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Calculating Aeration Flow and Pressure Requirements

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All materials presented are educational. Each blower system is unique and must be evaluated on its own merits.

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About the Speaker

Tom Jenkins, JenTech Inc.

- President of JenTech Inc.
- Has over 30 years of experience with aeration blowers and blower controls

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AERATION BLOWER SELECTION

IT'S ALL ABOUT THE BUBBLES

WEBINAR THURSDAY, 5/26/2016

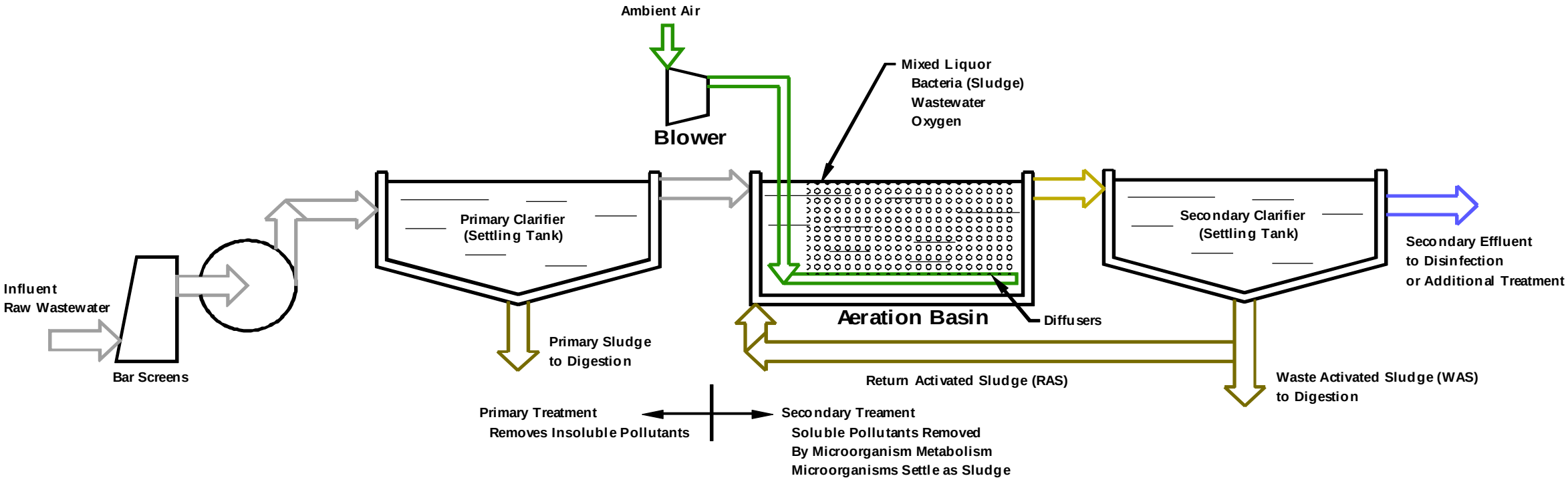
2:00 PM TO 2:30 PM EST

BLOWER & VACUUM BEST PRACTICES®

TOPICS

- BASIC WASTEWATER TREATMENT PROCESS
- BLOWER FUNCTIONS
- BASICS OF DETERMINING AIR FLOW RATE
- BASICS OF DETERMINING DISCHARGE PRESSURE
- SUMMARY OF APPLICATION CONSIDERATIONS

PROCESS BASICS

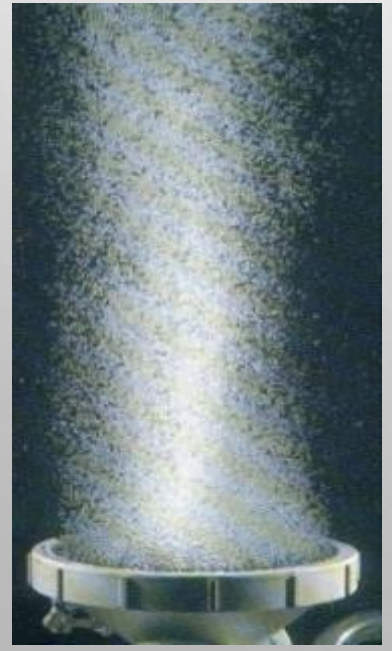


AIR SUPPLIED TO AERATION BASINS HAS MULTIPLE FUNCTIONS

- PROVIDE OXYGEN NEEDED FOR METABOLIZING ORGANIC COMPOUNDS
- PROVIDE OXYGEN NEEDED FOR CONVERTING AMMONIA (NH_3) TO NITRATE (NO_3)
- KEEP BASIN CONTENTS (MIXED LIQUOR) MIXED AND SOLIDS IN SUSPENSION
  - MIN FLOW 0.12 CFM/SQ FT TYPICAL
  - MAX AIR FLOW DICTATED BY DIFFUSER LIMITATIONS

A BLOWER'S FUNCTION IS TO SUPPLY THE NEEDED AIR FLOW RATE TO THE BASINS

- THE MOST COMMON PROCESSES USE DIFFUSERS TO INTRODUCE AIR TO THE BOTTOM OF THE BASINS
- IT'S ALL ABOUT THE BUBBLES!




DETERMINING AIR FLOW RATE

- REQUIRED AIR FLOW RATE IS USUALLY SPECIFIED AS "SCFM"
  - LOOKS LIKE VOLUME FLOW RATE, BUT IS REALLY MASS FLOW RATE
  - "STANDARD" CONDITIONS IN WASTEWATER USUALLY 68 °F, 14.7 PSIA, AND 36% RH
  - THIS IS EQUIVALENT TO 0.075 LB/FT^3

DETERMINING AIR FLOW RATE

- IF RELATIVE HUMIDITY IS IGNORED:

$$\mathrm{ICFM} = \mathrm{SCFM} \cdot \frac{460 + \mathrm{T}}{528} \cdot \frac{14.7}{\mathrm{p}}$$

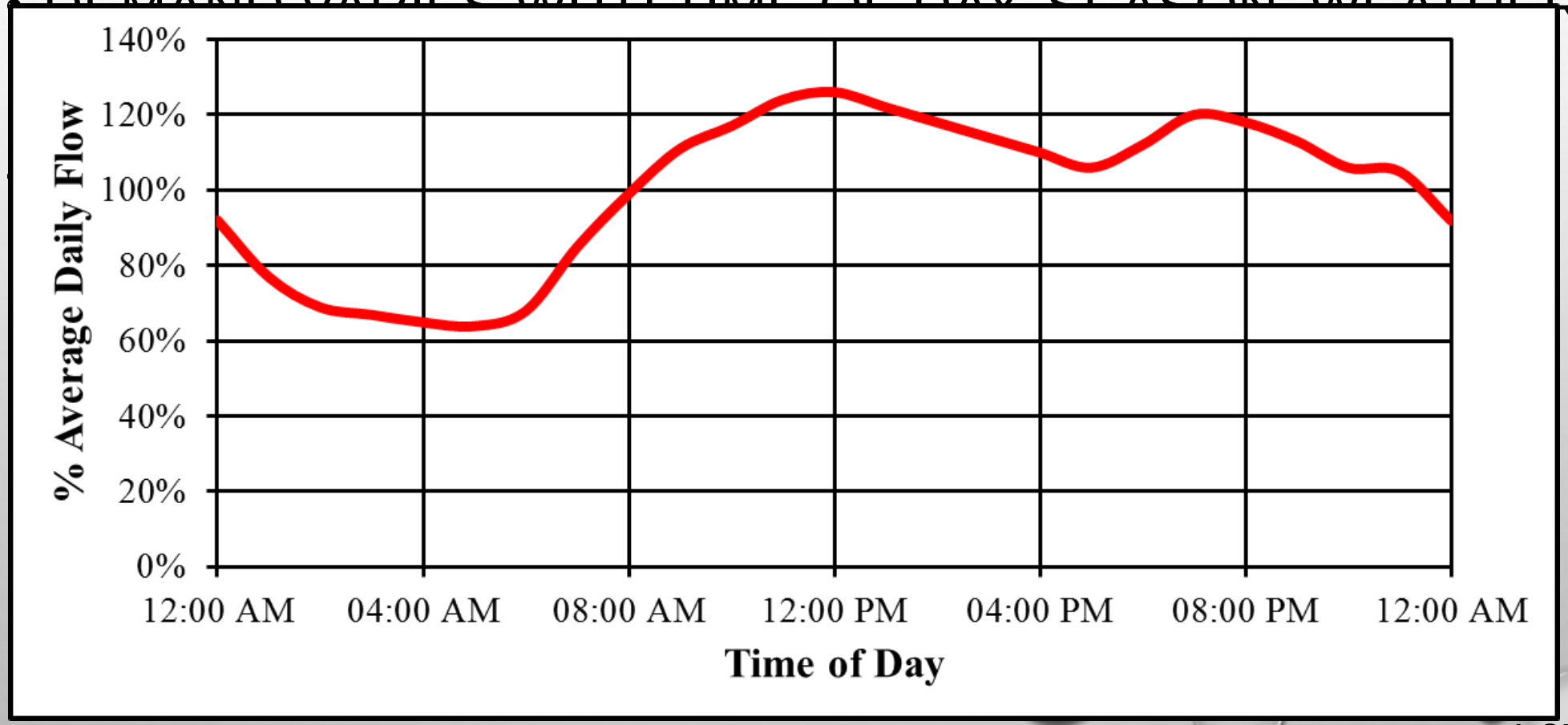
ICFM	=	Inlet Flow Rate ft^3/min
T	=	Temperature °F
p	=	Pressure psia

DETERMINING AIR FLOW RATE

- NOTHING IN AN AERATION SYSTEM IS STEADY STATE
  - DEMAND VARIES WITH TIME OF DAY, SEASON, WEATHER, OPERATION
  - GREATEST VARIATION IS TIME OF DAY – “DIURNAL” VARIATIONS

DETERMINING AIR FLOW RATE

- NOTHING IN AN AERATION SYSTEM IS STEADY STATE
- DEMAND VARIES WITH TIME OF DAY, SEASON, WEATHER,



DETERMINING AIR FLOW RATE

$$\mathrm{SCFM} = \frac{0.335 \cdot \mathrm{mgd}}{\mathrm{OTE}} \cdot (\mathrm{ppmBOD} \cdot 1.1 + \mathrm{ppmNH_3} \cdot 4.6)$$

SCFM	=	Air Flow Rate standard ft^3/min
OTE	=	Oxygen Transfer Efficiency, decimal
ppmBOD	=	parts per million Biochemical Oxygen Demand
$ppmNH_3$	=	parts per million ammonia

- FIELD OTE VARIES FROM 0.004 TO 0.008 PER FOOT OF SUBMERGENCE (0.4% TO 0.8% OTE/ft.)
- NONE OF THE TERMS ARE STEADY STATE

DETERMINING AIR FLOW RATE

- TURNDOWN FOR BLOWERS IS MORE IMPORTANT THAN EFFICIENCY
  - NEEDED FOR PROCESS CONTROL
  - NEEDED FOR ENERGY OPTIMIZATION
- TYPICALLY AT LEAST 5:1 (80%) TURNDOWN IS DESIRABLE

$$\text{Turndown}\% = \frac{q_{max} - q_{min}}{q_{max}} \cdot 100$$

DETERMINING AIR FLOW RATE

- EPA REQUIRES STANDBY BLOWERS
  - MUST HAVE FULL DESIGN AIR FLOW WITH LARGEST UNIT OUT OF SERVICE
- MOST BLOWERS CAN PROVIDE ABOUT 50% TURNDOWN EACH
  - USE MULTIPLE SMALL BLOWERS INSTEAD OF TWO LARGER ONES
  - THREE AT 50% OF DESIGN FLOW COMMON BUT NOT MY PREFERENCE
  - I PREFER TWO AT 50% OF DESIGN FLOW AND TWO AT 25% OF DESIGN FLOW

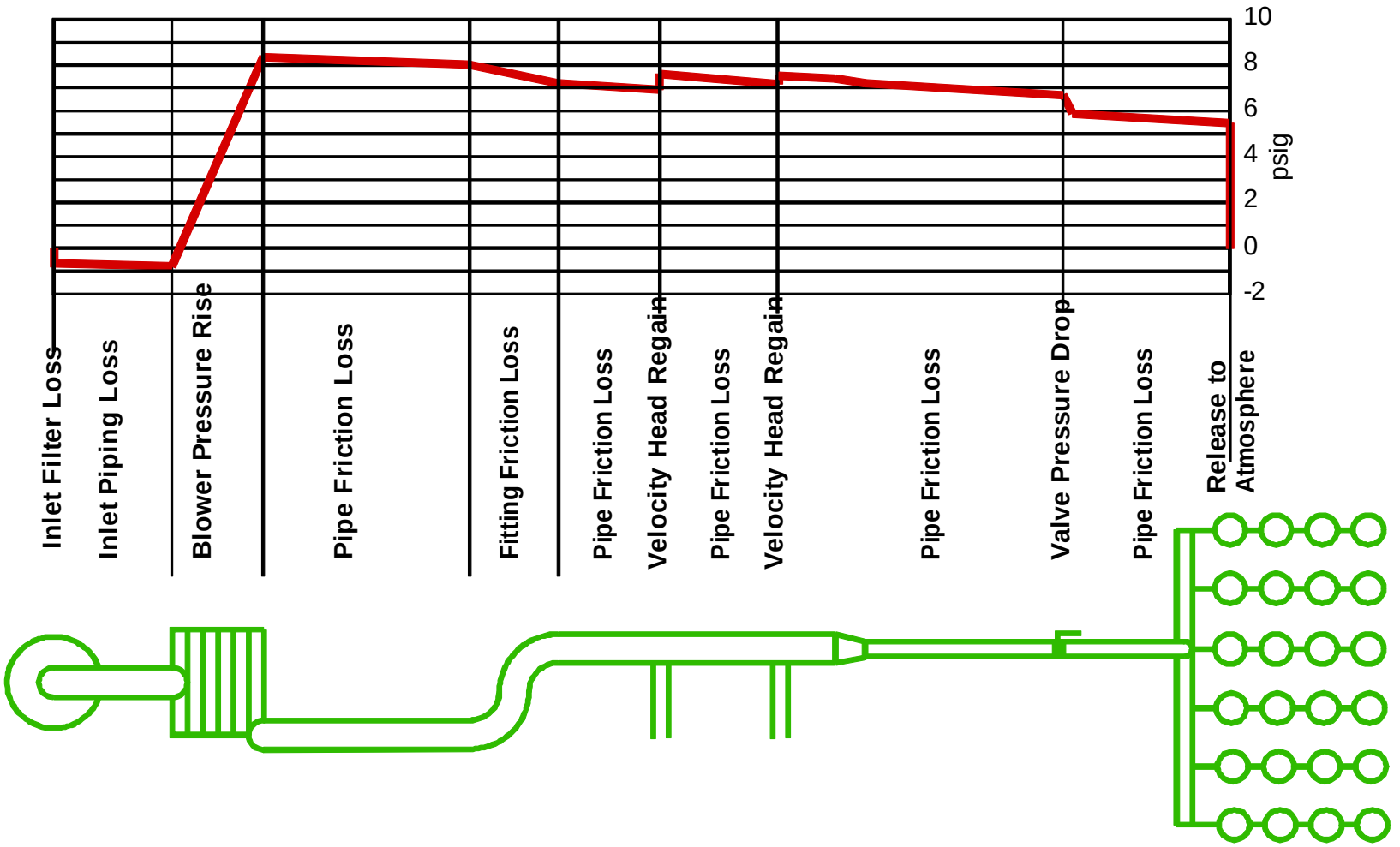
DETERMINING SYSTEM PRESSURE

- BLOWERS DO NOT PRODUCE PRESSURE – THEY PRODUCE FLOW
- THE SYSTEM RESISTANCE TO THE FLOW CREATES THE PRESSURE
- BLOWERS WILL KEEP AIR MOVING UNTIL THE BACK PRESSURE EXCEEDS THE BLOWER'S CAPABILITY
  - CENTRIFUGAL BLOWERS WILL GO INTO SURGE – NO FLOW
  - PD (POSITIVE DISPLACEMENT) BLOWERS WILL OPEN RELIEF VALVE OR OVERLOAD MOTOR

DETERMINING SYSTEM PRESSURE

- PRESSURE CONSISTS OF TWO PARTS
  - STATIC PRESSURE FROM DIFFUSER SUBMERGENCE IS USUALLY 80% TO 90% OF TOTAL
  - THE REST IS FRICTION FROM PIPE, FITTINGS, AND DIFFUSERS

DETERMINING SYSTEM PRESSURE



DETERMINING SYSTEM PRESSURE

- TO DETERMINE FLOW RATE BOTH BLOWER PERFORMANCE CURVE AND SYSTEM CURVE MUST BE PLOTTED
  - THE INTERSECTION OF THE TWO CURVES IDENTIFIES THE FLOW RATE
  - STATIC PRESSURE IS CONSTANT

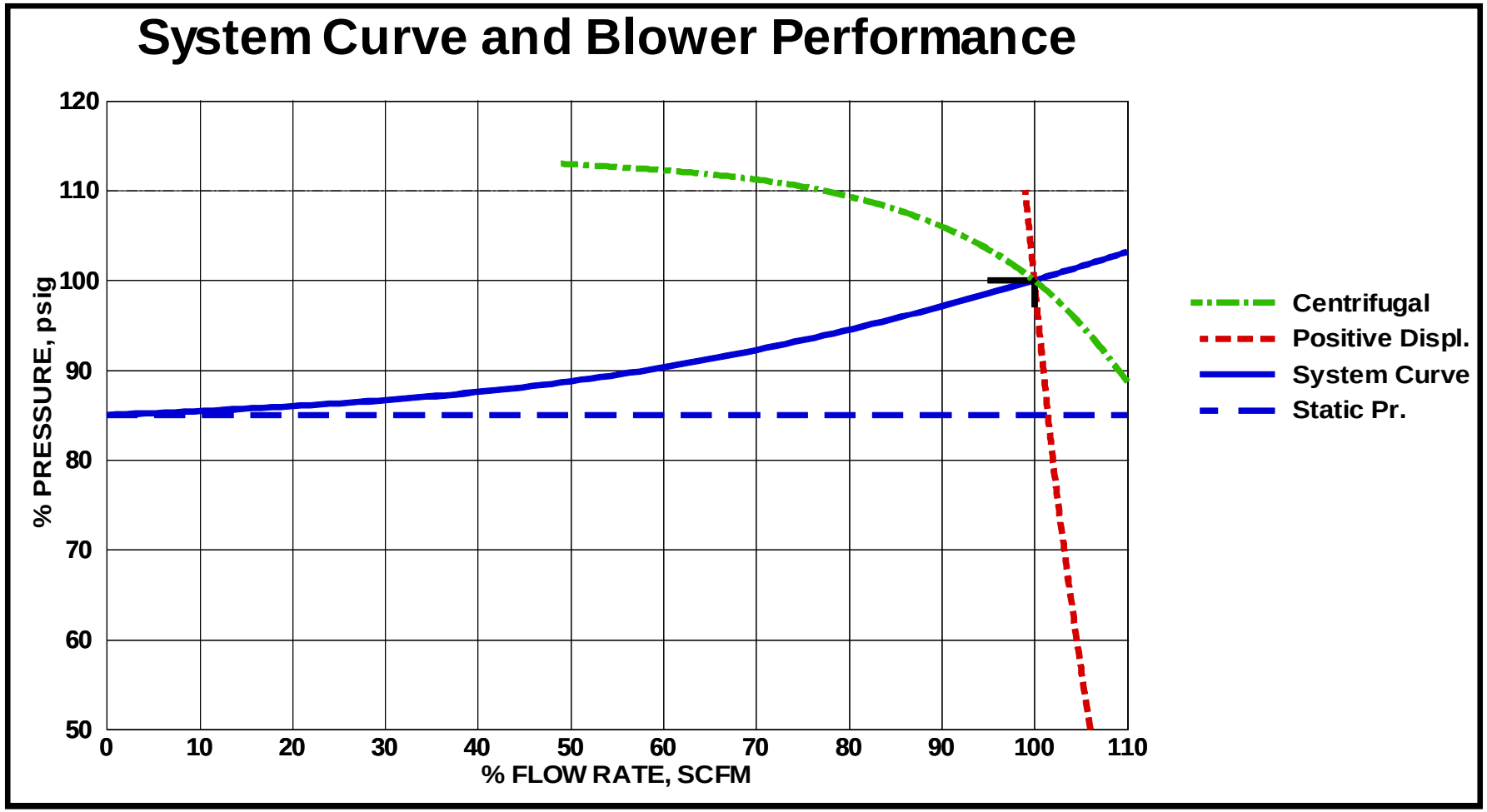
$$\text{psig}_{\text{static}} = \frac{\text{submergence, ft}}{2.31}$$

DETERMINING SYSTEM PRESSURE

- TO DETERMINE FLOW RATE BOTH BLOWER PERFORMANCE CURVE AND SYSTEM CURVE MUST BE PLOTTED
  - FRICTION IS TYPICALLY 1.0 TO 2.0 PSIG
  - FRICTION IS PROPORTIONAL TO THE FLOW RATE SQUARED

$$\Delta psig_{friction} = k \cdot q^2$$

DETERMINING SYSTEM PRESSURE



SUMMARY OF APPLICATION CONSIDERATIONS

- DETERMINE FLOW BASED ON PROCESS REQUIREMENTS
  - MAX AND MIN FLOW LIMITS
  - REQUIRED TURNDOWN
- DETERMINE PRESSURE BASED ON SYSTEM GEOMETRY
  - SUBMERGENCE AND FRICTION
- INCLUDE VARIATIONS IN AMBIENT CONDITIONS IN SELECTION

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About the Speaker

John Conover, Atlas Copco

- Sales Manager, Blowers & Low-Pressure Compressors, for Atlas Copco
- Has over 20 years of experience in Product Marketing and Management

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COMBINED TECHNOLOGY SOLUTION – ZS/ZB

SCREW VS CENTRIFUGAL TECHNOLOGY

	ZS Screw	ZB Centrifugal
Efficiency	Good	Best
Turndown	Best	Good
Reliability	Best	Best
Press Range	Best	Good
Maintenance	Good	Best

ZS Screw Blower

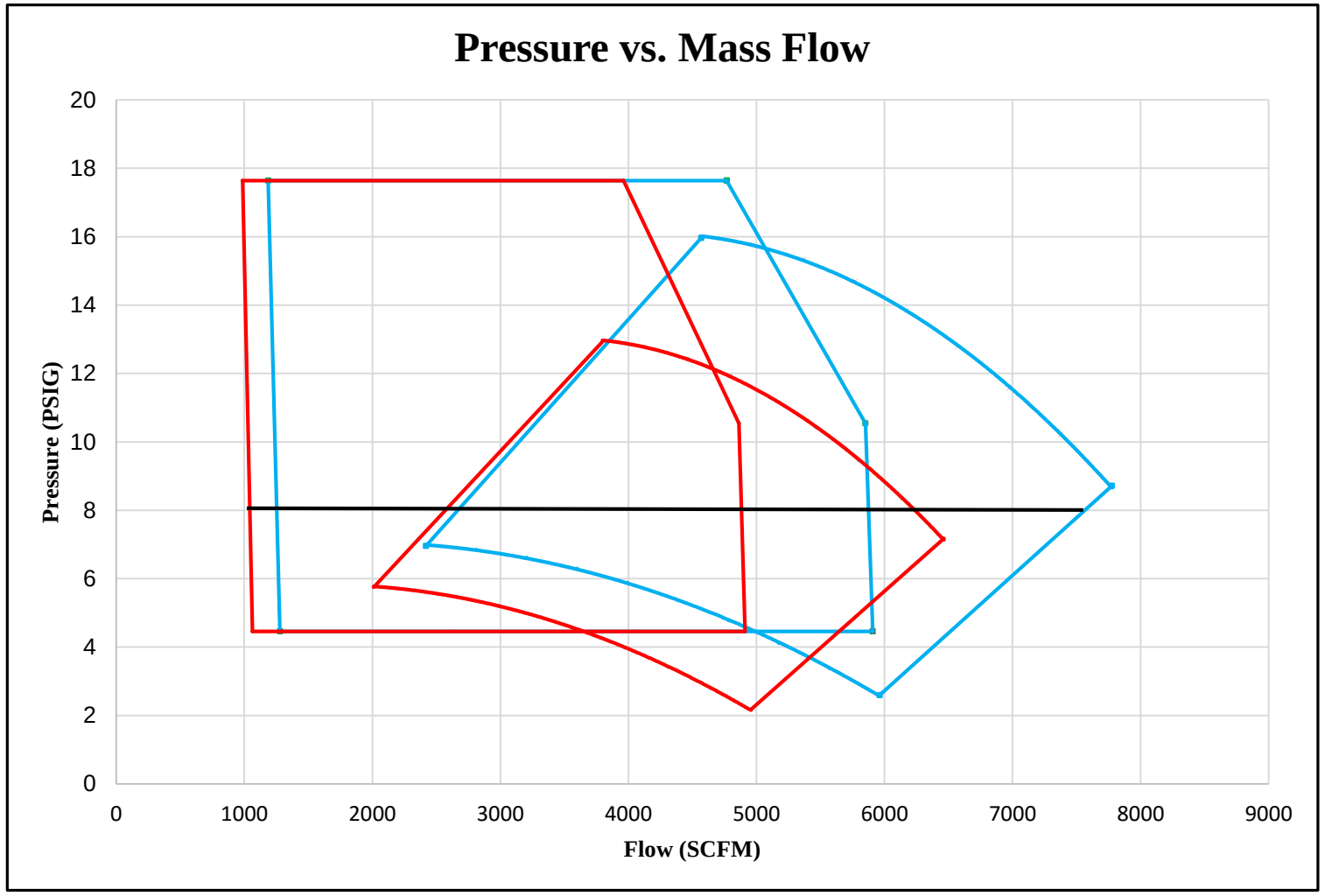
ZB Centrifugal Blower

REAL WORLD EXAMPLE

Site in Pacific Northwest

- Max capacity required is 15,000 SCFM @ 8 PSIG.
- Moderate temperature swing:
  - Summer is 105F
  - Winter is 22F
  - Average is 60F
- 10:1 diurnal loading

TEMPERATURE EFFECT ON MASS FLOW



	Max Flow
ZS Summer	4800
ZS Winter	5800
ZB Summer	6250
ZS Winter	7500

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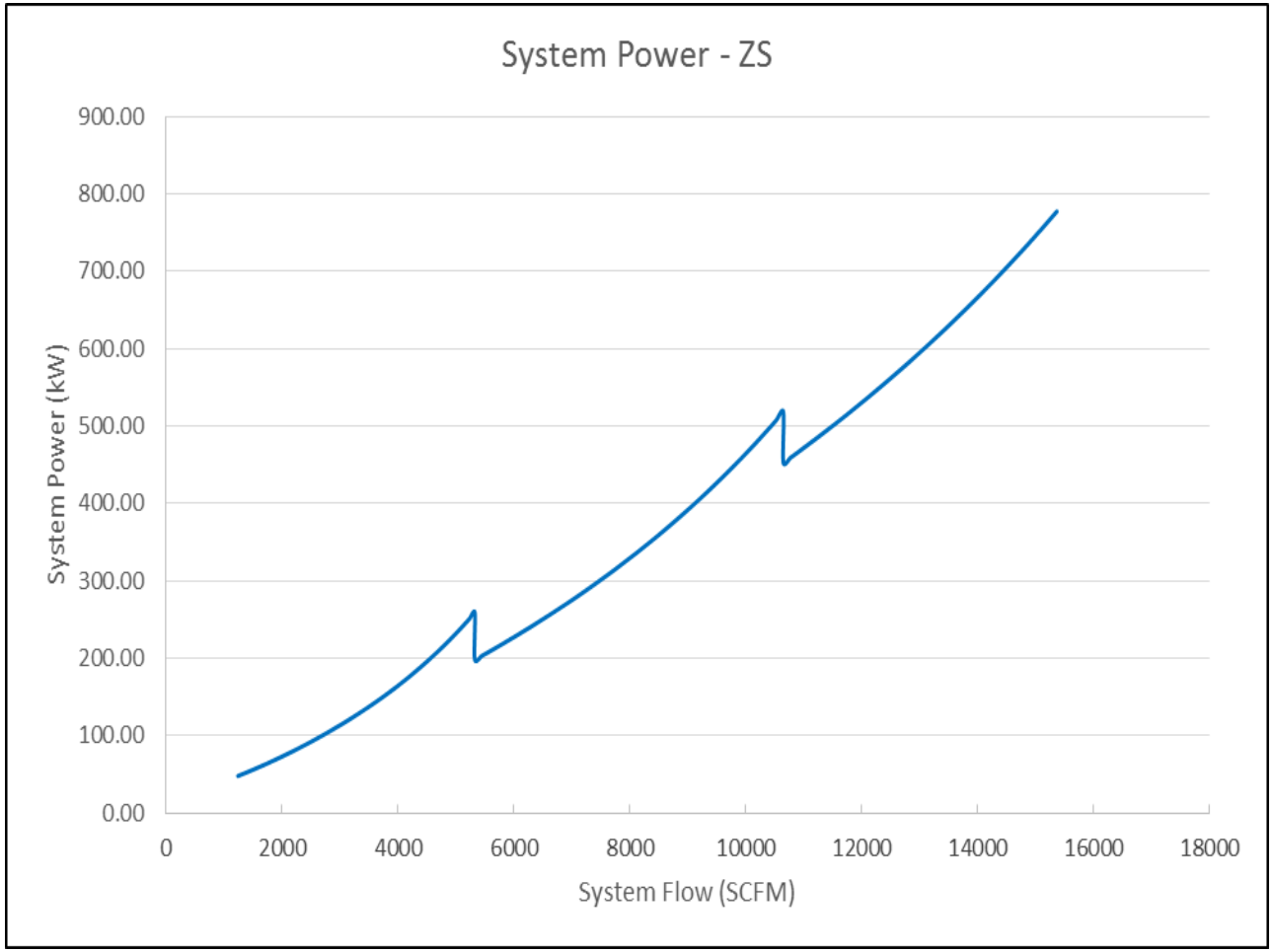
SIMULATED SYSTEM – SCREW BLOWERS

3 + 1 System (8 PSIG)

System Property	Value
Min Flow	~1500 SCFM
Max Flow	~15000 SCFM
Avg. Power	4.02 kW/100CFM



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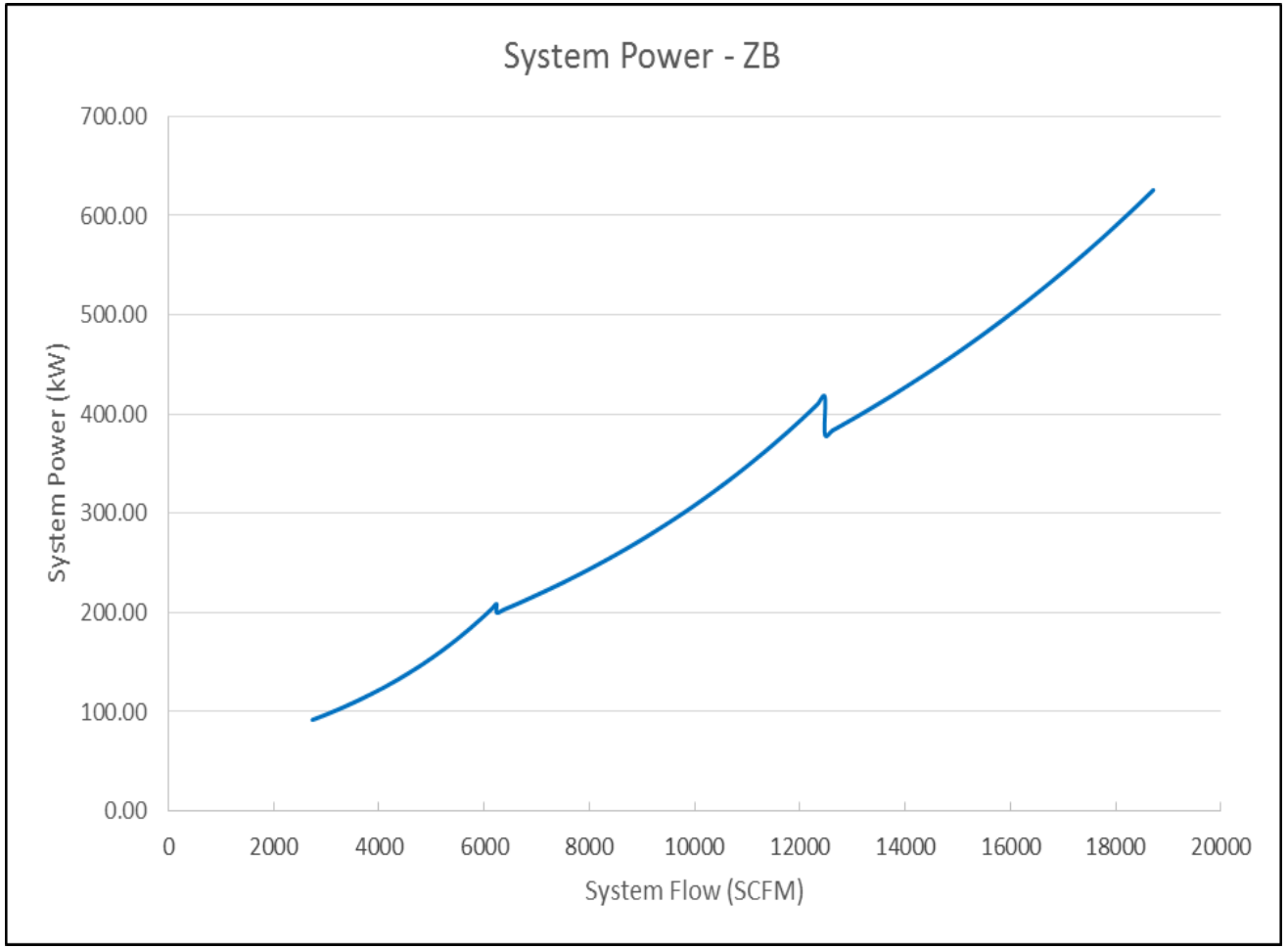
SIMULATED SYSTEM – CENTRIFUGAL BLOWERS

3 + 1 System (8 PSIG)

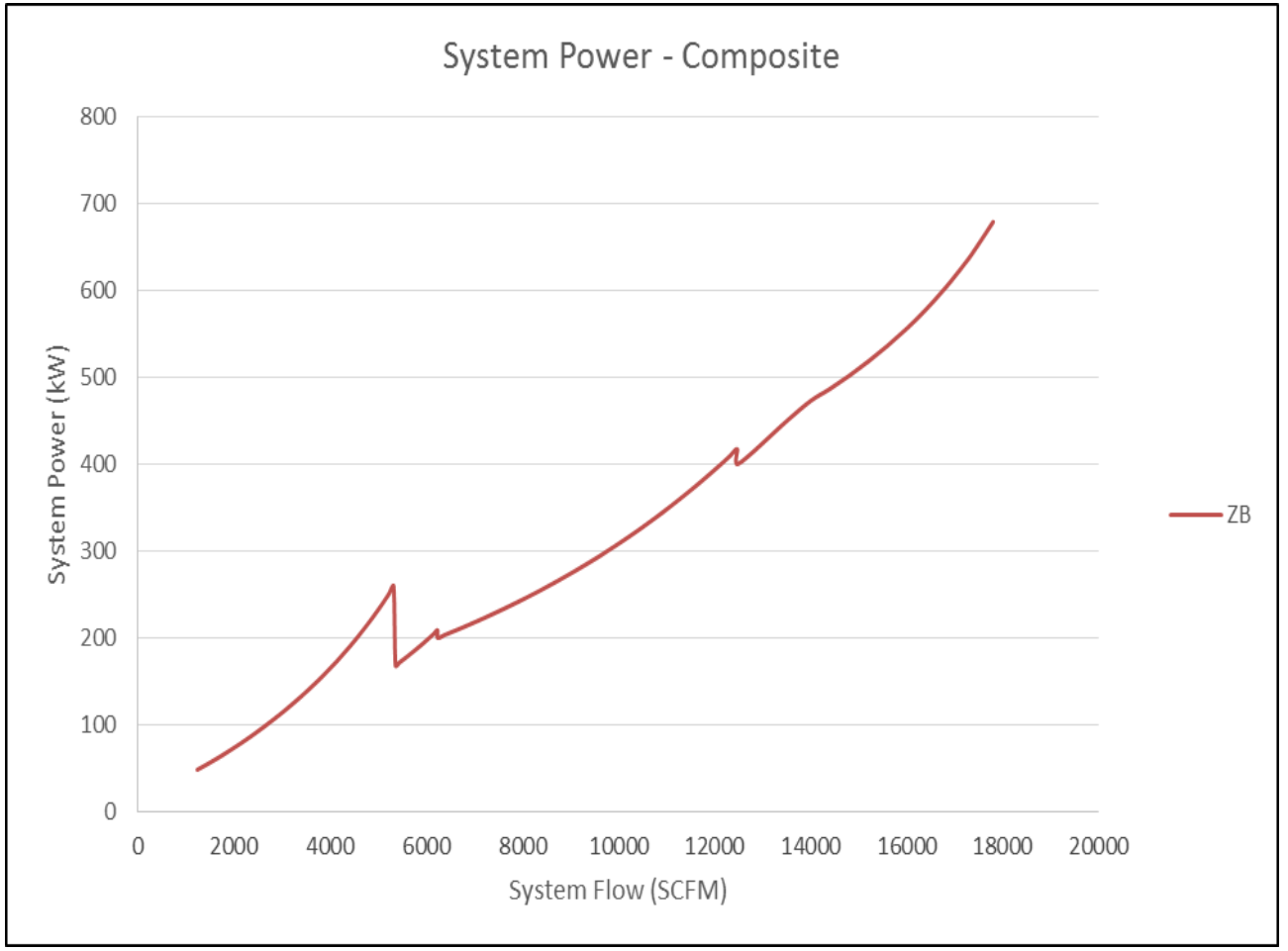
System Property	Value
Min Flow	~2750 SCFM
Max Flow	~18700 SCFM
Avg. Power	3.15 kW/100CFM



SIMULATED SYSTEM – COMBINED TECHNOLOGY

1 ZS + 2 ZB + (1 ZS Spare)

System Property	Value
Min Flow	~1200 SCFM
Max Flow	~17800 SCFM
Avg. Power	3.52 kW/100CFM



SIMULATED SYSTEM – COMBINED TECHNOLOGY

Power Comparison

System	Min Flow	Max Flow	Turndown	Avg. Power
Screw Only	1200	15000	~12.5	4.02
Centrifugal Only	2750	18700	~7	3.15
Combined	1200	17800	~15	3.52

- Depending on loading requirements, combined system makes sense
- Assume 10:1 diurnal loading for 15000 SCFM max system
  - Centrifugal only system can't turn down
  - Screw only system is less efficient by ~10%
  - Combined technology is best fit

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CONCLUSION

Combined System

- System requirements determine optimal solution
- Atlas Copco has the equipment to provide a variety of unique solutions
- By combining this equipment with the right control schemes, power savings can be significant
- Atlas Copco has the technical resources and knowledge to fit our technology to the application

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Hank van Ormer, Air Power USA
Keynote Speaker

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