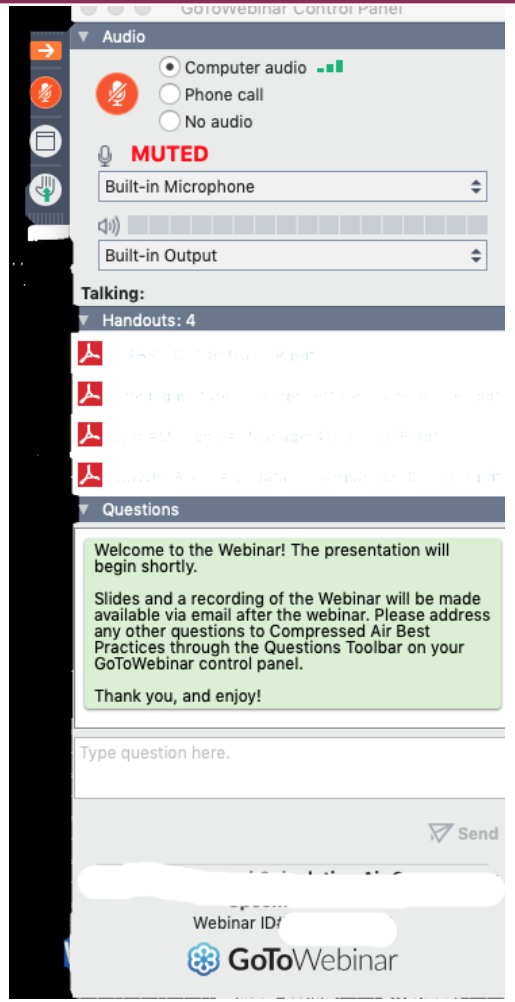
The Minimum 24/7 Compressed Air Performance Metrics to Have

Tim Dugan, P.E.
Keynote Speaker

The recording and slides of this webinar will be made available to attendees via email tomorrow.

PDH Certificates will be e-mailed to attendees within 2 days.

Q&A Format



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

- Please post your questions in the Questions Window in your GoToWebinar interface.

- Direct all questions to Compressed Air Best Practices® Magazine

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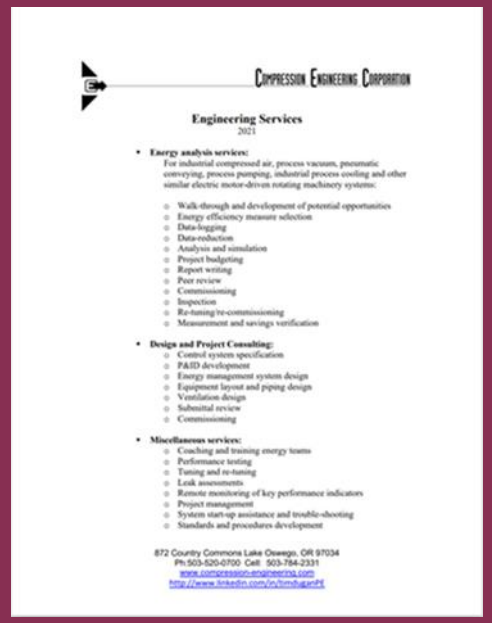
Handouts



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2021

- **Energy analysis services:**
  For industrial compressed air, process vacuum, pneumatic conveying, process pumping, industrial process cooling and other similar electric motor-driven rotating machinery systems:
  - Walk-through and development of potential opportunities
  - Energy efficiency measure selection
  - Data-logging
  - Data-reduction
  - Analysis and simulation
  - Project budgeting
  - Report writing
  - Peer review
  - Commissioning
  - Inspection
  - Re-tuning re-commissioning
  - Measurement and savings verification
- **Design and Project Consulting:**
  - Control system specification
  - PA/ID development
  - Energy management system design
  - Equipment layout and piping design
  - Ventilation design
  - Submittal review
  - Commissioning
- **Miscellaneous services:**
  - Coaching and training energy teams
  - Performance testing
  - Tuning and re-tuning
  - Leak assessments
  - Remote monitoring of key performance indicators
  - Project management
  - System start-up assistance and trouble-shooting
  - Standards and procedures development

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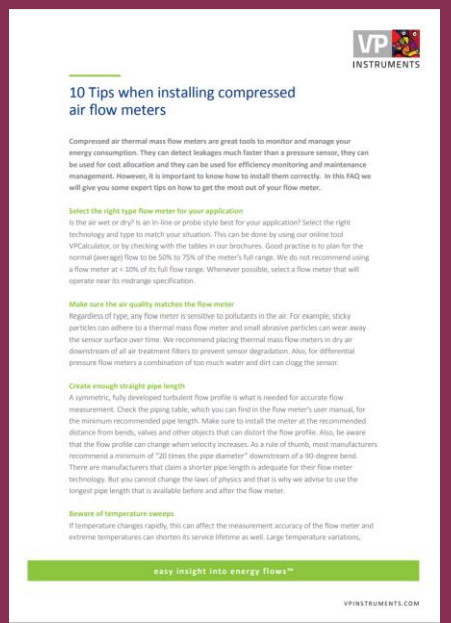

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10 Tips when installing compressed air flow meters

Compressed air thermal mass flow meters are great tools to monitor and manage your energy consumption. They can detect leakages much faster than a pressure sensor, they can be used for cost allocation and they can be used for efficiency monitoring and maintenance management. However, it is important to know how to install them correctly. In this FAQ we will give you some expert tips on how to get the most out of your flow meter.

Select the right type flow meter for your application

Is the air wet or dry? Is an in-line or probe style best for your application? Select the right technology and type to match your situation. This can be done by using our online tool VPCalculator, or by checking with the tables in our brochures. Good practise is to plan for the normal (average) flow to be 50% to 75% of the meter's full range. We do not recommend using a flow meter at < 10% of its full flow range. Whenever possible, select a flow meter that will operate near its midrange specification.

Make sure the air quality matches the flow meter

Regardless of type, any flow meter is sensitive to pollutants in the air. For example, sticky particles can adhere to a thermal mass flow meter and small abrasive particles can wear away the sensor surface over time. We recommend placing thermal mass flow meters in dry air downstream of all air treatment filters to prevent sensor degradation. Also, for differential pressure flow meters a combination of too much water and dirt can clogg the sensor.

Create enough straight pipe length

A symmetric, fully developed turbulent flow profile is what is needed for accurate flow measurement. Check the piping table, which you can find in the flow meter's user manual, for the minimum recommended pipe length. Make sure to install the meter at the recommended distance from bends, valves and other objects that can distort the flow profile. Also, be aware that the flow profile can change when velocity increases. As a rule of thumb, most manufacturers recommend a minimum of "20 times the pipe diameter" downstream of a 90-degree bend. There are manufacturers that claim a shorter pipe length is adequate for their flow meter technology. But you cannot change the laws of physics and that is why we advise to use the longest pipe length that is available before and after the flow meter.

Beware of temperature sweeps

If temperature changes rapidly, this can affect the measurement accuracy of the flow meter and extreme temperatures can shorten its service lifetime as well. Large temperature variations,

easy insight into energy flows™

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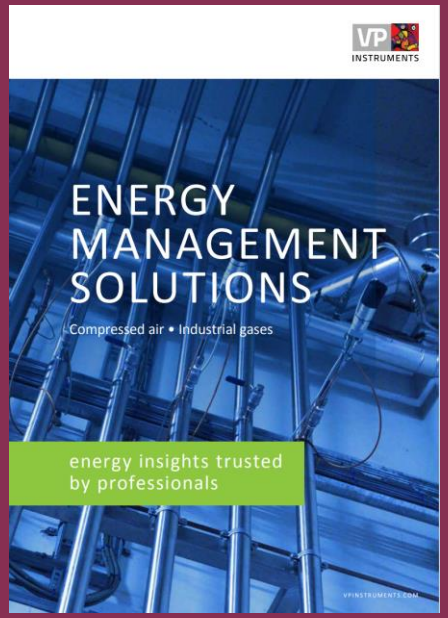

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Disclaimer

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

The Minimum 24/7 Compressed Air Performance Metrics to Have

Introduction by

Compressed Air Best Practices® Magazine

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About the Speaker

Tim Dugan, P.E.
Compression Engineering Corporation

- President and Principal Engineer, Compression Engineering Corporation

- Over 32 years of experience in the industry

- 20 years of independent consulting experience

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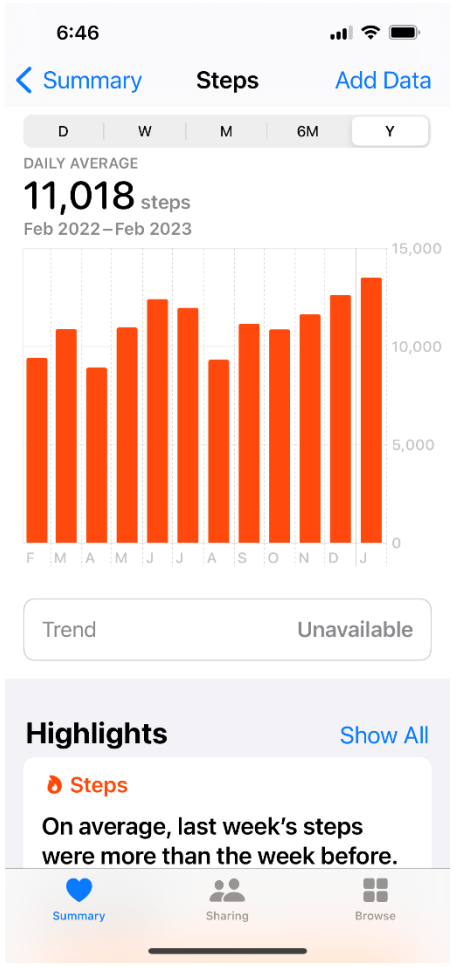
Outline

- What Are “Key Performance Metrics” (or KPI’s)?
- Ideal and Simple Starter Measurement System for Capturing KPIs
- Compressor Efficiency KPIs

Running KPI Example

- We use KPIs for Fitness
- Steps Measured w-Tiny Accelerometer and Datalogger
- Miles/mo, steps/day etc. Calculated in Cloud



What Are KPIs?

A Few Simple Numbers to Know:
Where Am I Now? What is Optimal? Where Could I Be, Realistically?

What Are KPIs?

- “KPI” = Key Performance Indicator
- KPIs are Calculated Numbers That Are Used to Answer Questions:
- How ***Efficient*** is Each ***Compressor***?
- How ***Effective*** are Your Compressor ***Controls***?
- Some KPIs Need Two or More Measurements To Get One Number

Measurement System for Capturing KPIs

- **Ideal External Sensors:**
- Measurement: Power, Flow and Pressure
- Power:
  - 3-Phase Power is Best, Especially with Unloading Compressors
- Flow:
  - Low Cost Thermal Mass Flow Meters After Dryers
  - Higher Cost Differential Pressure or Vortex Needed Before Dryers
  - Hot Tap is Recommended
- Pressure:
  - Before and After Dryers

Measurement System for Capturing KPIs

- **Long Term, Permanent System:**
- Need a Calculation, Trending and Display “Engine”
- Local: EMS, DCS or SCADA System; HMI System
- Remote/Cloud
- Math Functions Needed:
  - Data filtering
  - Averaging
  - Min and Max Over Time Window
  - Basic Arithmetic Functions (+, -, x, and /)
  - Basic Logic Functions (if / then / else)
- Trending
- Data visualization
- System P&ID

Simplest Starting Point

- **Simple System to Get Started:**
- Data Logger with Analog Input Channels (4-20mA) and 24V Power for Sensors
- CTs
- Data Logger Software
- Easy Download to Phone or Laptop
- Permanent Connection Between Data Logger and Desktop if Possible

Simplest Starting Point

- **Basic External Sensors:**
- Motor Current, One Phase:
  - Low Cost Open Current Transmitter (CT), One on Each Compressor & Dryer

Simplest Starting Point

- **Basic Data Logger:**
- Four to Eight Channels, Preferably Not Sensor-Specific
- 120V to 12-24VDC Power Supply, Integrated Ideally
- Easy-to-Use PC Software
- A Person with Two Legs, Two Arms, Ears, Eyes and a Brain

Simplest Starting Point

- **Some Cool New Tools:**
- Systems that Log Field Sensors & Compressor Operation and Connect Real-time to the Cloud:

Simplest Starting Point

- **Values You Can Get From Compressor Controllers:**
  - Usually Available on Modbus
  - Need a Datalogger Compatible with Modbus, Usually Takes Automation Skills to Set Up.
  - Load state (1 or 0)
  - Electrical Current (Amps)
  - Inlet valve or Inlet Guide Vanes (IGV) percent, 0-100% (100% = open)
  - Blow-off Valve (BOV) percent , 100-0% (100% = closed)
  - Speed

Compressor Efficiency KPI

- **Ideal Method:**
- Option 1 = "**compressor specific performance**", the ratio of output to input:
- Flow Out / Package Power
- Scfm/kW (or 100 m3/kWh)
- I Like flow/power Because *Bigger Number = Good*
- Option 2 = "**compressor specific power**",
- Package Power/Flow Out
- kW/100 scfm (kWh/100 m3)

Compressor Efficiency KPI

- **Problems:**
- Cost:
  - To do Correctly and Reliably, You Need a Wet Side Flow Meter, Power Transmitter, for Each Compressor, $5k to $10k Investment Each
  - Only Worth it For Large Compressors
  - Recommended for Centrifugals
- Installation Difficultly:
  - Need Straight Length of Pipe Between Compressor and Dryer, Often Not There
- Staff to Interpret Data?
  - You Could be Trading Brains for Technology That's Useless – Be Careful!
  - "Artificial Intelligence" without a Person in the Loop = Automated Stupidity

Simple Compressor KPI Example

- Learn How to HEAR Inefficiency Walking Through Compressor Room
  - Blow-off
  - VFD Hunting
  - Drains
  - Dryer Purge
  - ***If it Makes You Jump, it is Probably Wasteful!***

Simple Compressor KPI Example

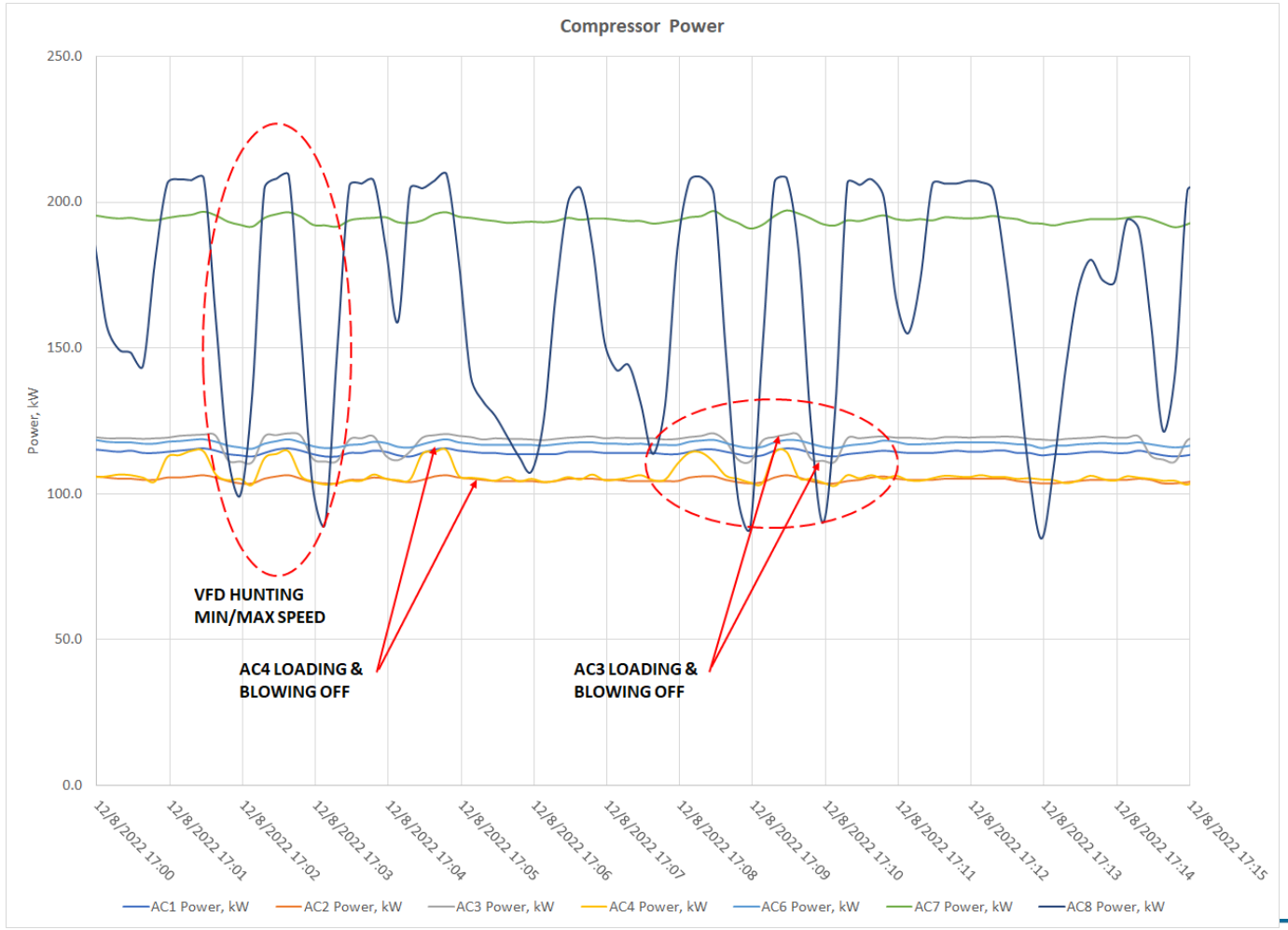
- Example of VFD and Blow-off:
  https://www.dropbox.com/s/3tb2jqc65k
  k5lw8/IMG_7960

Simple Compressor KPI Example

- Learn How to SEE Inefficiency Glancing at Compressor Room Data:
  - VFD Amps constant
  - VFD Amps Up/down
  - Fixed Speed Amps Up/down
  - Fixed Speed Amps Floating 50-80%
  - ***You Should See All Fixed Speed Compressors Constant at Close to Nameplate Amps, or Off***
  - ***You Should See Load-unload Compressors with Less than 5% Total Time Unloaded if You Have a VFD, and Only One Compressor Loading and Unloading at a Time if You Don't.***
  - ***You Should See VFD Compressors at 50-80% Most of the Time***

Simple Compressor KPI Example

- After I used my ears, I looked at data.
- I just measured current and pressure.
- A simple trend shows what I heard.



Simple Compressor KPI Example

- How Can You Calculate an Appx KPI for Your Compressor's Specific Power Without a Dedicated Flow Meter and Power Transducer?
- Start with the CAGI Data Sheet Full Load Efficiency and Derate it by a KPI From Measured Data.
- If It's Load-unload, the KPI Should be % Unloaded Time/Day:
  - Spot-measure unloaded and loaded power with a power meter!
  - Percent Derate = Unload / Full Load Power x % Time Unloaded
- If It's VFD, the KPI Should be % Time Between and at Min / Max Speed:
  - Percent Derate = [(% time at low speed) x low speed kW/100 scfm + (% time at high speed) x high speed kW/100 scfm] / ideal kW/100 scfm

Summary

- Although a Permanent SCADA or EMCS System with Real-time Calculations is Ideal for a Compressed Air KPI, You Can Use a Data-logger and CTs to Start.
- A real Person Looking at Data-logged Amps Alone Can Diagnose Many Efficiency Problems and Estimate Specific Power.

About the Speaker

Pascal van Putten
VPInstruments

- CEO, VPInstruments
- > 20 years experience
- VPInstruments offers industrial clients Energy Management Solutions for compressed air, technical gases as well as other utilities

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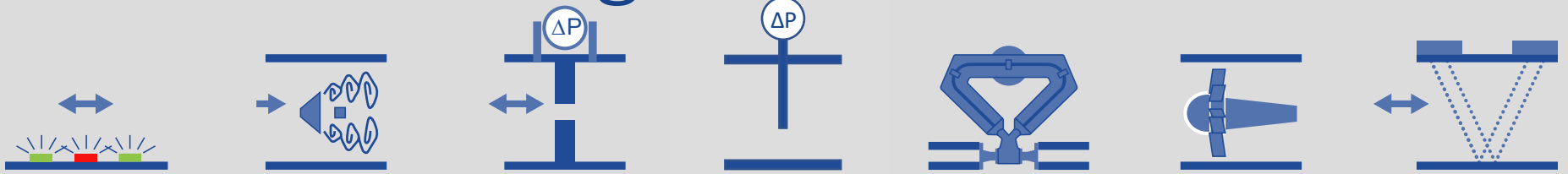
Garbage in = Garbage out

The art of measurement

Flow sensor technologies

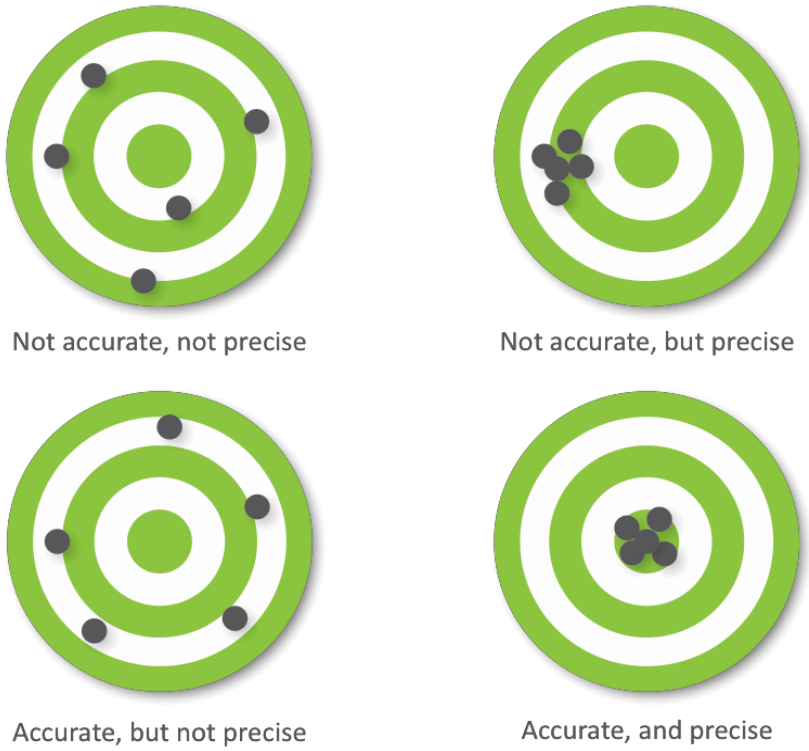


	Thermal	Vortex	DP – Orifice plate	DP – Insertion	Coriolis	Turbine/ rotary displacement	Clamp on ultrasonic
Mass flow	Yes	Optional	Optional	Optional	Yes	Optional	Optional
Meter run	20D	15D	15D	20D	0D	10D	20D
Pressure loss	Low	Medium/high	high	Low	Low	Low	Low
Dirty air	Fouling	OK	Clogging	Fouling/Clog	Internal fouling	Faillure	OK
Wet Air	Spikes	OK, spikes	OK	OK, orientation	Yes, but affects reading	Faillure	Spikes
Range	1:250	1:10	1:10	1:10	1:100	1:100	1:100
Accuracy	2%	2%	2%	2%	0.5 .. 1%	0.5…1 %	1%
Purchase price	$	$	$	$S	$$$$	$$	$$$
Maintenance	Medium	Low	Medium	Medium	Low	High	Low

Accuracy and precision

What do you need?

- **Trending leakages:** Systematic error can be acceptable, when comparing over long periods of time
- **Control systems:** High accuracy and precision is required
- **Long term measurements:** Lower precision can be acceptable combined with high accuracy: noise will be averaged out
- **Sensor drift:** “loss” of accuracy → regular service/recalibration can solve this



Flow range is critical

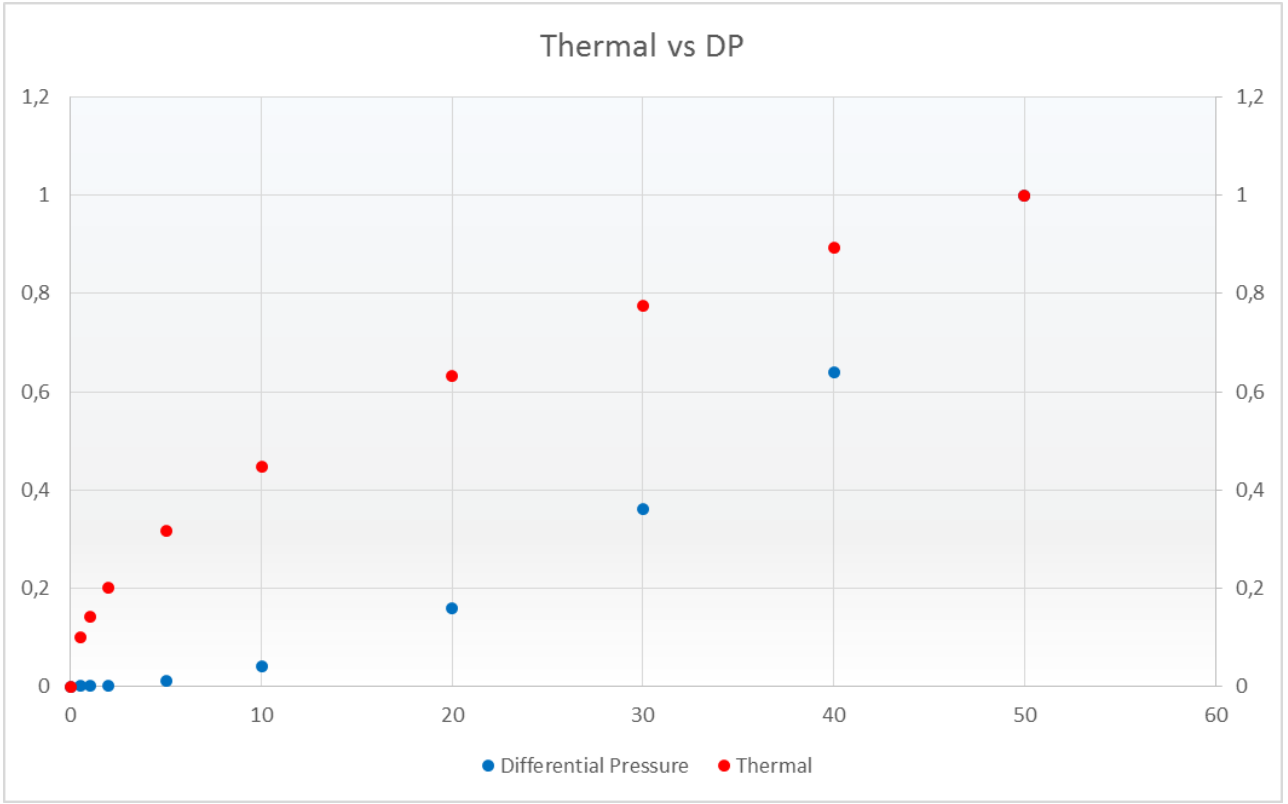
Thermal vs DP technology: 1:300 range vs 1:10 (1:5) range

Thermal:

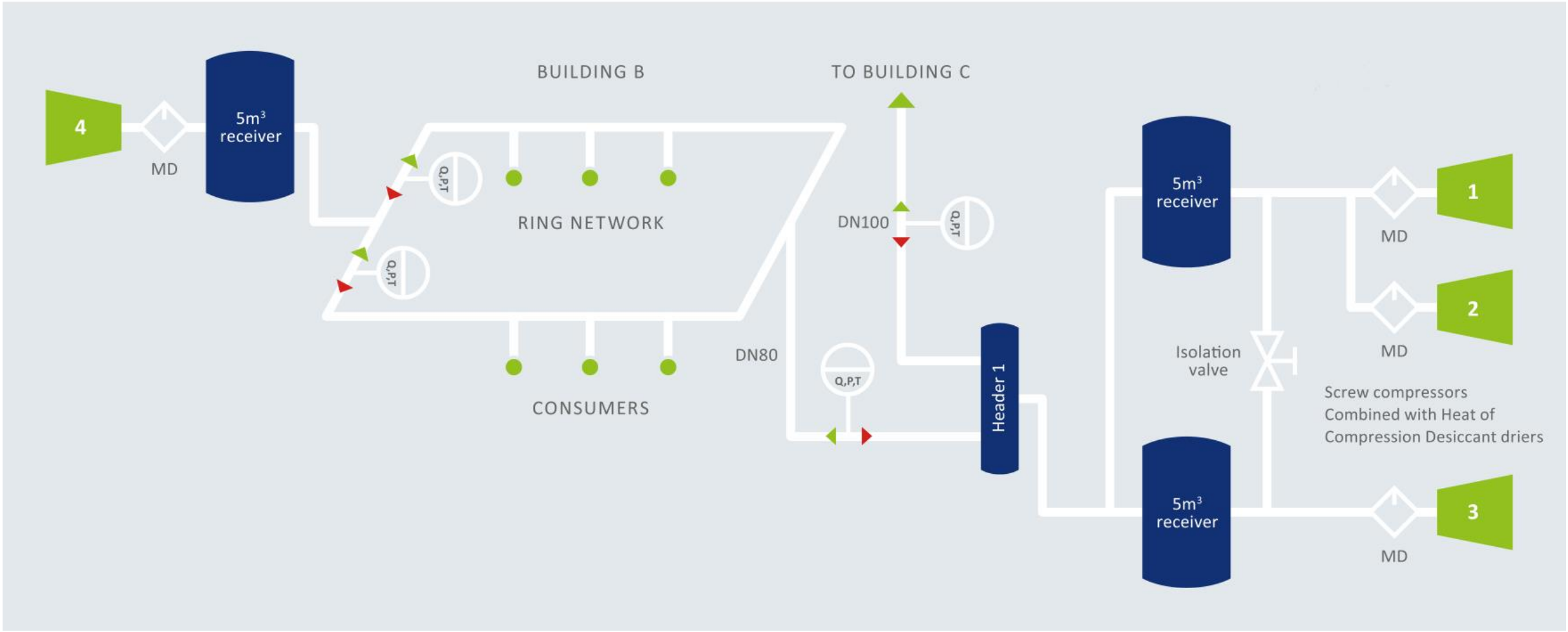
- From leakages to high flow
- Dry air only
- Temp: ~140°F

Differential Pressure (DP):

- Medium to high flow rates
- Wet air + dry air
- Temp: ~300°F

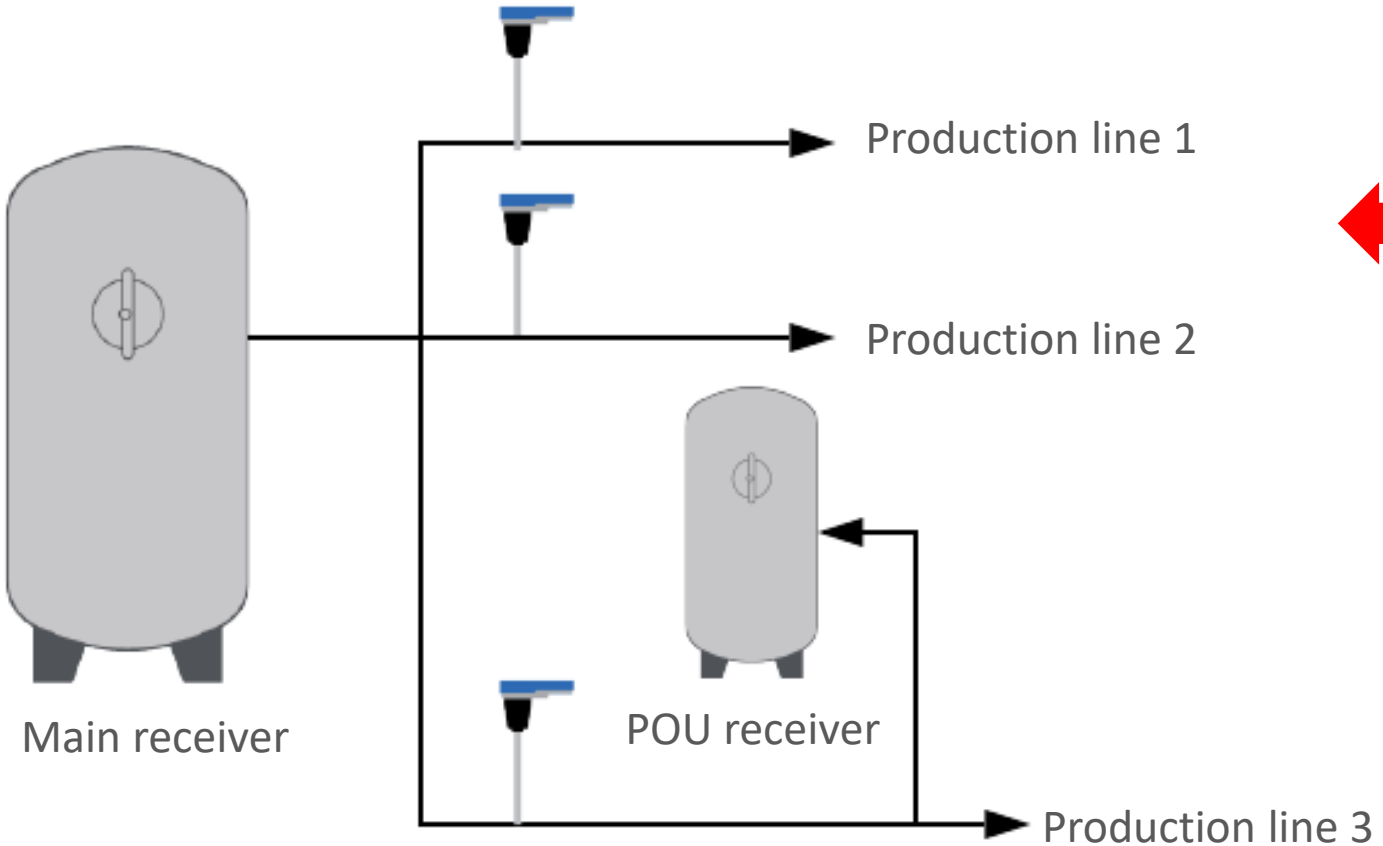


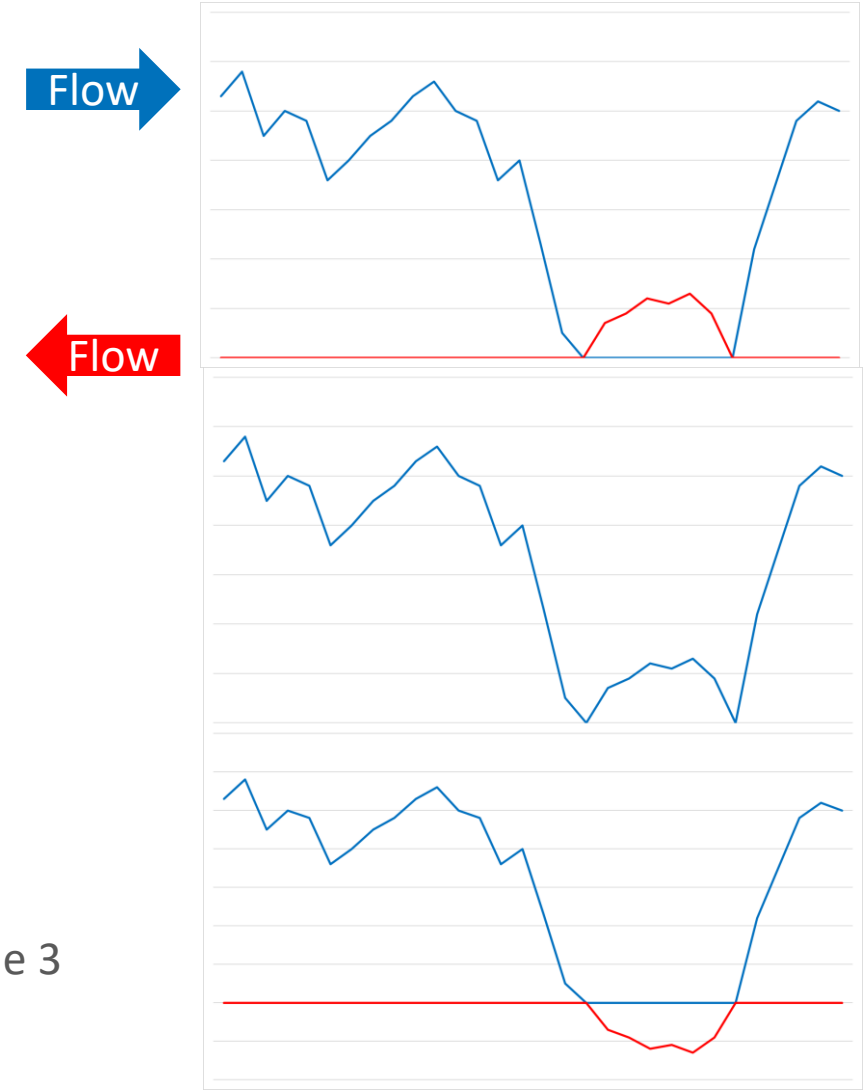
Bi-directional flow: air can go both ways!



Importance of bi-directional flow measurement

Demand side (reverse flow)





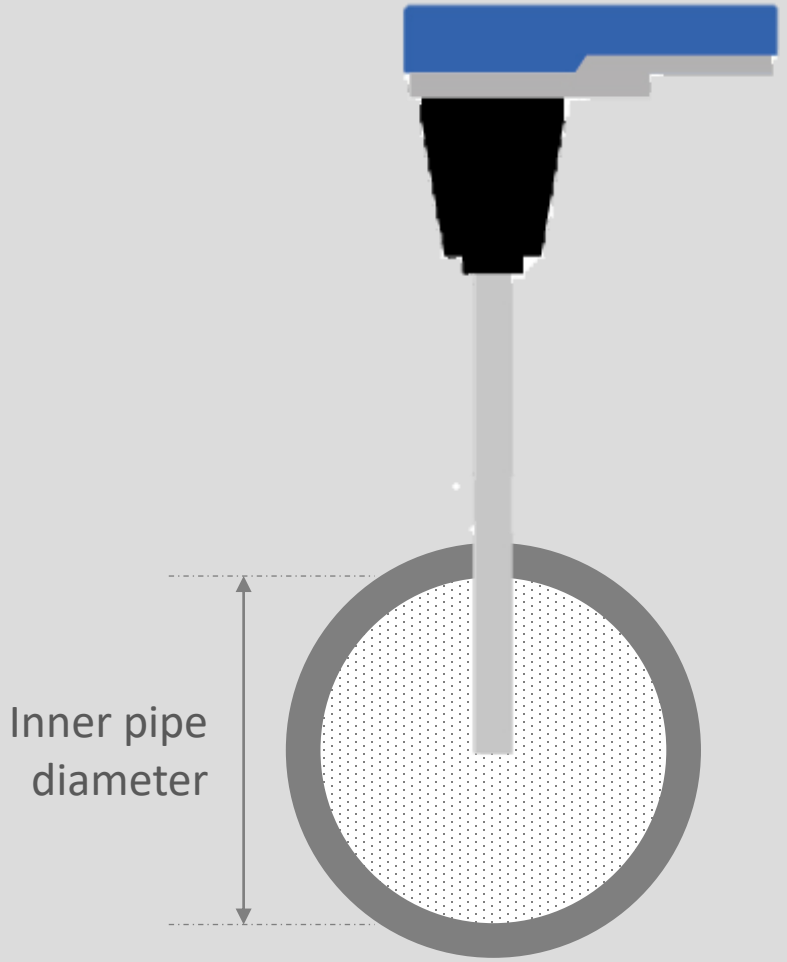
Check air quality

Before you install the flow meter…

Impact of inner pipe diameter

Area $A = 1/4\ \pi * D^2$

True diameter (inch)	Diameter error (inch)	Measured diameter	Flow signal error
2”	+ 0.12”	2.12”	**+12 %**
4”		4.12”	**+6 %**
8”		8.12”	**+3 %**
12”		12.12”	**+2 %**



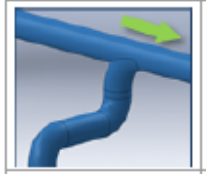
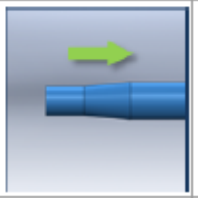
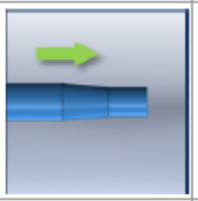
Importance of straight pipe run

General minimum rule:

- 20*D upstream length (even 40*D preferred)
- 5*D downstream length (10*D preferred)

The longer the better

It’s based on physics: All other claimed shorter lengths are not true

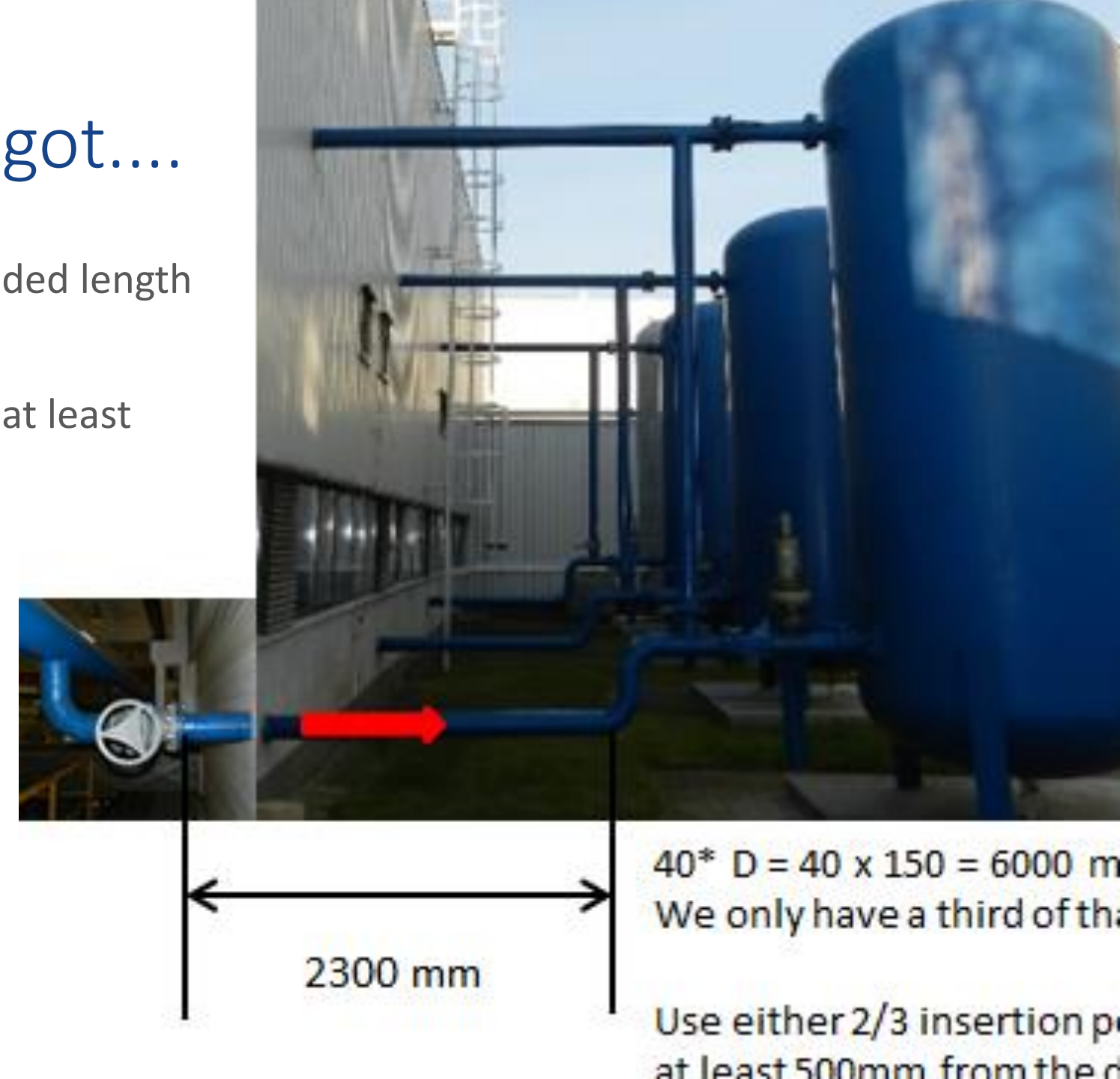
Picture	Description	Upstream length	Downstream length	Effect
	Complex feed-in situation (header)	40 * D[1]	10 * D[1]	Flow profile will be distorted
	Double elbow, multiple elbows following each other	40 * D[1]	10 * D[1]	Distorted profile + swirl
	Diameter change from small to large (gradual or instant)	40 * D[1]	5 *D[1]	Jet shaped flow
	Diameter change from large to small (gradual change, between 7 and 15 degrees)	10 * D[1]	5 * D[1]	Flattened flow profile
	Single elbow	30 * D[1]	10 * D[1]	Distorted flow profile

[1] = inner diameter

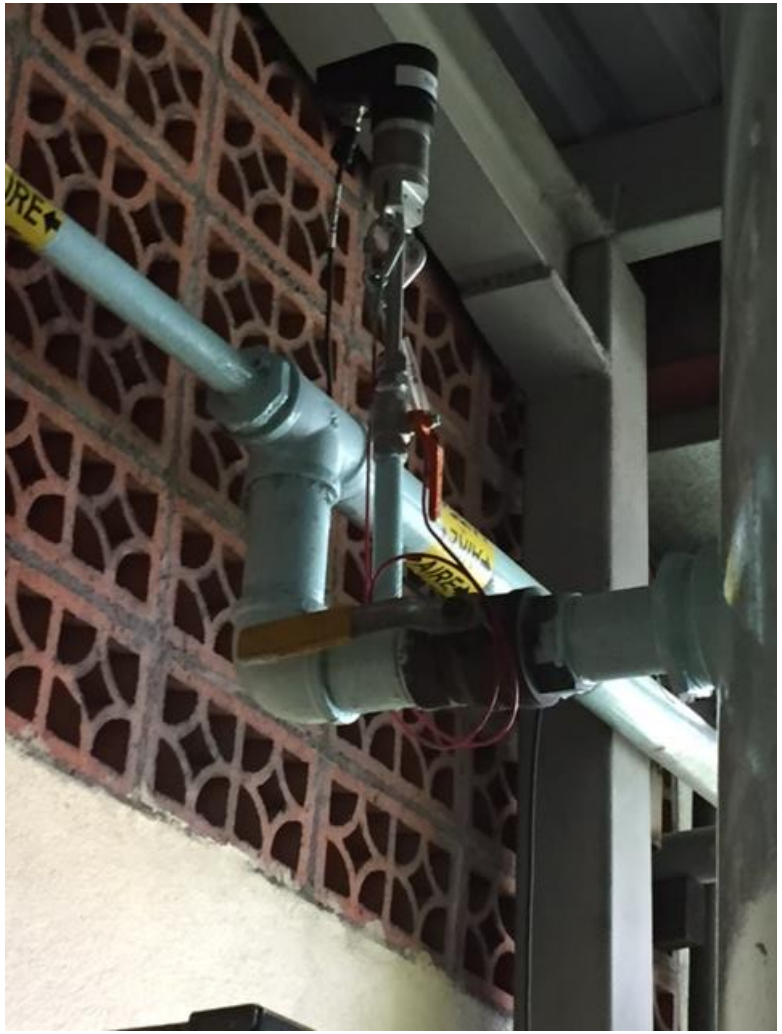
Work with what you got….

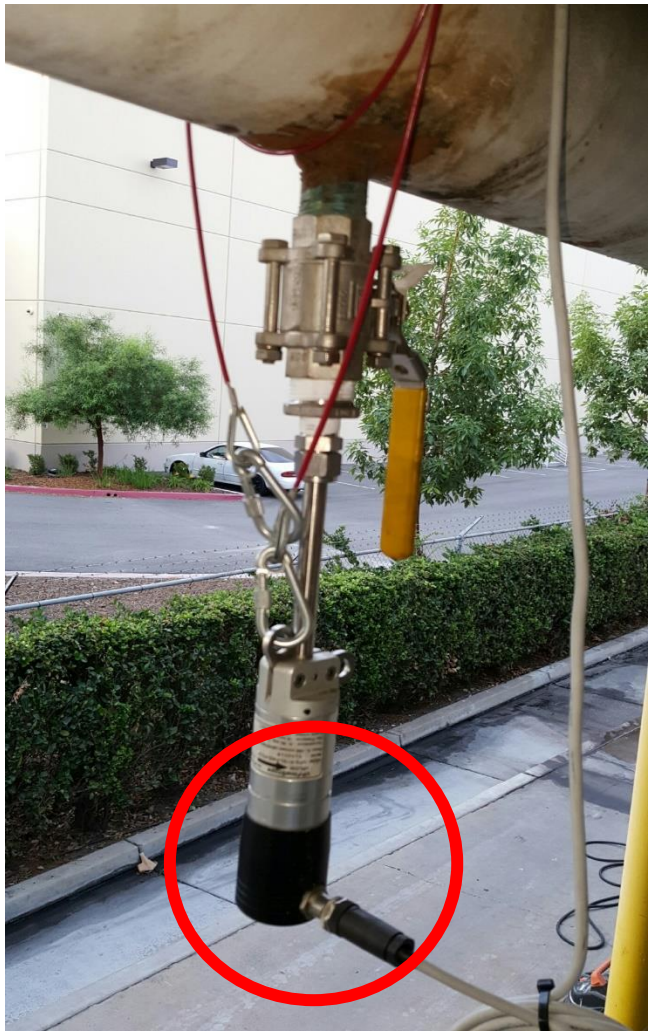
In this case, we only have $^1/_3$ the needed length

Use either $^2/_3$ insertion point and/or at least 20” from the elbow.

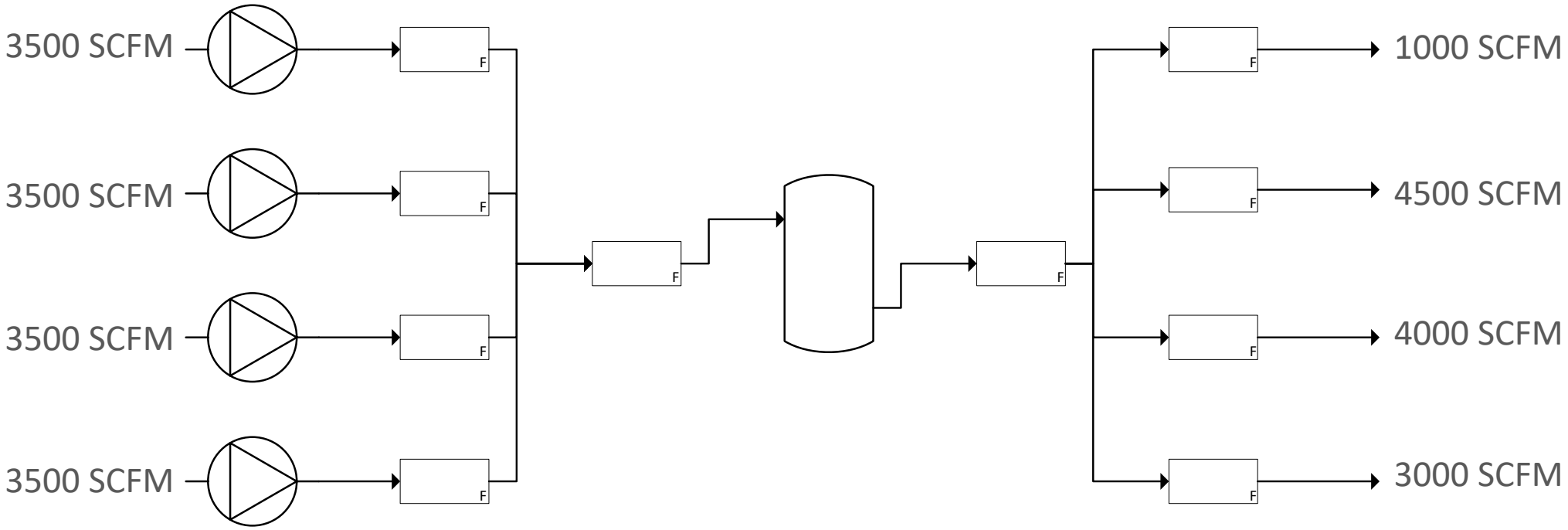


Examples wrong field installations





Measurements in reality



Sum = 14,000 SCFM

Sum = 12,500 SCFM

(8.9% missing)

Flow meter selection checklist

Key to correct measurements and to prevent damage to your flow meter

Basics:

- Type of gas
- Flow range
- Humidity (dry/saturated)
- Inner Diameter
- Pressure range
- Temperature range

Full checklist:

THANK YOU!

Pascal van Putten

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About the Speaker

Justin Johnson
FS-Elliott

- >9 years of experience in product development and manufacturing of rotating equipment controls

- Lead the development of FS-Elliott's newest control panel, R2000

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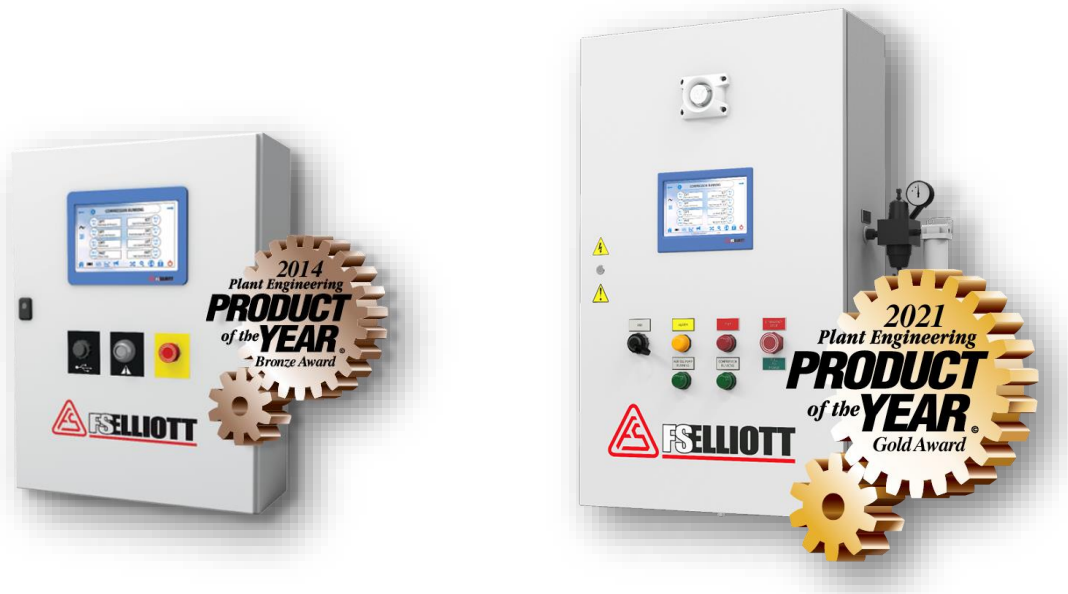
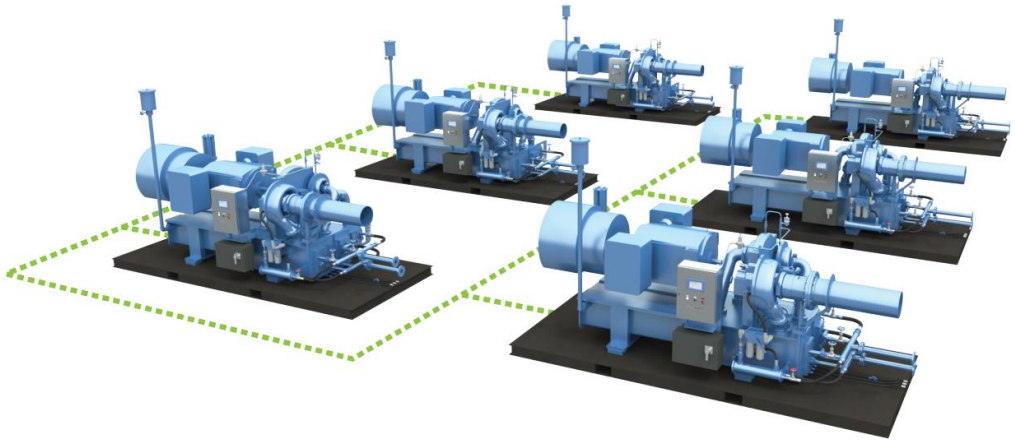
The Importance of Updated Technology, with Compressor Controls

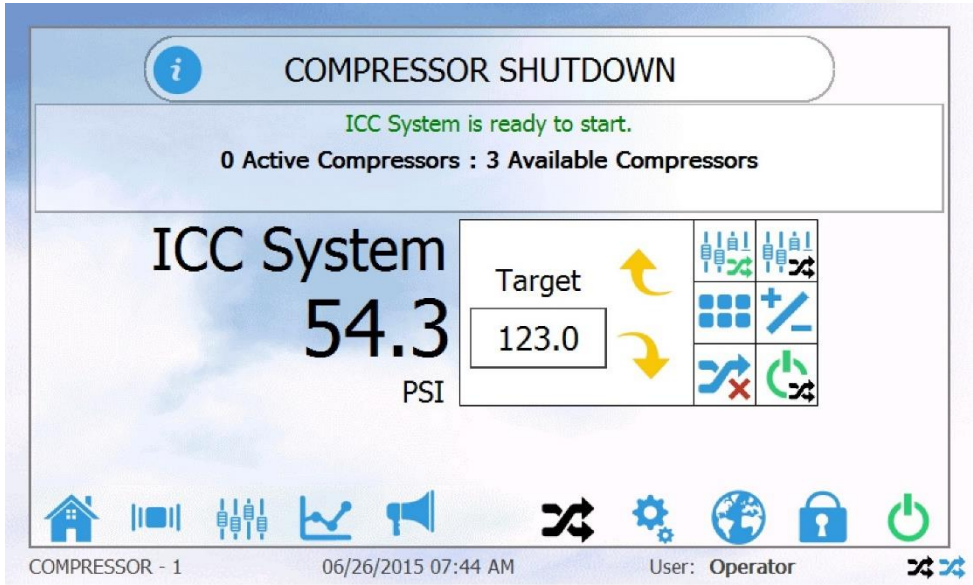
Presented by:
Justin Johnson
Controls Product Manager, FS-Elliott

Outline

- Where Does Your Technology Land?
- Advantages of New Technologies
- FS-Elliott Upgrade Options
- Open Q&A







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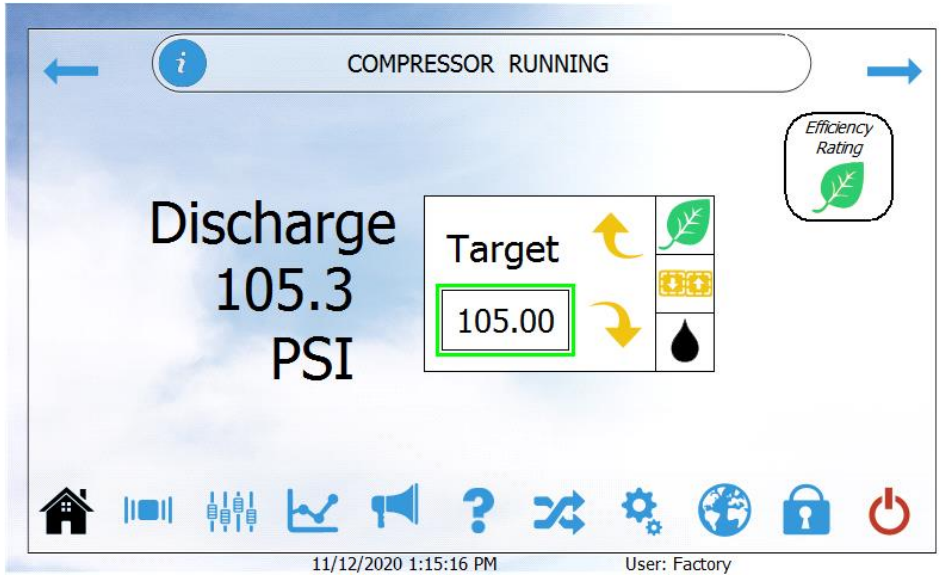
Where Does Your Technology Land?

OLD TECHNOLOGIES

- Electro-Pneumatic Controls
- VME Systems
- Microprocessor with 2 Line Displays
- Outdated PLC Hardware

NEW TECHNOLOGIES

- Newer PLC Hardware
- Newer Microprocessor Hardware
- Color Touchscreen HMIs
- Web based Remote Monitoring



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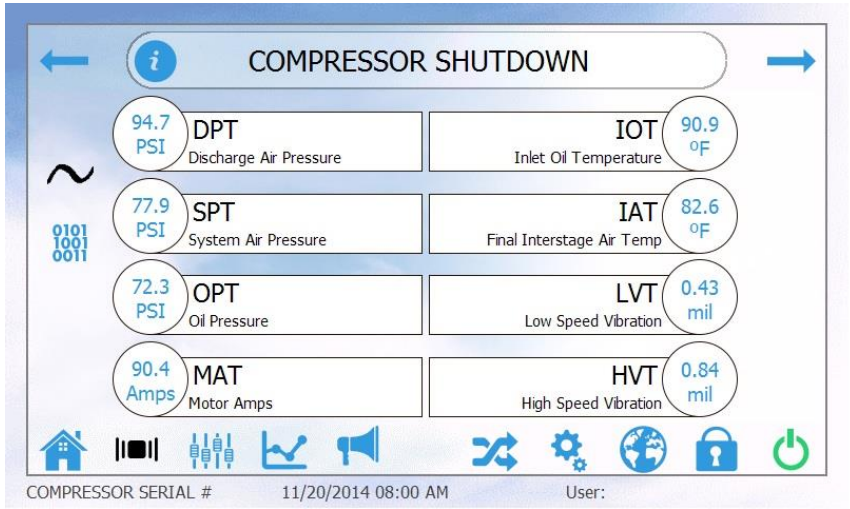
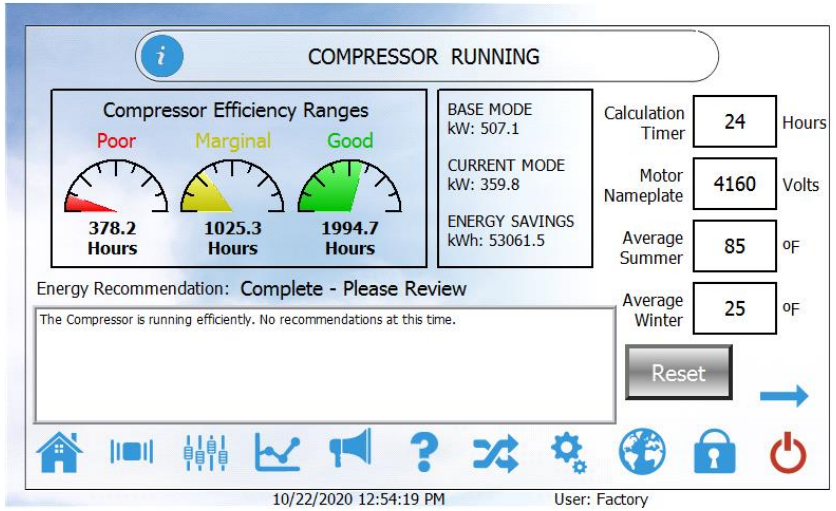
Advantages of Ensuring Updated Technology

- Ease of Use
- Energy Efficiencies
- Predictive Maintenance Options
- Increased Processing Speeds
- Modern Communication Protocols
- Data Logging Capabilities
- Updated Software/Programming Applications
- Readily Available Replacement Hardware





FS-Elliott Control Panel Offerings

R1000 Control Panel

Entry Level Controls
Microprocessor
9” Color Touchscreen
Feature Rich

R2000 Control Panel

PLC Based Controls
Siemens & Allen Bradley
Wide Range
Flexible & Feature Rich

R400 Control Panel

PLC Based Controls
Siemens & Allen Bradley
Simplex or Redundant
Built per Specifications

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Control Panel Retrofit Kits

- Retrofits available for Centrifugal Air Compressors
- All inclusive packages for retrofit panel installation, including:
  - Panel Mounting Bracket
  - Pressure Transmitters
  - Temperature Transmitters and/or RTDs
  - Interconnecting Cables
  - Junction Blocks with Homerun Cables
  - Vibration Monitoring Probes
  - Vibration Extension Cables
- Included as a standard with all retrofit packages
- Provides an easy and effective installation and commissioning process

For more information related to FS-Elliott Control Panel offerings, please visit www.fs-elliott.com or email marketing@fs-elliott.com

Thank you for your time.

The Minimum 24/7 Compressed Air Performance Metrics to Have

Q&A

Please submit any questions through the Question Window on your GoToWebinar interface, directing them to Compressed Air 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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The recording and slides of this webinar will be made available to attendees via email tomorrow.

PDH Certificates will be e-mailed to Attendees within 2 days.

April 2023 Webinar

Compressed Air as a Quality/Safety Manufacturing Process Variable

Tom Taranto
Data Power Services
Keynote Speaker

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