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Blowers and Variable Level Processes

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Tom Jenkins, P.E., *JenTech Inc.*
Keynote Speaker

Omar Hammoud, *APG-Neuros*
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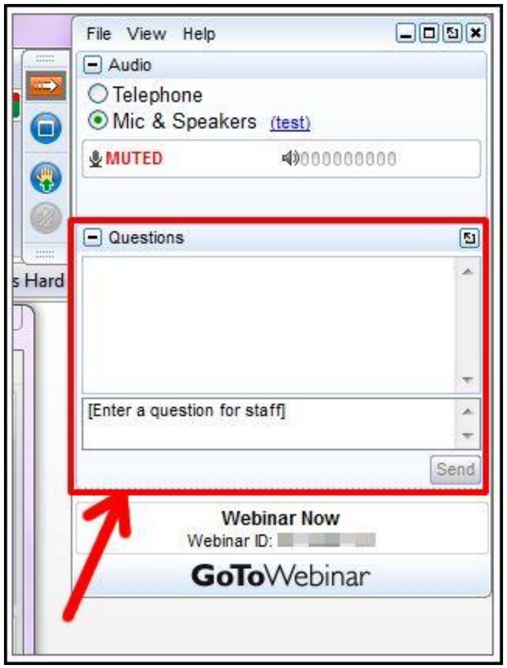

- Panelists will answer your questions during the Q&A session at the end of the Webinar.

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Handouts

BEST PRACTICES 2018 EXPO CHICAGO COMPRESSED AIR VACUUM COOLING

THE INAUGURAL 3-DAY CONFERENCE & EXPO!

IMPROVING PLANT PROFITABILITY THROUGH INDUSTRIAL UTILITY OPTIMIZATION

Why

Industry self-provides the key industrial utilities of compressed air, vacuum, blower and cooling. The BEST PRACTICES 2018 focuses on the significant opportunities presented by these inter-related utilities, **to reduce kW and water intensity – per unit of production.**

Industrial plants must continuously seek ways to be more competitive. BEST PRACTICES 2018 will also explore how **production machinery output volumes can increase by optimizing these utilities.** Visit BEST PRACTICES 2018 to discover true "Win/Win" long-term enhancements to plant profitability and environmental sustainability.

Who

The BEST PRACTICES 2018 event is designed to educate and provide tools to the people who make industrial utility projects happen at a factory. Factory personnel (General Managers, Production Managers, Energy Managers, Plant Engineers, Maintenance Managers) will convene here to identify **Key Performance Indicators**, learn to measure them and identify projects to reduce kW and H_2O consumption per unit of product produced.

All levels of expertise from the compressed air, vacuum, blower and cooling system industries will attend to either share or enhance their knowledge of these systems. Sales engineers, in particular, will be trained on techniques to help their industrial accounts embrace these opportunities. Specifying engineers and utility incentive program representatives will also attend to learn to better advise their industrial accounts.

Travel & Hotel

The Chicago O'Hare Crowne Plaza Hotel & Conference Center, conveniently located in Rosemont, IL offers a free shuttle from the O'Hare International Airport. Room Reservations may be made by calling Reservations at 1-877-337-5793 or by visiting www.crowneplazaohare.com. Reference the BEST PRACTICES EXPO or use Group Code "SPE" to receive the special Room Block Rate of $189 and $17 parking per day.

Registration

Conference registration includes, within the specified day, workshop and conference tracks, meals and expo hall access. Register at www.cabpexpo.com.

	Before 7/15/18	After 7/15/18
Single Day Conference Pass:	$390	$475
• September 17 Workshops, Lunch, Opening Session, Expo Hall & Evening Reception		
• September 18-19 Breakfasts, Lunch, Conference Sessions, Expo Hall & Evening Reception		
Full Conference Pass:	$795	$875
• September 17-19 all functions and meals		
2018 EXPO HALL OPEN HOURS		FREE
• Monday, September 17, 4:30 PM – 7:30 PM		
• Tuesday, September 18, 11:30 AM – 7 PM		
• September 17 or 18 lunch Tickets $40 each		

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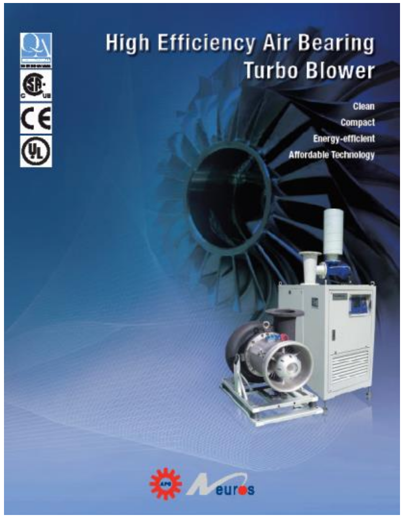

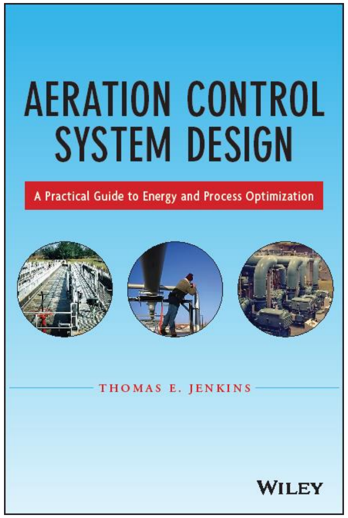

BLOWER & VACUUM

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Blowers and Variable Level Processes

Introduction by *Rod Smith*, Publisher

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About the Speaker

Tom Jenkins, P.E.
JenTech Inc.

- President of JenTech Inc.

- Over 30 years of experience with aeration blowers and blower controls

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Blowers and Variable Level Processes

April 12th, 2018
1:00 PM CDT

Thomas E. Jenkins
President, JenTech Inc.
414-352-573
tom.jenkins.pe@gmail.com

Topics

- Types of Processes
- Determining Variable Pressure Requirements
- Impact on Blower Performance
  - Positive Displacement
  - Centrifugal
- Control System Responses

Types of Proceses

Many wastewater processes have frequent level changes, often more than 2:1 range

- Equalization basins
- Sequencing Batch Reactors (SBRs)
- Sludge storage tanks
- Aerobic digesters

Types of Processes

- The depth may affect required air flow rate
  – Mixing energy
  – Oxygen requirements
- The depth will **always** affect the system pressure
- The blower discharge pressure is dictated by the system pressure
  – Static pressure varies with depth of diffusers
  – Friction losses in diffusers, pipes and fittings varies with air flow rate

Pressure Requirements

- Static pressure can be calculated from depth of submergence:

$$p_{static} = \gamma \cdot d$$

$$p_{static} = \text{static pressure}$$

$$\gamma = \rho \cdot g = \text{specific weight}$$

$$\gamma_{water} = 62.4\ \text{lbf/ft}^3$$

$$d = \text{depth of submergence}$$

For Water:

$$p_{static} = 0.433 \cdot d$$

$$d = \text{feet}$$

$$p_{static} = \text{psi}$$

Pressure Requirements

- Friction loss for design air flow in piping:

$$\Delta p_f = 0.07 \cdot \frac{Q_S^{1.85}}{d^5 \cdot p_m} \cdot \frac{T}{528} \cdot \frac{L_e}{100}$$

Δp_f = pressure drop due to friction, psi
Q_S = air flow rate, SCFM
d = actual pipe inside diameter, inches
p_m = mean system pressure, psia
T = air temperature, °R
L_e = equivalent length of pipe and fittings, feet

$$p_m = p_{initial} - \frac{\Delta p_f}{2} = p_{final} + \frac{\Delta p_f}{2}$$

Pressure Requirements

- Once pressure drop for one flow rate is determined it can be calculated for other flow rates:

$$p_{\mathrm{friction}} = k_f \cdot Q^2$$

$$k_f = \frac{(p_{\mathrm{des}} - p_{\mathrm{static}})}{Q_{\mathrm{des}}^2}$$

k_f = constant of proportionality for friction losses, psi/SCFM^2
p_{static} = static pressure, psig
p_{des} = total system pressure at design flow, psig
Q_{des} = design system air flow rate, SCFM

Pressure Requirements

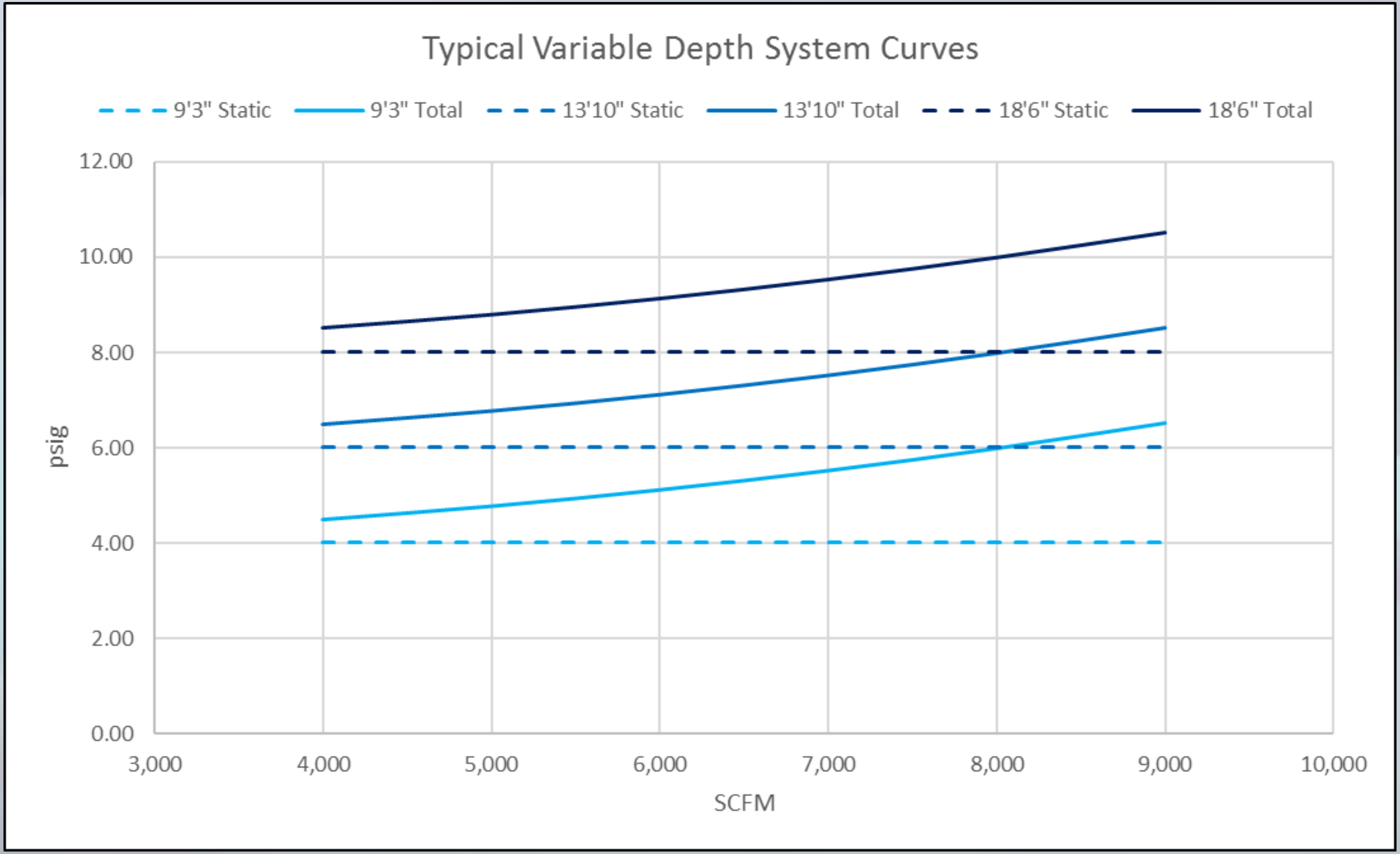
- The total system pressure can be calculated for any flow and submergence:

$$p_{total} = 0.433 \cdot d + k_f \cdot Q^2$$

- The result is a family of system curves showing the pressure required at the blower discharge vs. flow rate and depth

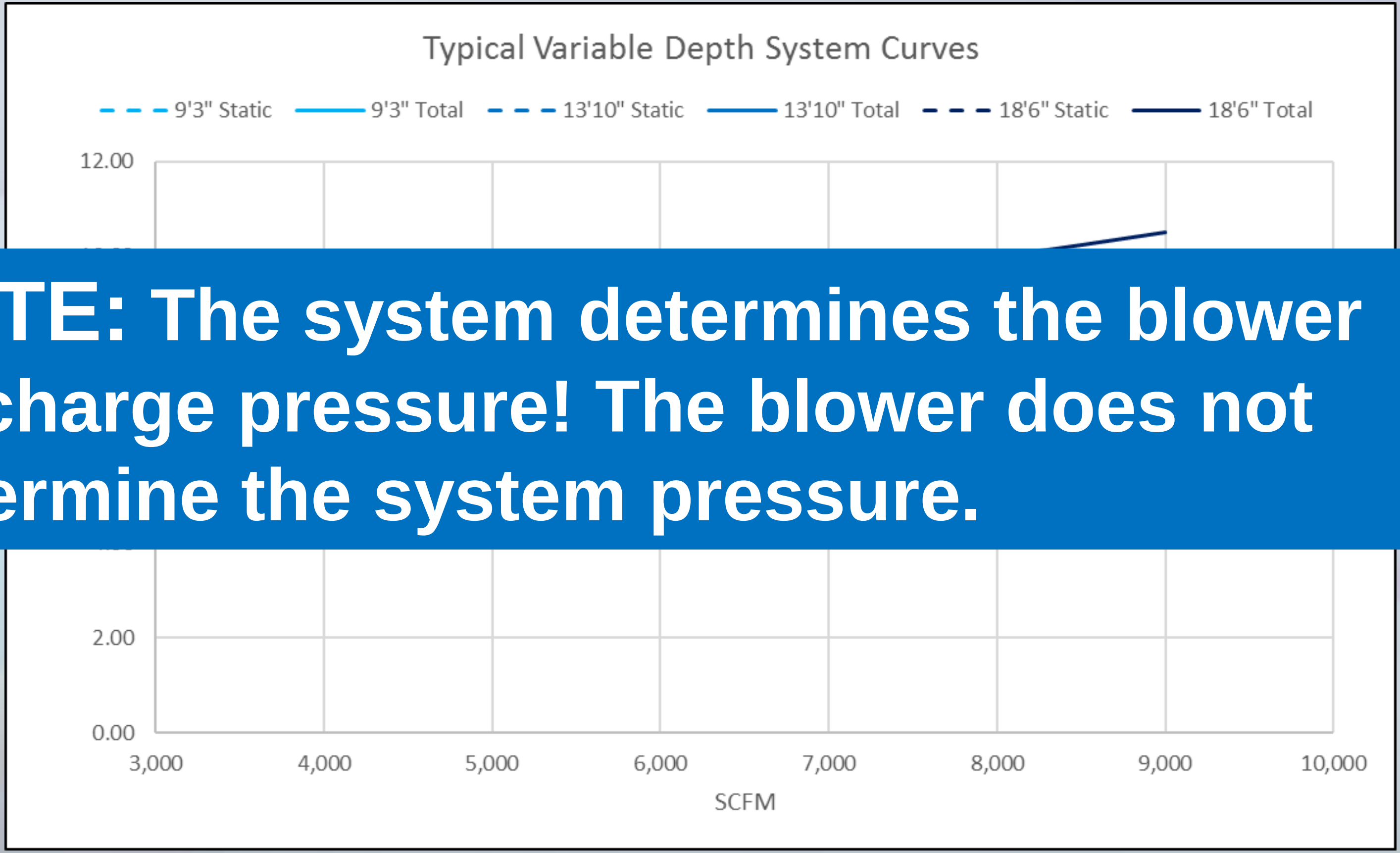
Pressure Requirements

- Example system curves:



Pressure Requirements

- Example system curves:



NOTE: The system determines the blower discharge pressure! The blower does not determine the system pressure.

PD Blower Performance

- PD (Positive Displacement) blowers move a fixed volume of air for every revolution
  - Lobe (Roots) type
  - Screw type
- The delivery volume is essentially unaffected by discharge pressure
- Discharge pressure increases and decreases to match system restriction

PD Blower Performance

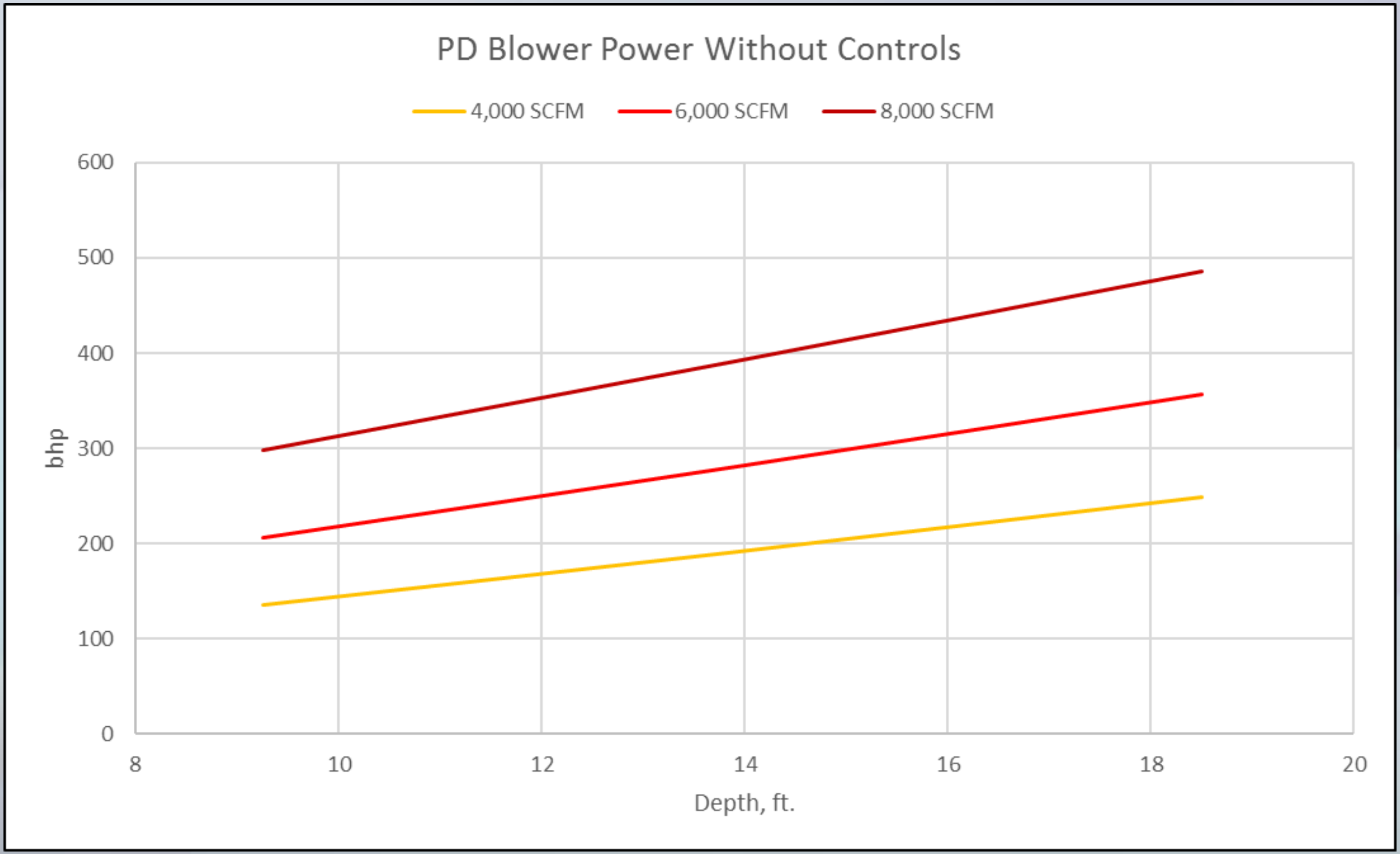
- With PD blowers the efficiency changes with speed because friction is constant
- With all PDs efficiency changes with pressure because of internal leakage
- With screw blowers the efficiency also changes with discharge pressure because they have a fixed internal pressure ratio
- Historically only PD blowers were used for variable level applications

PD Blower Performance

- On rising water level:
  - The discharge pressure will naturally rise to meet system needs without control system intervention
  - The blower power draw will increase because of system pressure increases
- The blower speed must change to change flow rate
  - Typically with VFD

PD Blower Performance

- On rising water level:



Centrifugal Blower Performance

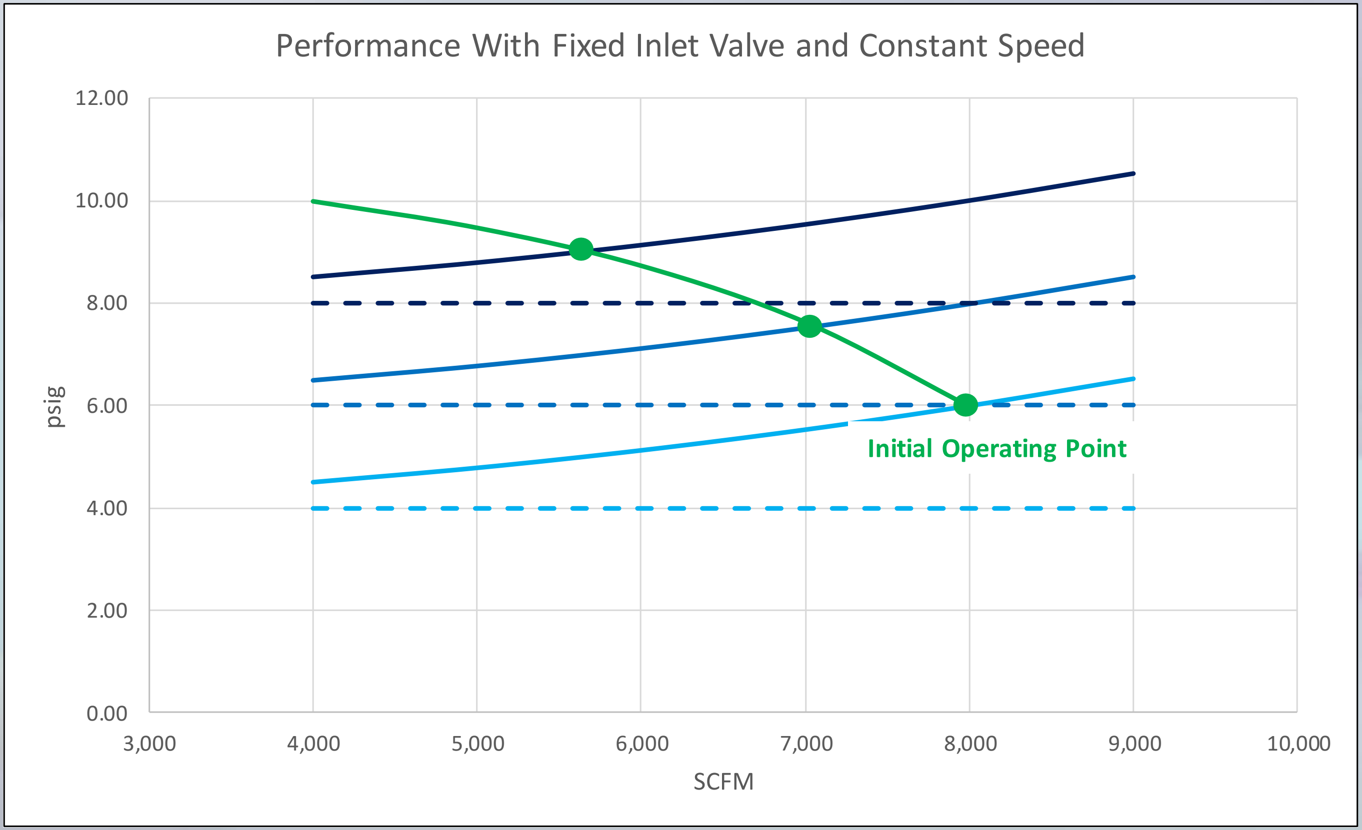
- Centrifugal (dynamic) blowers are variable volume and variable pressure
  - Multistage Centrifugal
  - Geared Single Stage Centrifugal
  - High Speed “Turbo” Centrifugal
- The delivery volume changes with discharge pressure changes
- Flow rate increases and decreases until the performance curve intersects the system curve

Centrifugal Blower Performance

- On rising water level:
  - The discharge pressure will rise and the flow rate will decrease without control system intervention
  - The blower power draw will decrease because of lower flow rate
- The blower speed or throttling must be used to change the flow rate
  - Without controls, changing water level could create damaging surge or overload conditions

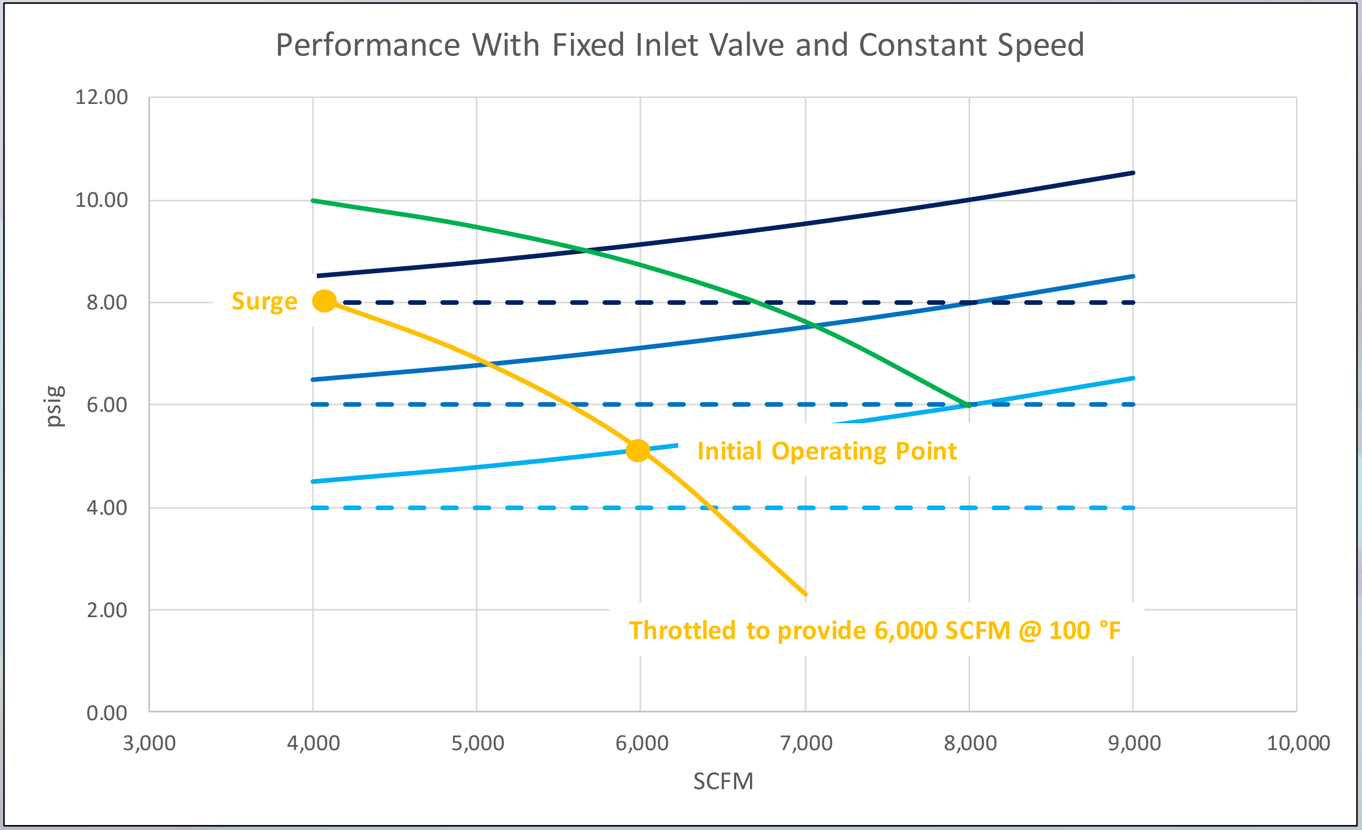
Centrifugal Blower Performance

- On rising water level:



Centrifugal Blower Performance

- On rising water level:



Control System Performance

- The control system should monitor flow rate and use it for blower control
- The controlled process variable is flow rate
- The manipulated variable (controller output) is:
  - Valve position for throttled centrifugals
  - Speed is preferred for centrifugals
  - Speed is required for PDs

Control System Performance

- For PD blowers no control response is required if flow rate is constant
- Flow changes must use speed changes
- Speed may be limited to clamp power draw
- Note that at constant pressure PD blowers are constant torque and constant amps
- Blower protection should include air temperature

Control System Performance

- Centrifugal blowers should be used on variable level applications only when combined with automatic control
  - Surge, overload, and air temperature protection at minimum
  - Automatic control to maintain set flow rate as the water level changes is the most practical system

Control System Performance

- Centrifugal operation is more complicated, but may have advantages
  - Possible lower power consumption
  - Compatible with other plant equipment
  - Noise
  - Maintenance

Control System Performance

- Centrifugal operation is more complicated, but may have advantages
  - Possible lower power consumption
  - Compatible with other plant equipment
  - Noise
  - Maintenance
- **Every application is different and should be analyzed for the optimum configuration!**

Control System Performance

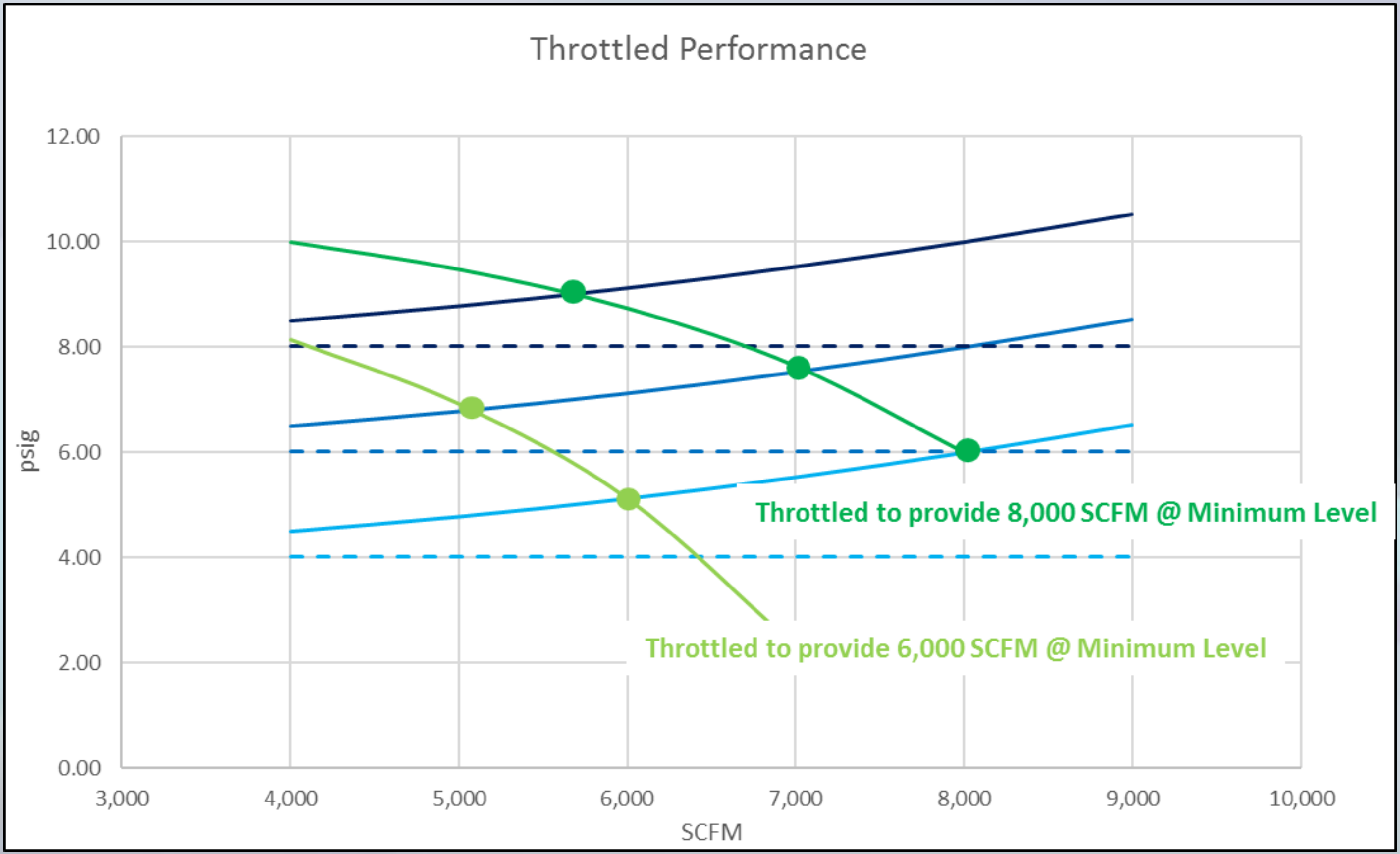
- For centrifugal blowers the control system must modulate the blower to maintain the desired flow rate
- Modulation may use an inlet throttling valve or a variable speed (typically VFD)
  - Cost vs. power tradeoff
- If using inlet throttling the discharge temperature must be considered

Control System Performance

- With throttled centrifugal blowers the Δp across the blower doesn’t change
- Discharge pressure changes because some of the pressure rise through the blower is taken at the inlet valve
- Power demand changes primarily with flow rate changes

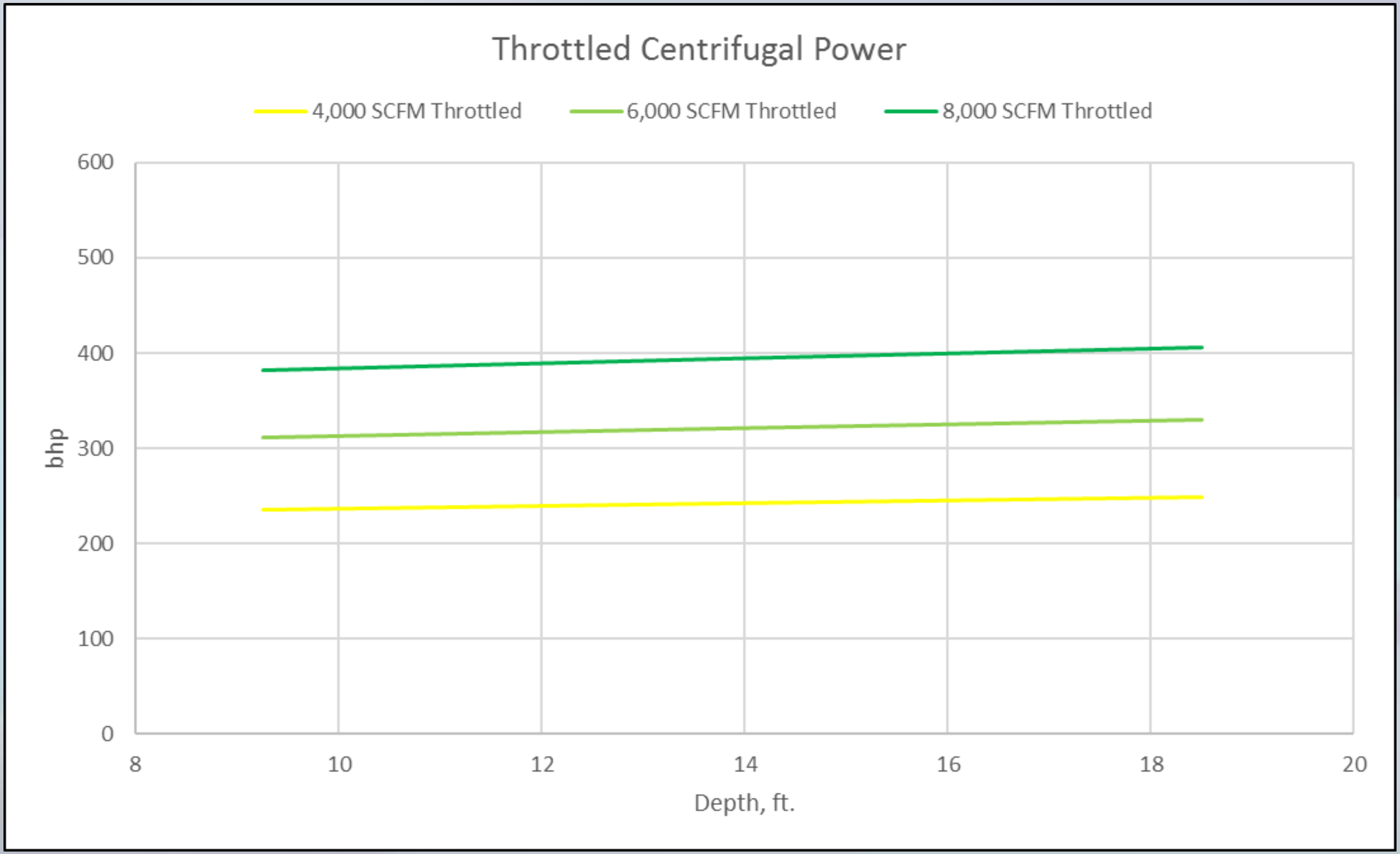
Control System Performance

- Throttled:



Control System Performance

- Throttled:



Control System Performance

- For variable speed centrifugal blowers the Δp across a blower changes with speed^2
- Discharge pressure changes because the pressure rise changes
- Flow rate changes directly with speed
- Power draw changes with flow rate and pressure as a function of speed^3

Control System Performance

- The new blower performance curves are calculated from the affinity laws

$$Q_a = Q_c \cdot \frac{N_a}{N_c}$$

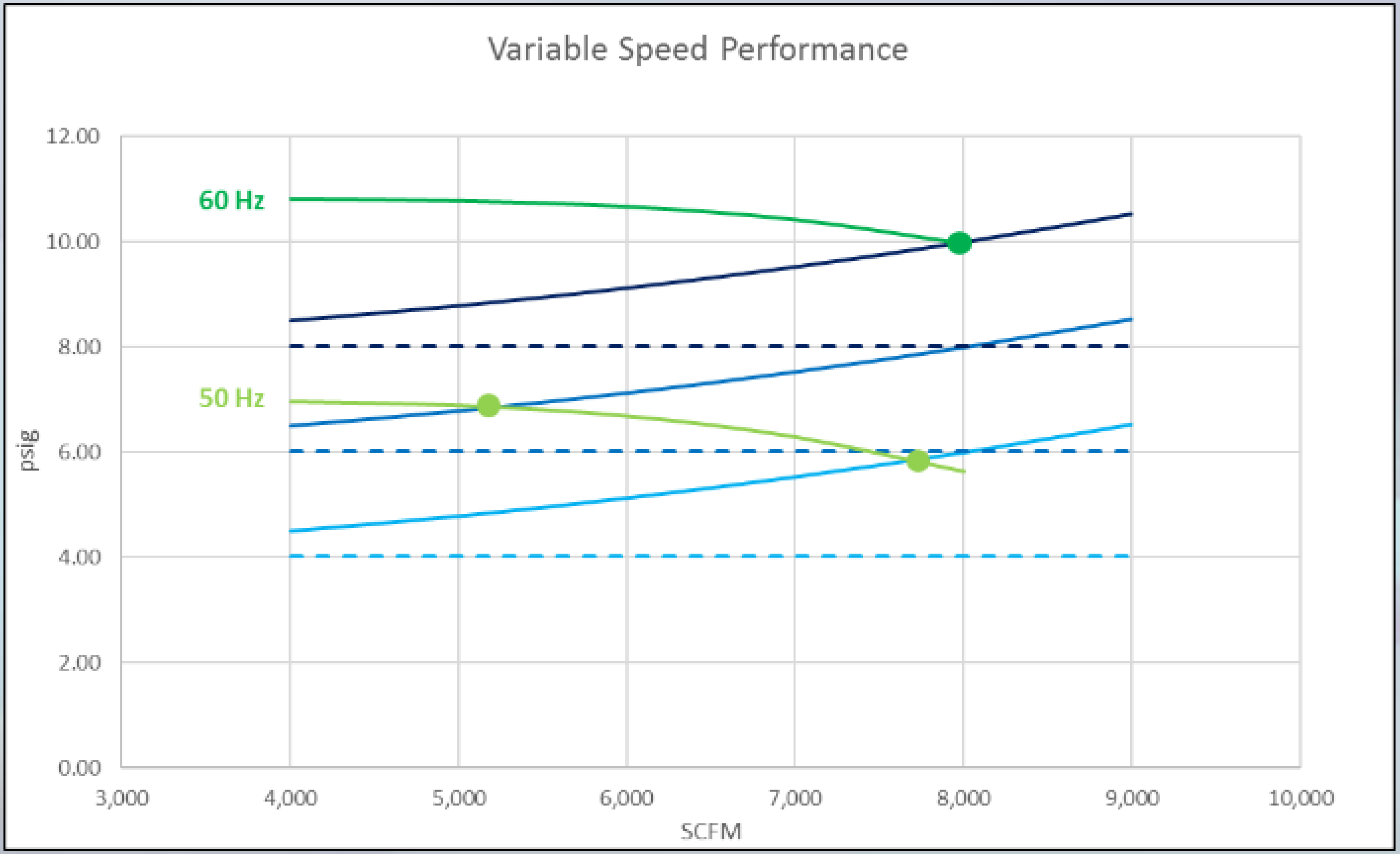
$$X_a = X_c \cdot \left(\frac{N_a}{N_c}\right)^2 \qquad X = \left(\frac{p_d}{p_i}\right)^{\left(\frac{k-1}{k}\right)} - 1$$

$$P_a = P_c \cdot \left(\frac{N_a}{N_c}\right)^3$$

- The performance curves and the system curves establish the new operating point

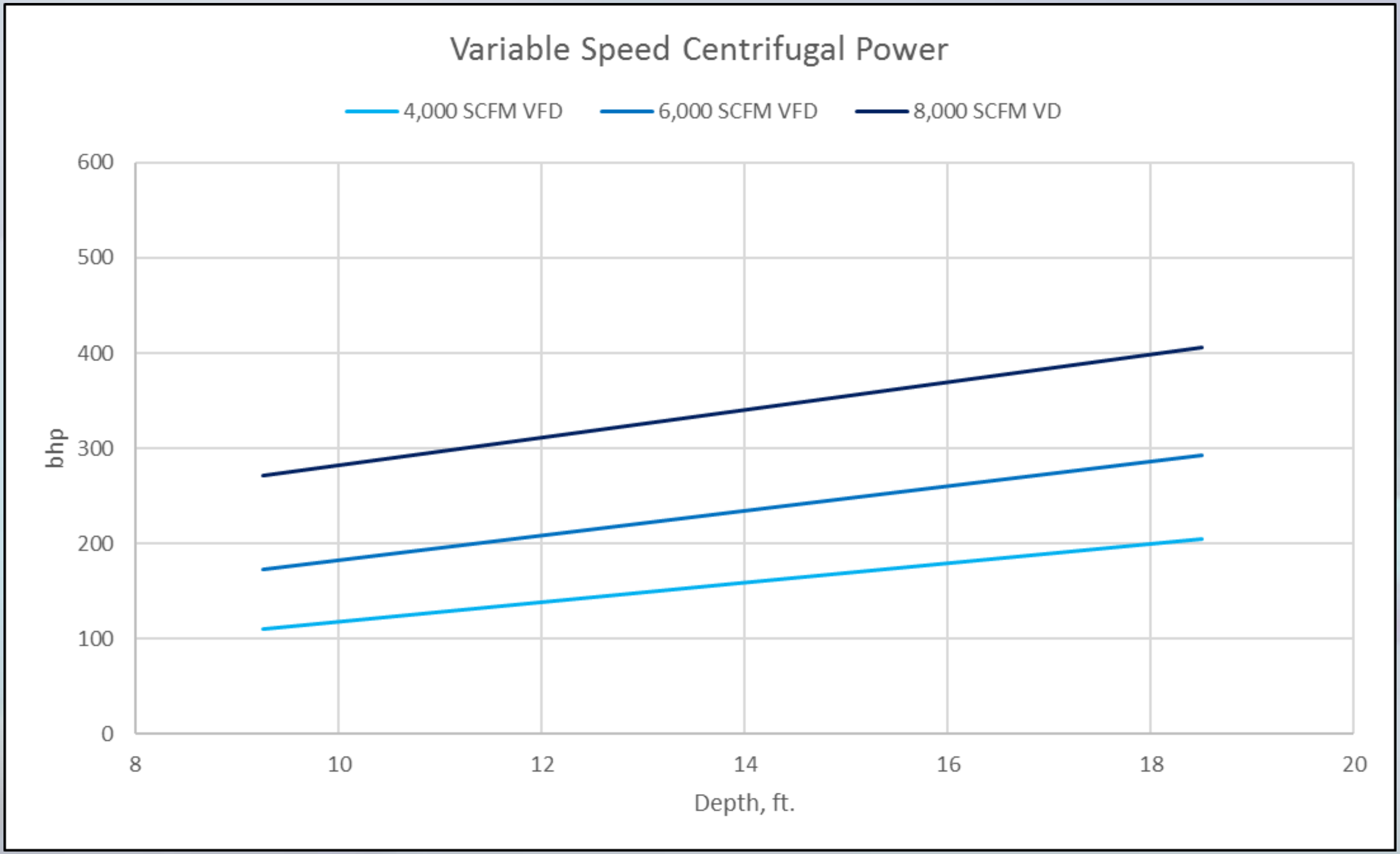
Control System Performance

- Variable Speed:



Control System Performance

- Variable Speed:



Summary

- Variable level processes create challenges for blower systems
- The impact of level changes depends on the type of blower
- Control systems can make the application of any type of blower in variable level applications practical
- The type of control is a function of the type of blower

Thank You

Thomas E. Jenkins
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About the Speaker

Omar Hammoud
APG-Neuros

- CEO and President of APG-Neuros
- Over 30 years of experience with leaders in the aerospace and defense industry

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High Speed Turbo Blowers in Varying Water Depths

Omar Hammoud, President & CEO of APG-Neuros

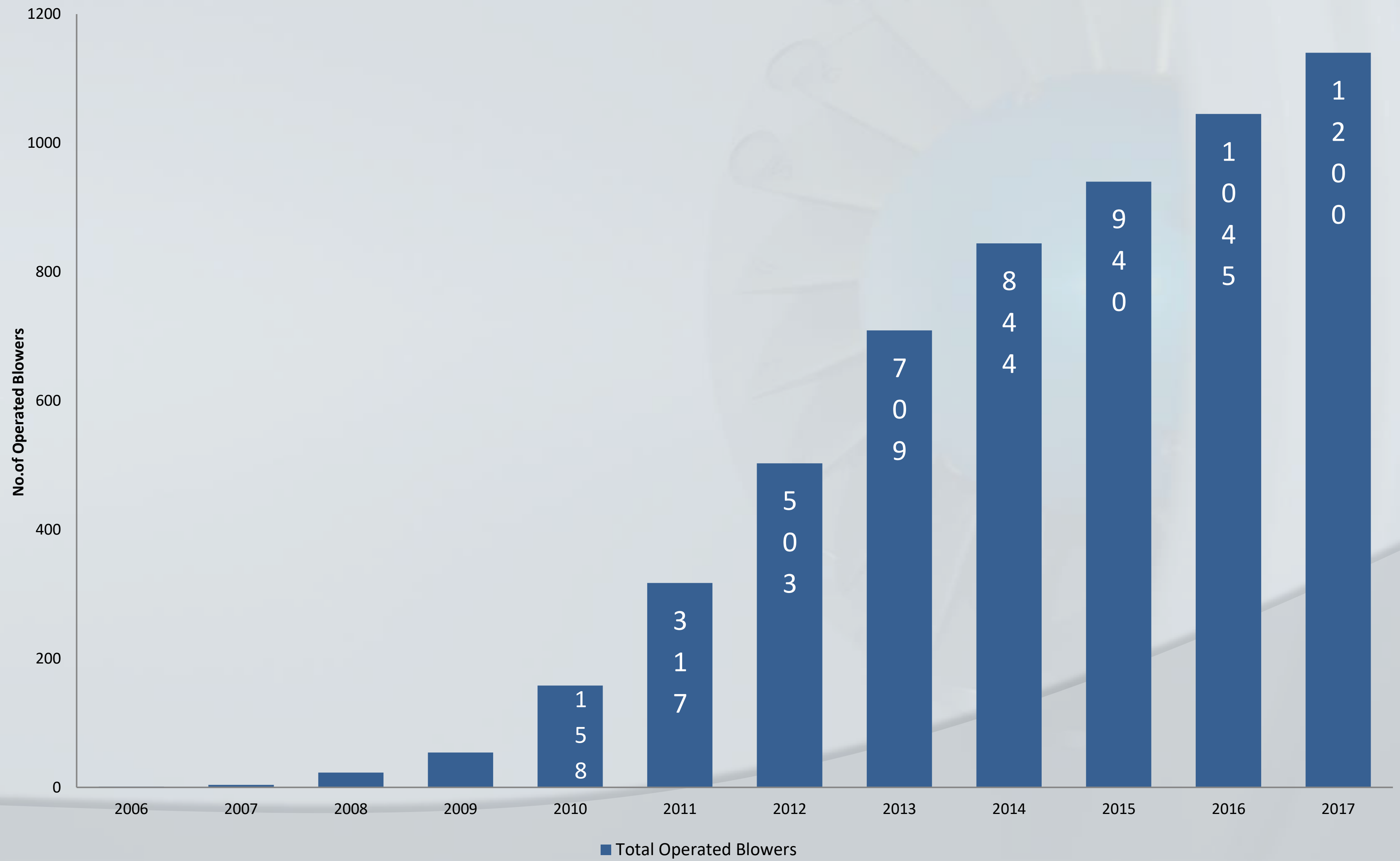
APG-Neuros – Blowers & Complete Aeration Systems

Customer Benefits - Overview

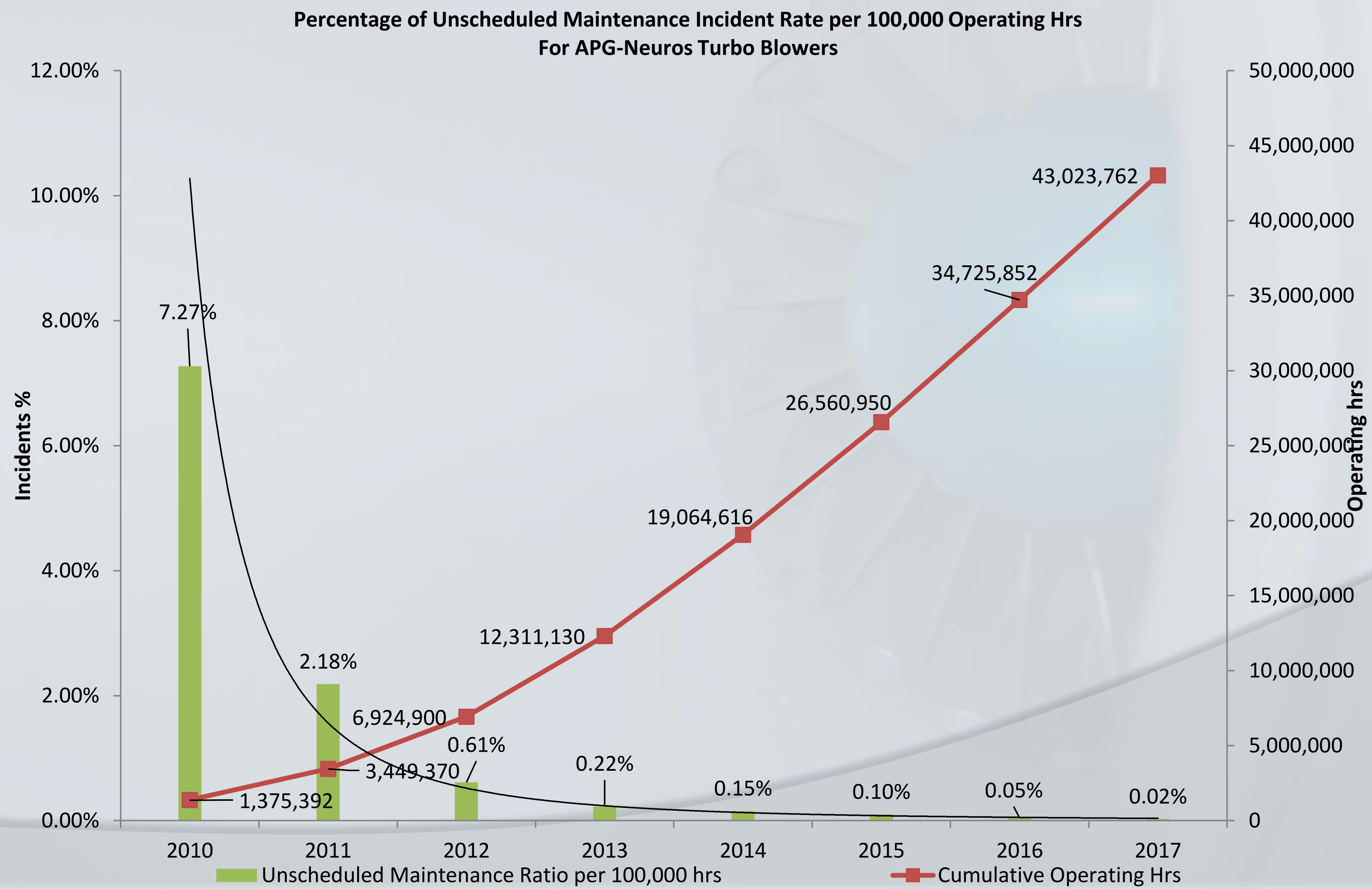
- **We offer the widest range of products**
  - 30 HP to 1600 HP Single and Multiple Core models
  - Air Bearing all models 30 to 1600 HP models
  - Magnetic Bearings 150 to 1450 HP models
- **Higher efficiency over other technologies**
  - Up to 35% over traditional blowers
  - Up to 11% over other turbo blowers
- **Low maintenance**
  - Condition based maintenance – no scheduled periods
  - Filter Changes is only routine maintenance action
- **Environmentally friendly**
  - No Oils to change or dispose
  - Quiet Operation below 80 dBa
  - No Heat Rejection into Blower Room
- **Easy installation**
  - Plug and Play, small footprint
  - Indoor and outdoor installation
- **Smart connect for remote monitoring**

Woodland, California
2 x NX300-C070, 2 x NX200-C070

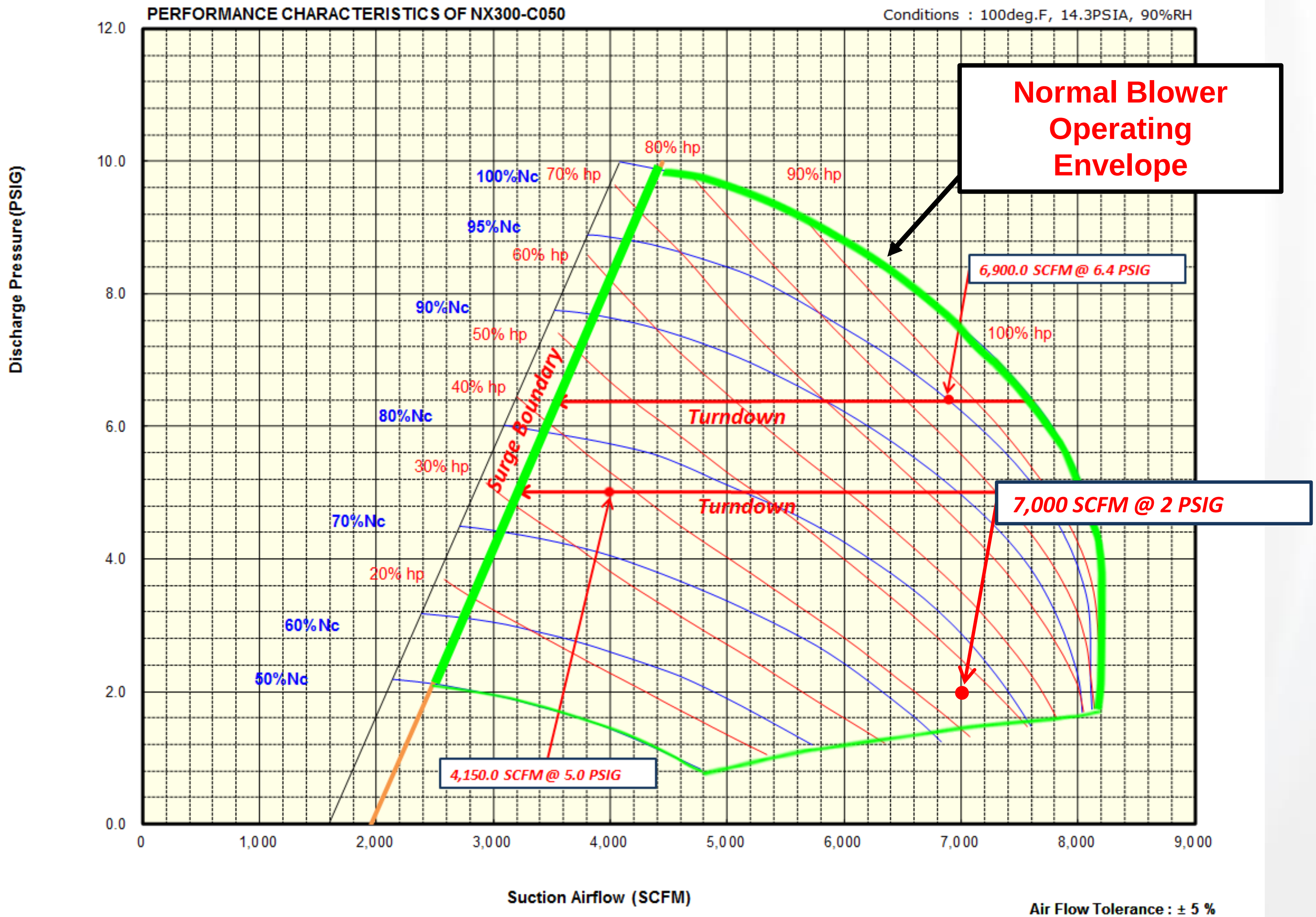
APG-Neuros Blower Installation Growth Over 10 years



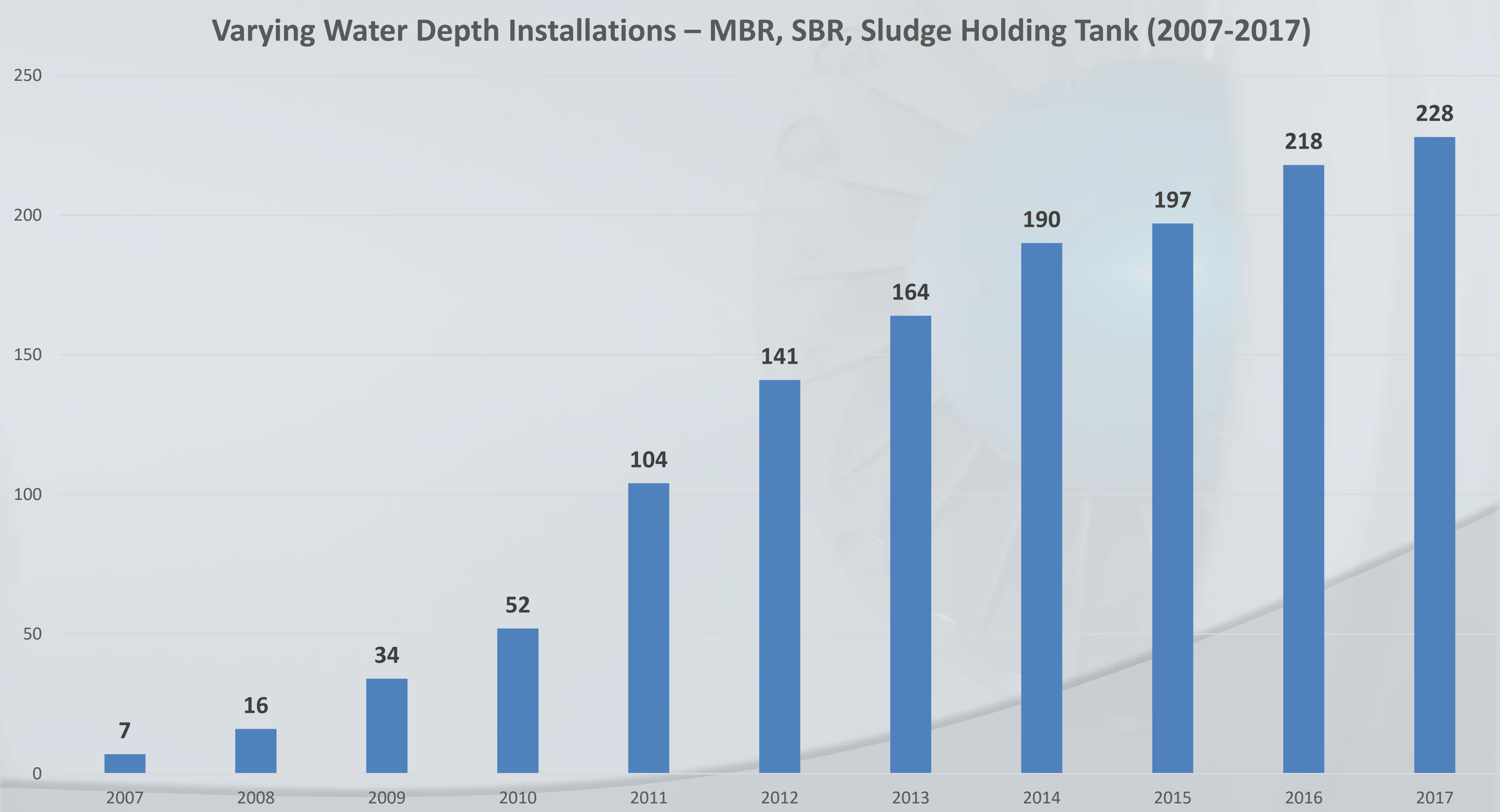
APG-Neuros Turbo Blower Reliability Over 10 Years



Operating Variable Pressure – Ballenger-McKinney, MD

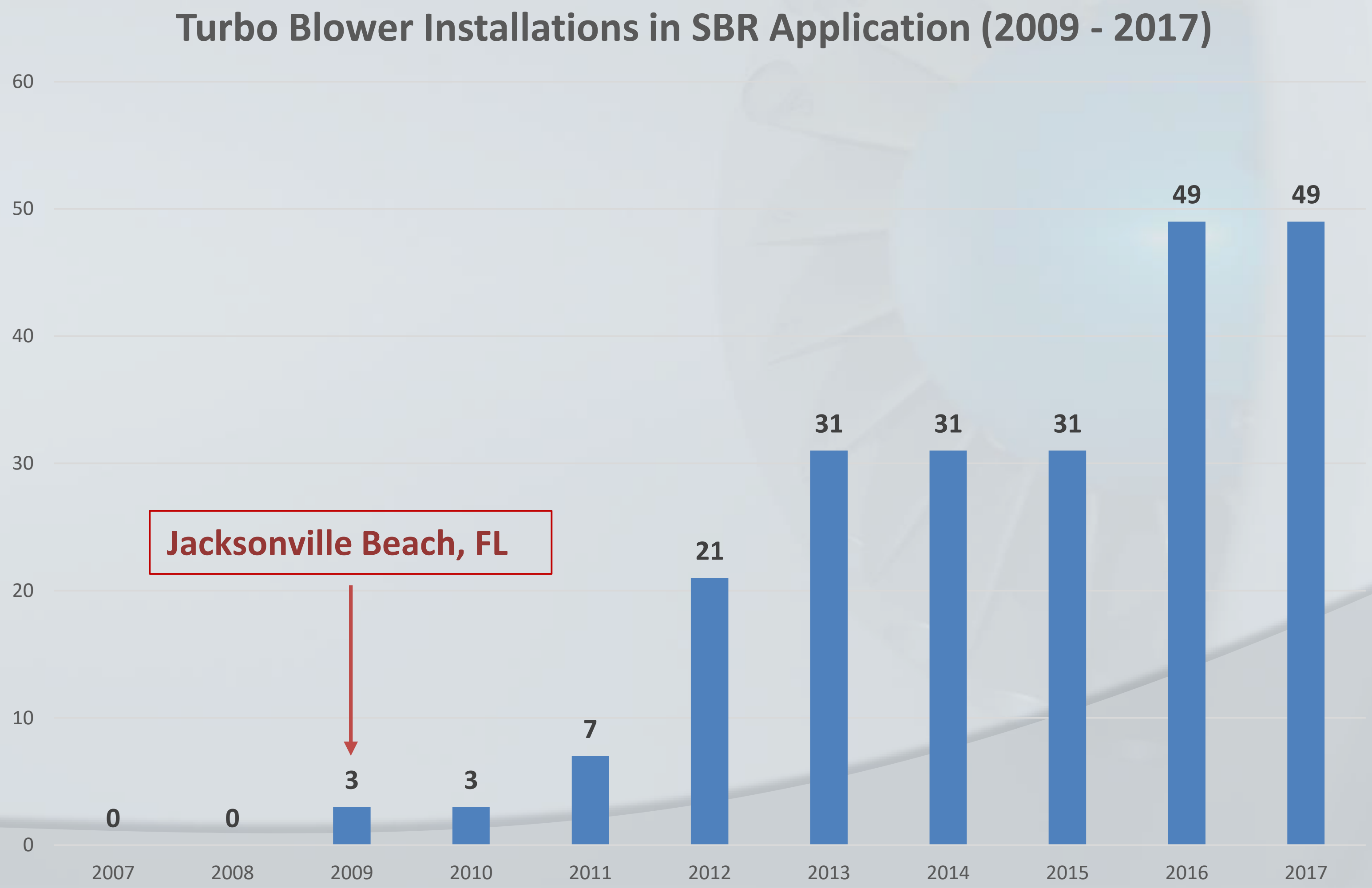


Varying Water Depth Blower Installations



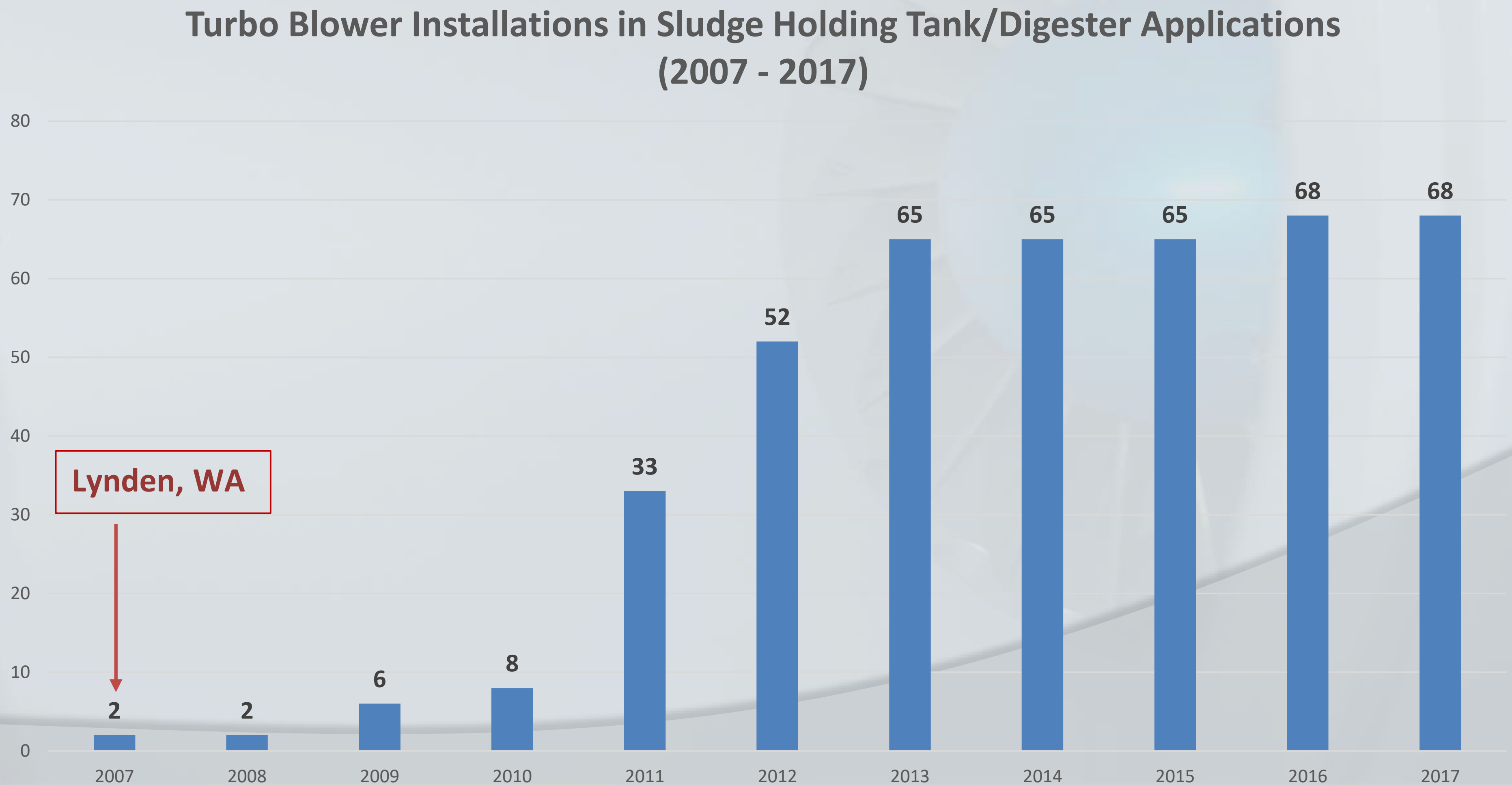
SBR Turbo Blower Installations – N. America

49 units in SBR Installations – Over 9 years of experience



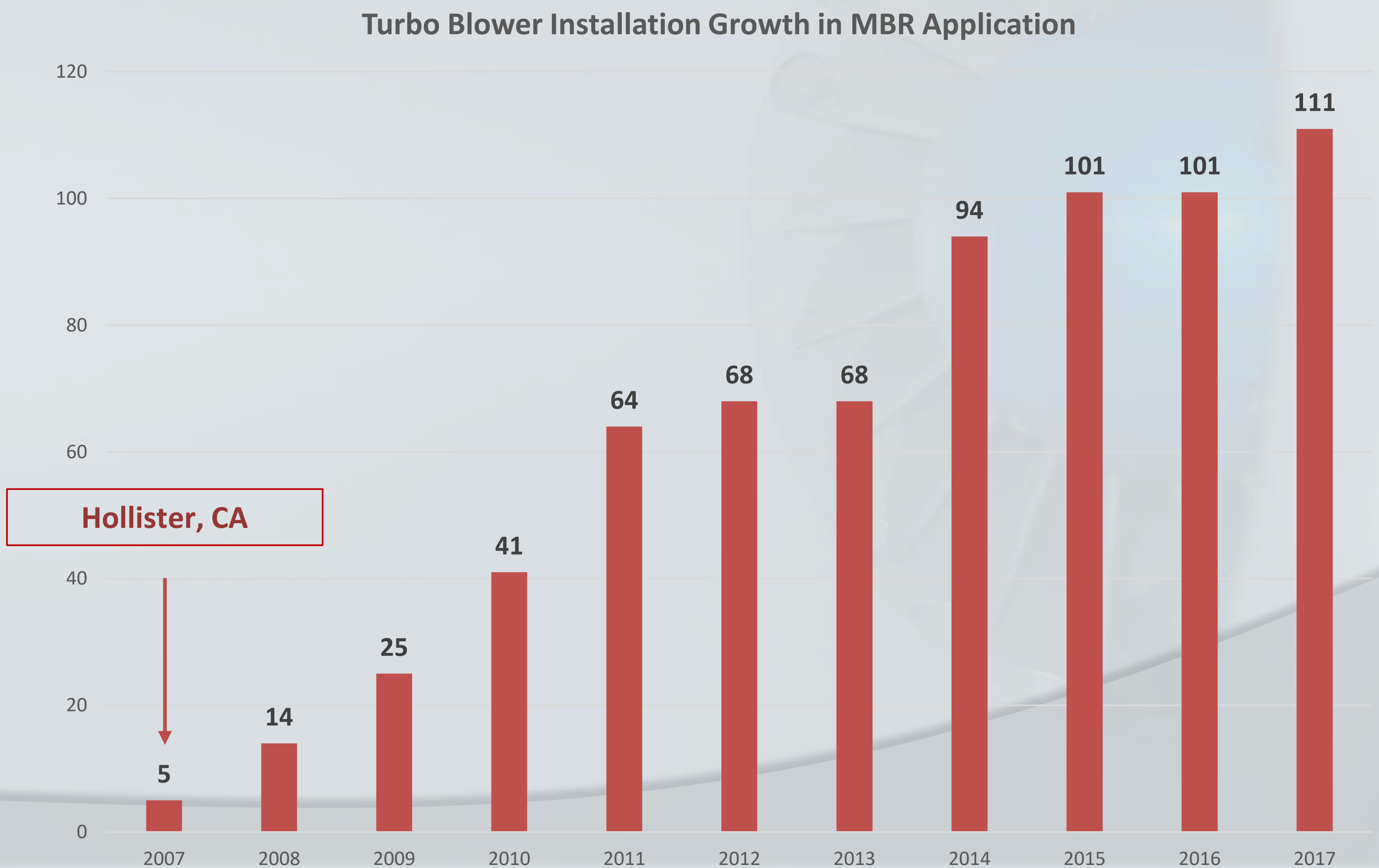
Sludge Holding Tank/Digester Installations – N. America

68 units in SHT/Digester Installations – Over 10 years of experience



MBR Turbo Blower Installations – N. America

111 units in MBR Installations – Over 10 years of experience



Ballenger-McKinney, MD – Sludge Holding Tanks - 2011

- Blower # 2 trends: Dec-21 to Dec-29, 2017
- Pressure variation from 10 psig down to below 4.5 psig

Ballenger-McKinney, MD – Sludge Holding Tanks - 2011

- Blower #1: Jan-6 to Jan-8, 2018
- Pressure ranges from 7 psig to 3.8 psig

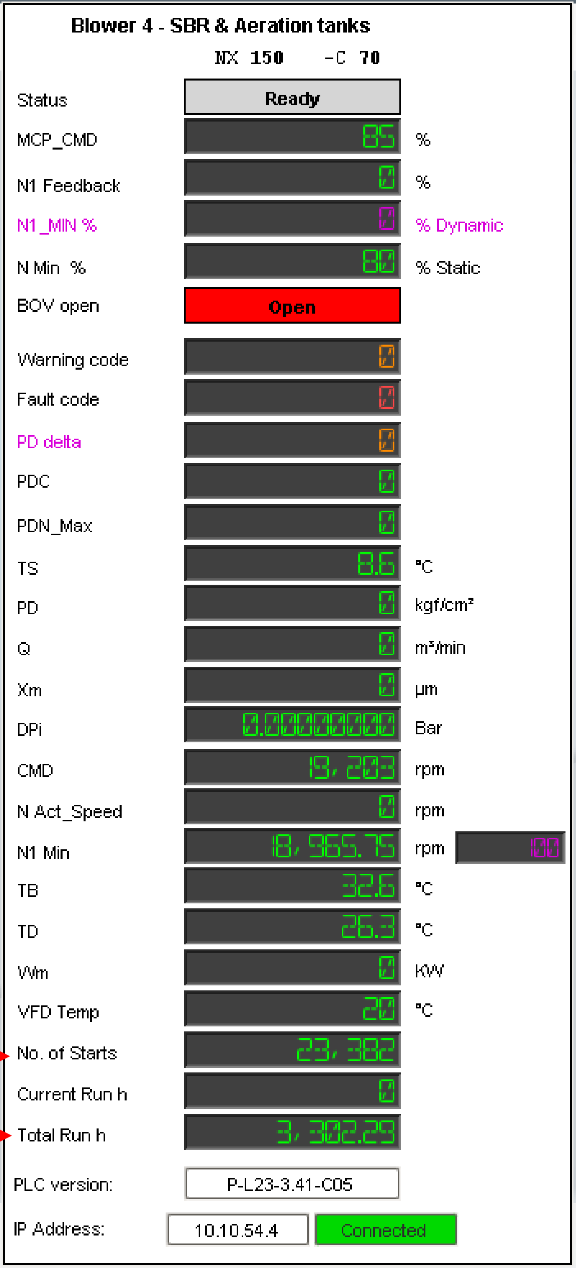
SBR Application - Frequent Start/Stops

City of Dryden, ON

Operating since September 2011 – 7 years

Total Run Hours to date: 2,020 hrs

Total Start/Stop cycles to date: 14,802



Number of Start/Stops

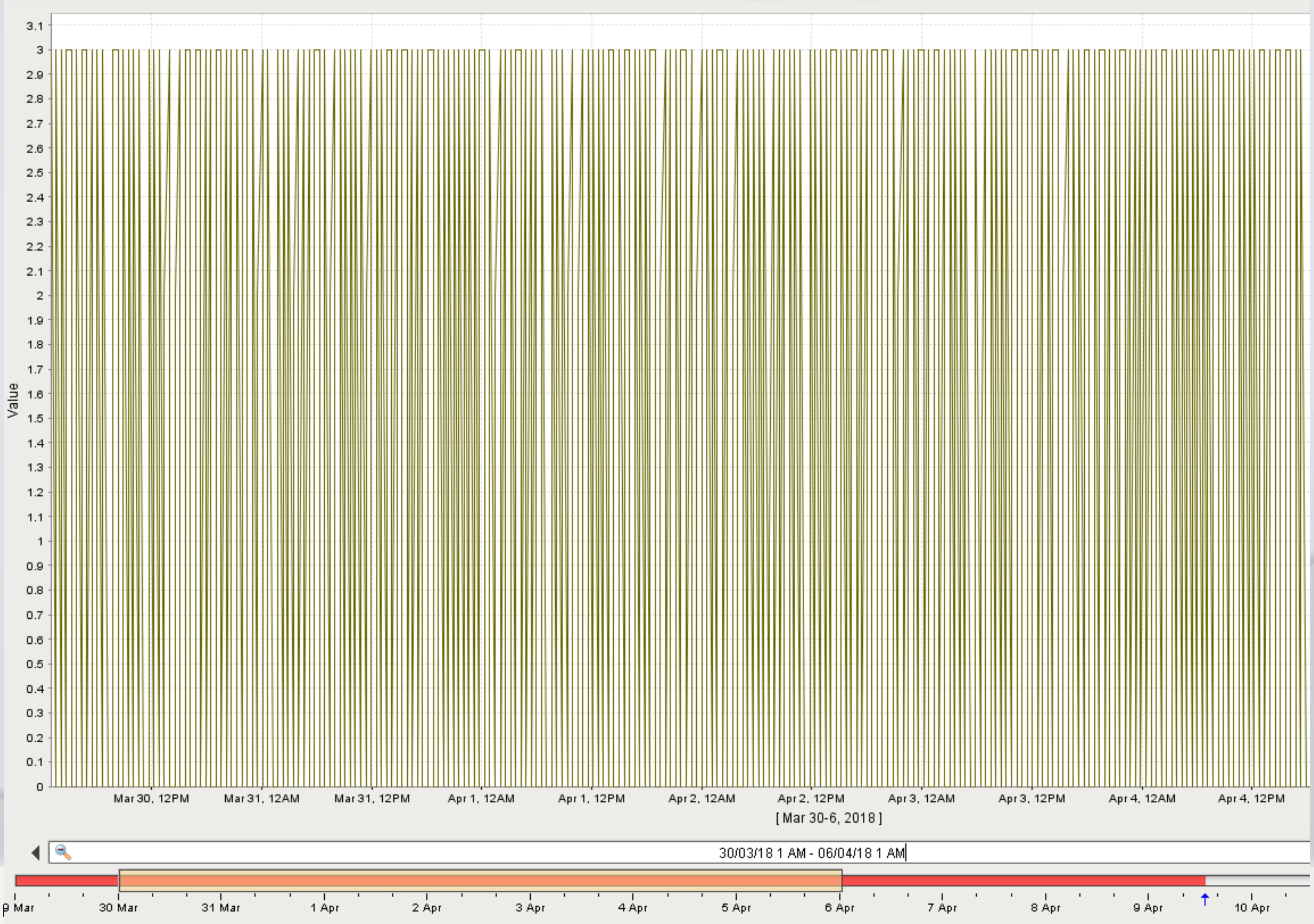
Total operating Hours

Frequent Start/Stops – City of Dryden, ON

Blower #4: Apr-4 to Apr-6, 2018 - start/stop cycles over 2 days

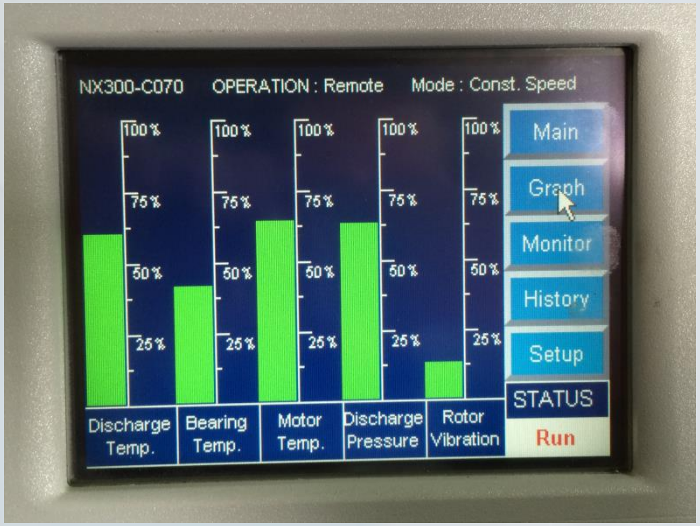
Frequent Start/Stops – City of Dryden, ON

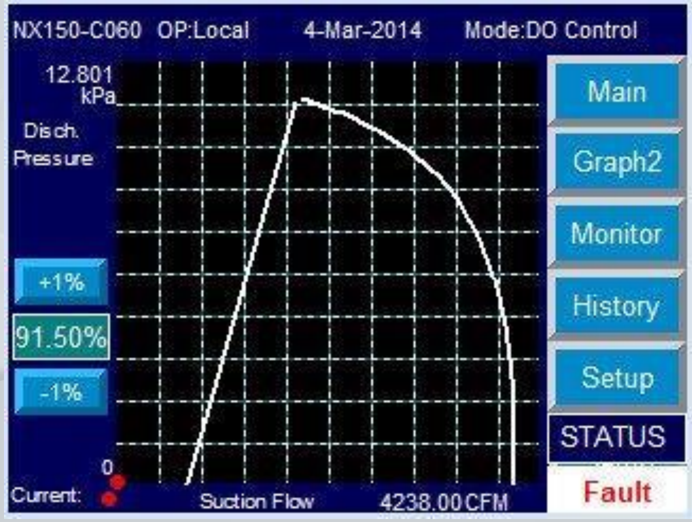
Blower #5: start/stop cycles over the course of 5 days



Easy Control & Monitoring for Varying Water Depth Applications

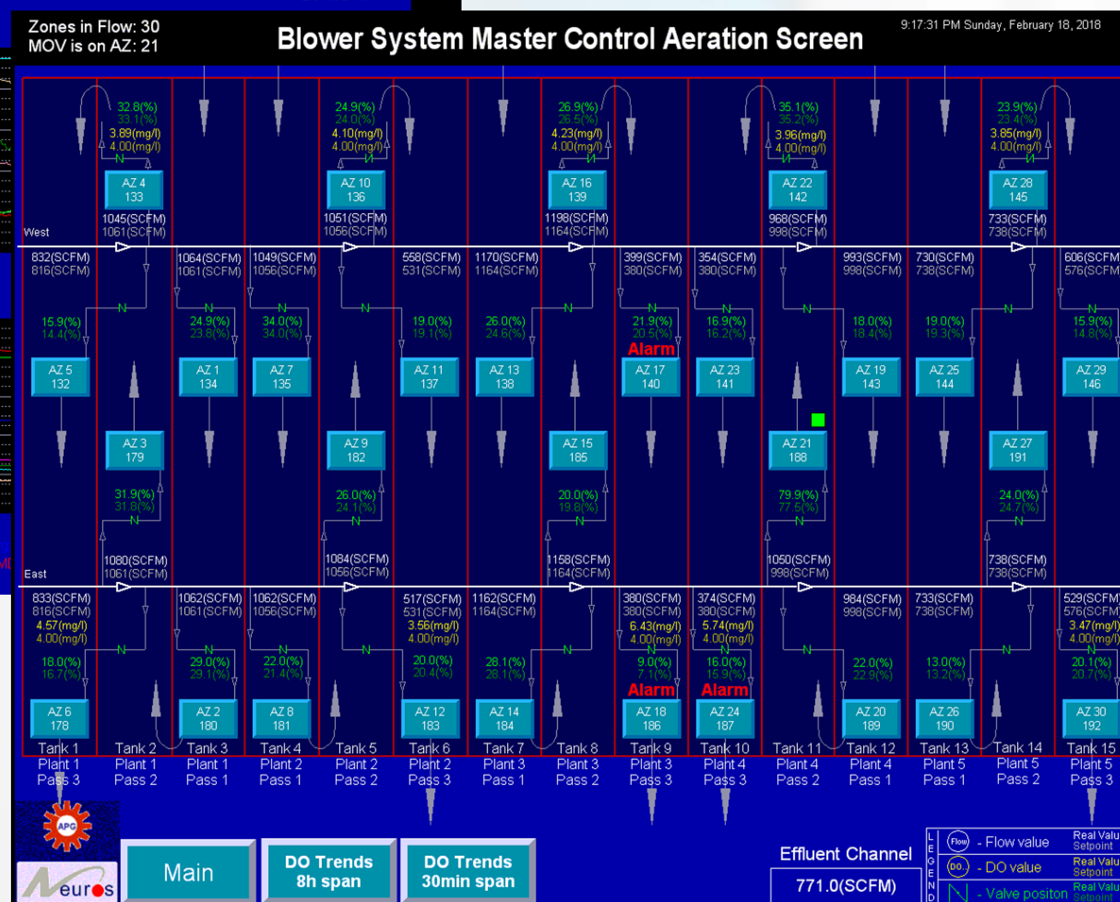
- High monitoring and control capabilities
- Different blower control modes
- Control and protection
  - DO, Pressure, Flow, Speed, Time
  - Dynamic Adjustment to Ambient Conditions
  - Dynamic Speed adjustment to prevent Surge
  - Remote communication for monitoring and diagnostics





Master Control Panel – Complete Aeration Control

Fox Metro – North Plant – 4 NX700-C070



Remote Monitoring System

Pima County Arizona

Operating since October 2012

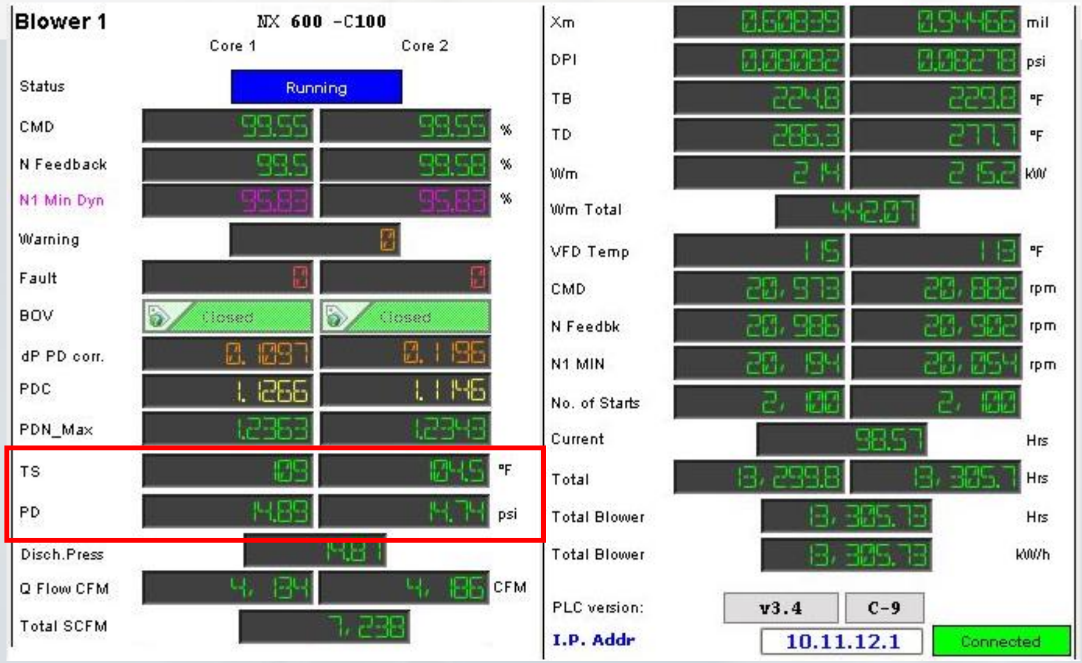
5 Dual Core NX600-C100 blowers

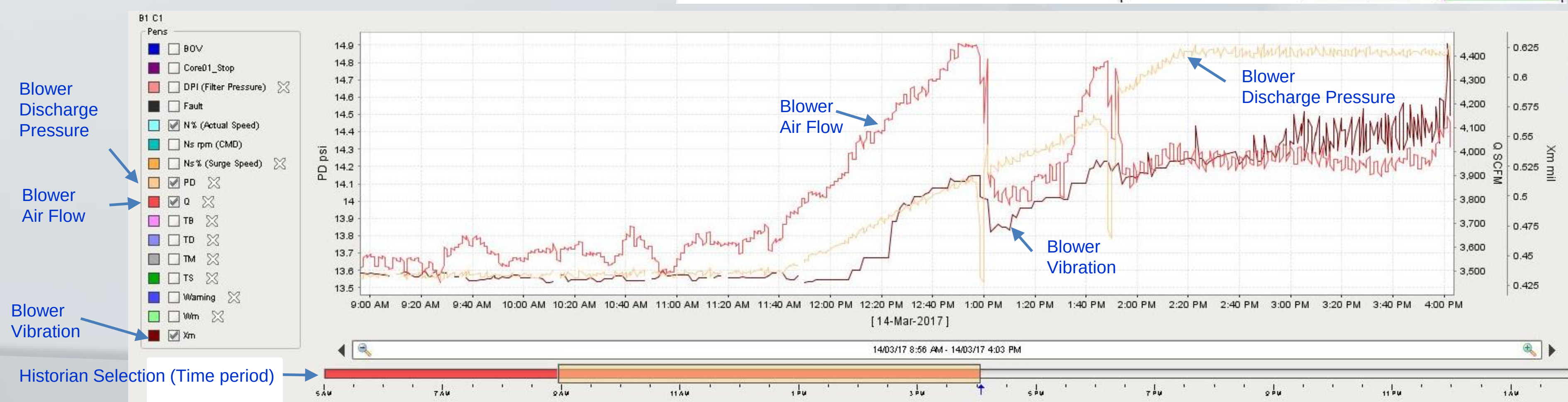
Elevation: 2839 FASL

Temp: highs of 100˚F during summer months

Pamb: 13.6 psia

Pdisch: 14.7 psig





High Speed Air Bearing Turbo Blowers comfortably operate in high varying pressure operations such as SBR, MBR and Sludge Holding Tank/Digester.

Our high-speed turbo blowers have been proven to operate adequately in frequent start/stop operations for over ten years with the rate of 7 starts/stops per hour.

Lessons learned in more than 10 years of operation have resulted in product improvements such as preventing surge.

Our lessons learned also helped us design better for the various environmental conditions in wastewater treatment plants.

Blowers and Variable Level Processes

Q&A

Please submit any questions through the Question Window on your GoToWebinar interface, directing them to Blower & Vacuum Best Practices Magazine. Our panelists will do their best to address your questions, and will follow up with you on anything that goes unanswered during this session. **Thank you for attending!**

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For more information and registration, please visit www.cabpexpo.com.

Date

September 17-19, 2018

Location

Chicago O'Hare Crowne Plaza Hotel

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May 2018 Webinar

Heat of Compression Desiccant Dryers: Clearing up the Confusion

Hank van Ormer
Air Power USA
Keynote Speaker

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Thursday, May 17, 2018 – 2:00 PM EST
Register for free at
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