Northeast Ohio Regional Sewer District

Southerly WWTC Blower Serviceability Testing and Technology Selection for Energy Efficiency

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One Water Conference

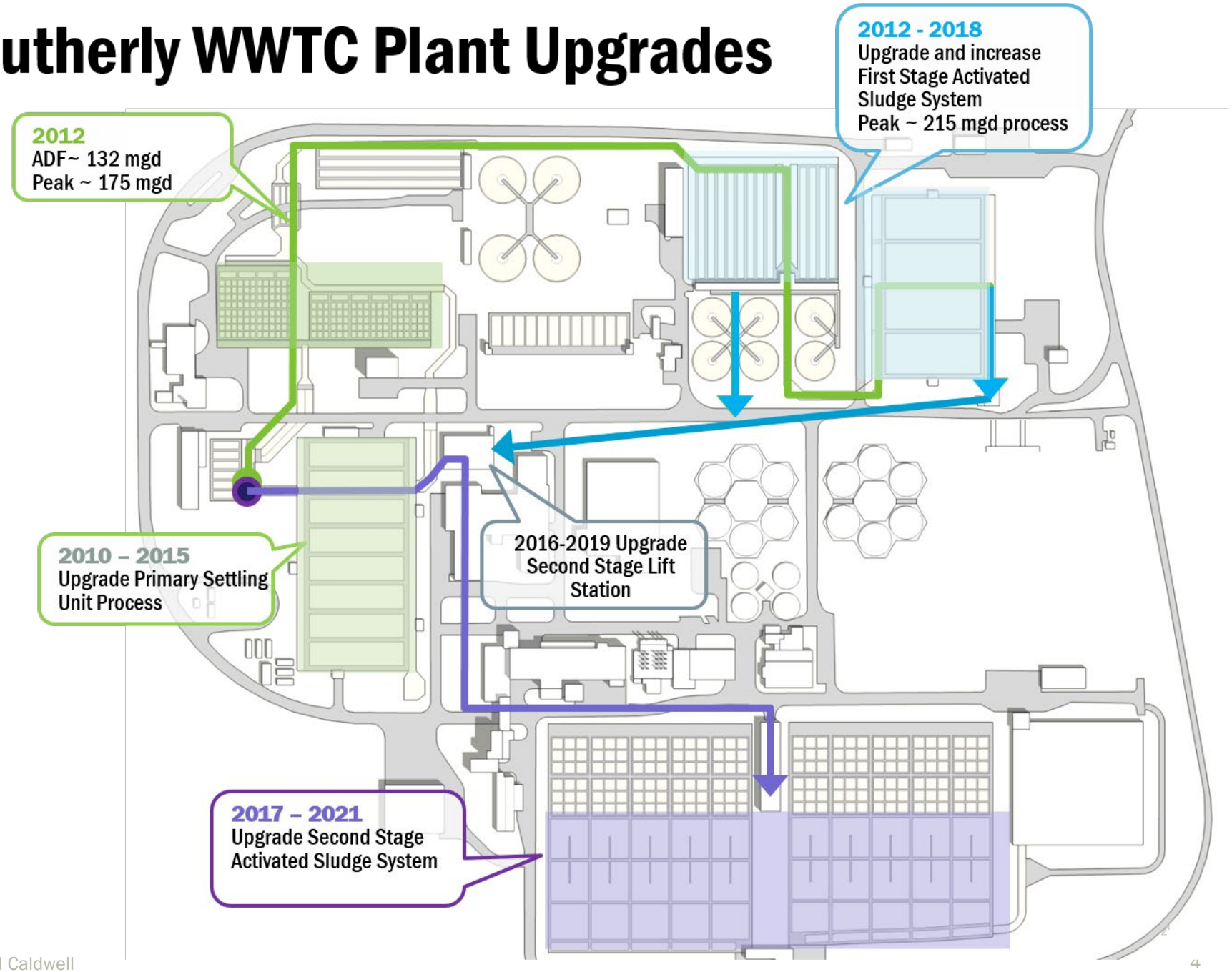
Summary

- NEORSD Overview
- Project Background and Objectives
- Evaluation
- Design
- Performance and Feedback from Plant

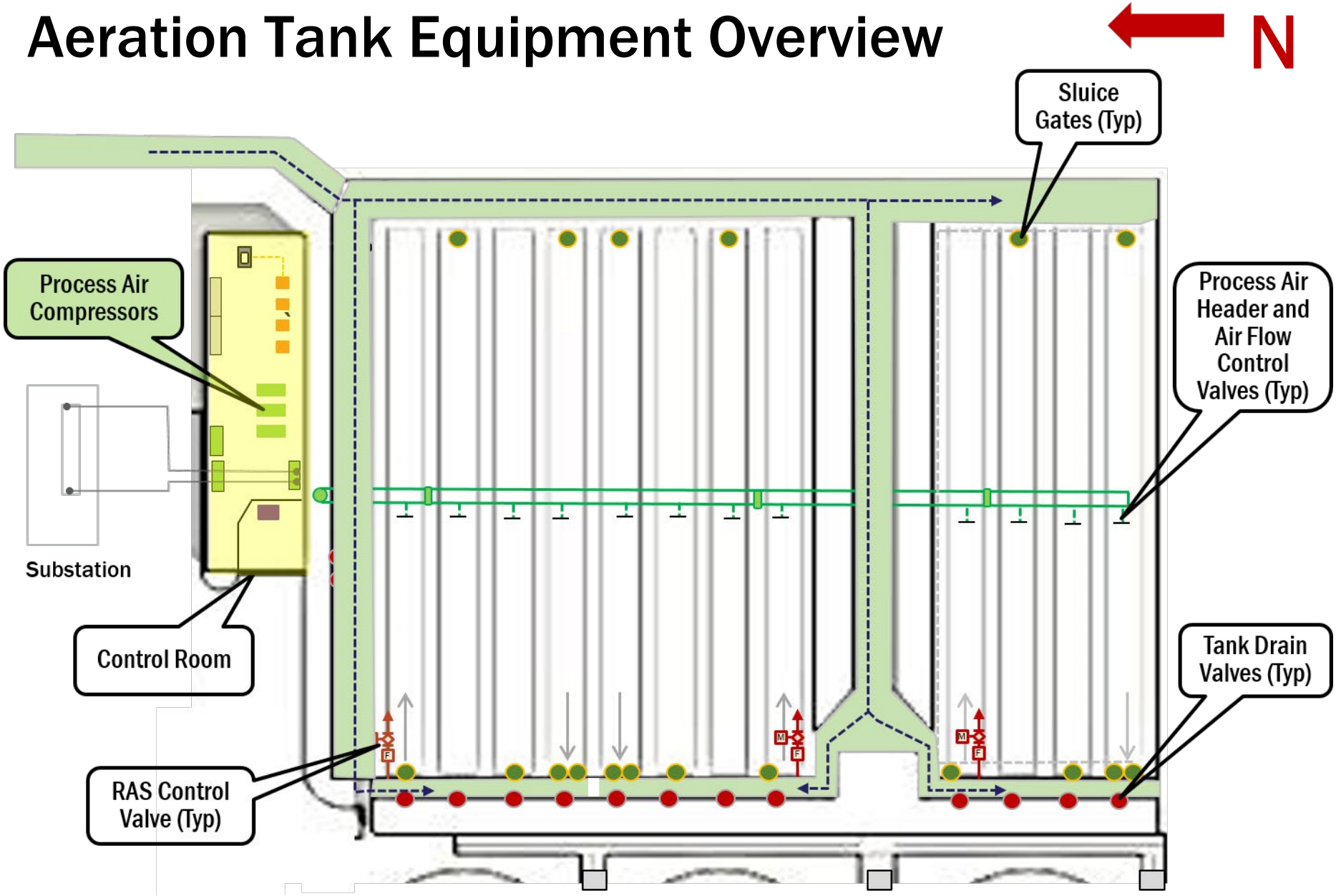
NEORSD Southerly WWTC

- Two-stage advanced treatment facility
- Serves 500,000 residents of Cleveland, OH and Suburbs
- First Stage Aeration System (FSAS) reduce carbonaceous biological oxygen demand prior to Second State Aeration System (SSAS)
- Two stages operate in series during dry weather but after FSAS is capacity reached a portion of primary effluent directed to SSAS (capacity of 400 mgd)

Southerly WWTC Plant Upgrades



Aeration Tank Equipment Overview

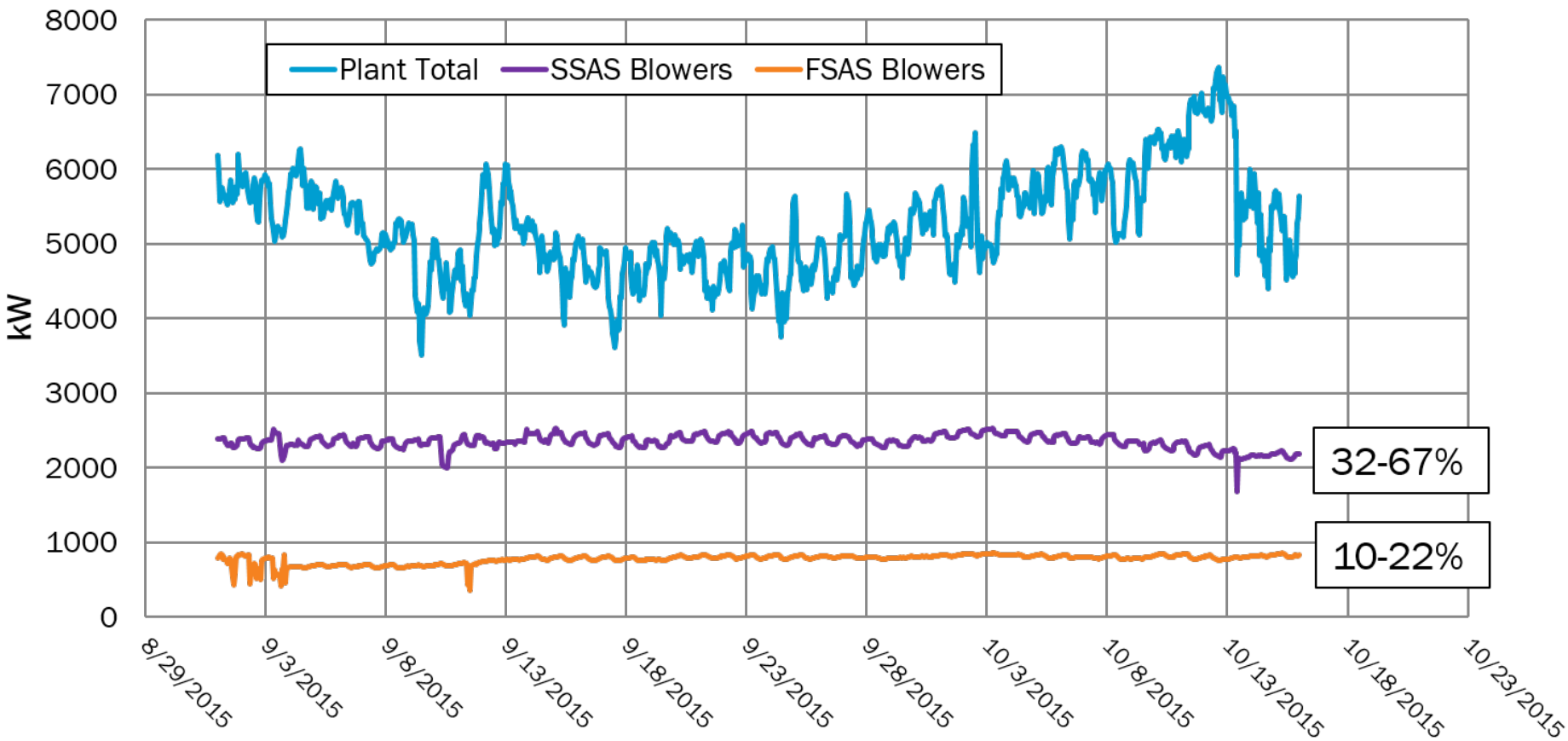


Overview and Objectives

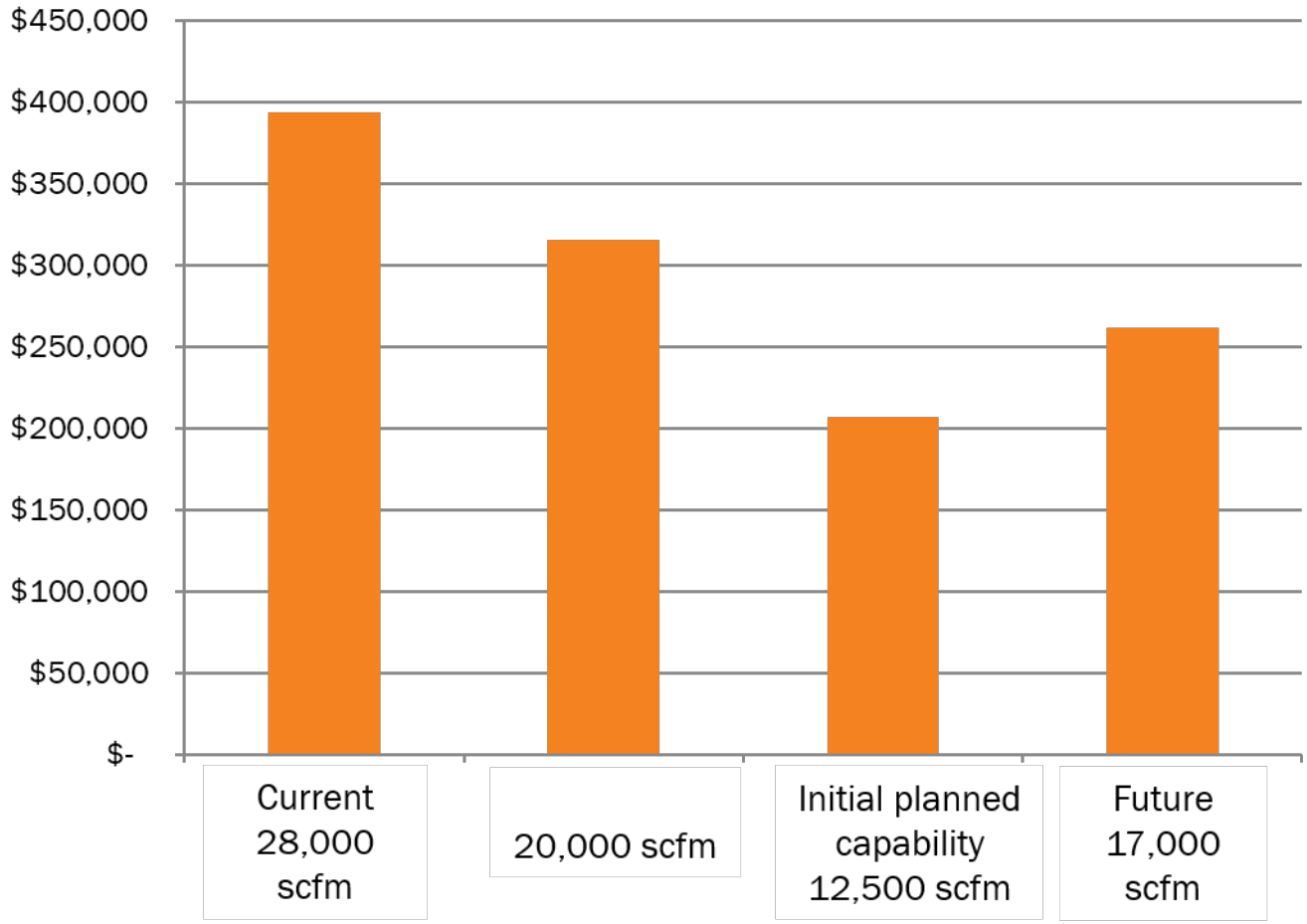
- Four 4160V motor driven units installed in 1980s were oversized
- Units did not operate at best efficiency point
- At off-design flow rates, the risk of creating unusual aerodynamic flow patterns that can excite normal benign natural frequencies is increased
- Higher bearing loads which work against extended bearing life are encountered at low flows
- BC retained MSI for testing and analysis to help evaluate various options to “right size” the installation

Goal: Improve the mechanical reliability and efficiency of the unit process with improved automation and energy efficiency of the process air blowers.

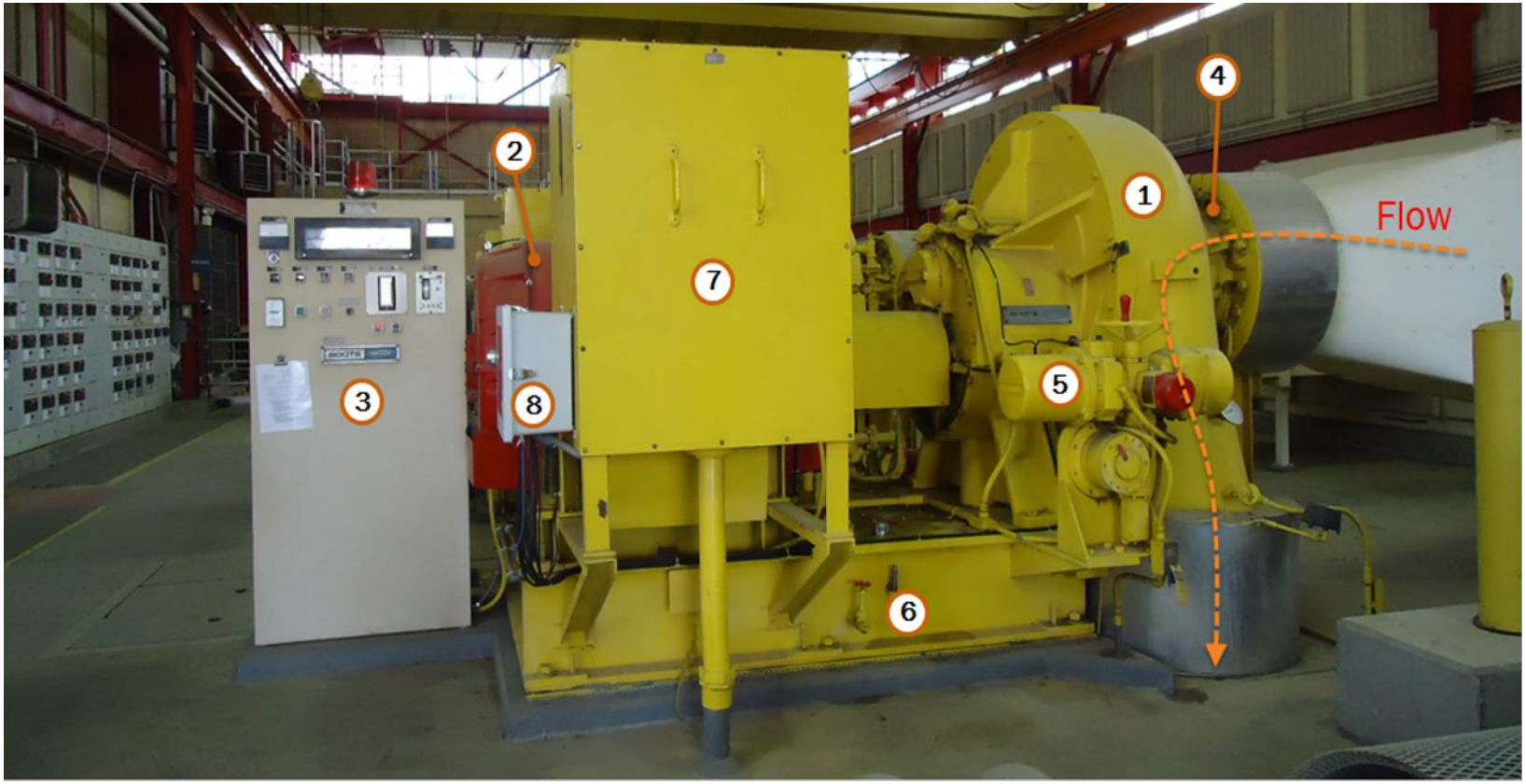
Southerly WWTC Energy Demand



Annual Energy Costs



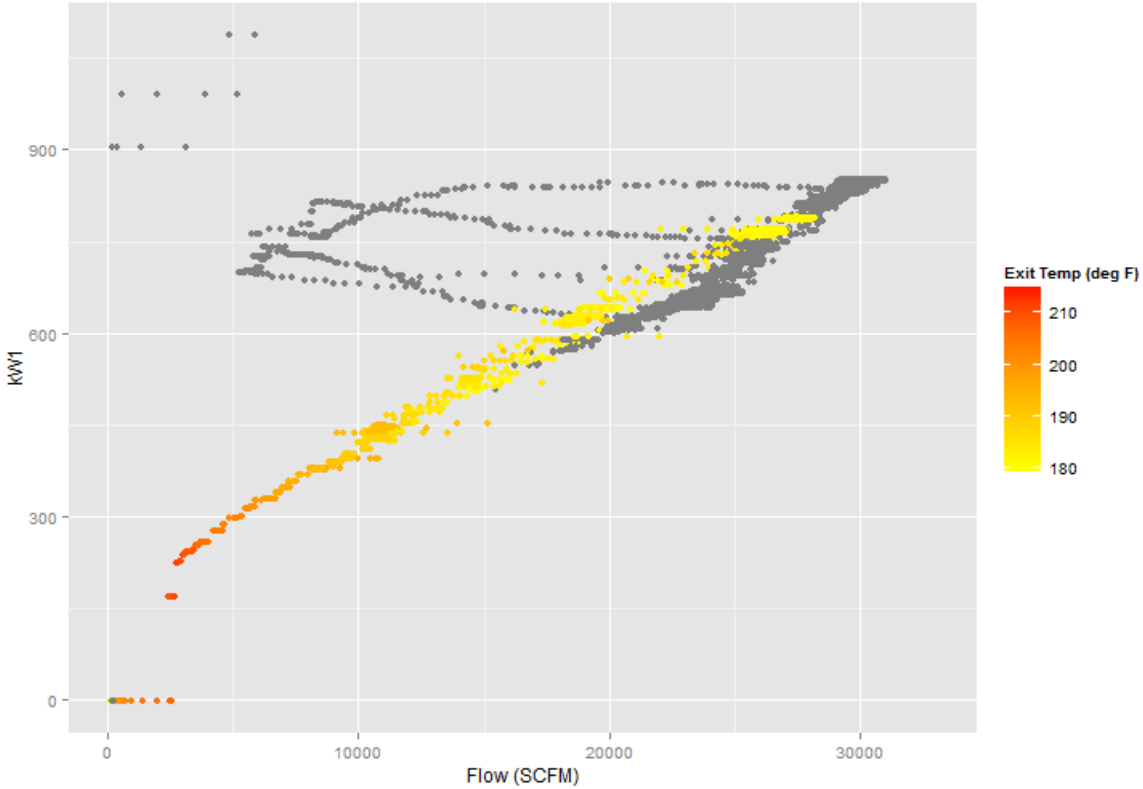
Process Air Compressor Components



1. Compressor
2. 1250 HP Motor
3. Control Panel
4. Inlet Guide Vane Control
5. Discharge Diffuser Vane Actuator
6. Base Plate and Vibration Isolation
7. Power Termination Box
8. Vibration Monitoring

Turndown Limitations

- Disabled surge warnings and alarms
- Q<19,000 scfm resulted in T ~ 180° F discharge and alarm
- Manufacturer confirmed temp up to 220° F discharge was ok

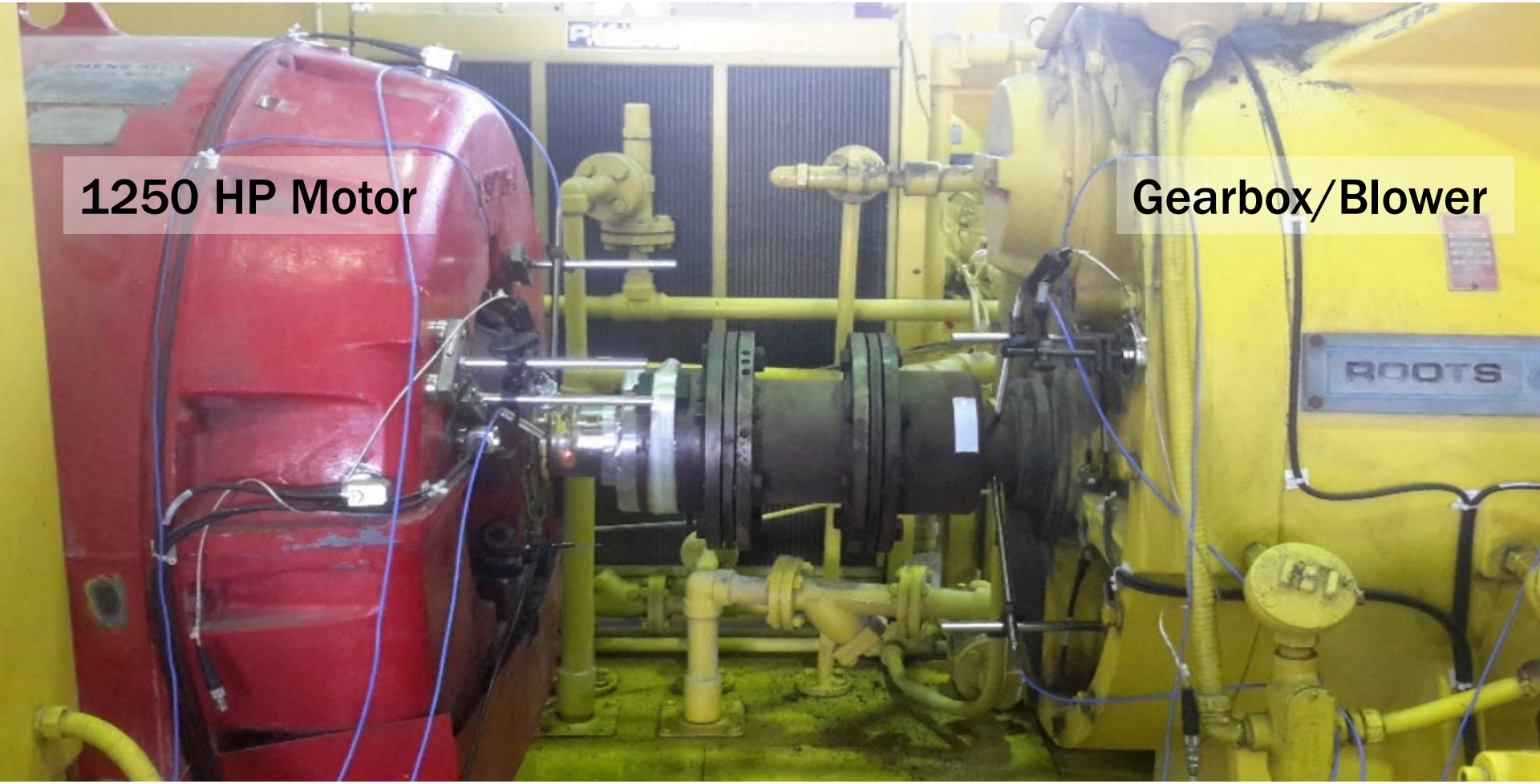


Process Air Compressor Testing

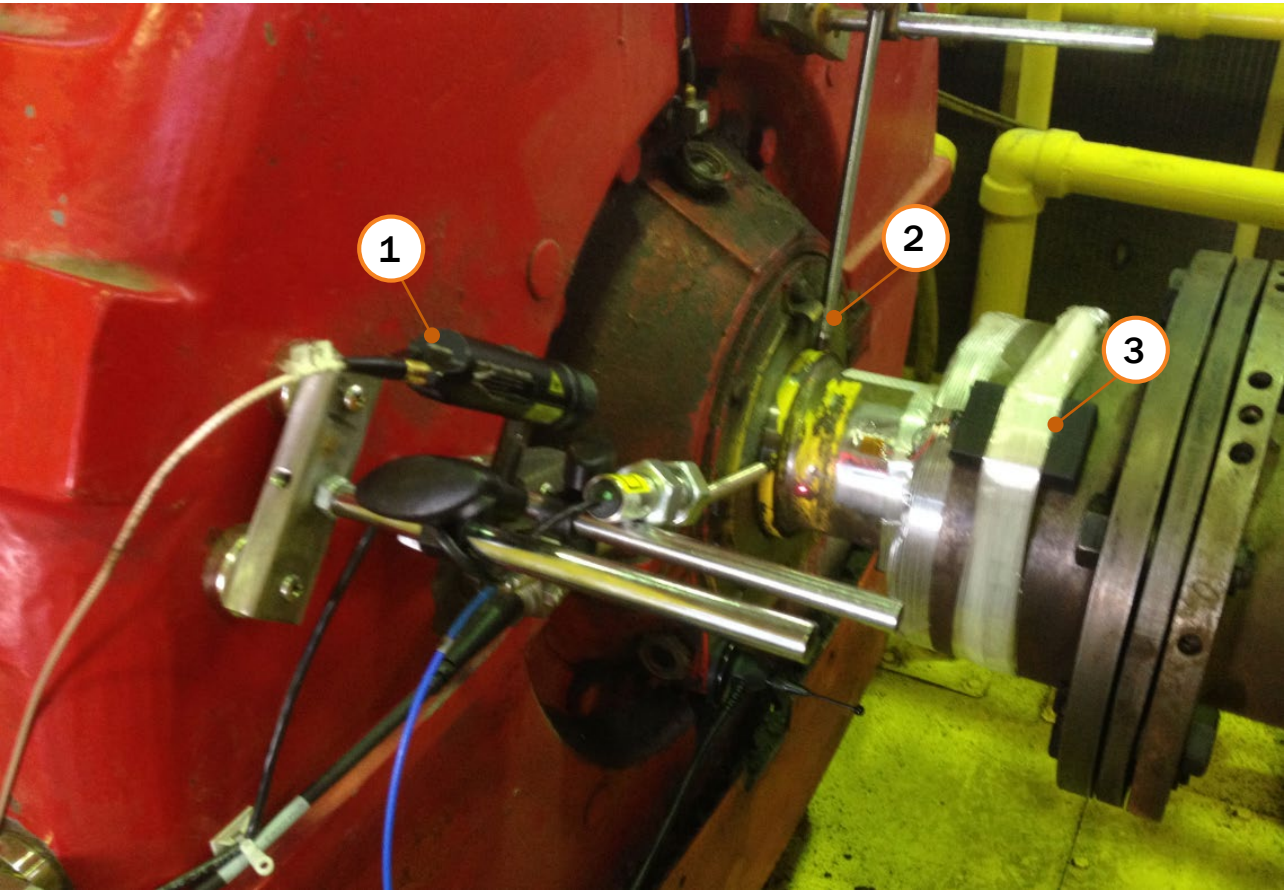
Goals

1. Verify blower performance curves
2. Verify turndown capability
3. Check for vibration and resonant frequencies
   - Identify structural problems & weak points
   - Evaluate application of a VFD

Equipment Setup



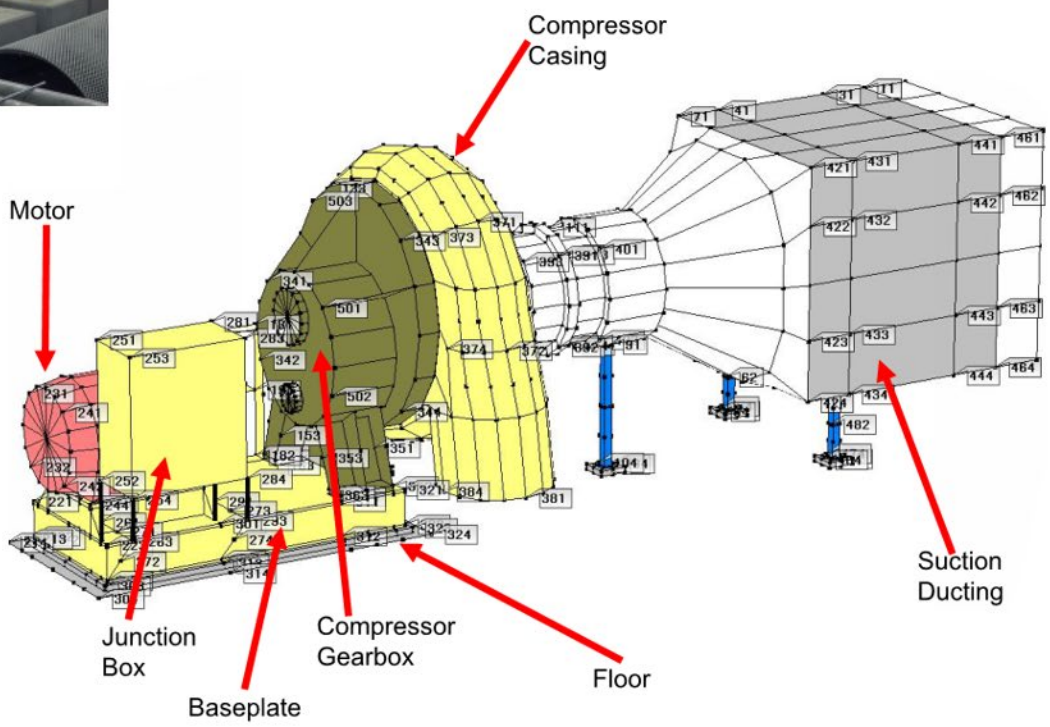
Equipment Setup



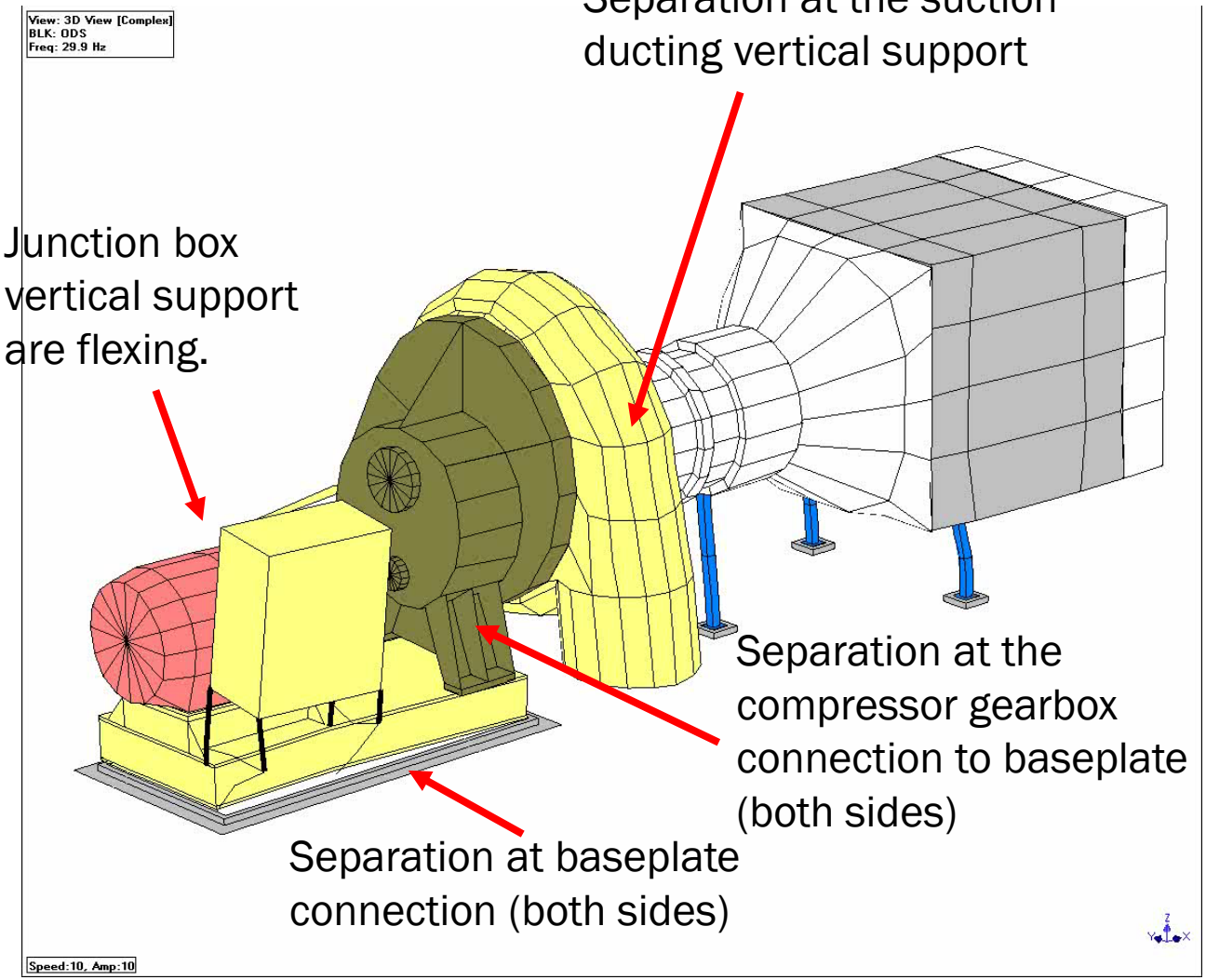
1. Tachometer
2. Torque gauge with telemetry
3. Shaft proximity sensors

Experimental Modal Analysis & Operating Deflection Shape

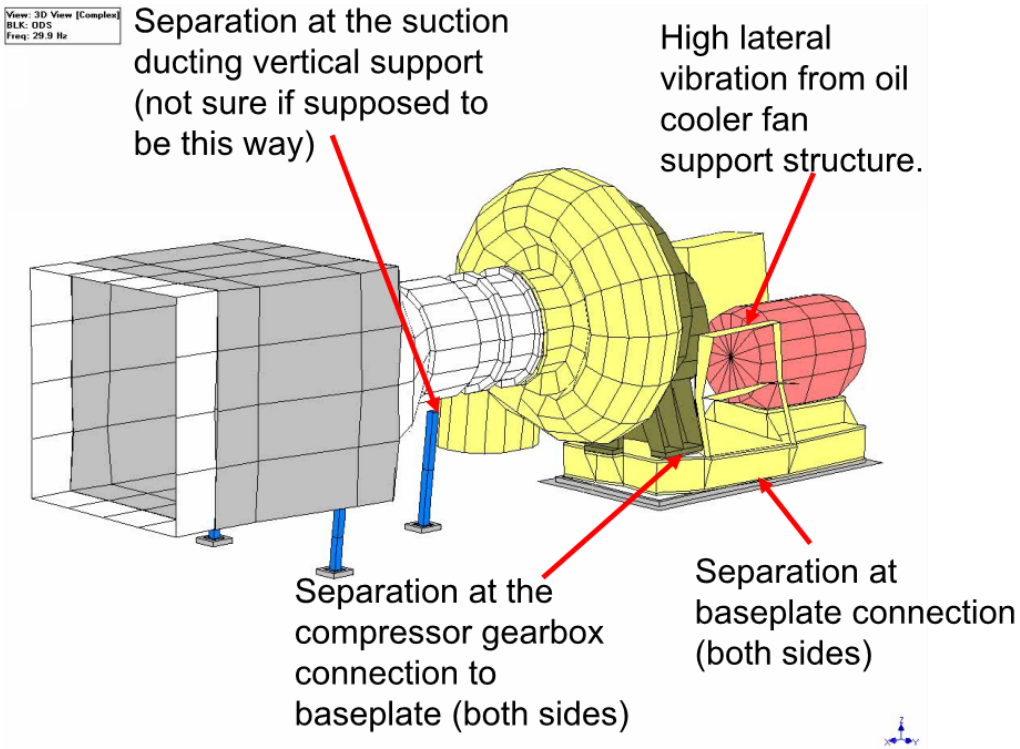
Compressor 4 Modal Data Points
(24 vibration locations/ 72 directions)



Compressor #4 Global ODS Vibration at 29.9 Hz (1x Input RPM) ISO View



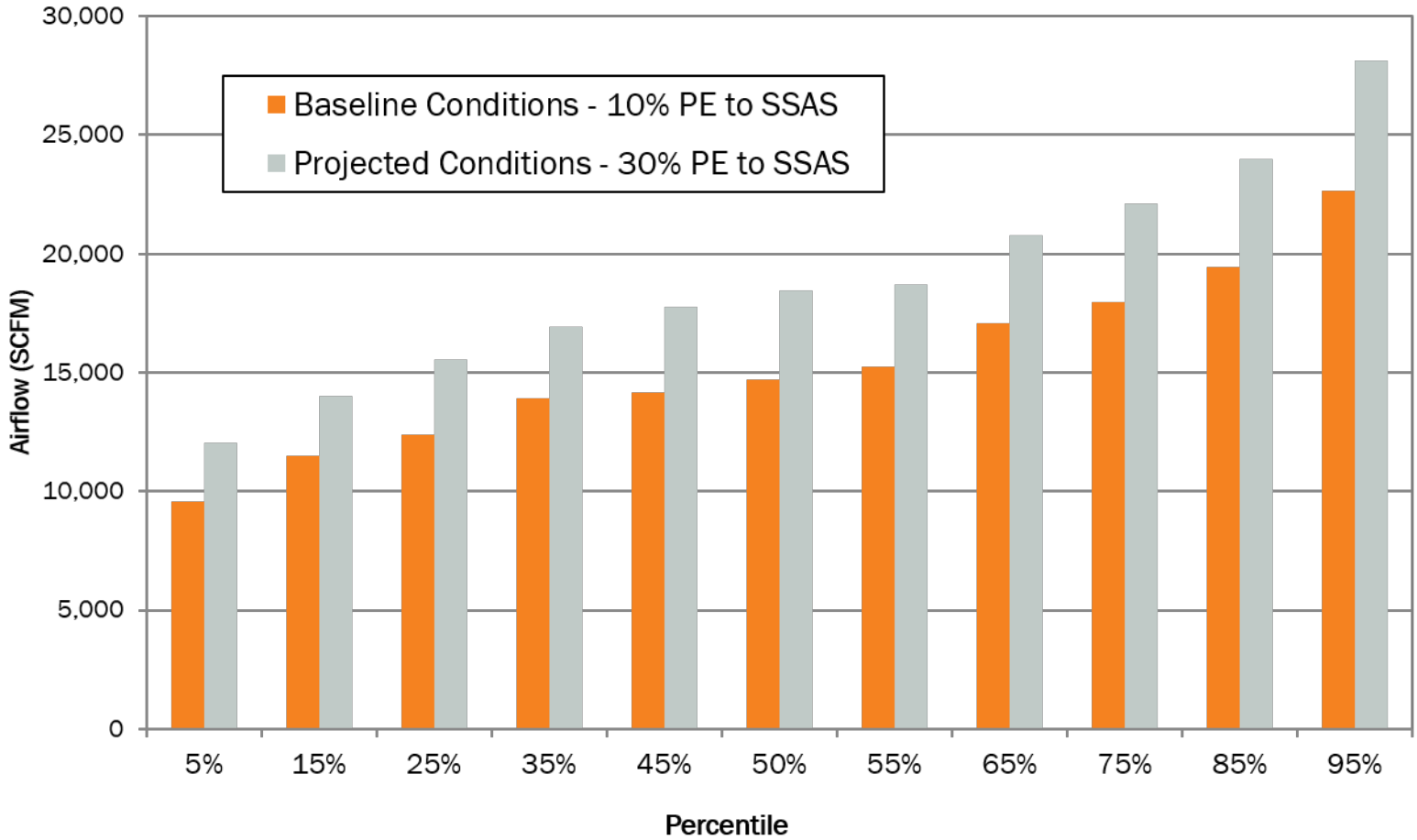
Findings



- Field data compared well to the 1986 OEM HP vs. flowrate curve
- Rotordynamics lateral characteristics ok
- ~3% efficiency loss
- Unit #3 and #4 produced more flow than #1 and #2
- Mitigate soft foot issues
- Unit #3 Inlet Guide Vane indication and position not well matched

Discharge Diffuser Vanes must work in tandem with Inlet Guide Vanes to realize performance efficiency

Design Air Requirements – Modeled 10% Bins

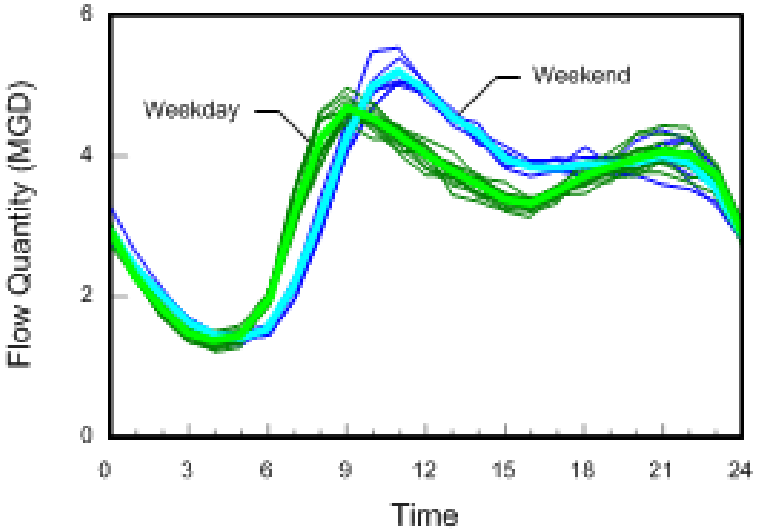


Percent less than based on the midpoint of the bin. For the 0-10 percentile bin the values were based on the 5th (0.05) percentile.

Operating Strategy Affects Demand

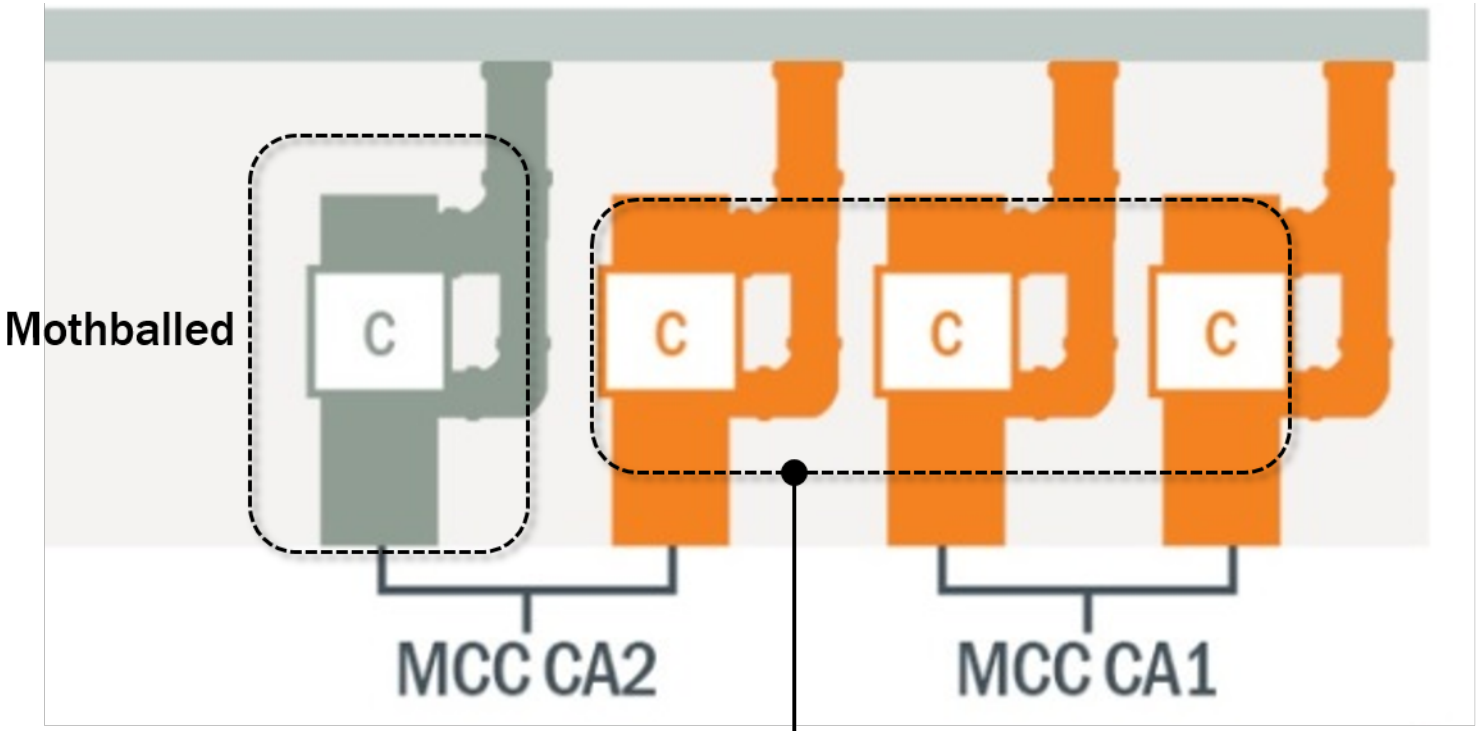
FSAS Airflows Required at Standard Conditions, SCFM							
Tank Configuration	Design Minimum[1]	Current Annual Average	Current Maximum Month	Current Peak Hour	Future Annual Average	Future Maximum Month	Future Peak Hour
Step Feed (2 Tanks)	6,500	11,200	22,900	27,500	13,200	28,300	33,800
Plug Flow (3 Tanks)	6,500	14,100	29,600	35,700	17,000	36,000	43,000

[1]Minimum airflows are based upon the 1) minimum process airflow requirements, 2) minimum aeration basin mixing and 3) minimum diffuser airflow



- Designing for plug flow, peak hour future condition oversizes blower
- Oversizing increases surge potential

Alternative Layouts



Alt 1 – Rehab existing ~ 11,000 to 28,000 scfm

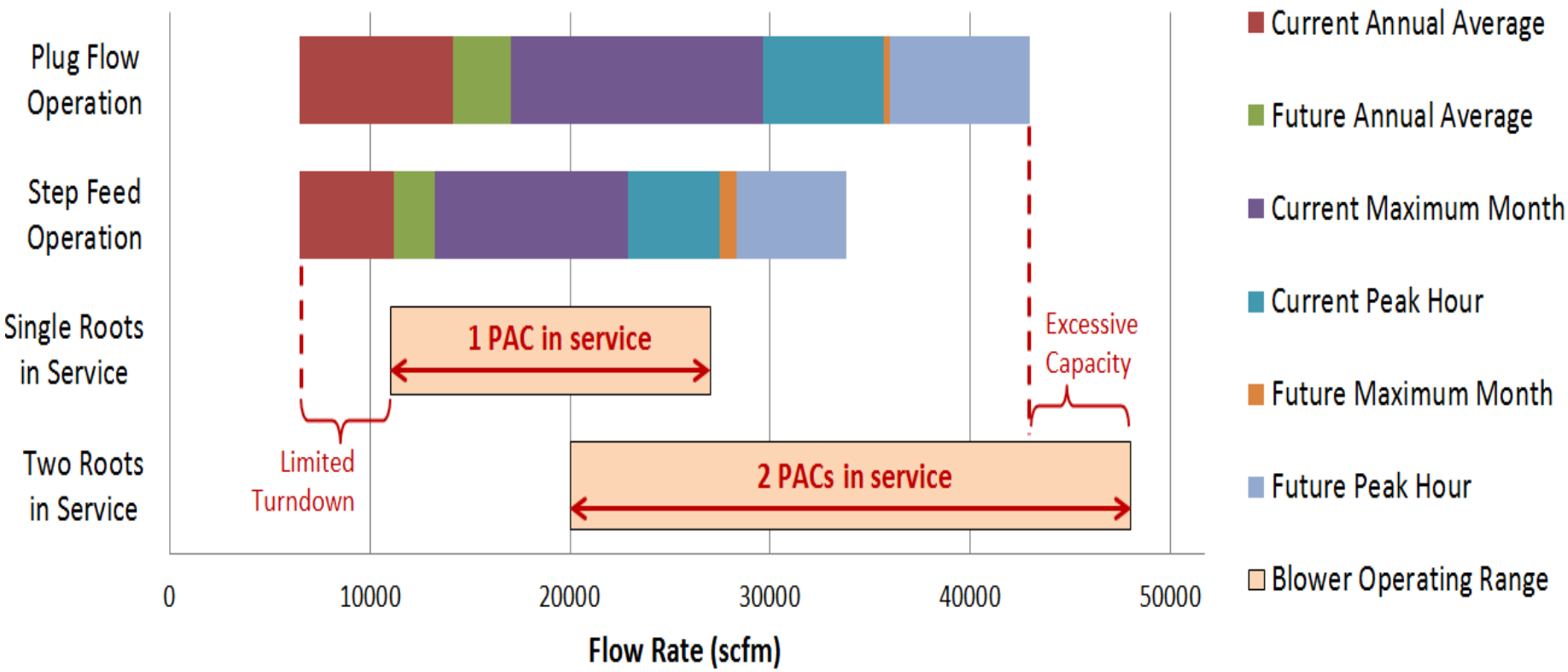
Alt 2 – Rehab existing, new impeller/motor ~16500 to 14500 scfm

Alt 3 – New single stage ~ 6500 to 14500 scfm

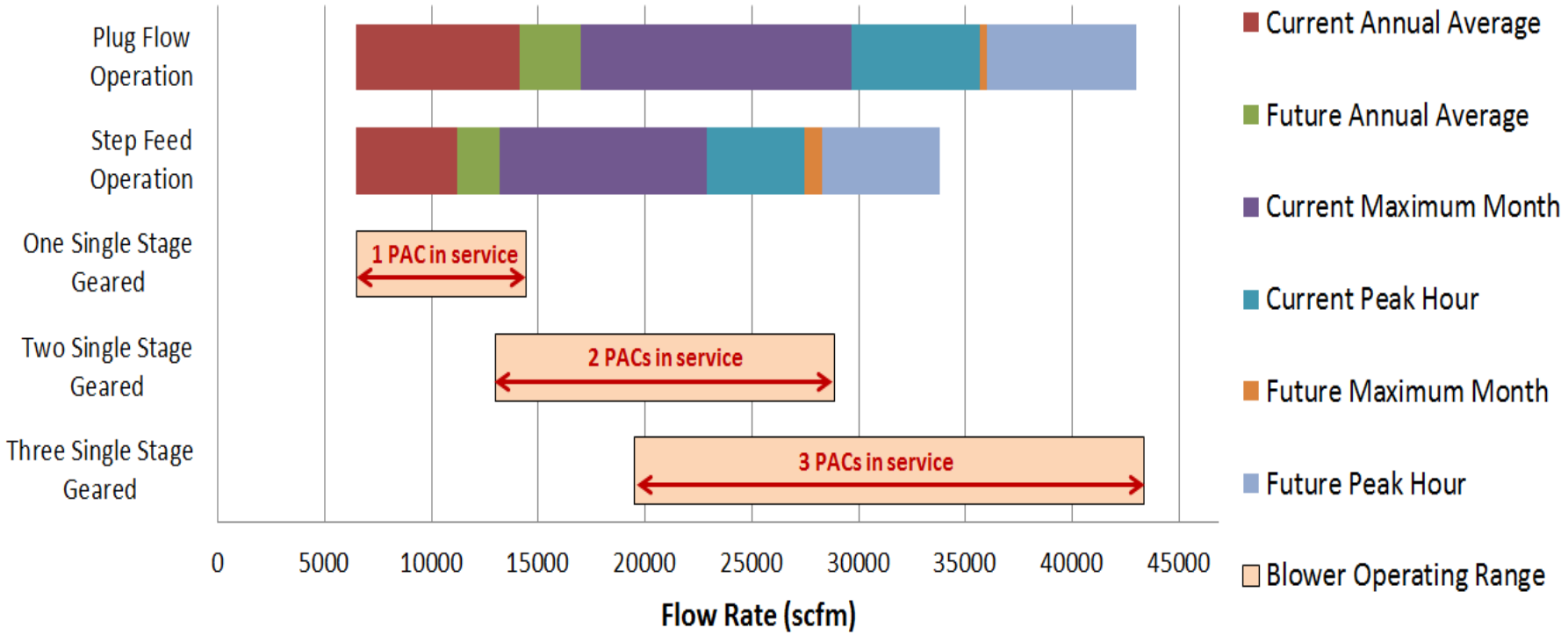
Alt 4 – New high-speed gearless turbo 6500 to 14500 scfm

Alt 5 – Multistage

Existing Operating Envelope



Modified Operating Range



Preliminary Cost Analysis

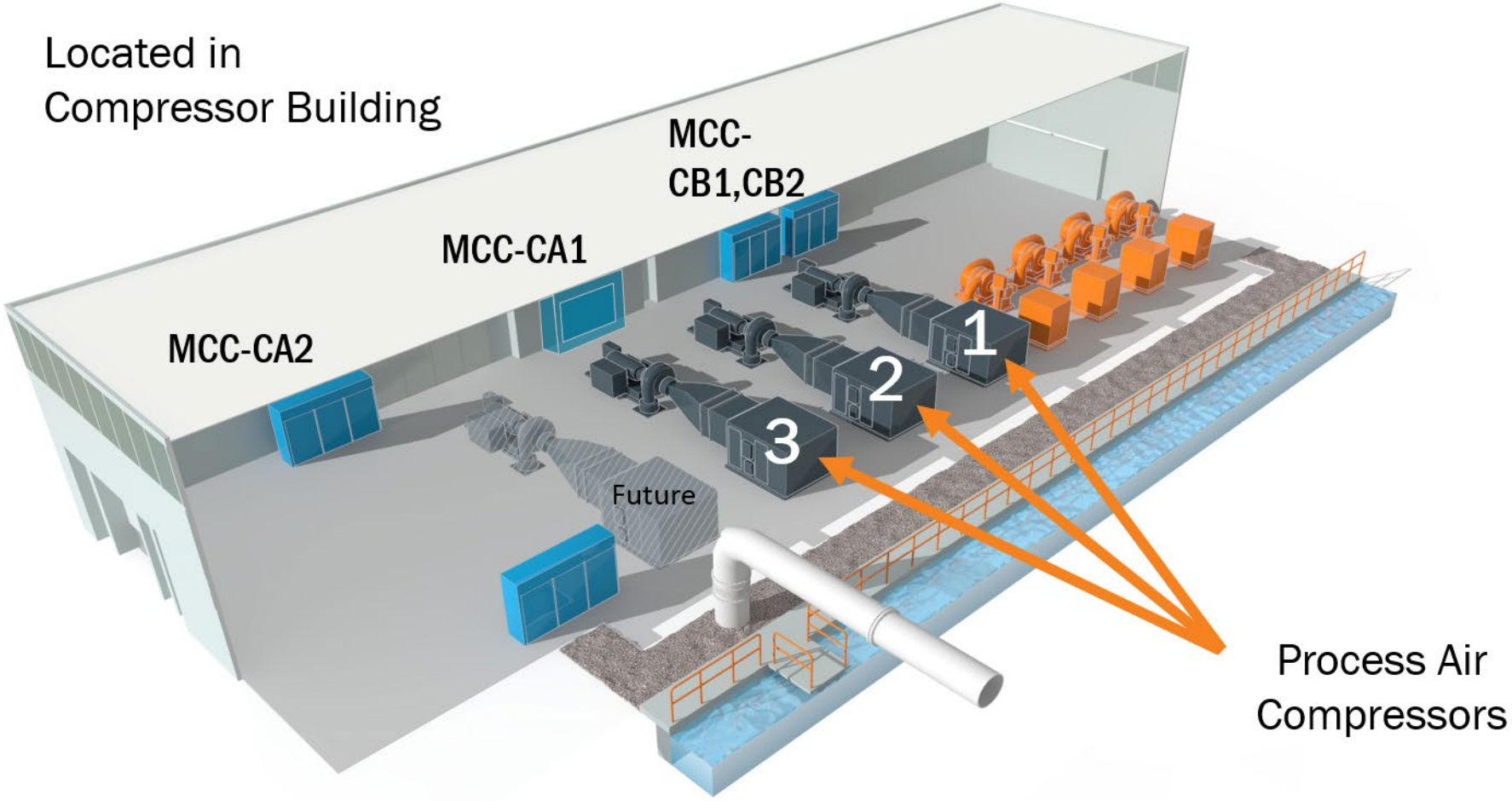
Alternative Costs ($)						
Alternative	Capital Cost	Annual O&M Costs	Major Maintenance	Annual Energy 2017-2032	Annual Energy 2032-2047	30-Year NPV
Current Operation (Status Quo)	-	-	-	520,000	744,000	
1 – Rehabilitate Existing	3,709,000	37,000	390,000	292,000	508,000	17,210,000
2 – Rehabilitate Existing and Modify Impellers	4,259,000	37,000	390,000	310,000	548,000	18,630,000
3 – New Singe Stage	4,209,000	33,000	390,000	310,000	548,000	18,460,000
4 – New High Speed Direct Drive (air/magnetic bearing) 480V Turbo Blowers	4,674,000	29,000	600,000	275,000	536,000	18,310,000

Recommendation:

Alternative 3 - New Single Stage

- Ability to design for higher pressures (rise to surge reliability)
- Similar in energy savings
- Availability of high-speed turbo blower w/VFDs limited to 480V service, more susceptible to surge, corrosion or failure
- Least disruptive to 4160VAC electrical feed
- Time required for rehabilitation and “unforeseen” conditions
- Better comprehensive warranty than rehabilitation

Process Air Compressors



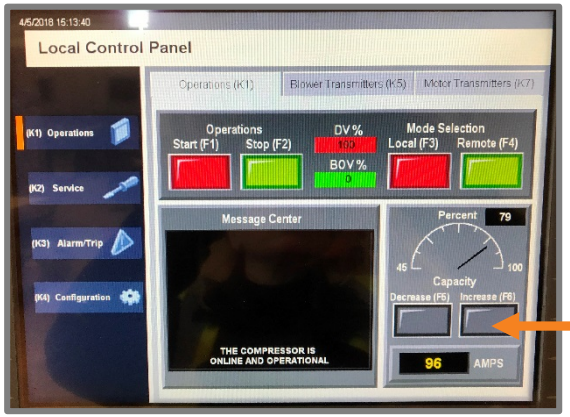
New Process Air Compressors

Location	Building
Compressor Manufacturer	Siemens
Model Number	STC-GO (44SV-GL225)
Number of Compressors	Three
Capacity	14,500 scfm
Inlet Pressure	14.7 psia
Discharge Pressure	23.5 psia 9.2 psig
Motor Horsepower	900 Hp
Motor Speed	3,565 rpm

Process Air Compressors (Control Modes)

Local-Manual Mode

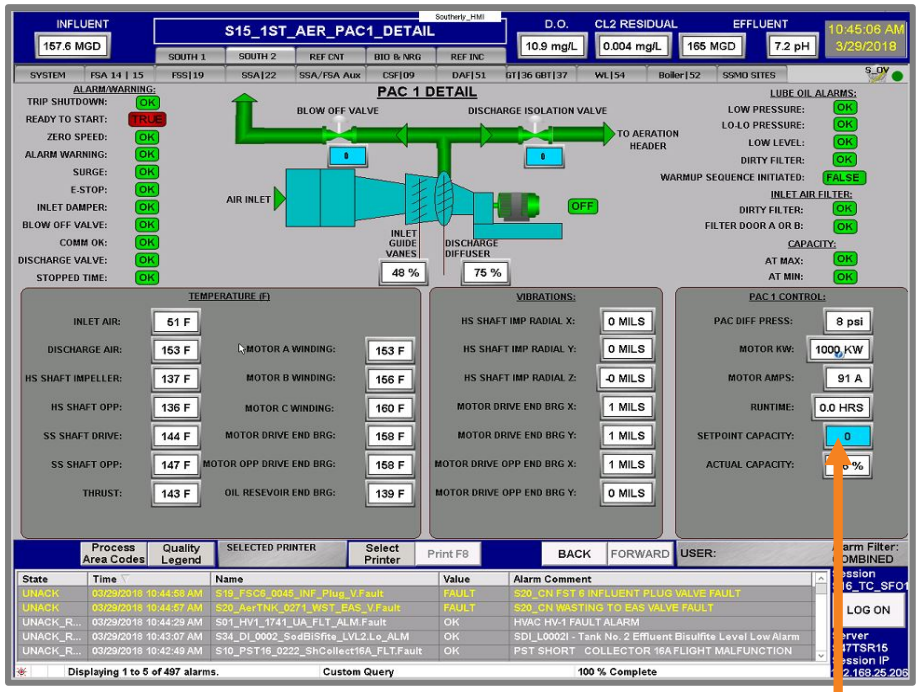
- Start/Stop
- Enter setpoint capacity (%)
- E-Stop



Increase / Decrease Setpoint Capacity Here

Remote-Manual Mode

- Start/Stop at OIT (Panelview) or SCADA (Wonderware) screens
- Enter setpoint capacity (%) OIT (Panelview) or SCADA (Wonderware) screens
  - ➢ PAC will adjust VDs to maintain this capacity.
- Stop at the vendor LCP



Enter Setpoint Capacity Here

Performance / O&M Feedback

One unit in continuous operation since May 2018 ~ 70% to 100% capacity, most frequently ~ 12,500 scfm

Two parallel units as of early August

- ✓ Foundation footprint was critical to align discharge elbows
- ✓ Decision to incorporate a master PLC by vendor, or Owner area-wide PLC
- ✓ Selection of cooling system (air vs. water) was a key decision as well as the location of cooling unit
- ✓ Assignment of responsibility for motor starting profile is important
- ✓ Standard/alternative lubricants and responsibility to maintain
- ✓ Buy-in on automatic operation

Thank You

it's about connecting

Northeast Ohio Regional Sewer District

Brown AND Caldwell essential ingredients®

Presented by:
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Blower Differentiating Features

Feature	Direct Drive Turbo	Integrally Geared Turbo	Multi-stage centrifugal
Cost	Moderate	Highest	Low
Wire efficiency	~72%	~78%	~64%
Noise	Lowest (80 dBA)	Highest (94 dBA)	High
EI&C Requirements	Highest	High	Low
Capacity, cfm	< 15,000 (dual core)	< 70,000	< 50,000
Pressure, psig	<15	<30	<25
RPM	< 40,000	< 25,000 (3,500 motor)	< 3,500
Drive	Direct-inline	Planetary gear	Direct coupled
Bearings	Air Foil/magnetic	Oil lubricated journal	Roller bearing
Motor	Permanent magnet synchronous	Squirrel cage, induction, asynchronous	
Cooling	Air or Water	Air or Water	Air
Capacity Control	VFD (up to 450 Hz)	Inlet guide and diffuser vanes	Inlet control valve