clear that provision of smaller more efficient blowers can result in significant savings once the process and sludge holding basin air requirements are segregated. Based on the present worth cost evaluation and the values presented above with regard to aeration during low-flow periods, it is apparent that the high-efficiency turbo blowers offer a modest economic advantage.
- The multistage centrifugal blowers have economic characteristics similar to the turbo blower; however, to achieve turndown via inlet throttling a modulating valve would be necessary and concerns related to control complexity and surging make this option less desirable.
- The rotary positive displacement blower option carries the highest present worth cost, but as previously stated, it is comparable in cost to the other alternatives. Precise air flow control, the use of well-proven technology, a wide turndown range, and the provision of a programmable logic controller that only requires an input DO signal compensates for a slightly higher cost of the rotary positive displacement blower packages; therefore, they are considered to be equal to the turbo units in terms of desirability. To facilitate a final selection, it is suggested that City Staff visit local installations featuring both types of equipment and make a decision based on operator preference.

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Aerated Sludge Holding Tank Blower Options

Multi-stage centrifugal blowers have very “flat” delivery curves which make them somewhat undesirable in applications that involve varying water depths. Since the levels in the holding tanks vary, centrifugal blowers do not appears to merit consideration as an option for the dedicated holding tank blower. In view of this factor, the following options appear feasible.

High-Efficiency Turbo Blowers: A single high-efficiency turbo blower similar to the units considered for process aeration could be installed adjacent to the sludge holding basins to act as the primary source of air for the basins. The existing multi-stage centrifugal blowers located in the blower building would act as a back-up source air in the event that the new turbo blower becomes inoperable. Attachment D presents manufacturer’s cuts sheet and performance curves for this option.

Rotary Positive Displacement Blowers: This type of blower is similar to the rotary positive displacement machinery considered for process aeration; however, it would have straight lobes rather than helical lobes. As in the case with the turbo blower, a single unit could be installed adjacent to the sludge holding basins to act as the primary source of air for the basins while existing multi-stage centrifugal blowers located in the blower building would act as a back-up source air. Attachment E presents manufacturer’s cuts sheet and performance curves.

When comparing annual operating and present worth costs as part of a blower evaluation, it is typical to consider the design air flow of resulting from an aeration intensity of 30 SCFM/1,000 CF. It is understood that lower air demands may provide acceptable mixing and DO levels, however, using the typical design aeration intensity provides a useful “baseline comparison” that reflects the relative compression efficiency of the options under consideration. Accordingly, Table 9 presents the estimated equipment, annual operating and present worth costs for each of the blower options at an air flow of 4,800 SCFM.

TABLE [illegible]

ESTIMATED CAPITAL, OPERATING, & PRESENT WORTH COSTS FOR SLUDGE HOLDING TANK BLOWER

		High Efficiency Turbo Blower			Rotary Positive Displacement Blower		
CAPITAL COSTS							
Blower Equipment				$180,000			$125,000
Piping Modifications				$17,000			$17,000
Tax, Overhead, Profit, & Installation				$102,000			$80,000
Sub-Total				$299,000			$222,000
Engineering & Contingency				$59,800			$44,400
Total Capital Cost				**$358,800**			**$266,400**
POWER COSTS							
Year	**Air Required @ AADF (SCFM)**	**Total Operating Power (HP)**	**Annual Power Cost ($/year)**	**Present Worth of Power Cost**	**Total Operating Power (HP)**	**Annual Power Cost, $/year**	**Present Worth of Power Cost**
1	4,800	216	$140,953	$132,350	258	$168,714	$158,417
2	4,800	216	$140,953	$124,273	258	$168,714	$148,748
3	4,800	216	$140,953	$116,688	258	$168,714	$139,670
4	4,800	216	$140,953	$109,566	258	$168,714	$131,145
5	4,800	216	$140,953	$102,879	258	$168,714	$123,141
6	4,800	216	$140,953	$96,600	258	$168,714	$115,626
7	4,800	216	$140,953	$90,704	258	$168,714	$108,569
8	4,800	216	$140,953	$85,168	258	$168,714	$101,942
9	4,800	216	$140,953	$79,970	258	$168,714	$95,721
10	4,800	216	$140,953	$75,089	258	$168,714	$89,878
10-Year PW of Power Costs				**$1,013,287**			**$1,212,858**
TOTAL PRESENT WORTH				**$1,372,087**			**$1,479,258**

Notes:

1. The total operating horsepower value presented reflect total power draw and include applicable allowances to address motor and VFD efficiencies.
2. Power costs are based on a unit cost for energy of $0.10/kWh.
3. Present worth costs are based on a discount rate of 6.5%.

Turbo Blower more Expensive but more Efficient

As shown in Table 9 the turbo blower is considerably more expensive than the rotary positive displacement unit from a capital cost standpoint; however, the increased compression efficiency of the turbo machine more than compensates for the additional capital cost when present worth is calculated. This finding is useful, but there are two operating options that merit consideration which might alter the present worth analysis. First, since the aerated sludge holding tanks do not provide significant VSS reduction, the detention time does not appear to be critical; therefore, the operating volume can be decreased without significantly affecting operation. To accomplish liquid levels in the holding tanks could be reduced, which would lower the discharge pressure for the blowers and decrease the volume that needs to be aerobically mixed. Second, it is likely that an aeration intensity of 20 SCFM/1,000 CF will be adequate to mix the reduced basin volume and maintain aerobic conditions, which reduces the needed air delivery. Implementing both of these operational modifications would result in an air flow of approximately 2,100 SCFM and a blower discharge pressure of 5.0 psi. In practical terms, the 4,800 SCFM machinery previously described would be installed, but operated at much more favorable conditions that would lead to decreased power consumption. Table 10 presents an economic comparison of the two blower options under the reduced air flow and discharge pressure scenario.

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ESTIMATED CAPITAL, OPERATING, & PRESENT WORTH COSTS FOR SLUDGE HOLDING TANK BLOWER AT REDUCED AIR FLOW & PRESSURE

		High Efficiency Turbo Blower			Rotary Positive Displacement Blower		
CAPITAL COSTS							
Blower Equipment				$180,000			$125,000
Piping Modifications				$17,000			$17,000
Tax, Overhead, Profit, & Installation				$102,000			$80,000
Sub-Total				$299,000			$222,000
Engineering & Contingency				$59,800			$44,400
Total Capital Cost				**$358,800**			**$266,400**
POWER COSTS							
Year	**Air Required @ AADF (SCFM)**	**Total Operating Power (HP)**	**Annual Power Cost ($/year)**	**Present Worth of Power Cost**	**Total Operating Power (HP)**	**Annual Power Cost, $/year**	**Present Worth of Power Cost**
1	2,100	67	$43,915	$41,235	72	$47,052	$44,180
2	2,100	67	$43,915	$38,718	72	$47,052	$41,484
3	2,100	67	$43,915	$36,355	72	$47,052	$38,952
4	2,100	67	$43,915	$34,136	72	$47,052	$36,574
5	2,100	67	$43,915	$32,053	72	$47,052	$34,342
6	2,100	67	$43,915	$30,096	72	$47,052	$32,246
7	2,100	67	$43,915	$28,260	72	$47,052	$30,278
8	2,100	67	$43,915	$26,535	72	$47,052	$28,430
9	2,100	67	$43,915	$24,915	72	$47,052	$26,695
10	2,100	67	$43,915	$23,395	72	$47,052	$25,066
10-Year PW of Power Costs				**$315,697**			**$338,247**
TOTAL PRESENT WORTH				**$674,497**			**$604,647**

Notes:

1. The total operating horsepower value presented reflect total power draw and include applicable allowances to address motor and VFD efficiencies.
2. Power costs are based on a unit cost for energy of $0.10/kWh.
3. Present worth costs are based on a discount rate of 6.5%.

Two Rotary or Turbo Blowers for Process Aeration and One Rotary for Sludge Holding

Blower Recommendations

Based on the various analyses described above, it is recommended that the City install two (2) high efficiency turbo blowers or two (2) rotary positive displacement blowers rated for 3,500 SCFM each for process aeration. The final selection of machinery should be completed after visiting treatment plants for other communities to observe the operation of similar units. For sludge holding tank aeration, it is suggested that the City install a single rotary positive displacement blower adjacent to the existing holding tanks. This blower should be designed to provide an air flow of 4,800 SCFM and function with a VFD to allow the delivery to be decreased to 2,100 SCFM. Further, it is suggested that liquid depth in the holding tank should be decreased to about 11 feet on a trial basis. This operational modification will lead to significant power cost savings due to decreases in air delivery volume and blower discharge pressure.

The net impact of the new equipment on power cost is difficult to accurately ascertain for a variety of reasons. Regardless of the possible shortcomings, it is still reasonable to make some sort of estimate of the potential savings that are associated with the recommended improvements. Table 11, below, provides a comparison of the operating scenarios and costs with and without the suggested improvements.

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POTENTIAL POWER COST REDUCTIONS

Current Operating Scenario	
<u>1 – 300 HP Blower Operating @ 240 HP (24 Hours/Day)</u>	
Annual Energy Consumption:	1,568,000 kWh/year
Estimated Power Cost:	$156,800/year
<u>1 – 300 HP Blower Operating @ 240 HP (16 Hours/Day)</u>	
Annual Energy Consumption:	1,046,000 kWh/year
Estimated Power Cost:	$104,600/year
Total Estimated Power Cost:	**$261,400/year**
Suggested Operating Scenario	
<u>2 – 200 HP Turbo Blowers Operating @ 117 HP Each (24 Hours/Day): Process Aeration</u>	
Annual Energy Consumption:	1,529,000 KWh/year
Estimated Power Cost:	$152,900/year
<u>1 – 250 HP Rotary Positive Displacement Blower Operating @ 75 HP (24 Hours/Day): Sludge Holding</u>	
Annual Energy Consumption:	471,000 KWh/year
Estimated Power Cost:	$47,100/year
Total Estimated Power Cost:	**$200,000/year**
Estimated Savings:	**$61,400/year**

Air Delivery Automation

Automation of Air Delivery: Currently blowers are started and stopped manually based on observed operating conditions. Similarly, the airflows to the various zones within the process basins and holding tanks are manually controlled by adjusting the position of several butterfly valves. Providing a dedicated blower for the holding tanks will simplify the overall operation of the system; however, to provide an automated system, various modifications will be necessary. First, the number of blowers that run at any given time and the speed at which they operate should be controlled in response to DO and/or ammonia signals. Ideally, one DO probe would be installed for each dropleg zone and one ammonia probe would be installed in the central aeration zone in each train. The signals from these probes would then be used to automatically start and stop the blowers, and vary their speeds, based on the measured DO or ammonia values. Additionally, electrically actuated valves and air flow meters should be installed to control the amount of air delivered to each aeration grid. The electrically actuated valves and flow meters will necessitate the installation of entirely new droplegs due to "straight run" requirements for the flow meters. It is probable that the existing plant-wide SCADA system could be reprogrammed to achieve the desired level of control; however, it will still be necessary to invest in DO probes, ammonia probes, electrically actuated butterfly valves, air flow meters and related piping, electrical and fiber optic components. Figure 4 presents an overall schematic showing the piping improvements as well as the suggested locations for the various process monitoring probes.

High Speed Turbo Blowers for Wastewater Treatment Aeration

This paper is included in the intelligence system. It provides a valuable analysis of a control program to maximize efficiency and take advantage of features of the turbo blowers.

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This paper presents a case study of the City of Garland, Texas Rowlett Creek Wastewater Treatment Plant. In 2009 the City began designing an upgrade to the aeration system at the plant. During design, high-speed turbo blowers were investigated and specified as the preferred technology for the plant. These blowers were integrated with four existing multistage centrifugal blowers. Blowers were installed and started in 2011. Discussions on technology, specifications, controls, instrumentation, startup and operational experiences will be included in the paper.

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Paper, cont.

In addition to the operational advantages, an investigation into costs was made. Although the capital purchase costs for HST blowers is about 50% higher than purchase costs for MSC blowers, the higher efficiency/lower energy costs for HST blowers recoup the additional capital costs within 2 years. Figure 5 below shows the long term costs for three different blowers.

	Quantity	Units	Description	Unit Cost	Extended Cost
High Speed Turbo Blowers					
	2	EA	5,800 cfm HST Blowers @ 7.8 psig (250 Hp)	$176,475	$352,950
	1	EA	Electricity, NPV @ 6% annually for 20-yrs @ 9.3¢/kWh	$1,831,486	$1,831,486
				Total 20-Year Cost	$2,184,436
Multistage Centrifugal Blower #1					
	2	EA	5,800 cfm MSC Blowers @ 7.8 psig (350 Hp)	$121,465	$242,930
	1	EA	Electricity, NPV @ 6% annually for 20-yrs @ 9.3¢/kWh	$2,990,181	$2,990,181
				Total 20-Year Cost	$3,233,111
Multistage Centrifugal Blower #2					
	2	EA	5,800 cfm MSC Blowers @ 7.8 psig (350 Hp)	$113,750	$242,930
	1	EA	Electricity, NPV @ 6% annually for 20-yrs @ 9.3¢/kWh	$2,803,295	$2,803,295
				Total 20-Year Cost	$3,030,795

Mode	Lead (Primary) Blower	Lag 1 (Secondary) Blower	Lag 2 (Next) Blower	Lag 3 (Final) Blower
Warm	Higher Capacity HST	First Available MSC	Last Available MSC	N/A
Cold	Lower Capacity HST	Higher Capacity HST	First Available MSC	Last Available MSC

Figure 11 - Operational Modes

In determining the order of blowers started, the following points are considered:

1. The Control Room Operator chooses to operate the system in Warm Mode or Cold Mode based on weather conditions and plant experience.
2. The two HST blowers are not to run at the same time.
3. In Cold Mode, there are still days when the air capacity is greater than what the single lower capacity HST blower can deliver. In that case, the higher capacity HST blower will start and the lower capacity blower will stop if the lower capacity HST blower cannot keep up with air demands.
4. Whenever the higher capacity HST is unable to keep up with air demands, the two MSC blowers are started in a sequence set by the Control Room Operator and run in parallel with the HST.

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One HST Blower for Hot Weather and Another for Cold - City of Garland

Blower surge was a main design concern. The existing blowers, which were already prone to surge, would be connected to the same air header as the new HST blowers. Operationally, one HST blower would act as the main blower and an existing MSC blower would provide supplemental air. This arrangement led to the requirement that both new HST blowers must have the same maximum discharge pressure as the existing MSC blowers. By operating at the same maximum pressure, the new blowers would not over pressure the air header to and send the existing blowers into surge.

As designed, one HST blower would operate when air demand is between 2,900 cfm and 5,800 cfm (the HST operating range). If aeration demand exceeds 5,800 cfm, the HST blower will turn down to 2,900 cfm and the existing MSC blower will start, providing 2,900 cfm of air. The HST blower can then ramp up to any point between 2,900 cfm and 5,800 cfm to provide up to 8,700 cfm. If air demands exceed 8,700 cfm, the second HST blower or a second MSC blower can be started to provide additional air.

Following startup, one core was replaced on the HST blower. Operators had been unable to adequately turn down the blower speed for cold weather operation and were forced to "waste" air. By replacing only one core, the City had the ability to use one HST blower for cold weather operation and one HST blower for warm weather operation. Since there is a significant overlap in the operating range for the two cores there was no loss in redundancy.

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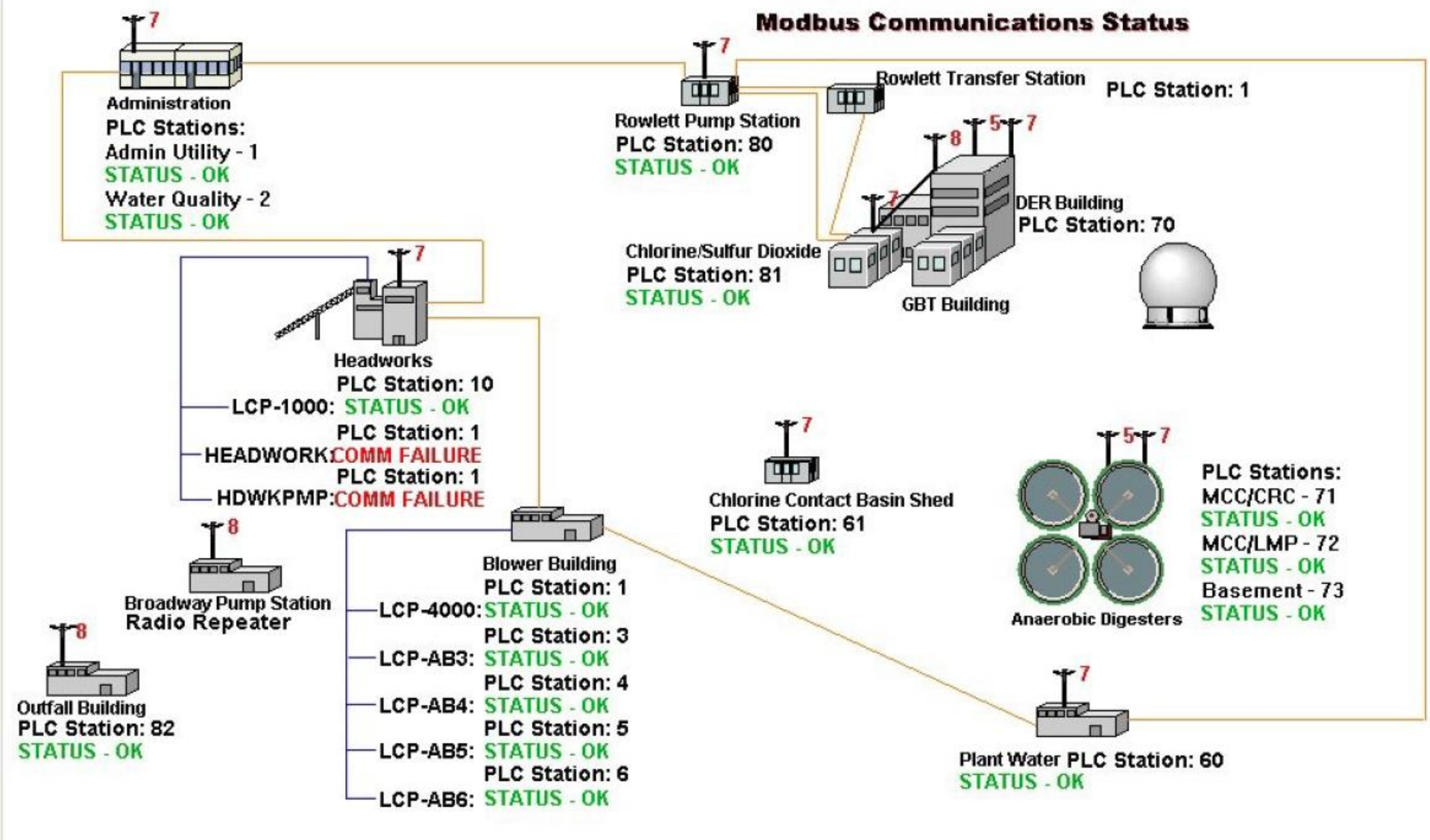
City of Garland Controls



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WRPB WWTF – Franklin, New Hampshire

- Winnipesaukee River Basin Program
  - State-owned and operated
  - 10 community regional facility
  - Located in lakes region of New Hampshire
- Secondary Treatment Facility
  - Placed into operation 1979
  - 11.5 mgd design flow; 6.6 mgd current flow

WRPD Aeration History

- Original plant
  - 5-Cord PD each rated @ 3200 cfm
  - Coarse bubble diffusers
- Blowers replaced with 5-Roots PD 824 RCS in early 1990s
  - 124 HP, 2650 cfm, 8.0 psi, 2250 rpm
- Fine bubble diffusers installed in mid 1990s
  - Two of the Roots blowers removed
- Automatic DO control installed in 2000
  - Original motors and DC drives replaced
    - New motors and VFDs
  - Vibration issues prohibited auto DO control
  - Significant constraints on blower operation
    - Plant running inefficiently with high DOs @ low demand, insufficient DO @ high demands

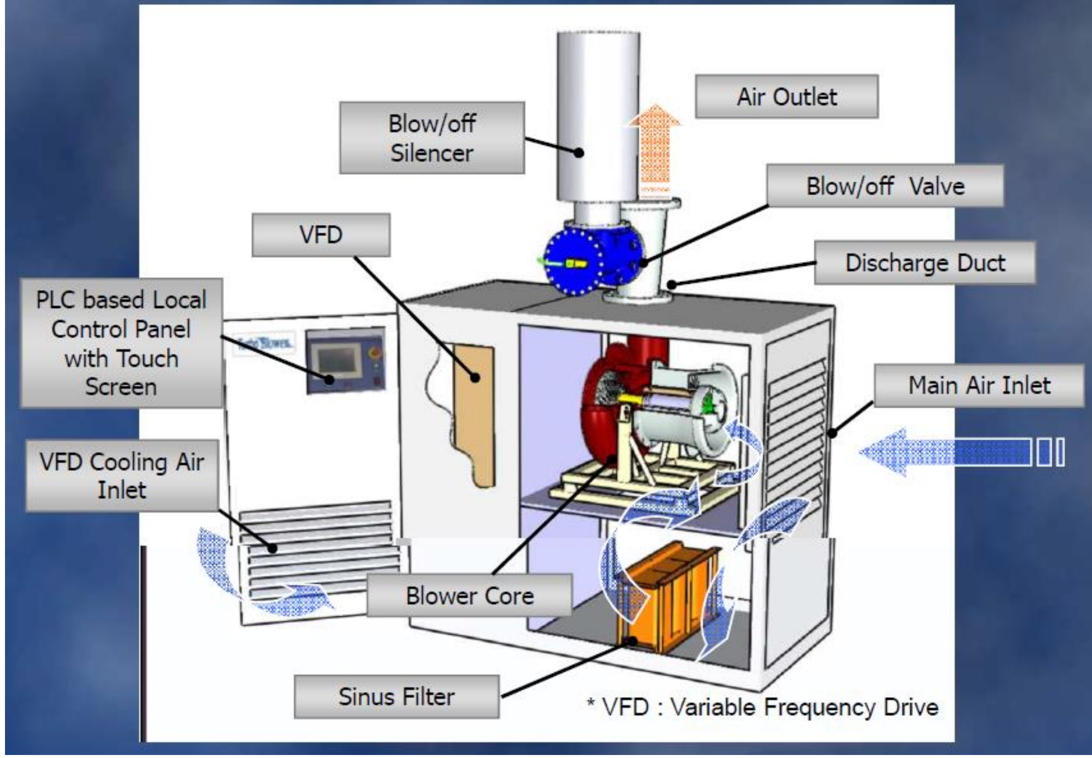
Multi-phased Capital Improvement Program

- Focus
  - Sustainable design with long-term sustainability
  - Appropriate incorporation of green technologies
  - Governor mandated reduction of energy consumption by 10% in state facilities
    - Energy consumption at all new construction 20% less than state energy code
- CDM retained in June 2008
- Initial focus: Aeration system
  - Accounts for 36% of total electrical consumption @ plant

60 Day Neuros Pilot at Franklin NH

- Unit supplied by APG-Neuros Inc., Quebec Canada Neuros Co., Inc
- Started operation in Franklin Sept 25, 2008
- Operating evaluation through November 2008
- Goals
  - Validate claims made by direct drive manufacturers
  - Increase blower reliability
  - Simplify operation
  - Significant reduction in energy consumption

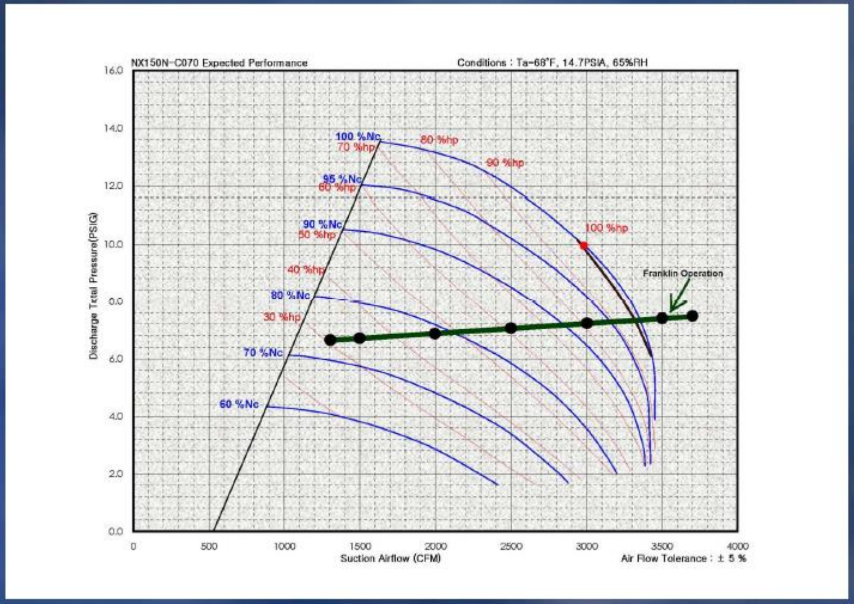
Packaging of Neuros NX Turbo Blower



Manufacturer	APG-Neuros Inc
Model	NX150-C070
Speed (max)	21,870 rpm
Motor	150 HP Permanent Magnet
Discharge Pressure	8.5 psi (impeller) 10.7 psi (machine)
Impeller	Single, Forged Aluminum (Axial + Centrifugal)
Air Flow Range	1,175 – 2,600 scfm
Bearing Type	Bump Air Foil, Oil less
Dimensions	30 in wide x 68 in length x 53 in high
Weight	1,675 lbs

- Air flow rates approaching max capacity of existing units:
  - Demonstration unit 20% more efficient
- Air flow rates at lower limits of existing capacity
  - Demonstration unit 30% more efficient
- Average air demand @ WRBP WWTF = 2,600 scfm
  - Efficiency of the demonstration unit at 2,600 scfm 32% less than average power consumption of existing blowers

Operating Points on Blower Curve



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Blower Noise

- Measurements at approx 3 ft from blower enclosure.
- Operating at 1360-1390 cfm, 18400 rpm, 6.6 psi discharge
- 69-75 dBA
- Startup (20 seconds)
  - 95-100 dBA
- Shutdown (4 seconds)
  - 90-95 dBA
- Shutdown and startup through relief discharge directly to room

Conclusions from Demonstration

- Direct drive unit consumed 32% less power than existing PDs (direct wire to water)
- Automatic DO control & optimized unit sizing will reduce power consumption to 49-54% less than existing PDs
- Unit efficiency constant over full operating range
- Very quiet operation (69 to 75 dBA with no silencers)
- Small space requirement
- Equipment pad and anchor bolts optional
- Vibration free from speeds approaching surge to full speed of 21,870 rpm
- Installation is “plug &play”

Fayetteville Wastewater Treatment Plant Lowers Operational Costs, Increases Efficiencies

At the Fayetteville WWTP, action has taken the form of a forward-thinking approach to plant operation and multiple initiatives designed to lower the costs of operation and improve efficiencies. Among its initiatives is a $5 million plant upgrade involving the installation of advanced technology, including:

A Supervisory Control and Data Acquisition (SCADA) system.

Updated aeration basins featuring Luminescent Dissolved Oxygen (LDO) probes. Before the plant upgrade, it also installed Variable Speed Frequency Drives (VFDs) on mechanical surface aerators used on the aeration basins.

High-efficiency aeration blowers for optimization of its digester storage tanks.

A state-of-the-art dewatering system, featuring a high-efficiency centrifuge and other equipment designed to save costs and more.

When planning the upgrade, FPU determined it could realize more cost-savings with updated aeration blowers used to provide oxygen needed to metabolize the organic compounds in the sludge, while also meeting BOD_5 levels. As such, it replaced its two 125-hp blowers with three, new Aerzen 75-hp positive displacement blowers as part of its plant upgrade. Each blower is rated to deliver 1,500 CFM at 6 psig.

During normal load conditions, the plant operates the digesters at 50 to 75 percent capacity. During the 36-hour aeration period, plant operators manually activate a single blower to provide all the aeration needed for both digesters. The aeration strategy calls for operators to activate a second blower during a rare situation when the plant has reached its peak daily flow and both digesters are at full capacity. The third blower provides system redundancy. The primary blower is turned off during non-aeration periods.

https://www.airbestpractices.com/industries/wastewater/fayetteville-wastewater-treatment-plant-lowers-operational-costs-increases-eff

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Snohomish Public Utility District selects High Speed Blowers for Energy Efficiency

- Snohomish Public Utility District undertook an energy efficiency program The wastewater facility ultimately selected an option with the high-speed blower and fine-bubble diffusers—which had the lowest annual energy and maintenance costs.
- High-speed blowers can offer significant efficiency improvements, compared to mechanical aerators, or positive displacement and multi-stage centrifugal blowers. They achieve this through the use of highly-efficient permanent magnet motors and a frictionless magnetic or airfoil bearing design that improves the unit's mechanical efficiency. The blower installed at the Washington wastewater facility also included integrated dissolved oxygen sensors and a variable speed drive that modulated the speed of the blower to maintain a specified oxygen concentration in the wastewater stream.
- https://www.airbestpractices.com/industries/wastewater/aeration-energy-offers-opportunities-save

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Kaeser says Rotary Screw Blowers are up to 35 Percent more Efficient than Conventional Blower

- Rotary screw blowers have better specific performance (more air per kW) than lobe blowers due to their compression process. Lobe blowers utilize external compression—air is not compressed within the block itself. Lobe blowers have two impellers and the inlet is directly opposite the discharge port. As one impeller begins to seal off the air inlet, air is trapped between the blower case and the impeller. Meanwhile, the other rotor begins to open at the outlet. The impeller sweeps the trapped air to the discharge port where it passes on to the discharge piping—pressure builds in the piping in relation to the length and diameter of the piping and the depth of the wastewater pond. Lobe blowers all have some degree of “slip” which allows air to flow from the high-pressure side to the low-pressure side. This is a source of inefficiency.
- https://www.airbestpractices.com/industries/wastewater/kaeser-rotary-screw-blowers-wastewater-aeration

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Magnetic Bearings: An Attractive Force for Energy-efficiency

- Reducing the energy requirements of aeration blowers will help plants cut their energy costs and CO2 emissions. SKF’s high-speed permanent magnet motor solutions that utilize magnetic bearings are already making it possible.
- Magnetic bearing systems represent an innovative approach to the support of rotating equipment, achieving performance levels not previously possible with traditional rolling element or fluid film bearing technologies. Magnetic bearings are a non-contacting technology, and as such they offer a range of important benefits, from almost zero friction, active vibration control, reduced energy consumption and the elimination of bearing wear. In addition, it is possible to operate at speeds that were unachievable with traditional technology. Magnetic bearings are ideal for use in processes that are sensitive to contamination since the need for lubrication and maintenance has been eliminated. A wastewater plant replaced lobe type blowers with centrifugal blowers featuring SKF permanent magnet motor with immediate success
- https://www.airbestpractices.com/technology/blowers/magnetic-bearings-attractive-force-energy-efficiency

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Evaluating Different Blower Technologies on a Wire-to-Air Basis

- Five basic blower technologies serve the water and wastewater markets: Positive Displacement Lobe Type, High Speed Screw, Multistage Centrifugal, Integrally Geared Single Stage and Gearless Single Stage “Turbo” Technologies that incorporate air or magnetic bearings. Each have all the same basic components, a compressor, motor, starter and inlet filter, and some technologies also have cooling systems, Power consumption, while important, is just one criterion in the selection of blower technology. Other factors such as noise levels, environmental impact, access to service, or even the performance characteristic of the application itself should be evaluated when selecting a blower technology. When comparing power usage, a wire-to-air approach, backed by a published standard, is the only fair and unbiased way to evaluate between technologies. Beyond evaluation, the manufacturer should have the facilities to perform testing in accordance with the specified code
- https://www.airbestpractices.com/technology/blowers/evaluating-different-blower-technologies-wire-air-basis

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Does Nutrient Removal put more Air Demand on Blowers versus BOD Removal?

- Definitely says Henryk Melcer, Senior Process Engineer, Vice President at Brown and Caldwell. When you nitrify one needs to supply approximately four-and-a-half parts of oxygen per one part of ammonia, compared to one part of oxygen per part of BOD. Allowing for the different concentrations of BOD and ammonia, the air demand increases by a factor of about two. As a result, a plant could end up doubling the number of blowers needed. More air, of course, equates to more energy cost.
- This means treatment plants might be looking at significant additional expenses when they upgrade to nutrient removal. This also drives the need for many plants to find more efficient blowers to replace older models when they upgrade.
- There are other ways of reducing overall demand for oxygen but there is still a very significant increase in the amount of air that needs to be delivered by the blower systems.
- https://www.blowervacuumbestpractices.com/system-assessments/blower-systems/brown-and-caldwell-tackling-wastewater-aeration-challenges

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Howden Explains Use of ASME PTC 13

- In 2010, the American Society of Mechanical Engineers (ASME) established the PTC 13 Committee to establish a power test code for all blower technologies. Blower & Vacuum Best Practices interviewed Committee Chair Jacque Shultz, HRO-Turbo Product Technical Leader, Howden North America, Inc., for an update on the new code. ASME PTC 13 includes sections that incorporate aspects of PTC 9 and PTC 10. This code also includes procedure flow charts to illustrate testing both positive displacement and centrifugal blowers based on the different methodologies these machines are designed specifically to operate to ensure the corrections in power conversions for these methodologies are accounted for during testing in the test stand, and best match the final conditions and performance in the field.
- ASME PTC 13 includes Tables 3.1 and 3.2, which are very useful since they can be used to correct for performance differences that can occur between the manufacturer's test stand and the field on different types of control mechanisms.
- https://www.blowervacuumbestpractices.com/standards/blower-standards/progress-continues-asme-ptc-13-blowers

Market Impact of High Speed Turbo Blowers and Rotary Screw Blowers

- Blower & Vacuum Best Practices® Magazine interviewed Ms. Julie Gass P.E., Lead Process Mechanical Engineer, from Black & Veatch on trends in the wastewater treatment industry especially pertaining to new technology aeration blowers and energy efficiency.
- The market has been impacted by the introduction of new gearless, high-speed turbo blowers. They are single-stage machines operating at 20,000 to 40,000 rpm – without multiple impellers and gearboxes. They have non-contact bearings (magnetic or air bearings) that eliminate the need for a lubrication system. Most deploy a variable frequency drive. These units also come in skid packages incorporating cooling systems and VFD's seemingly providing a lot of advantages. One significant advantage is that for the first time, there is a more efficient technology available for small and medium-sized wastewater treatment plants which is the gearless turbo technology. The single stage integrally geared units have been available for many years and offer good efficiency for the larger plants but were often not well suited for small to medium size plants. We see a trend towards using banks of smaller units to allow smaller plants to install horsepower ranges better suited to their varying load profiles.
- Second, the positive displacement blower manufacturers are coming out with new designs, like the rotary dry screw blower, that is optimized for the pressure ratio needed for wastewater aeration and offers improved efficiency in comparison with traditional positive displacement blowers. These are also packaged machines and they often incorporate Variable Frequency Drives that help match kW consumption with partial load conditions.
- https://www.blowervacuumbestpractices.com/industries/wastewater/black-and-veatch-provides-guidance-wwtp-design

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Blower Controls

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Control Comparison by Blower Type

There is a hierarchy of controls starting with the blower with single or dual point control. Then there is the communications between the physical controls and process management. This can be a sequence with an edge computer package which provides optimum energy use for the amount of air needed. The edge level system can also make determinations about optimum use of multiple blowers.

This edge level determination then is communicated to the process management system which can be cloud based and remote.
It can be simple with D.O measurement alone determining set points. It can be more sophisticated and make predictive calculations of oxygen requirements based on other process parameters.
We need input of these various options.

Blower Controls

Blower Manufacturer	Single-Point Control (Variable Speed)	Dual-Point Control (Variable Speed + Other)
Neuros	●	
Turblex		●
Aerzen	●	
HSi	●	
ABS	●	
Dresser Roots	●	
Atlas Copco	●	
Piller TSC	●	
Howden		●
Hoffman	●	

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Aerzen - Controls

Blowers control scheme: The purpose of the control system is to match the air flow to demand in the most efficient manner, therefore running the smallest number of machines and running them in the range of their best efficiency. The plant control system will be crucial in achieving the most efficient sequencing of the aeration blowers.

Four principles apply:

- 1. Run the least number of machines (a blower that does not turn does not use energy)
- 2. Run the largest number of machines in their most efficient range
- 3. Avoid idle operation and any bleeding off of air
- 4. Sequence the operation with longevity and maintenance intervals in mind

Flow control

- Direct flow control: This type of control is only suitable when the aeration blower system is dedicated to one basin and the pressure is equal for all the various aeration sectors.
- Indirect flow control: This type of control is required to adjust the air flow from a common air header to individual basins or individual aeration sectors. A control valve is inserted in the air line to each basin or sector. The pressure loss of such a control valve typically ranges from 0.3 psi (20 mbar) to 0.5 psi (35 mbar). While most of such systems use pressure to control the flow in a reactive manner, a more accurate and more energy efficient method is to anticipate the oxygen need and control the flow by means of flow sensors, then vary the control valve setting for each sector accordingly. In addition of being the most efficient, this aeration control system offers an additional advantage: it allows the blower discharge pressure to follow the system back pressure, therefore further lowering the energy usage.

Aerzen Blower Turn-down Capability

- Blower system turn-down capability Careful selection of equipment is required to achieve a high degree of flexibility in meeting a wide range of oxygen needs with the highest degree of energy efficiency.   Some aeration systems cycle individual blowers for various lengths of time and use the oxygen retention capability of the wastewater to adjust the oxygen feed.
- This segment discusses the ability of a system to adjust to any flow within the required range of operation. This requirement originates in the desire for highest possible efficiency of the overall wastewater treatment process over time. A large turndown means that the system will be able to meet the lowest e.   A larger turndown also provides additional flexibility and enables the blower system to meet the air requirements in a step-less manner with the minimum number of machines and lowest number of frequency inverters (VFD).
- The turndown of each machine must allow for some overlapping (preferably ≥ 5% of the flow of an individual machine). Therefore, a 55% turndown is required for a stable control system, avoiding steps and wasting power by blowing-off air. The number of blowers required depends on the turndown capabilities of each machine.   Example: if a system requires a 4:1 turndown ratio, this can be accomplished with two machines with each a 2:1 turndown. For ease of controls, some overlap is preferable and therefore, each machine in this example should be capable of a flow range from 45% to 100% under the worst conditions: highest pressure ratio and lowest air density combined.

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Aerzen - Other System Variables

- Upstream and downstream Inlet air filtration The filtration of the inlet air is crucial for the durability of the blowers, and the maintenance of the filters, while seemingly of little importance, impacts the energy costs. The degree of filtration as well as the dust retention capability of the filter elements has to be considered. The filter must be sufficiently fine to protect the blower as well as the diffuser system downstream from air-borne dust particles. On the other hand, a very fine filter will require a large filtration area and/or more frequent cleaning or replacement. Machines with high tip speeds, such as high-speed centrifugal blowers and turbo blowers, are particularly sensitive to particles and droplets in the air stream, and therefore require very fine filtration.
- if the pressure loss of the clean filter may be negligible, a dirty filter can easily cause an additional 0.5 psi (35 mbar) drop resulting in an increase in the compression ratio of some 3% based on sea level conditions, and a comparably higher use of energy. Inlet pressure losses have a much more important impact on power usage and actual flow than the same pressure drop on the discharge side.
- Filter location: It is preferable that the filter be the last element touched by the inlet air before entering the blower. This is most important in the case of very high speed machines such as the turbo and centrifugal blowers. It was found that most suppliers do not pay much attention to this detail, and there is a danger that loose particles from the silencers or even, as is the case with the standardized turbo blowers, from the acoustic enclosure could enter the blower. Cleanliness is particularly crucial in the case of high-speed machines and machines with high tip speeds. A few particles can damage an air bearing or cause damage when touching an impeller rotating at 1000 ft/sec tip speed. If the filter element is such that dust particles can fall off during the filter change, it is recommended to pay particular attention to remove the dust prior to installing the clean filter element. Particles that find their way into the downstream piping will ultimately restrict the air flow in fine bubble diffusers.
- Inlet piping: For various reasons, some engineers prefer to manifold the inlet of multiple blowers to pull air from outside a blower room. The additional inlet pipe pressure losses need to be accounted for. Moreover, frequently forgotten is the fact that inlet air noise is then being ducted out and may require additional acoustical treatment, which in turn causes additional pressure losses

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Component Decisions

- Pre-heating of the intake air: Some blower packages use the intake air to cool the electric drive motor and some of the power electronic. The result is a higher amount of energy to be used for the same amount of oxygen: the higher air inlet temperature results in lower air density and proportionally lower mass of oxygen per unit of air volume. For example: a 20ºF increase in inlet temperature results in about 4 % lower mass of oxygen per cubic foot of air, a 4 % lower density, a higher discharge temperature, higher air velocity and higher pressure losses.

- Discharge check valve: While nearly always required, the discharge check valve is one of those components that is frequently not included in a blower package or shipped separately. Whether the pressure loss caused by the check valve has been accounted for is not always clear. The pressure loss of a check valve should be less than 0.15 psi (10 mbar). The selection of the check valve must be such as it has a low opening pressure and will not chatter at reduced flow.

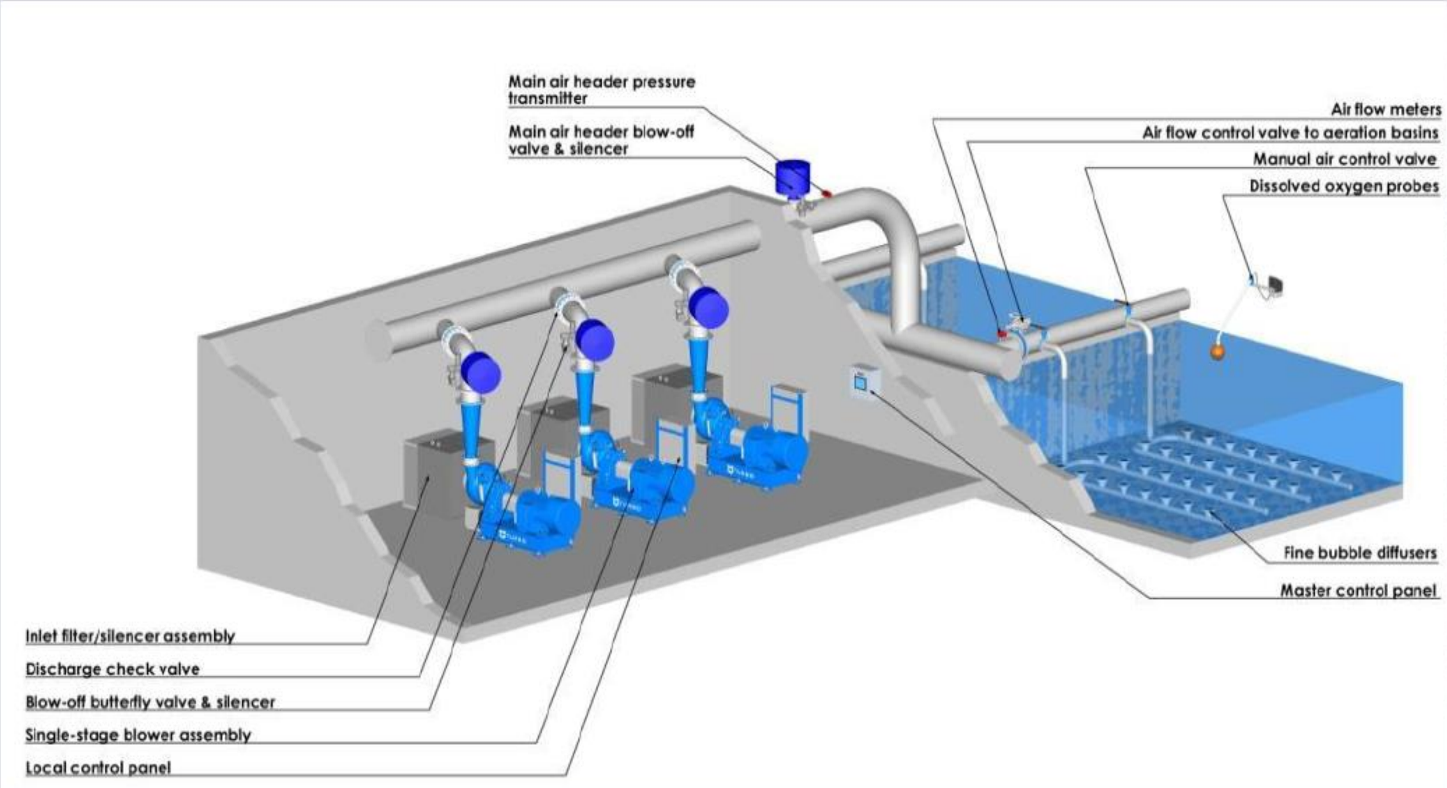
- Additional flow control valve: Some control systems, particularly used in conjunction with centrifugal or turbo blowers, make use of a discharge pressure control valve. This valve receives its signal from the Dissolved Oxygen (DO) control. Should less oxygen be required, the control valve will restrict the total air flow, therefore increasing its upstream pressure. The blower flow control, being set to maintain a constant discharge pressure, will reduce the blower flow until the set pressure is reached again. Not only is the pressure drop across such a control valve not negligible (0.3 to 0.5 psi or 20 to 35 mbar), but with such a control system, the pressure generated by the blowers remains constant, and may therefore not be able to take advantage of any drop in system pressure at partial flow.

Automation Solutions for Air Bio Control

Siemens Turbomachinery Solutions

Air Bio Control (ABC): Automation solutions for WWTP

SIEMENS



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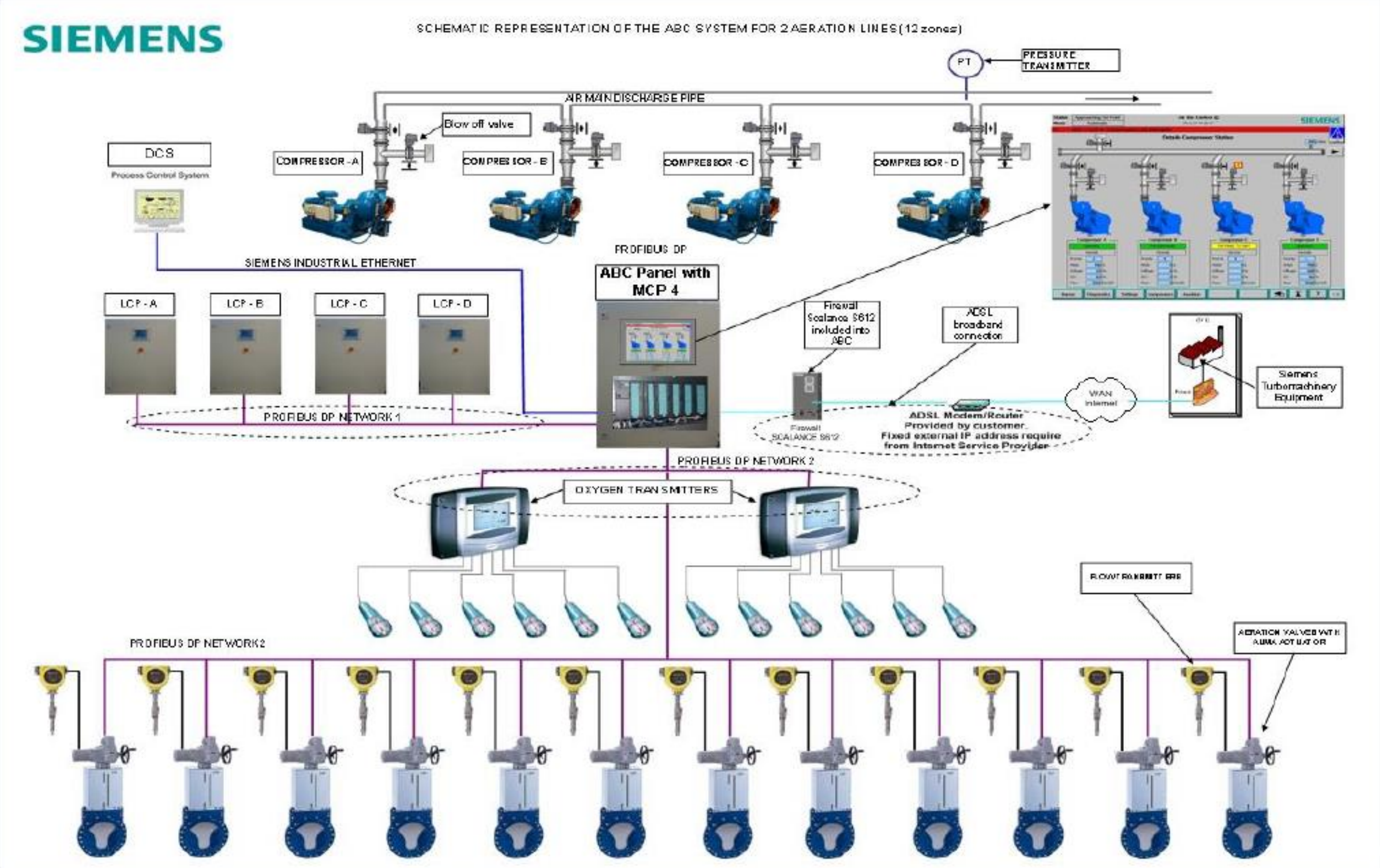
Siemens Turbomachinery Solutions

ABC solution for two aeration lines with 12 zones



Remote Monitoring Systems

- Wastewater plants are increasingly turning to remote monitoring. Large plants easily justify it based on economies of scale . Small plants can justify it based on the elimination of a night shift. McIlvaine has devoted a webinar to this subject. It can be viewed at
- **Recorded 50 Minute webinar on April 6, 2017 View YouTube Recording: https://youtu.be/AWB-vZIj5gk**

Aerzen

The Aerzen iAir Remote Monitoring System (RMS) is a comprehensive monitor that can be attached to any blower or compressor to capture real-time activities and conditions. Based on industrial cellular technology, the RMS can function in any location with cellphone coverage for both indoor and outdoor applications. The iAir Remote System reviews the actual usage of the equipment and sends alerts and reminders via text or email directly to the user.

Neuros

PG-Neuros, the leading manufacturer of high-efficiency turbo blowers offers the Remote Monitoring System to its customers for monitoring blower operation through real-time data using a VPN or a dedicated router. The system can be installed at the managed communication/Ethernet switch at an individual blower, master control panel or SCADA level to fit different plant needs and configurations. The Remote Monitoring System is easy to deploy with minimal to no interruption to the plant's system or operations. The real-time data is streamed through secure network to the cloud or APG-Neuros' servers for monitoring and diagnostics of operational issues. All the parameters are monitored remotely by APG-Neuros engineers to ensure optimized aeration system and blower operation, analyze trends and detect any abnormalities.

APG-Neuros demonstrated energy efficiency by replacing competitor's blowers in Nice, France, Narragansett Bay Commission, and Lowestoft, U.K. (Anglian Water).

With approximately 1,000 units installed and over 100 on order, their installations enjoy the highest success with large cities including Washington D.C., NYC, London (U.K.), Vancouver (B.C.) and Mexico City

Holistic Control Approach

- **EDI and BioChem Partnership provides Holistic Approach to Aeration Control**
- BioChem introduced its patented Bioprocess Aeration Control System (BACS) in 2009.
- Since then it has proven its effectiveness, efficiency and reliability in dozens of applications as a standalone subsystem to control the production and distribution of the aeration process. BACS is not the standard proportional integral (PI) loop utilizing high speed trial and error based control actions to chase the desired set-point. Rather BACS is an intelligent system which actually calculates the volume of air required to maintain the DO setpoint by analyzing the process metabolism in real-time. In fact, because of system response times, it is necessary to know what the oxygen demand will be 15 minutes from now in order to effectively maintain the proper DO concentration. BACS does this. It has a *Predictive* element in its nature.
- With BioChem's EDI partnership a new more holistic concept to process design and control was introduced. This new concept called *Symphony* considers all the critical subsystems required to control the biological treatment process utilizing digitized intelligence throughout. The goal is to achieve unprecedented economy and performance while providing practical, actionable information to manage the plant by incorporating such features as fault detection and isolation (FDI) and Reliability Centered Maintenance (RCM).
- EDI, headquartered in Columbia, Missouri has been a leader in the development, manufacturing and installation of advanced aeration products and solutions for over 40 years.
- EDI's Chairman, Charles Tharp provided this rationale for the partnership: "This represents a major expansion of EDI's capability to deliver superior aeration mixing solutions for biological treatment systems. The combination of predictive aeration logic and premium EDI aeration hardware will deliver unprecedented levels of performance in biological and aeration systems."
- George Lee, BioChem's longtime CEO and the father of its innovative technologies, and newly appointed CTO stated: "BioChem will continue to expand its knowledge and apply its core competencies in the complex and nuanced bio-chemical dynamics in the wastewater segment. The partnership with EDI for the distribution of our control solutions allows us to more quickly realize our shared goals and vision; which is to essentially transform the way wastewater treatment systems are built and operated, so as to incorporate the most advanced, efficient and effective wastewater treatment strategies that modern technology allows.

Drives

- Here are some Aerzen views about drives.
- 1) Narrow, cogged V-belt drives: a. 98% to 97% efficient when right-sized, constantly properly aligned and tensioned b. worst case: 90% efficient, resulting from over-sizing, poor design, lack of tension, poor alignment c. Advantage: flexibility of speed selection and motor sizing for best efficiency
- 2) Speed increasing gears: a. 97 to 99 % efficient b. Advantage: flexibility of speed selection and motor sizing for best efficiency; reliable and low maintenance
- 3) Frequency inverter: a. 95% to 98% efficient average, however, the efficiency is not constant over the entire range of operation. The total drive efficiency will vary with speed and load b. Moreover, the inverter and the motor influence each other c. Some VFD types and applications may limit the distance between the VFD and the motor. A high speed drive requires a high switching frequency of the inverter and generates a higher level of harmonics, heat generation, necessitates harmonics filters, and precludes the cable length between inverter and motor from being longer than some 20 ft (~ 7 m).
- 4) Asynchronous induction motors: a. > 95% for premium efficiency motors at 100 HP and above b. Efficiency drops as the load drops c. Power factor drops as the load drops, however the power factor is corrected with the use of a frequency inverter d. High-speed induction motors are used by some manufacturers to drive smaller blowers because the cooling of such motors is less critical than for permanent magnet motors. The distance between VFD and motor is limited due to high inverter switching frequency. 5) Permanent magnet motors: a. Permanent magnet motors used on high-speed turbo blowers are custom motors. At partial load, their efficiency is slightly better than that of premium efficiency asynchronous motors. Only little information is available on their performance. b. Magnetism may be affected at higher temperatures and exposure to magnetic fields; sufficient cooling is critical: some manufacturers require air conditioning of the blower enclosure; some require water/glycol cooling of the motor above a certain power rating or ambient temperature. c. The distance between VFD and motor is limited due to high inverter switching frequency.

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