



## 5 Installation Tips for Flow and kW Meters

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Tim Dugan, P.E., *Compression Engineering Corporation*  
*Keynote Speaker*

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



## 5 Installation Tips for Flow and kW Meters

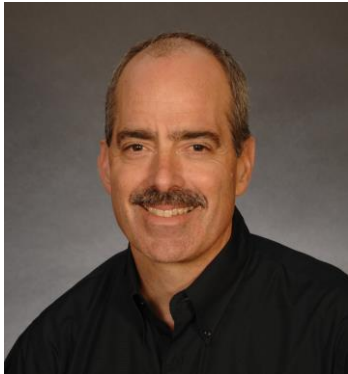
Introduction by *Rod Smith*, Publisher  
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## About the Speaker



**Tim Dugan, P.E.**

Compression Engineering Corp.

- President and Principal Engineer of Compression Engineering Corporation
- Over 25 years of experience in the industry

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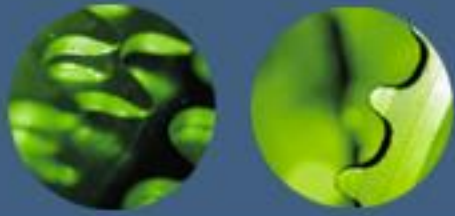
# 5 Installation Tips for Flow and Power Meters

**Tim Dugan**  
**Compression Engineering Corp.**

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Magazine  
2-22-18

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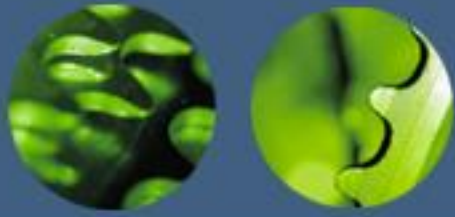


# Outline

1. Why Both Flow + Power Metering?
2. Flow Meter Installation Issues
3. Power Meter Installation Issues
4. Tracking Compressor Room Performance
5. Tracking System Usage







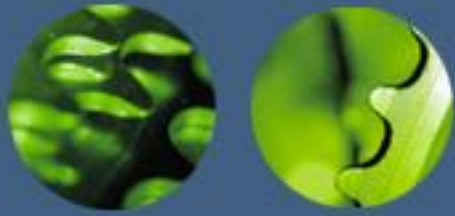
# Why Install Both Flow and Power Meters?

- Money In: Electricity



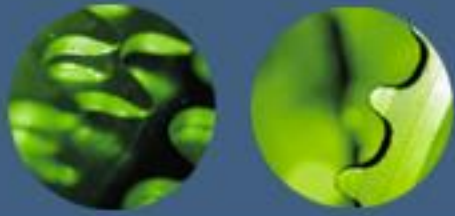
- Useful Power Out: Pneumatics





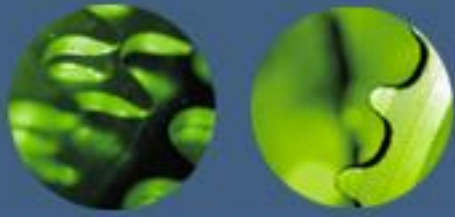
# Why Flow & kW Meter Compressor Room?

- Track Overall Compressor Room Efficiency:
  - In US: scfm/kW or kW per 100 scfm
  - SI: kWh/nm<sup>3</sup>
- Why Trend? Is an Audit Enough?
  - Dynamic Issues in Compressor Room:
  - Controls Change, Affecting Efficiency Dramatically
  - False Loads Change, Also Affecting Efficiency



# Flow Meter Installation Issues

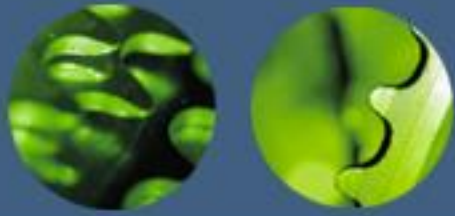
- **Simple Systems:**
- One Permanent Trending Flow Meter After Dryer
- One Portable Data-logging Meter for Temporary Measurement
- Consider “Hot-tapping”



# Installation Methods: Hot Tap

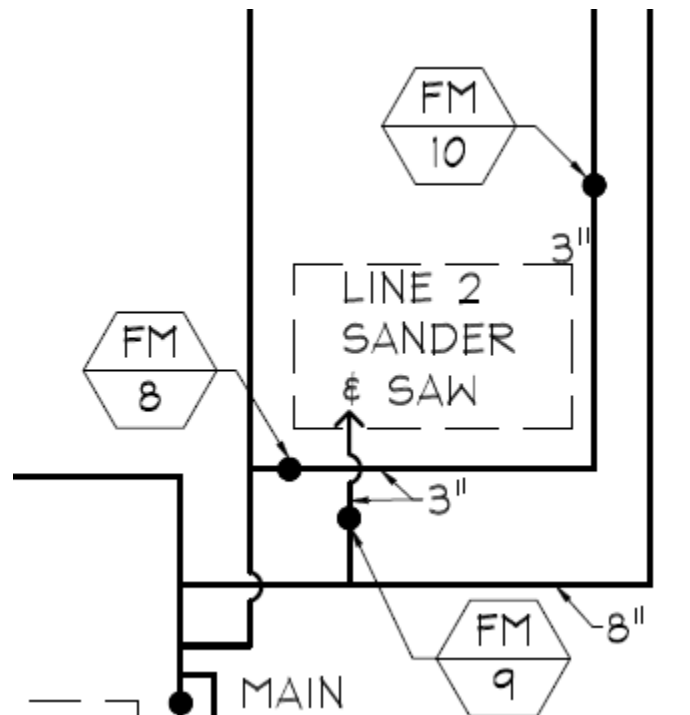


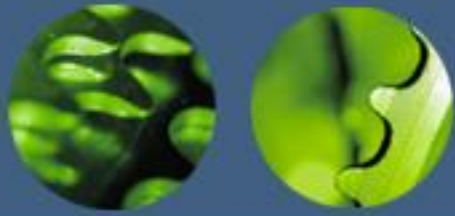
- Slightly loosen fitting
- Open valve
- Push meter to bottom of pipe
- Back meter out  $\frac{1}{2}$  of pipe diameter
- Straighten meter
- Adjust cable & tighten fitting



# Flow Meter Installation Issues

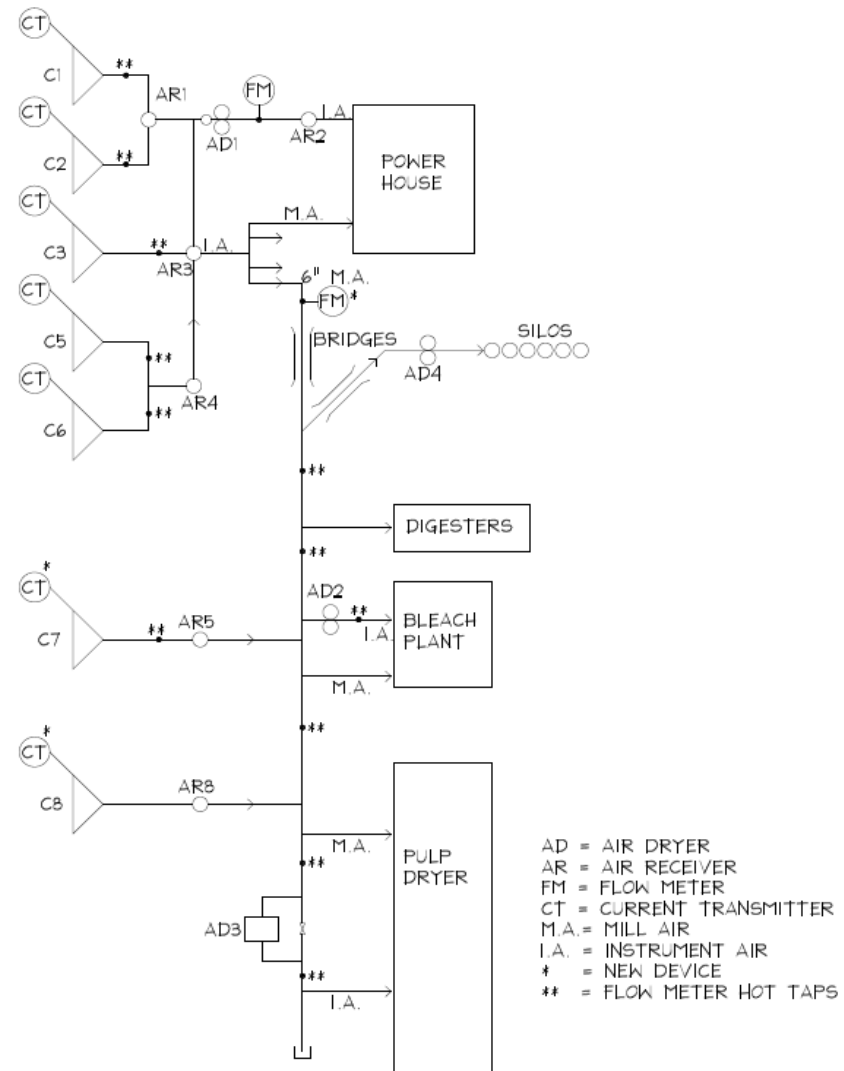
- Piping Network, “Looped”:
- “Double tap” metering recommended, bi-directional

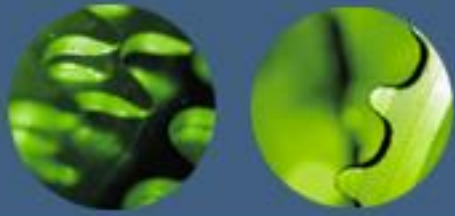




# Flow Meter Installation Issues

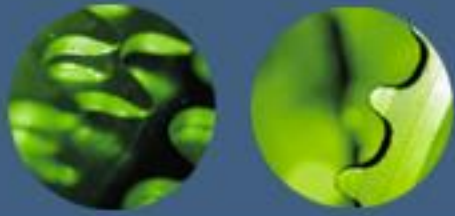
- Piping Network, “Linear”:
- “Double tap” metering recommended, single-directional





# Flow Meter Installation Issues

- **Common Issue In All Examples:**
- Don't Try to Measure Every Load
- Use Subtraction to Determine Flow to an Area

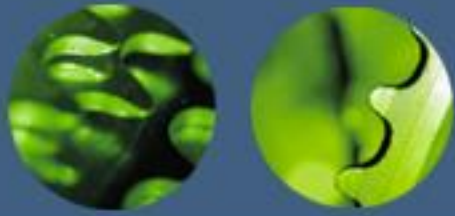


# **Power Meter Installation Issues**

- **For Fully-loaded Motors, Current is a Good Proxy for Power.**
- **For Unloaded Condition, Current is a Poor Proxy for Power. Large Variations in “Power Factor”.**
- **An Important KPI is Reduction of No-Load Power Waste.**
- **Power Measurement is More Accurate.**

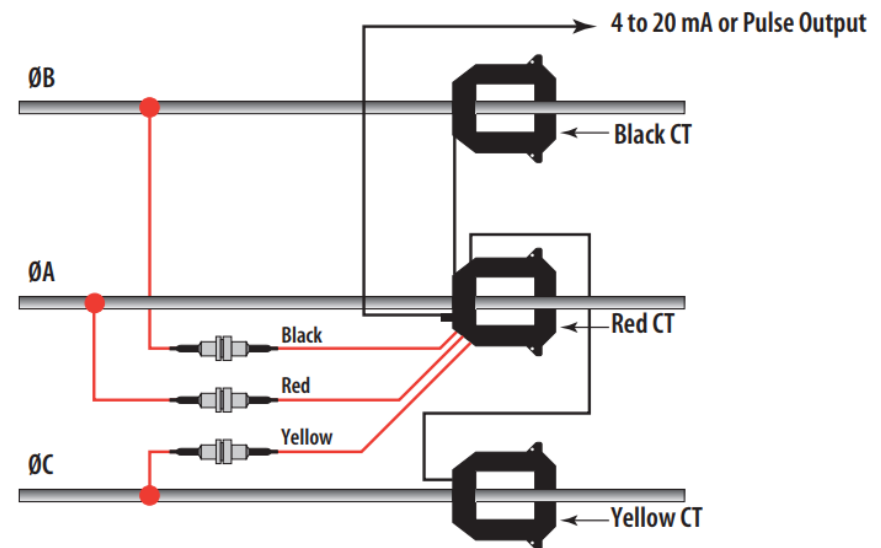


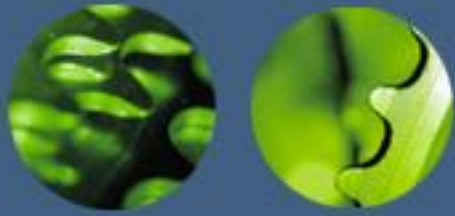




# Power Metering Installation Issues

- Minimum Cat III Rated Power Meter
- True RMS Power Meter
- 3-phase Meter
  - Requires (3) CTs and (3) Voltage Clamps

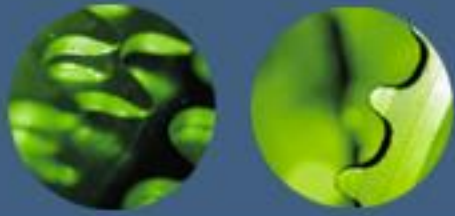




# **Power Metering Installation Issues**

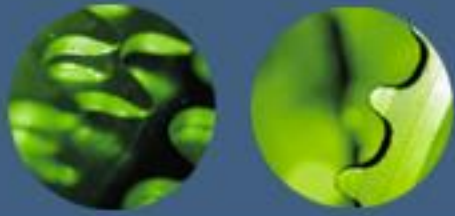
- **Don't Connect Voltage Leads on Live Load**
- **Have Electrician Install Meter & Require Them to Follow Safe Practices**





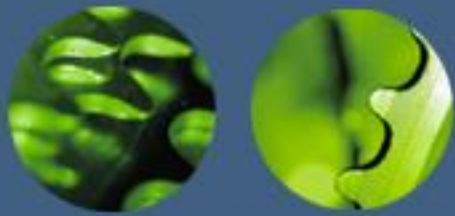
# Tracking Controls w- Performance Curve

- Measure Total Flow
- Measure Total Power
- Scatter Plot Power vs Flow at Commissioning
- Track Deviation From That Curve
  - VFD Operation – Is it Always “Trim”?
  - Sequencer Operation – Excessive Idling?
  - Control Band – Short-cycling?
  - Controls “Slope” - How Well do Controls “Shave” Power With Reduced Flow?

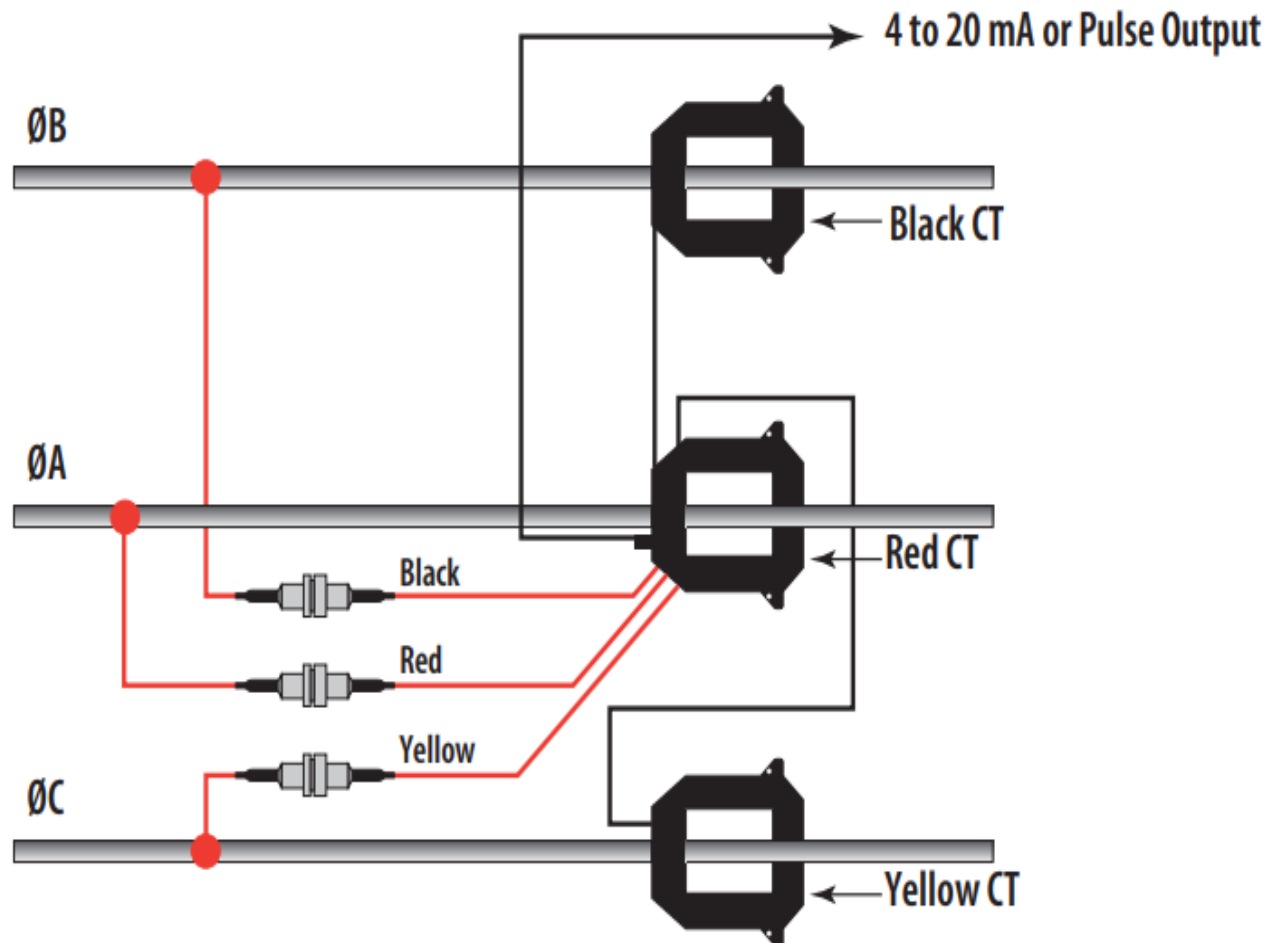


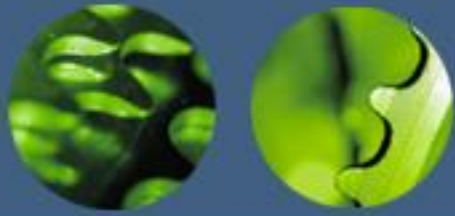
## Example System

- (1) 400hp VFD Compressor
- (1) 200hp Fixed Speed Compressor
- Refrigerated Air Dryers
- (1) Regenerative Nitrogen Generator
- N2 Generator Switching Caused Regular “Blips” in Flow Demand, Difficult to Tune Compressor Controls Optimally
- Detailed Audit Showed Problem, After Analysis
- Overall Flow and Power Plot is Better Way



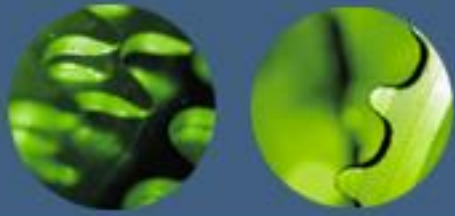
# Example Curve





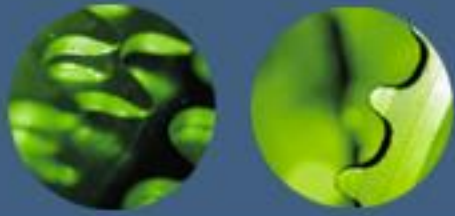
# Tracking Usage

- Complex Systems Have Big Supply – Demand Disconnect:
  - Flow Reduction in System Might Not Be Seen at Compressor Room Due to “Noise”
  - Departments Are Segregated – Cost Responsibility for Usage Can be Different than Generation
- Piping Runs Might be Too Short in Compressor Room for Flow Metering
- 100% System Flow Metering is Not Possible
- The Most Important Usage Might be the One You Can't Meter...



## Example System

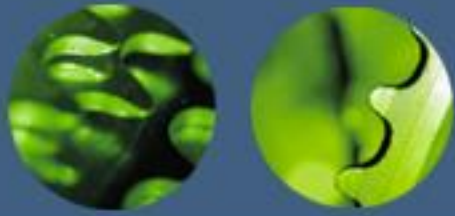
- Area of Concern is Less Than 20% of System Demand – You Think
- Project Reduces Flow 50% in That Area
- 10% Too Small to See and Quantify at Main Compressor Flow / Power Meters
- Use Hot Tap Meter Pre-Post for Area
- Determine Drop in Average Flow
- Assign Savings by the Flow Change and “Slope”:
- $\text{Reduced Energy} = \text{Reduced Flow} / (\text{scfm/kW slope}) \times \text{hrs/yr}$



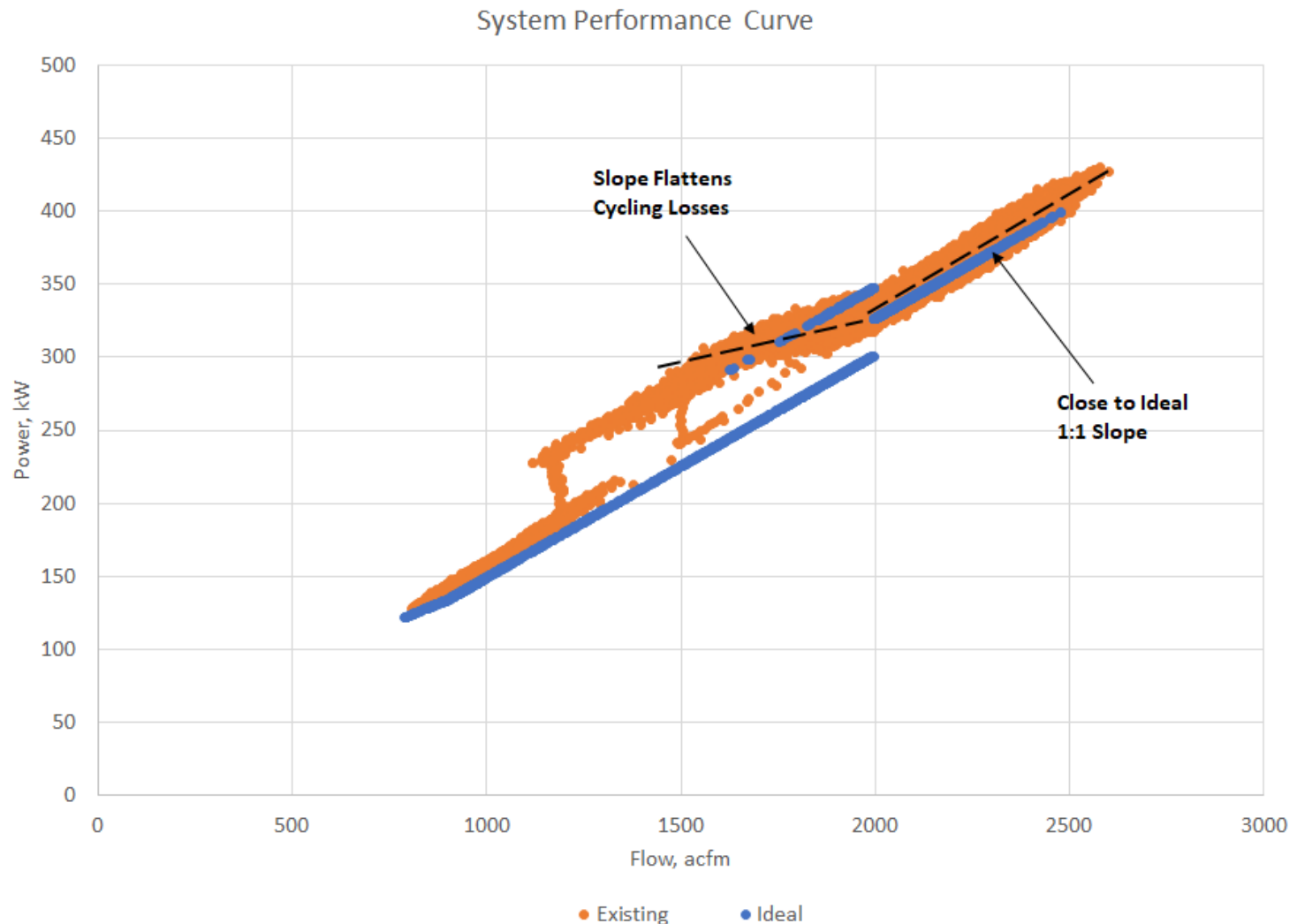
## **“Gap” Flow**

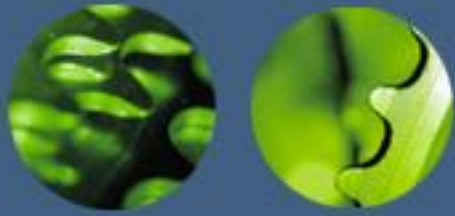
- After Metering “All” Demands, Total Flow is Far Less Than Compressor Room Flow.
- This Has Happened on my Last Two Large Metering Projects.
- Not a Loss. You Don’t Know Where Waste is Until You Start Measuring
- The Difference Between Compressor Room and Total System Flow is a Valuable Metric. SCADA System Can Track it.





# Example of Gap Flow





# Conclusions

- Measuring BOTH Power and Flow is Needed.
- Installing Flow Meters in the Best Place is Somewhat Trial and Error
- Power Metering is Most Accurate Way to Quantify Losses Due to Controls
- Power Meters Must be Safely Installed
- Two Calculations Are Important:
  - Flow Change
  - Power/Flow Slope



**Thank you**

**Tim Dugan**  
**Compression Engineering Corporation**

**503-520-0700**  
**[tim.dugan@comp-eng.com](mailto:tim.dugan@comp-eng.com)**

## About the Speaker



**Pascal van Putten**  
VPIstruments

- CEO of VPIstruments



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# Identify optimization opportunities

Turn measurement data into energy savings

Pascal van Putten, CEO  
VPInstruments

Compressed Air Best Practices<sup>®</sup> Magazine  
Webinar Feb 2018

# Common challenges

- Which signals to measure
  - Flow, Pressure, Temperature, kW, Dew Point
- Understanding measurement uncertainties and their causes
- Relating measurement results to real issues

# Where to install your sensors

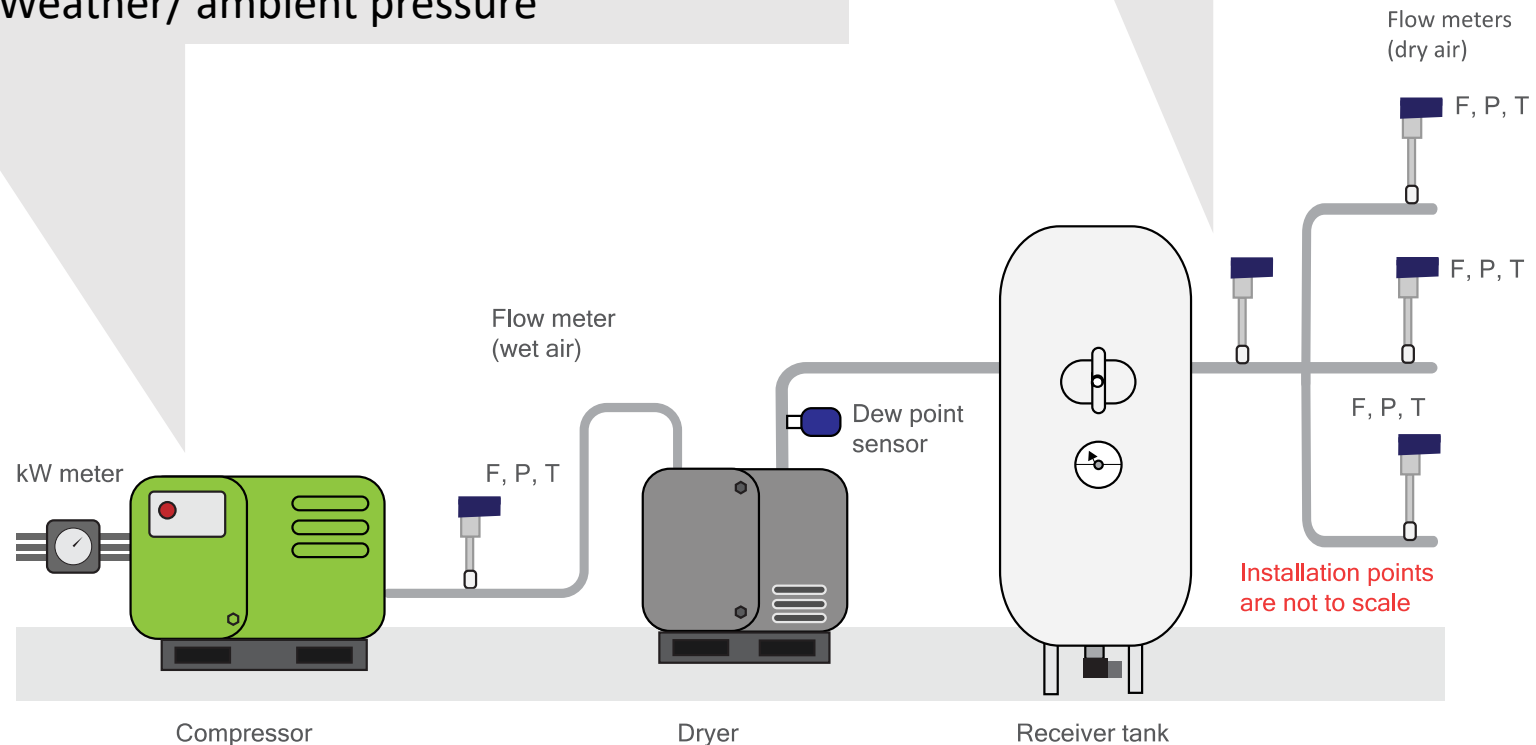
What's your goal?

## Compressor performance:

- Amp meter (or kW meter)
- Flow meter
- Pressure sensor
- Temperature sensor
- Weather/ ambient pressure

## Demand side:

- Flow
- Pressure / pressure drop
- Temperature
- Dew point



# Understanding measurement uncertainties

Key to the right conclusions

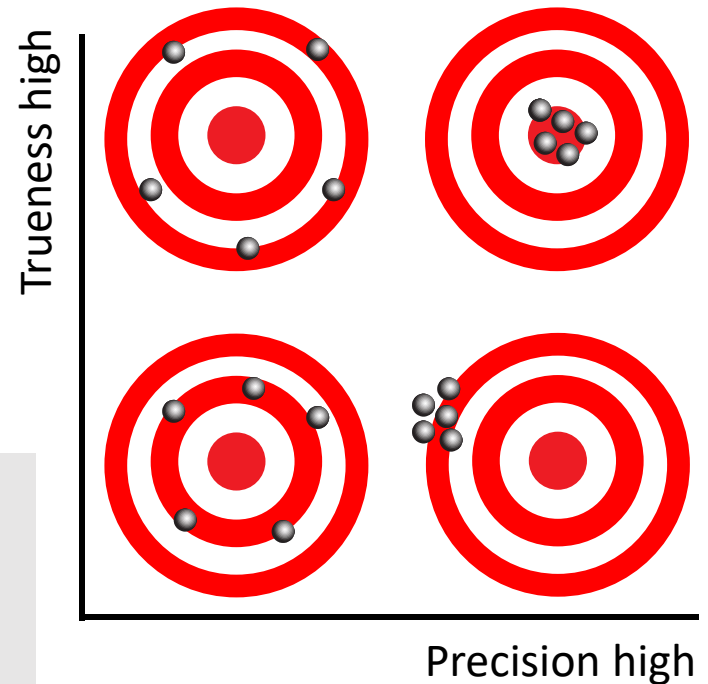
## Total Measurement Uncertainty (TMU):

- See ISO 17025 and similar directives
- Get familiar with the basics

$$U = \text{SQRT}(U_1^2 + U_2^2 + U_3^2 \dots)$$

## Compressor performance example TMU's:

- Amp meter (or kW meter) : < 1% f.s.  
-kW from amps vs real kW?
- Flow meter : +/- 5%
  - Inner pipe diameter
  - Flow profile
  - Temperature
- Pressure sensor : +/- 0.5% f.s.
- Temperature sensor : +/- 1 degree
- Weather/ ambient : +/- 20 mbar





# Understanding measurement uncertainties

Key to the right conclusions

## Some tips

- Know the uncertainty of all equipment involved
- Do not debate anything +/- 1%, first estimate the TMU
- System conditions can change: measure long enough
- Take seasonal/ weather/altitude influences into account

“ Your average air consumption is 30.397 SCFM”

**Should be re-phrased properly:**

Your air consumption is **30 SCFM\*** +/- 5%, or:

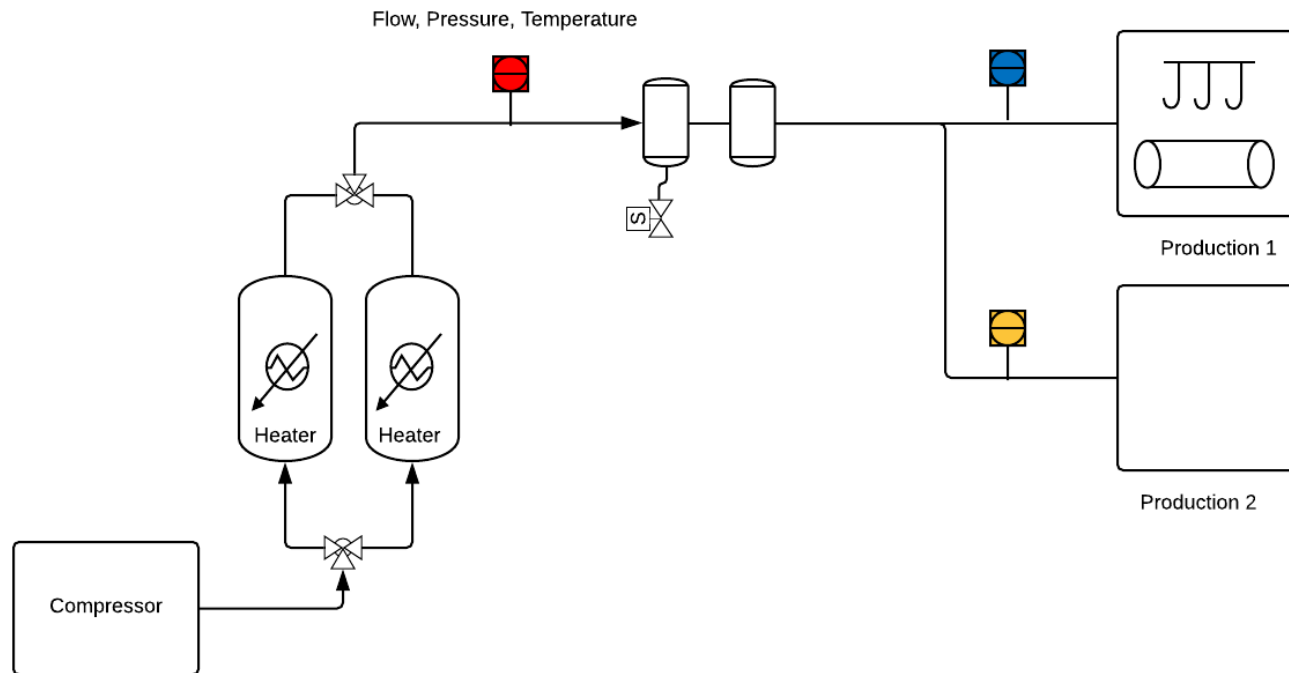
Your air consumption is between 28.5 and 31.5 SCFM\*

\*Reference conditions: 68 F, 0% RH, 14.73 Psi(a)

# 1. Pressure issues

## Optimize the control system

- Typical graph: Pressure drop over equipment
- Reasons: Receiver too small, Filters too small or internally polluted, pipe diameter too small for required demand, Control valve not properly tuned.
- Three in one flow meters can monitor system behavior

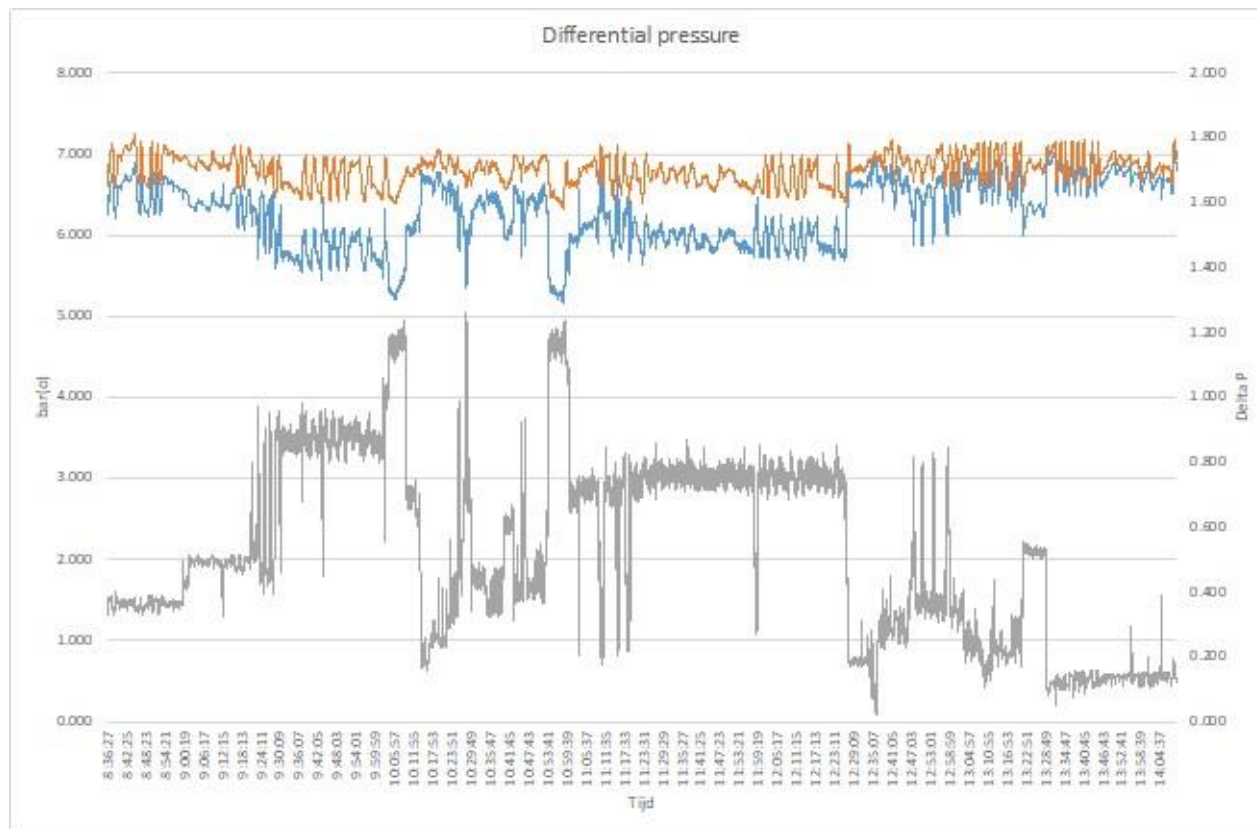


# 1. Pressure issues

Optimize the control system

Typical graph: Pressure varies significantly with flow

Reasons: Receiver too small, Control system not properly tuned, pipe size too small



> 1 bar !

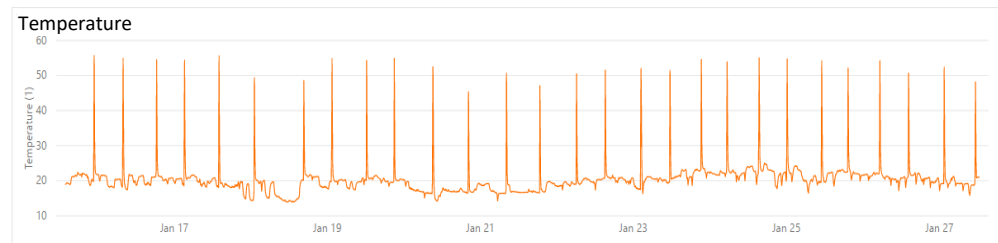
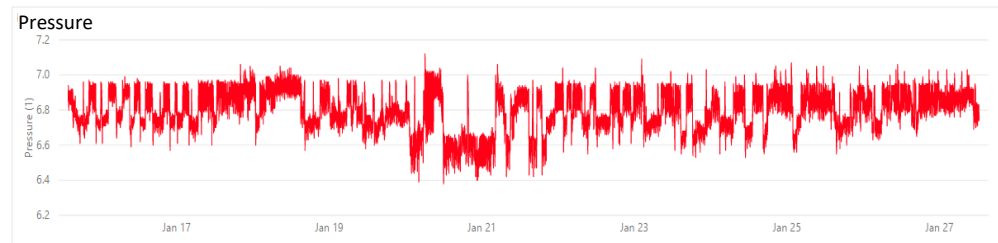
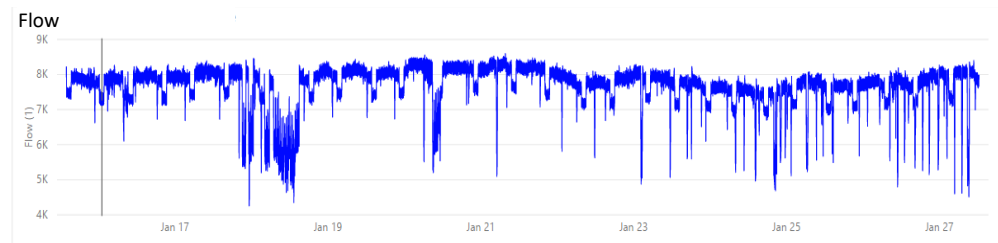
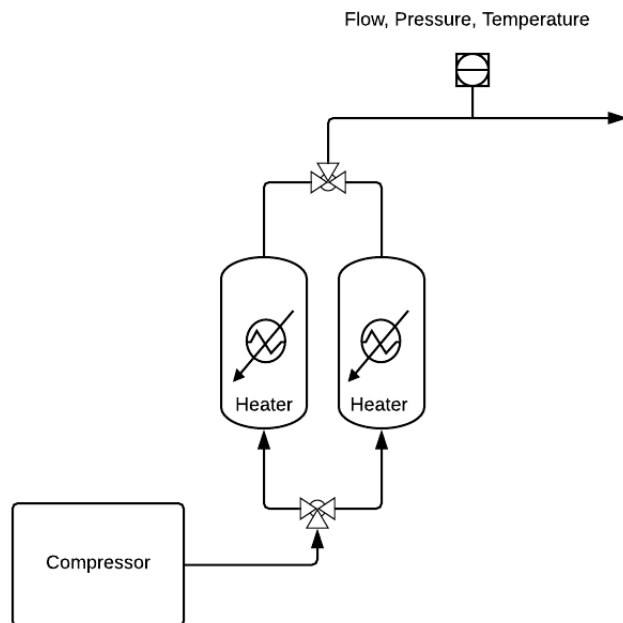
0,2 bar  
< 0.2 bar

## 2. Dryers: Temperature

Large temperature swings or peaks

### Symptoms:

- Temperature varies with demand or large temperature peaks
- Temperature difference before/ after dryer starts to increase when demand increases
- Reasons: Malfunctioning dryer, dryer too small for demand

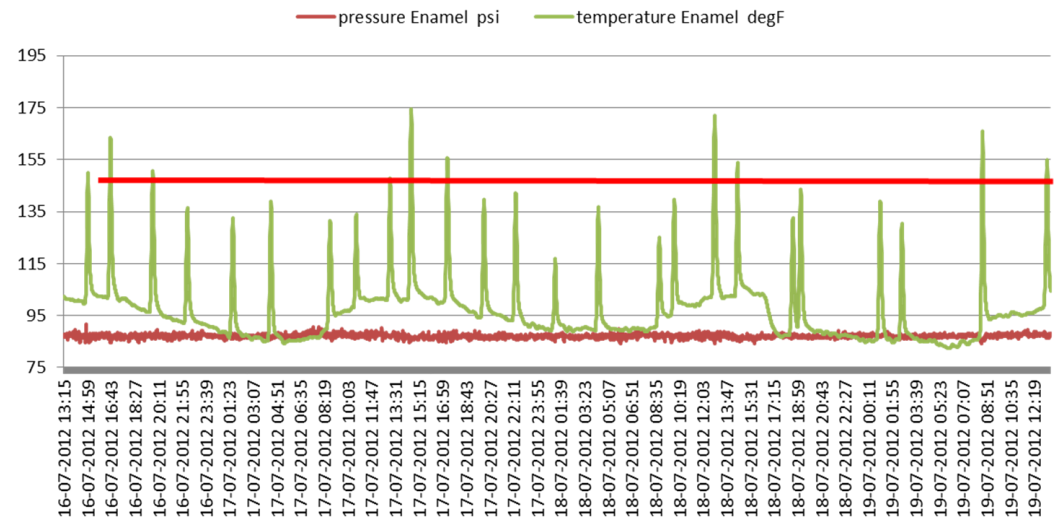
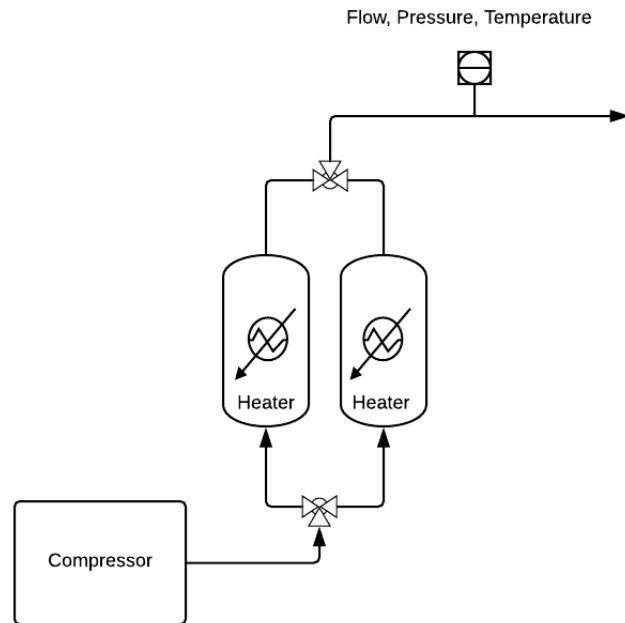


## 2. Dryers: Temperature

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- Reasons: Malfunctioning dryer, dryer too small for demand



### 3. Demand side: production equipment

Revealing the savings opportunity with flow measurement

- See the effects of lower pressure on air demand
- See difference between nozzles



Open blow pipes (two bolts used to shut off)



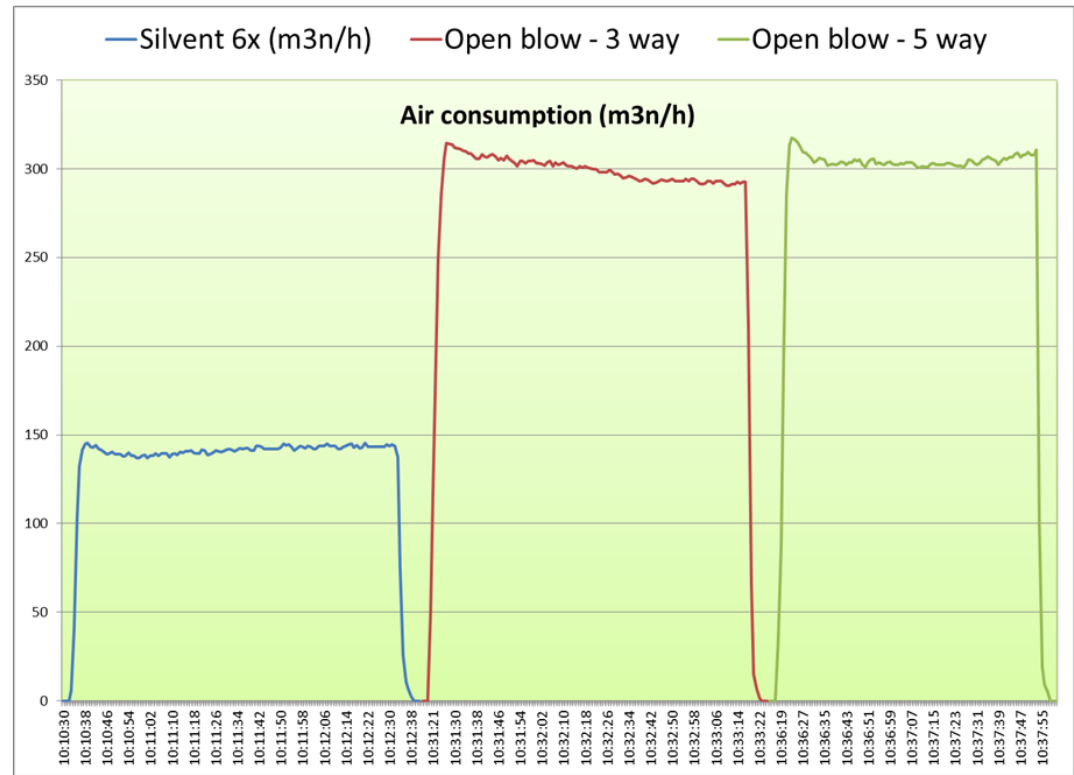
Engineered nozzle



### 3. Demand side: production equipment

Revealing the savings opportunity with flow measurement

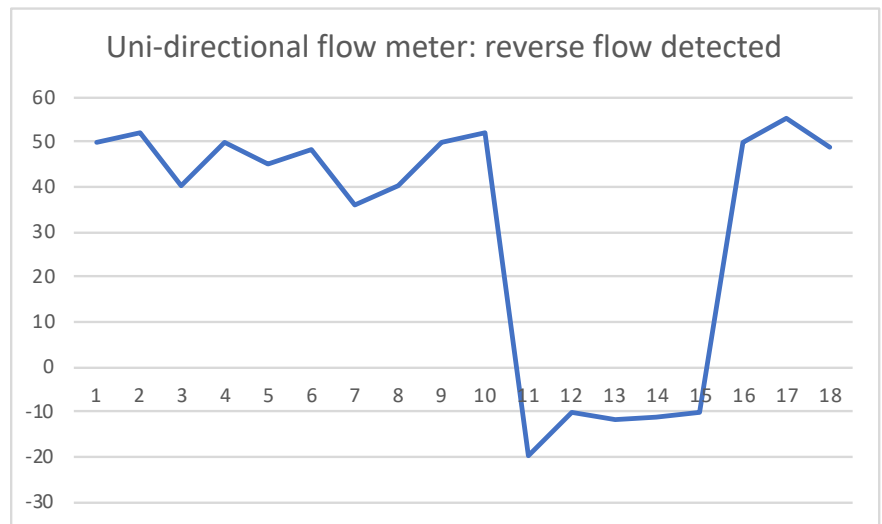
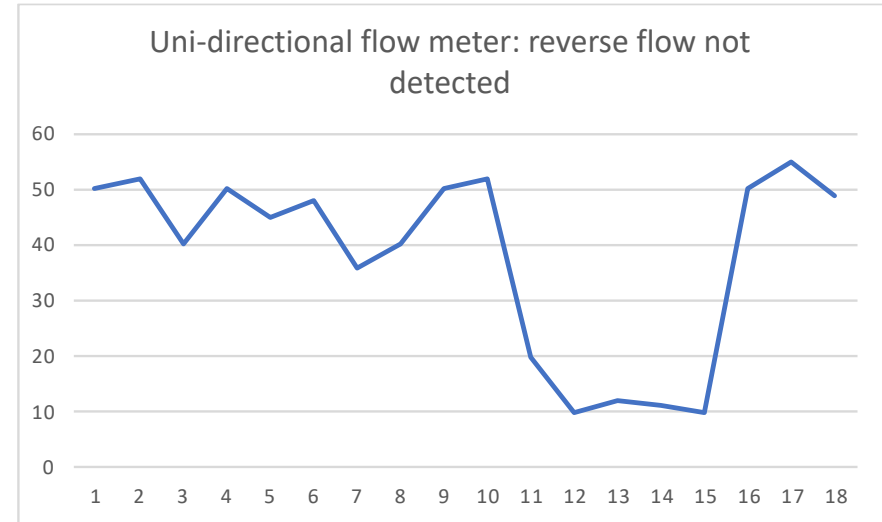
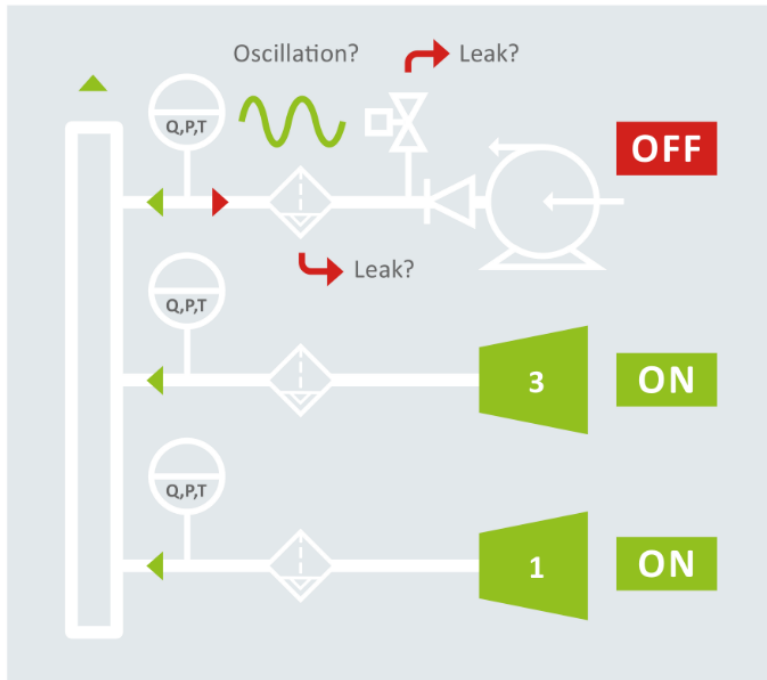
- Savings: 9 K USD per year
- Flow meter with integrated pressure sensor
- Real ROI calculation



#### 4. Bi directional flow measurement

## Directing you towards the right conclusions

- Reverse flow: expensive mistakes
- Non return valves
- Receiving tanks

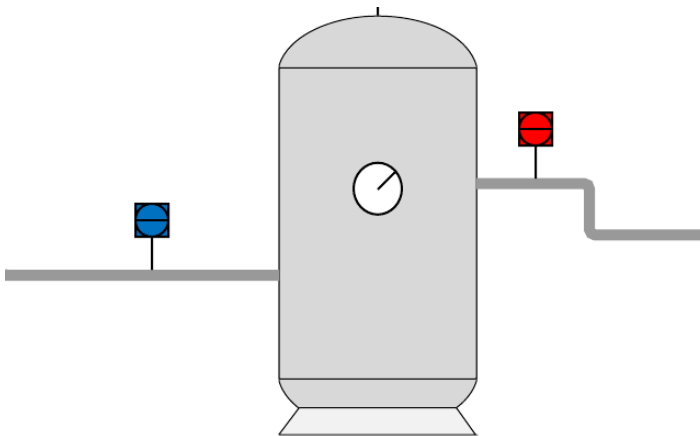




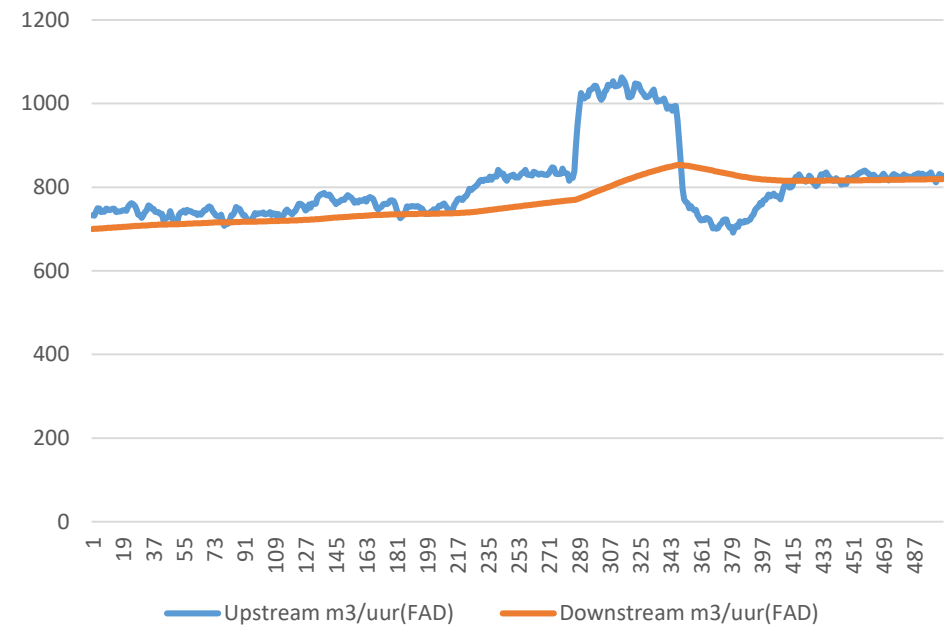
## 5. Receivers

Receivers are great signal filters

- Receiver tank: input is equal to output....
- Output is filtered
- Large receiver = large signal filter
- Downstream : filtered
- Upstream: unfiltered



The effect of a large receiver



# Tips & conclusions

- Be alert/ reasonable on measurement uncertainties
- Combining signals reveals more savings
- Knowing the PID = Crucial for analysis
- Hire an expert/ auditor to help

# Thank you!

## Worldwide contacts:

USA, Menno Verbeek: +312 2393052

Chuck Mays: +919 744 8003

[Menno.verbeek@vpinstruments.com](mailto:Menno.verbeek@vpinstruments.com)

ASIA/Pacific: Nietin Somaroe

[Nietin.somaroe@vpinstruments.com](mailto:Nietin.somaroe@vpinstruments.com)

Europe: Sjim Jansen

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## 5 Installation Tips for Flow and kW Meters

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

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### ***Date***

September 17-19, 2018

### ***Location***

Chicago O'Hare Crowne Plaza Hotel



March 2018 Webinar  
**Pros & Cons of Centralized Vacuum Systems**



**Tim Dugan, P.E.**  
**Compression Engineering Corporation**  
*Keynote Speaker*

Sponsored by



**Thursday, March 15, 2018 – 2:00 PM EST**

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