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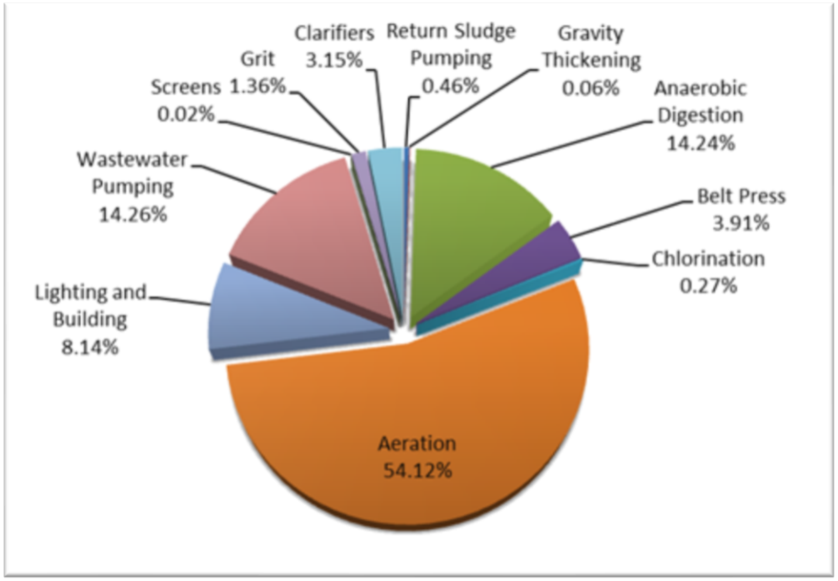
Water Environment Association of Texas

Process Energy Optimization

By advanced aeration control

Goals and why we care!

- Aeration makes up about 50-70% of a plants electric bill.
- Normally no more than 2mg/L DO is required to adequately treat and remove ammonia.
- Energy is a hot topic right now and reducing energy consumption is leading the charge.
- Infrastructure needs repair. Save Energy = Extra resources.



Credit: UIC, http://www.erc.uic.edu

Efficiency of Aeration Technologies

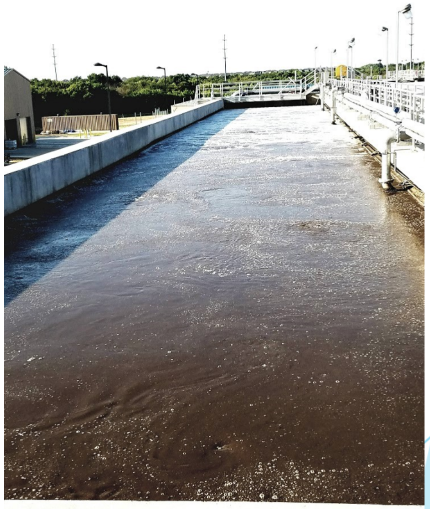
Aeration Technology	Oxygen Transfer Efficiency (OTE)
Fine Bubble Diffusers	7.0 - 10.0 lbs. O2/bhp*hr
Coarse Bubble Diffusers	3.0 - 4.0 lbs. O2/bhp*hr
Jet Aeration	3.0 - 4.0 lbs. O2/bhp*hr
Mechanical Aeration	2.0 - 3.5 lbs. O2/bhp*hr

Data courtesy of Xylem inc.

- Mechanical/Jet Aeration
  - Low capital costs
  - Easy install
  - Issues with freezing in cold climate
- Coarse Bubble Diffusers
  - Provides adequate mixing and aeration.
  - May have Lower Maintenance than fine
- Fine Bubble Diffusers
  - Excellent OTE
  - Easy swing zone install when combined with submersible mixers
  - Will decrease OTE over time

How do we monitor?

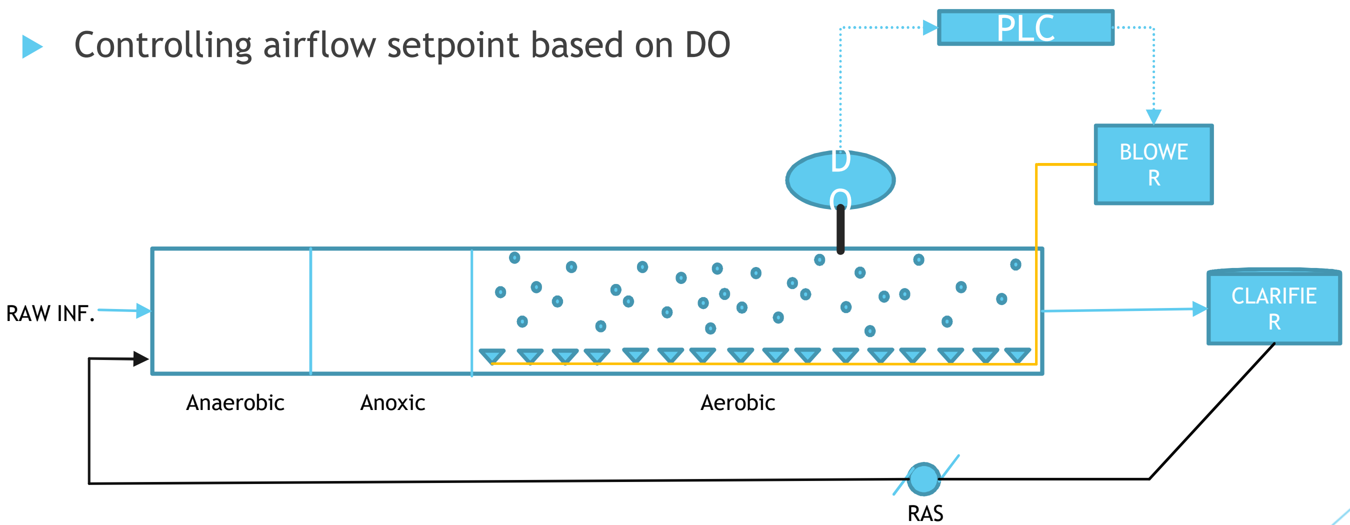
- Probes and online analyzers
- DO, Ammonia, Nitrate, ORP, Orthophosphate, pH, MLSS, …
- Each has a purpose and can help meet our goals.



BS1

Dissolved Oxygen (Luminescent)

- Utilize light to identify DO concentration
- Out of the box
- Est. 2 year probe life
- Minimal maintenance and no calibration
- Controlling airflow setpoint based on DO



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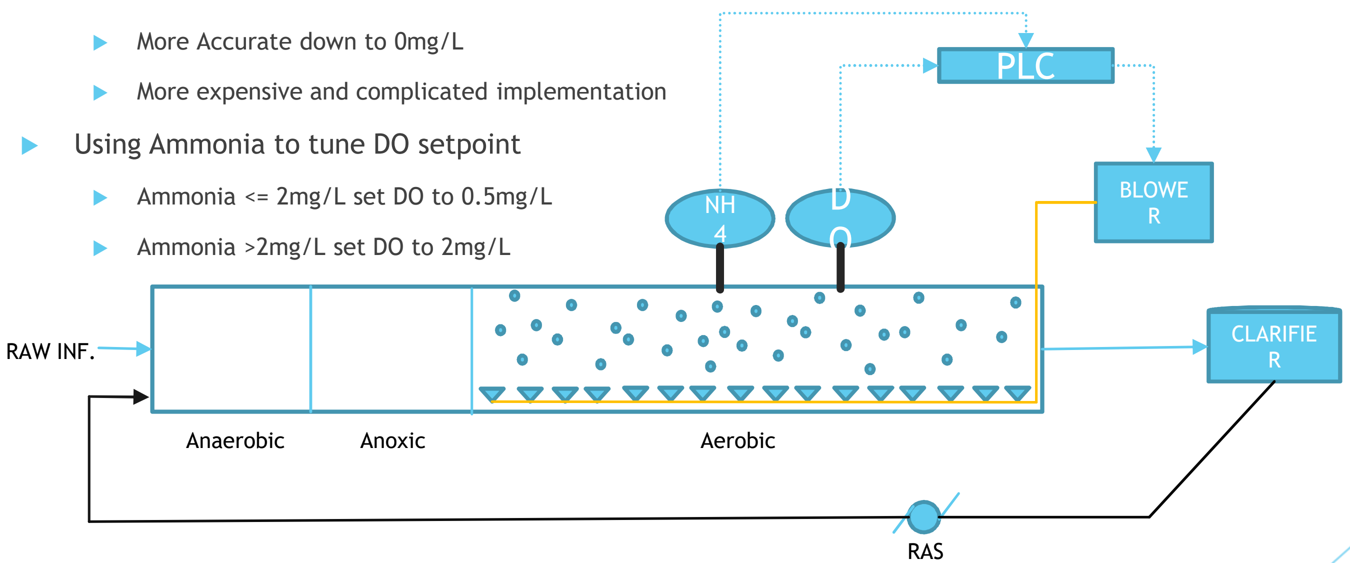
BS1

Ammonia

- ION Selective (ISE) or Gas Sensitive Electrode (GSE)
- ISE
  - Less Accurate at low concentrations
  - More calibration and cleaning
- GSE
  - More Accurate down to 0mg/L
  - More expensive and complicated implementation
- Using Ammonia to tune DO setpoint
  - Ammonia <= 2mg/L set DO to 0.5mg/L
  - Ammonia >2mg/L set DO to 2mg/L

GSE Picture Courtesy: HACH

ISE Picture Courtesy: YSI



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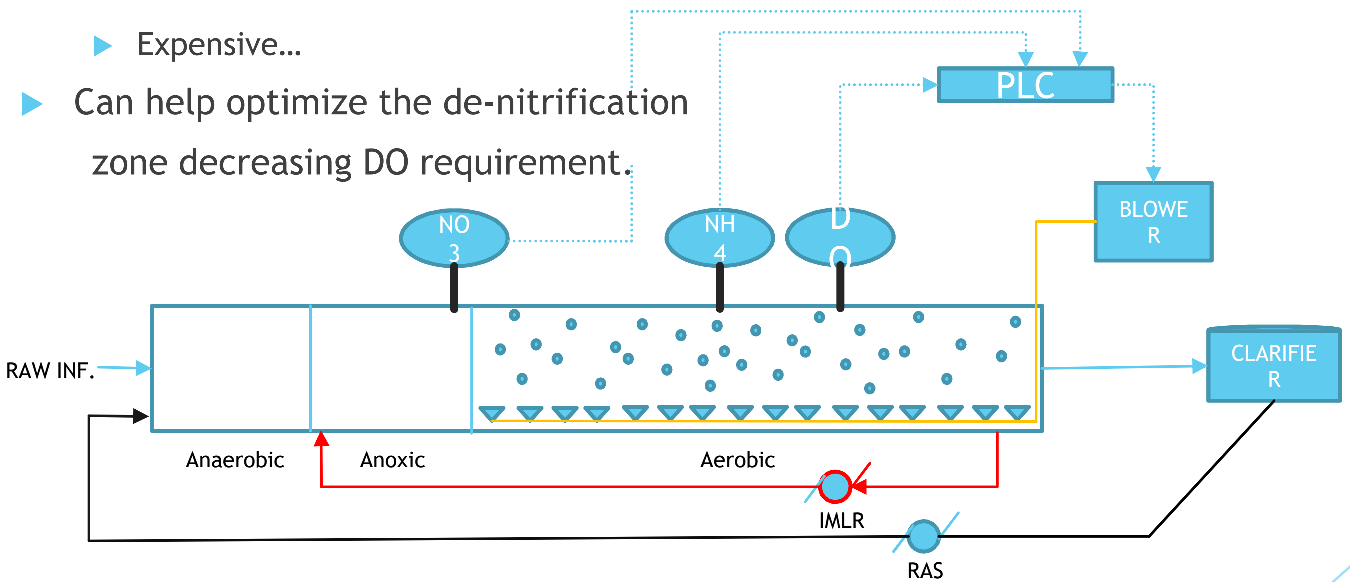
BS1

Nitrate

- ISE or UV Absorbance
- ISE
  - Requires Calibration and membrane replacement
  - Certain Ions interfere
- UV Absorbance
  - Expensive…
- Can help optimize the de-nitrification zone decreasing DO requirement.

UV and ISE Picture Courtesy: HACH



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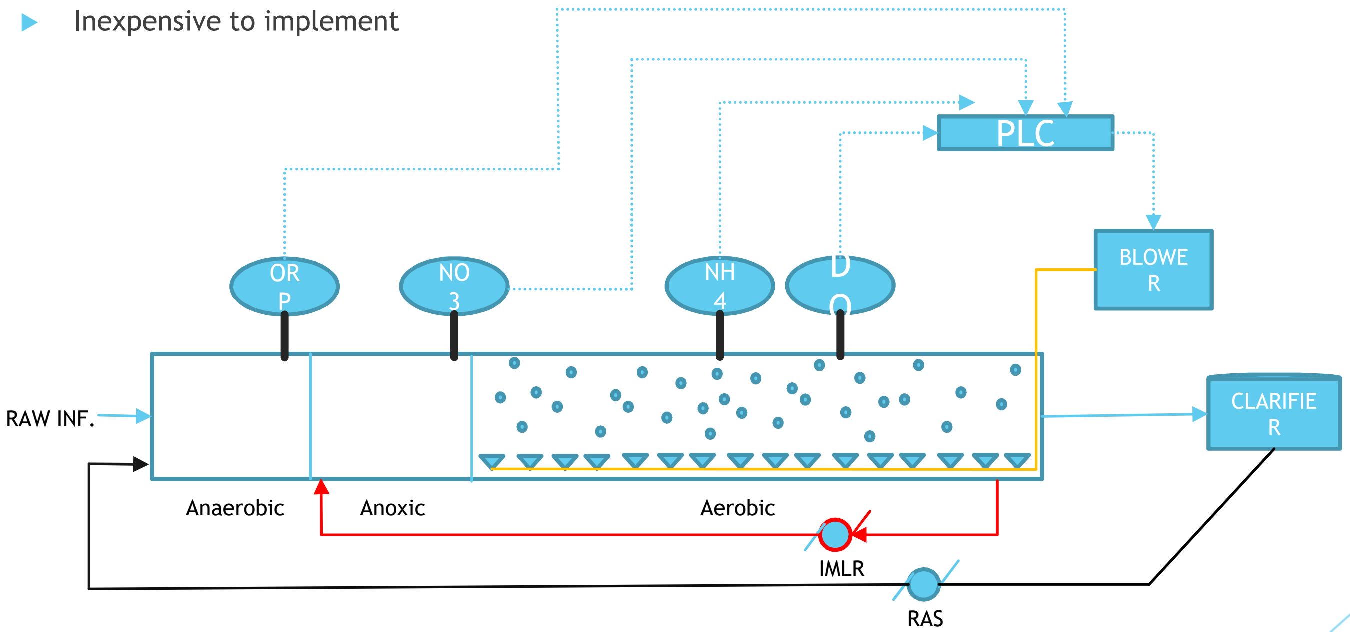
ORP

- Oxygen Reduction Potential measured in mV
- Measuring the sum of oxidants and reductants in H2O
- Multi Application probe
- Can help optimize Bio P. release and nitrogen removal
- Inexpensive to implement

Biochemical Reactions and Corresponding ORP Values

Biochemical Reaction	ORP, mV
Nitrification	+100 to +350
cBOD degradation with free molecular oxygen	+50 to +250
Biological phosphorus removal	+25 to +250
Denitrification	+50 to -50
Sulfide (H_2S) formation	-50 to -250
Biological phosphorus release	-100 to -250
Acid formation (fermentation)	-100 to -225
Methane production	-175 to -400

Chart Courtesy: YSI



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Which Blower is the Right Blower for the Application?

…It Depends!

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What Goes into Selecting the Right Blower?

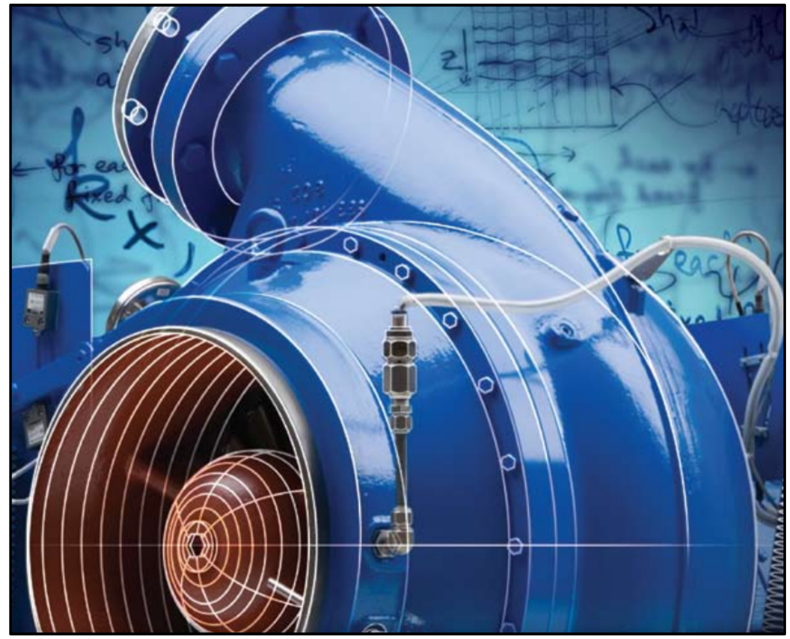
- System Requirements
  - Design Point Air Flow Rates
  - Turndown Requirements
  - System Pressure Range
  - Desired Wire-To-Air Efficiency
  - Constant or Variable Head
  - On/Off Cycling
  - Future Expansions
- Client Preferences
  - Cost vs Efficiency
  - Hands-on?
  - Prefer a Certain Blower Type?
- Environmental
  - Ambient Temperature
  - Atmospheric Pressure
  - Humidity
  - Makeup Air Quality
  - Blower Location: Building, Canopy or Direct Sunlight
  - Noise Requirements
  - Space Considerations

Positive Displacement Blowers

- Mature Technology
- 2 different types
  - Rotary Lobe
  - Screw (Hybrid)
- Lower Capital Cost
- Great for Lower Air Demands
- Louder
- Fixed Air Volume Transfer Rate
  - Air Flow Rate Varies Little with System Pressure Changes
  - Linear Flow Curves
- Typically Modulate Air Flow Rate with VFD
- Simple Instrumentation
  - Discharge Pressure, Discharge Temperature
  - Inlet Filter Differential Pressure (Monitor Dirty Inlet Filter)

Rotary Lobe Blower, Picture Courtesy: Aerzen USA

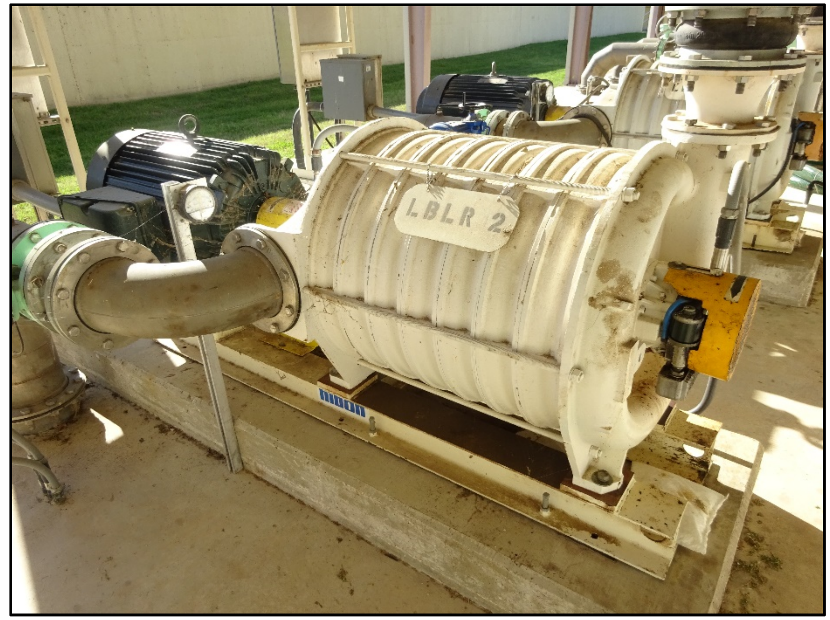
Centrifugal Blowers



- Mature Technology
- Larger Footprint
- Louder
- Discharge Air Flow Rate and Pressure are Heavily Dependent on System Pressure
- Bearings Either Greased or Oil Bath Lubricated
- Surging Potential
  - All Blowers have a Pressure Ceiling
  - Suction Side Flow Rate Not Enough to Build Up Pressure to Exceed System Pressure
  - Air Flow Reverses from System to Blower
  - Vibration in Blower Occurs and Potential Mechanical Damage

Multi-Stage Centrifugal Blowers

- Very Common
- Good Turndown
- Multiple Stages with Individual Impellers
- Pressure Increase at Each Stage
- Air Flow Modulation
  - Inlet Valve Throttling
  - Guide Vanes, Inlet and Discharge
  - VFD
- Simple Instrumentation
  - Vibration
  - Bearing temperature
  - Inlet Filter Differential Pressure



Single-Stage Geared Centrifugal Blowers

- Common at Larger Plants
- Single Impeller for Air Compression
- Constant Speed
- Air Modulation Achieved By
  - Variable Inlet Guide Vanes
  - Variable Discharge Diffusers
  - Single or Dual Point Control
- Complex Instrumentation
  - Vibration
  - Temperature
  - Differential Pressure for Vane Adjustment
  - Power

High Speed Turbo Blowers

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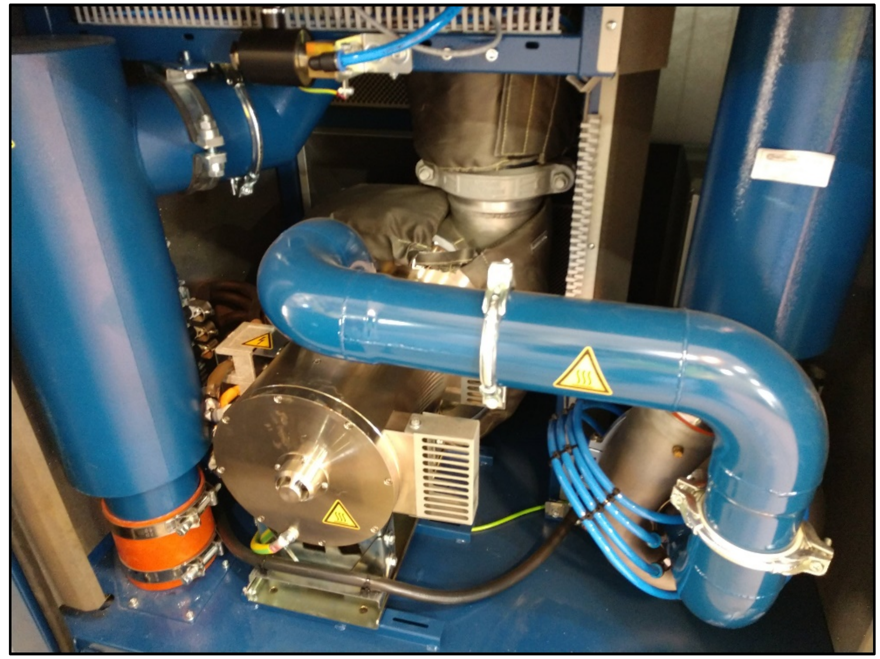
- Type of Single-Stage Centrifugal Blower
- Higher Capital Cost
- Good Turndown
- Efficient
- Small Footprint
- “Packaged System”, Controls by Manufacturer
- Driven by
  - Permamagnet Synchronous Motor (PMAC)
  - Induction Motor (Less Common)

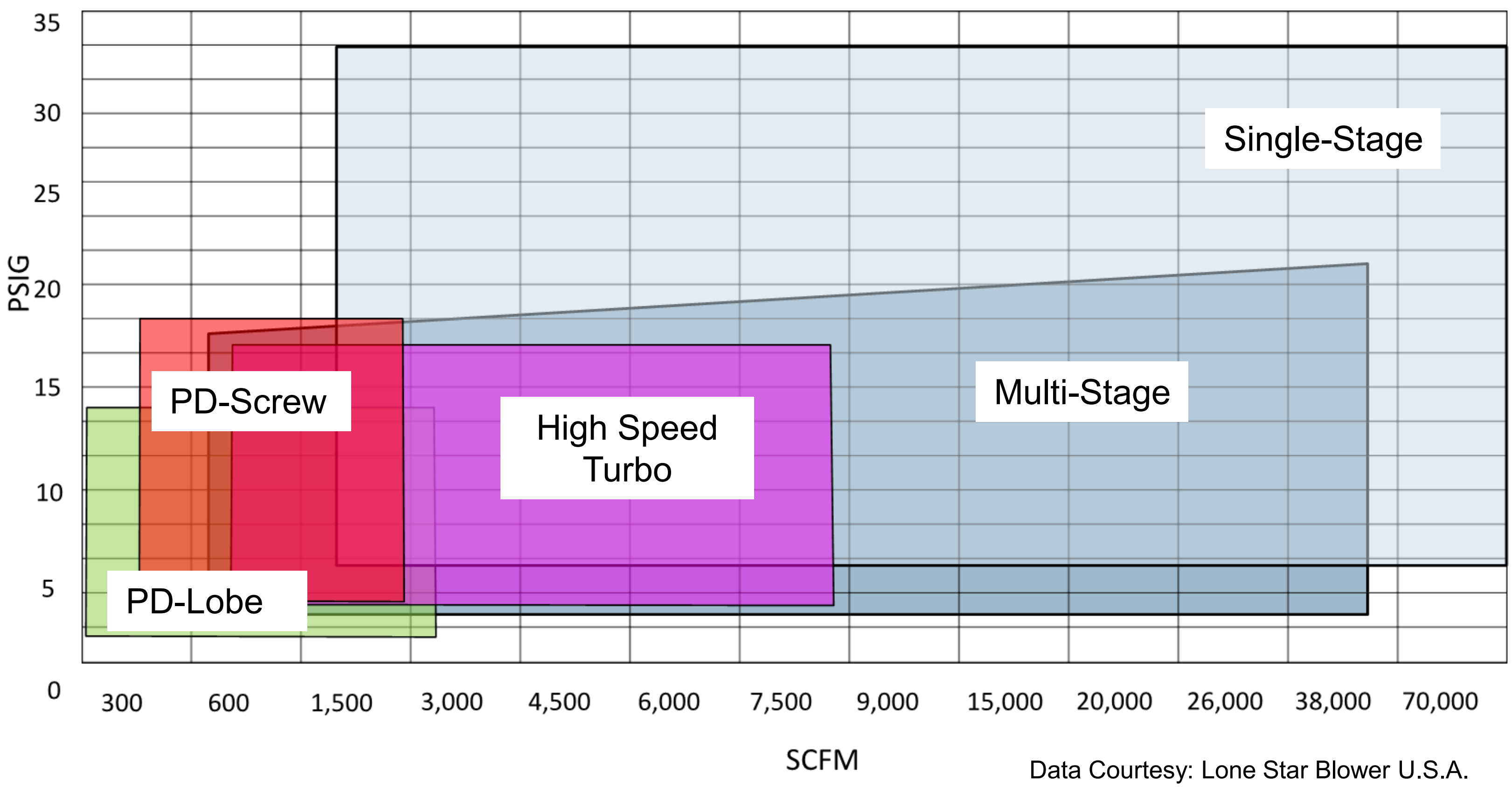
High Speed Turbo Blowers

PMAC Type

- Direct Drive
- High Speed (26,000 RPM)
- 2 Bearing Types
  - No Grease Ports!
- Quiet
- Requires Specialized VFD
- VFD Internal to Unit
- Harmonic Considerations
  - Tuned Harmonic Reactor
- Startup/Shutdown Procedures
  - Planned
  - Power Interruption
- Must Coordinate with Generator(s) upon startup



Blower Operating Ranges



Data Courtesy: Lone Star Blower U.S.A.

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Comparing the Technologies

	Positive Displacement	Multi-Stage Centrifugal	Single-Stage Centrifugal	High Speed Turbo
Wire-To-Air Efficiency (%)*	45-65	50-70	70-80	70-85
Volumetric Air Flow Rate Turndown (%)	50	50-60	45	50
Motor Type	Induction	Induction	Induction	PMAC
Integral Motor Controller?	Large Frame Only	No	No	Yes
Footprint	Small/Medium	Large	Medium	Small
Cooling Options (Heat Rejection)	External	External	External	Internal/ External
Noise	Loud	Loud	Loud	Quiet
Modulation: Inlet Throttling	-	-	X	-
Modulation: Guide Vanes	-	X	X	-
Modulation: VFD	X	X	-	X
Surging Possible?	-	X	X	X

Air Demand

- The blowers function is to supply the required air flow rate to the diffuser in the bottom of the basin.
- Minimum and Maximum air flow rates are calculated based on:
  - the number of diffusers in the basin
  - oxygen uptake rate
  - air temperature
  - required change in dissolved oxygen concentration levels
- Pressure is required to overcome:
  - friction losses
  - pipe lengths
  - fittings
  - valves
  - Diffusers
- The valves throughout the system split air flow as required at each zone of the basins.
- The lower the system pressure the better the energy savings.

Most Open Valve

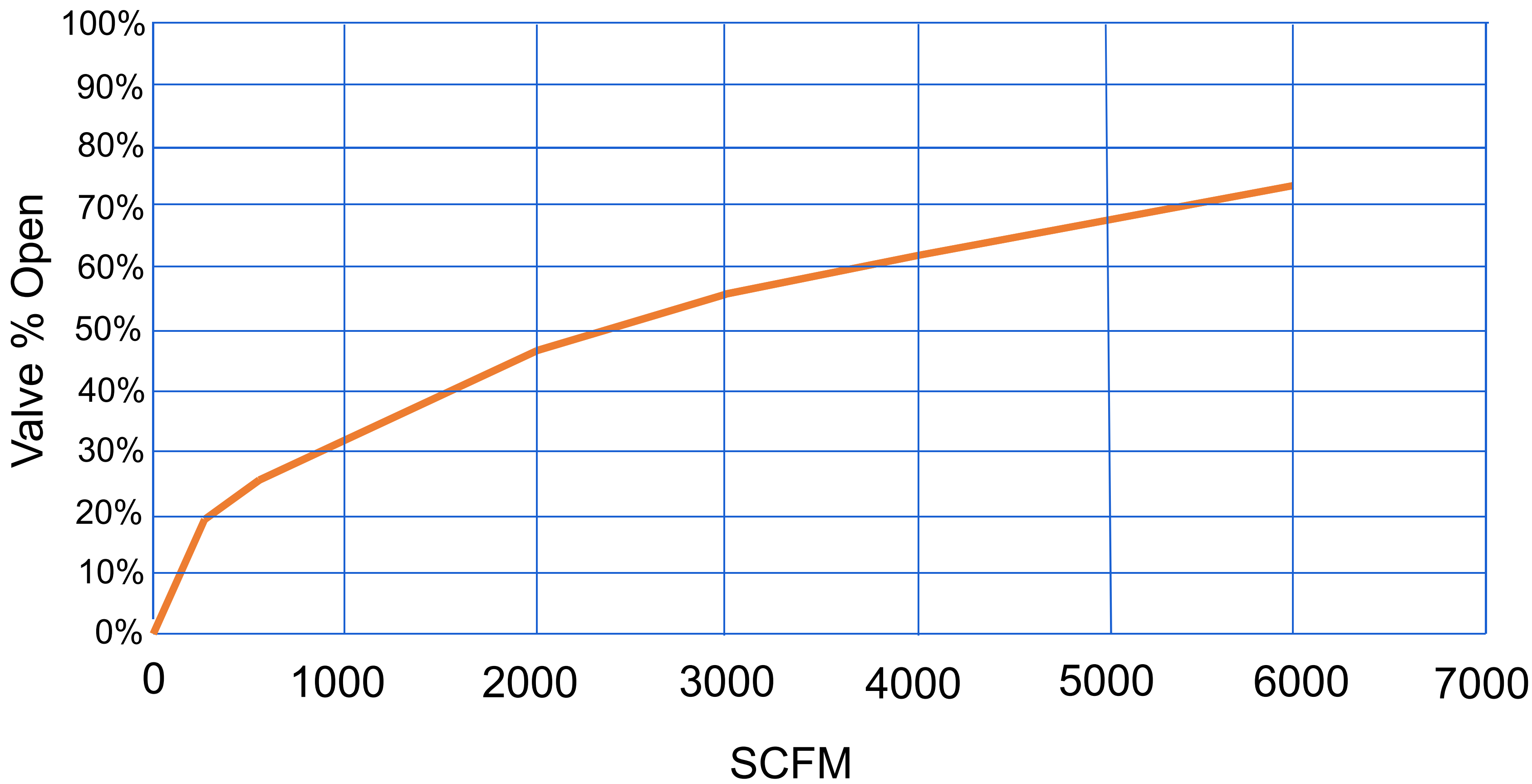
- Concept:
  - Keep one valve fully open to limit pressure drop
  - Adjust pressure on system to keep one valve in “fully open” state
- The goal:
  - Minimizing blower discharge pressure
  - Minimize pressure loss in air distribution system
    - Largest pressure drop is across valves
      - Keeping basin valves as close to open as possible

Valves

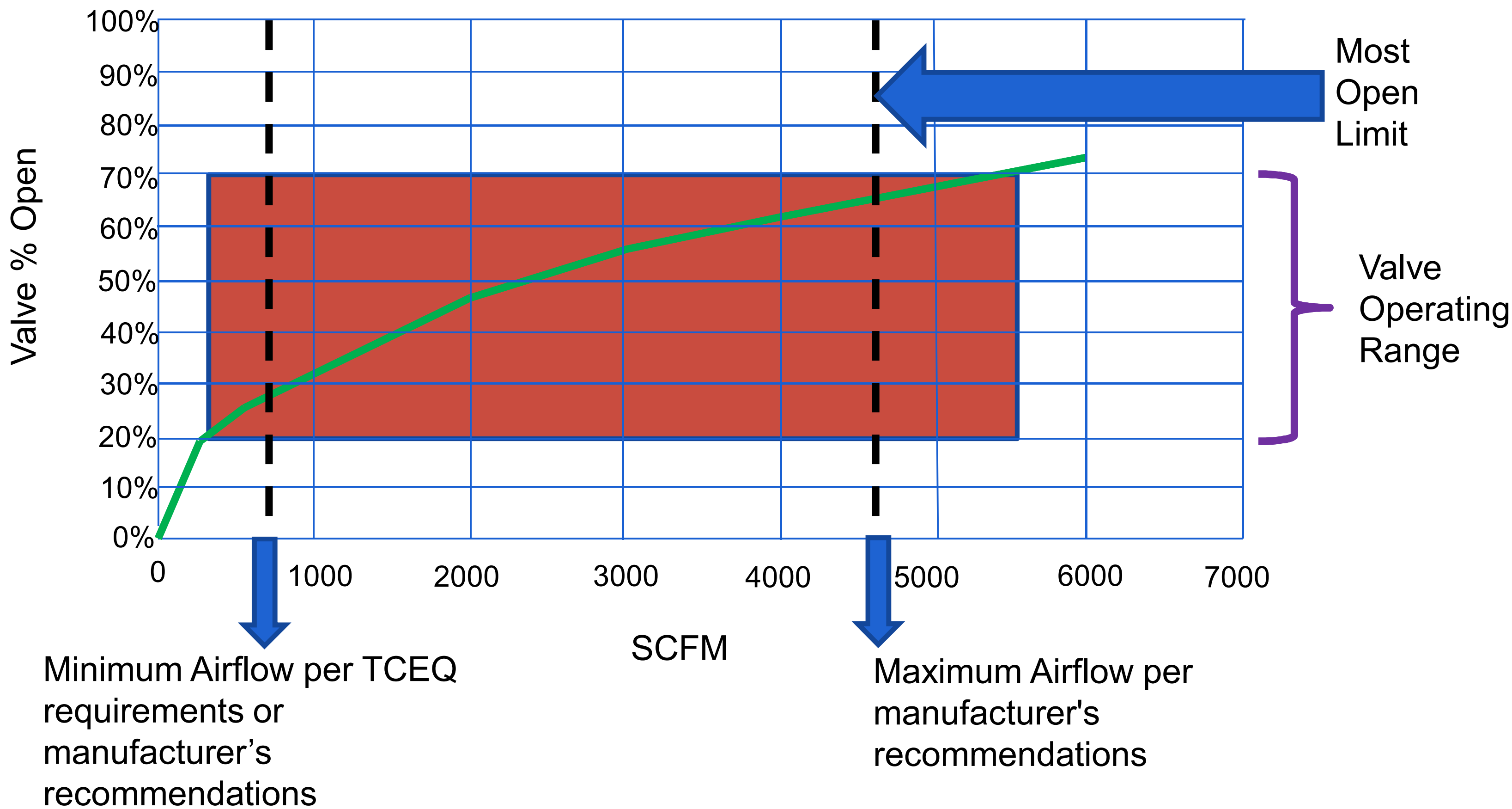
- Couple of valve Choices for flow control
  - Linear air flow
    - Iris (centrally closing) valve
  - Non-Linear air flow
    - Butterfly valve
- Sizing flow control valve is crucial for stable flow control

Courtesy of EGGER Iris

Air Flow Through Butterfly Valve



Air Flow Through Butterfly Valve



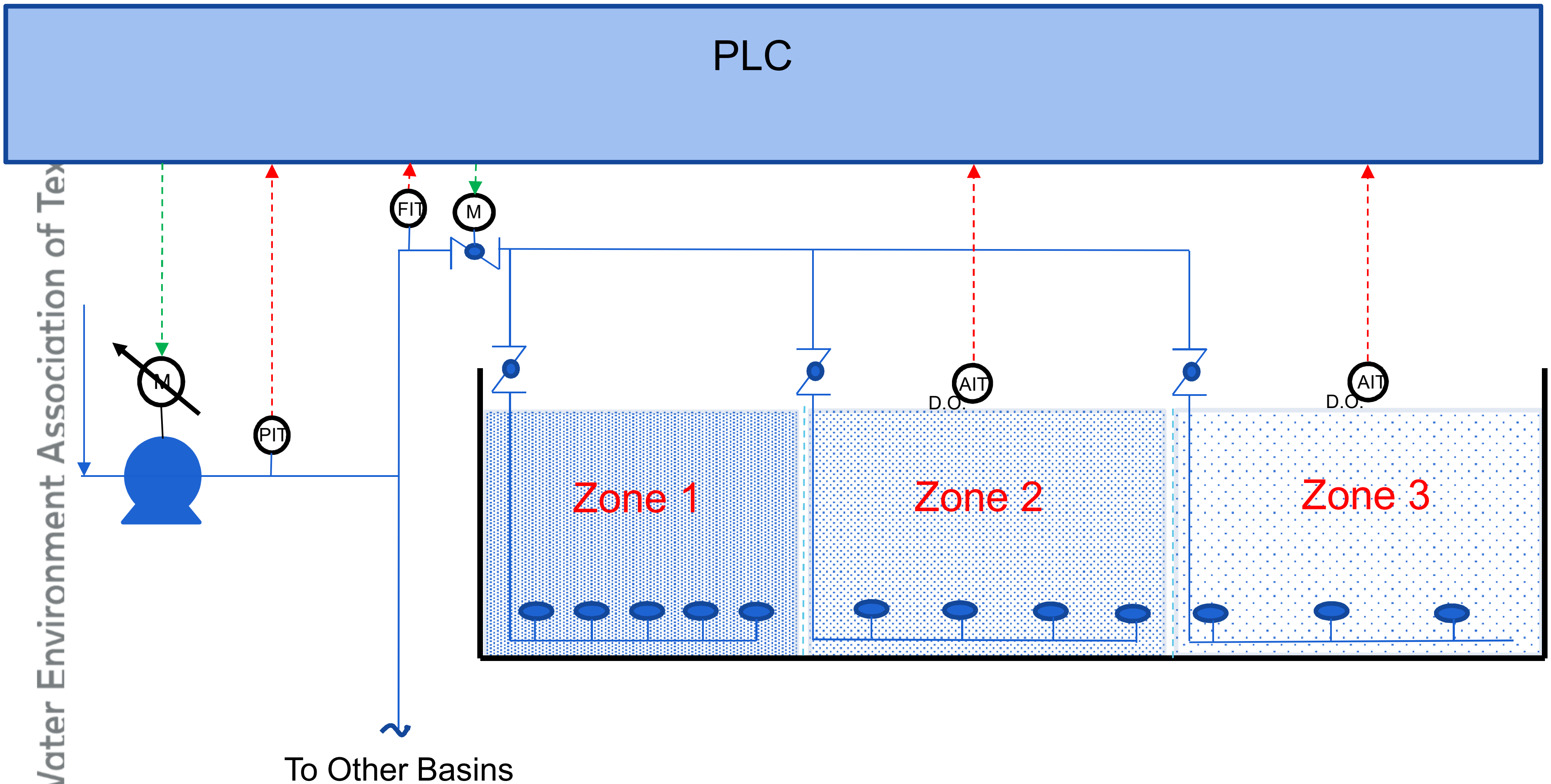
Most Open Valve (MOV) Logic

- Based on Pressure
  - Blower output is determined by header pressure
    - Pressure Transmitter Feedback
    - D.O. readings
  - Advantages
    - Fewer instrumentation required
  - Disadvantages
    - Not the most efficient method of controlling airflow for a desired D.O. level
    - Basin valve actuators tend to “hunt” more

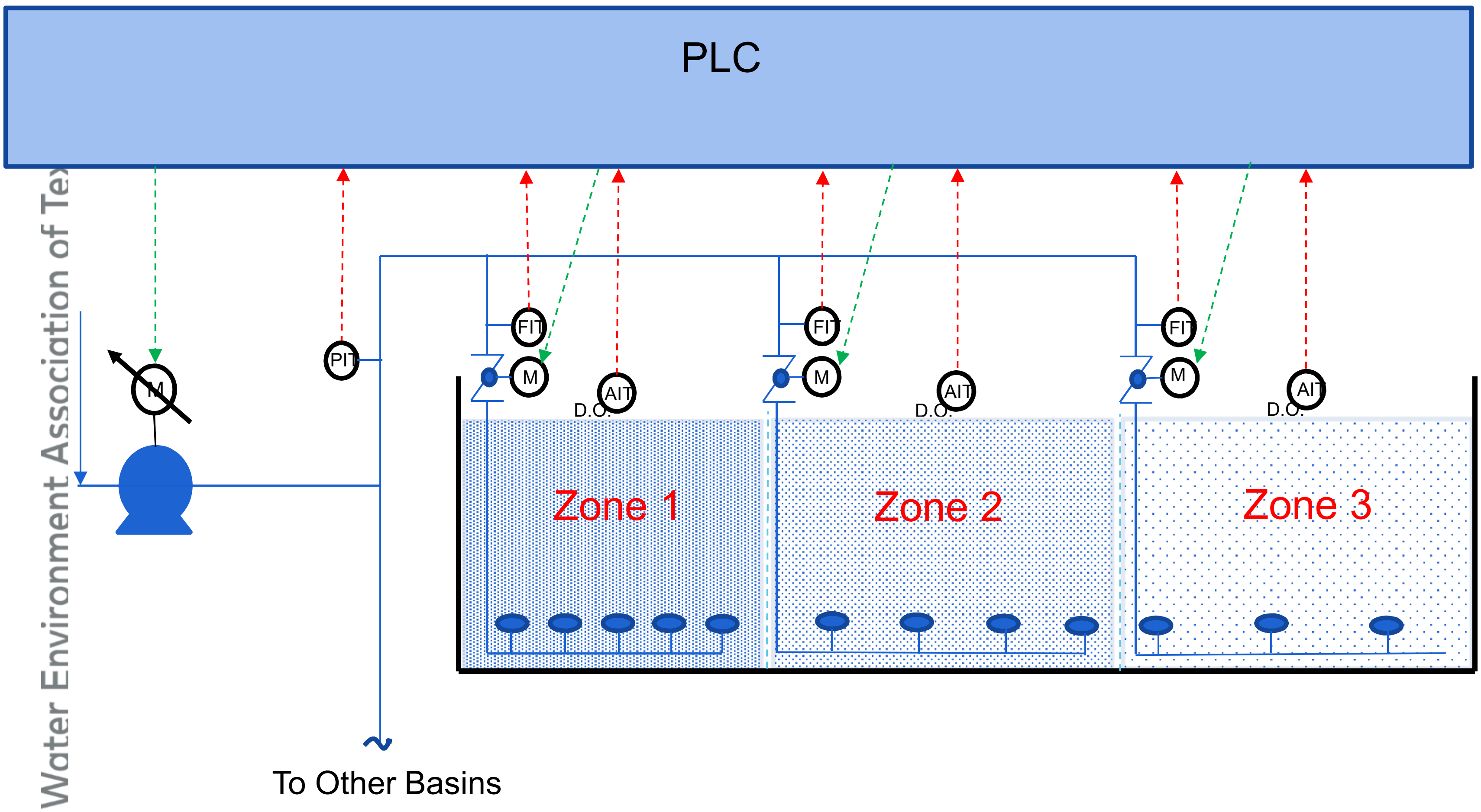
Most Open Valve (MOV) Logic

- Based on Flow Control
  - Blower output is determined by calculated air flow demand
    - Sum of flow meter readings compared to calculated air flow demand
  - Advantages
    - Better control resulting in lower power consumption
    - Better control the air flow rate
  - Disadvantages
    - Higher initial costs for instrumentation and motorized valves

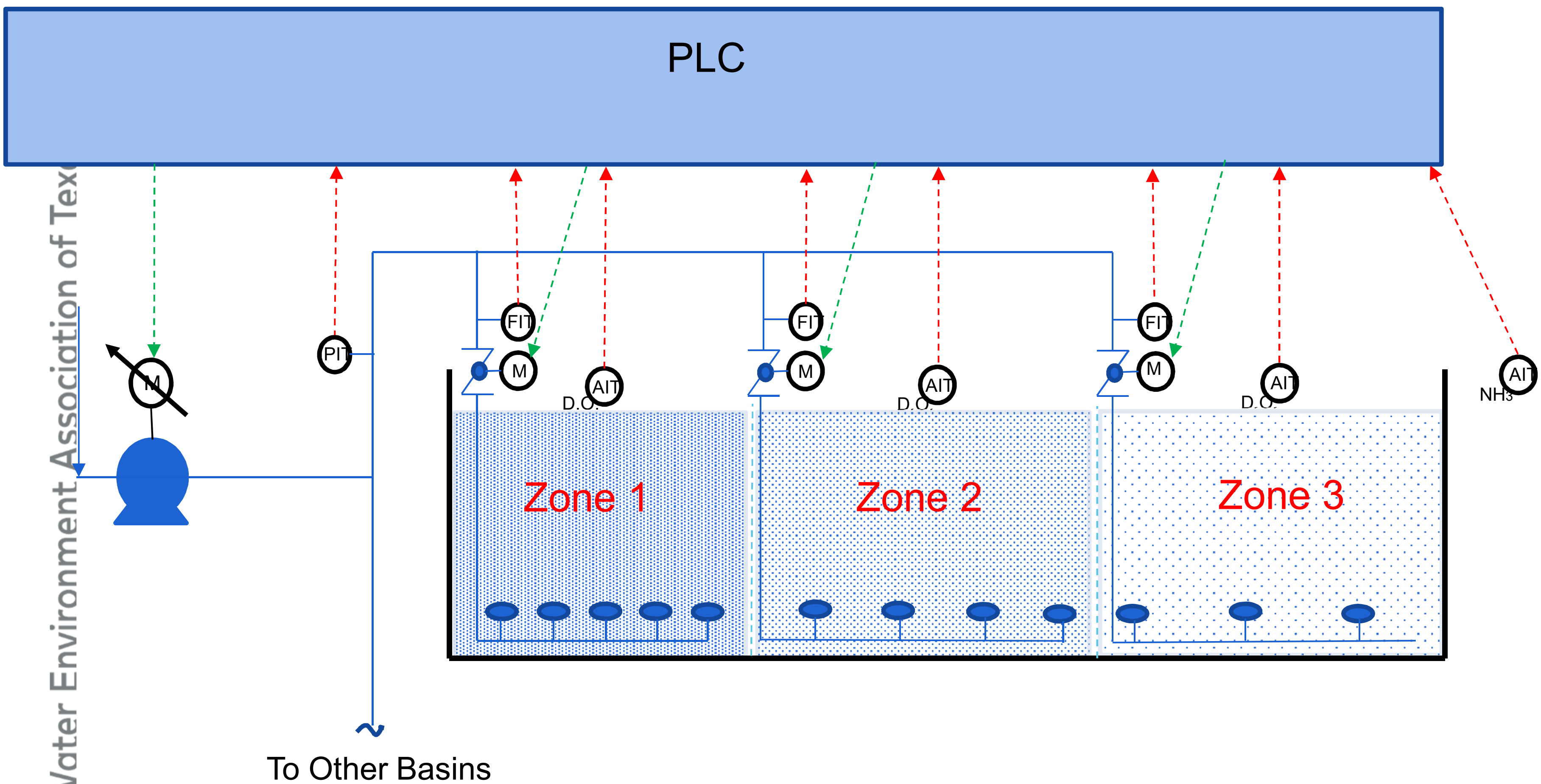
Lower Cost MOV Layout



Higher Cost MOV Layout

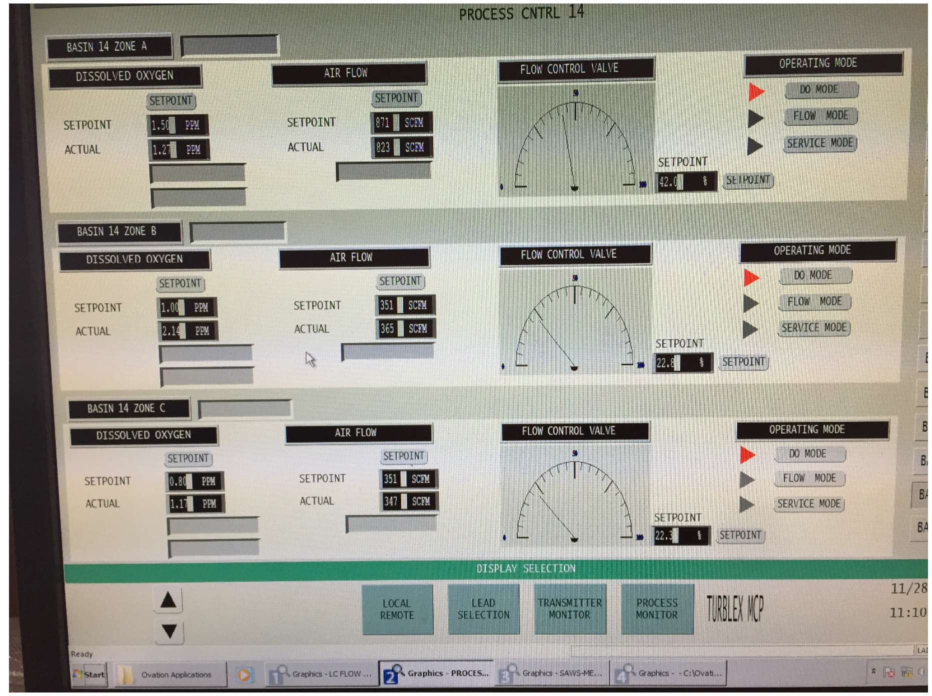


MOV with Ammonia Feedback



HMI Operation Considerations

- Simplified system
  - Automatic mode
    - D.O. Control
    - Air Flow Control
  - Service mode (manual)
    - Set Valves to a position
- Simplified graphics
  - Show status of each mode on same screen
- Make process troubleshooting manageable and flexible



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Questions??