Better Plants
U.S. DEPARTMENT OF ENERGY

In-Plant Trainings

8 – Session Virtual Platform

What is an In-Plant Training?

- In-Plant Trainings (INPLTs) are system-specific workshops led by Better Plants experts that train participants on how to identify, implement, and replicate energy-saving projects.
- The goal is to help manufacturing plants reduce energy consumption and become more efficient.
- During Pre-Covid days, Better Plant partners hosted an on-site, three-day training at one of their facilities, and invited others to attend.
- Due to the challenges from Covid, we conducted this Training virtually, with eight (8) 2-hour online training sessions.
- Through Better Plants:
  - Industrial organizations commit to efficiency goals
  - Receive technical assistance and national recognition for their achievements

The Facilitator

- Frank Moskowitz – Draw Professional Services
  - Compressed Air Challenge Instructor for Fundamentals & Advanced Workshop as well as an Instructor for AIRMaster+ Qualified Specialist Workshop
  - DOE Compressed Air System Energy Expert
    - In-Plant Training & Save Energy Now Assessments
  - CAGI – Certified Compressed Air System Specialist
  - Co-Vice Chair ASME EA-4 Energy Assessment for Compressed Air Systems
  - International Standards Organization (ISO) Technical Advisory Group Member
    - Air compressors and compressed air systems energy manageme
  - Contact Information:
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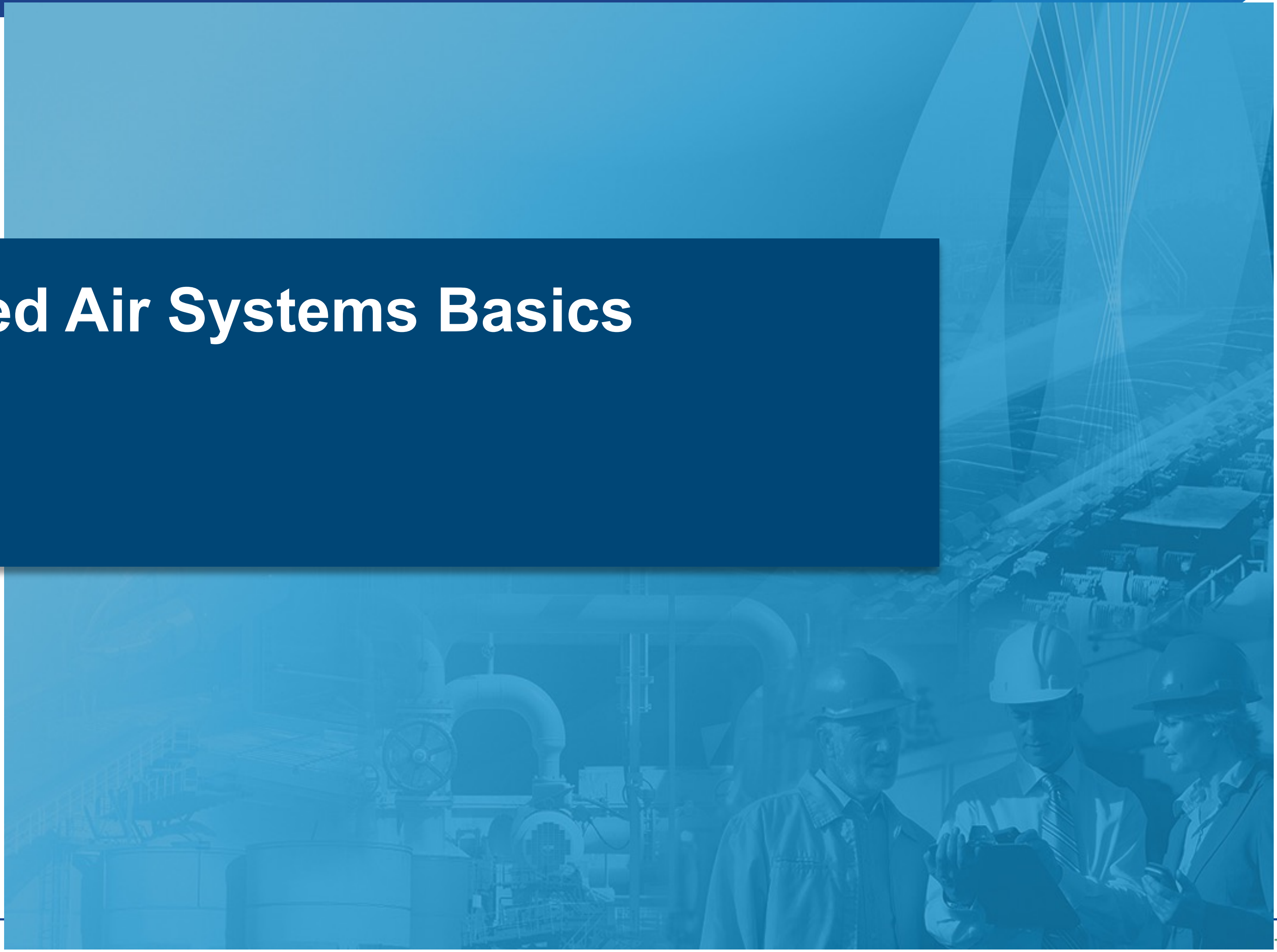
COMPRESSED AIR SYSTEM SPECIALIST
CAGI
Compressed Air & Gas Institute
CERTIFIED

TRAINING • EDUCATION • EFFICIENCY
COMPRESSED AIR
CHALLENGE
INSTRUCTOR

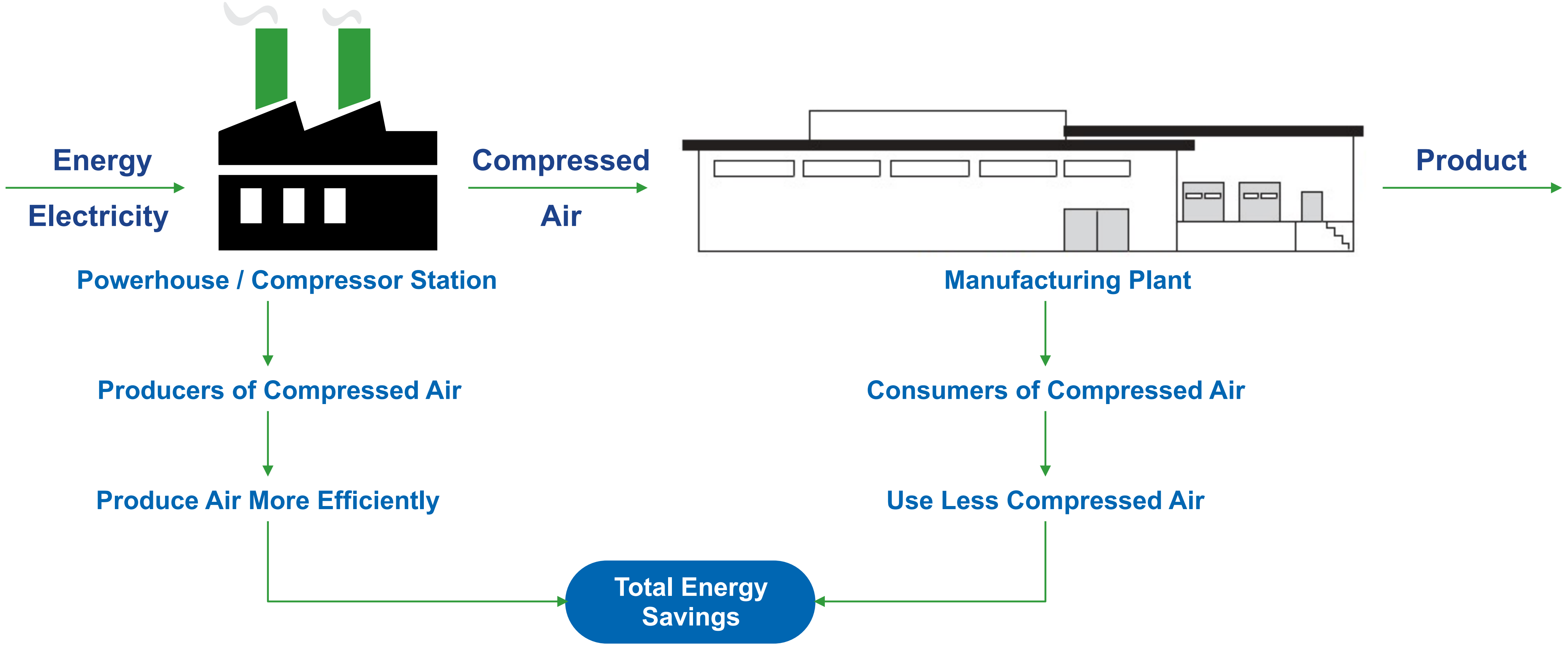
Week 1 we discussed:

Compressed Air Systems Basics



Compressed Air Systems Approach
plant efficiency: energy >> product

There are two basic ways to reduce the energy consumption of a compressed air system: produce compressed air more efficiently; and consume less compressed air.



What Are My Goals?

Produce more efficiently

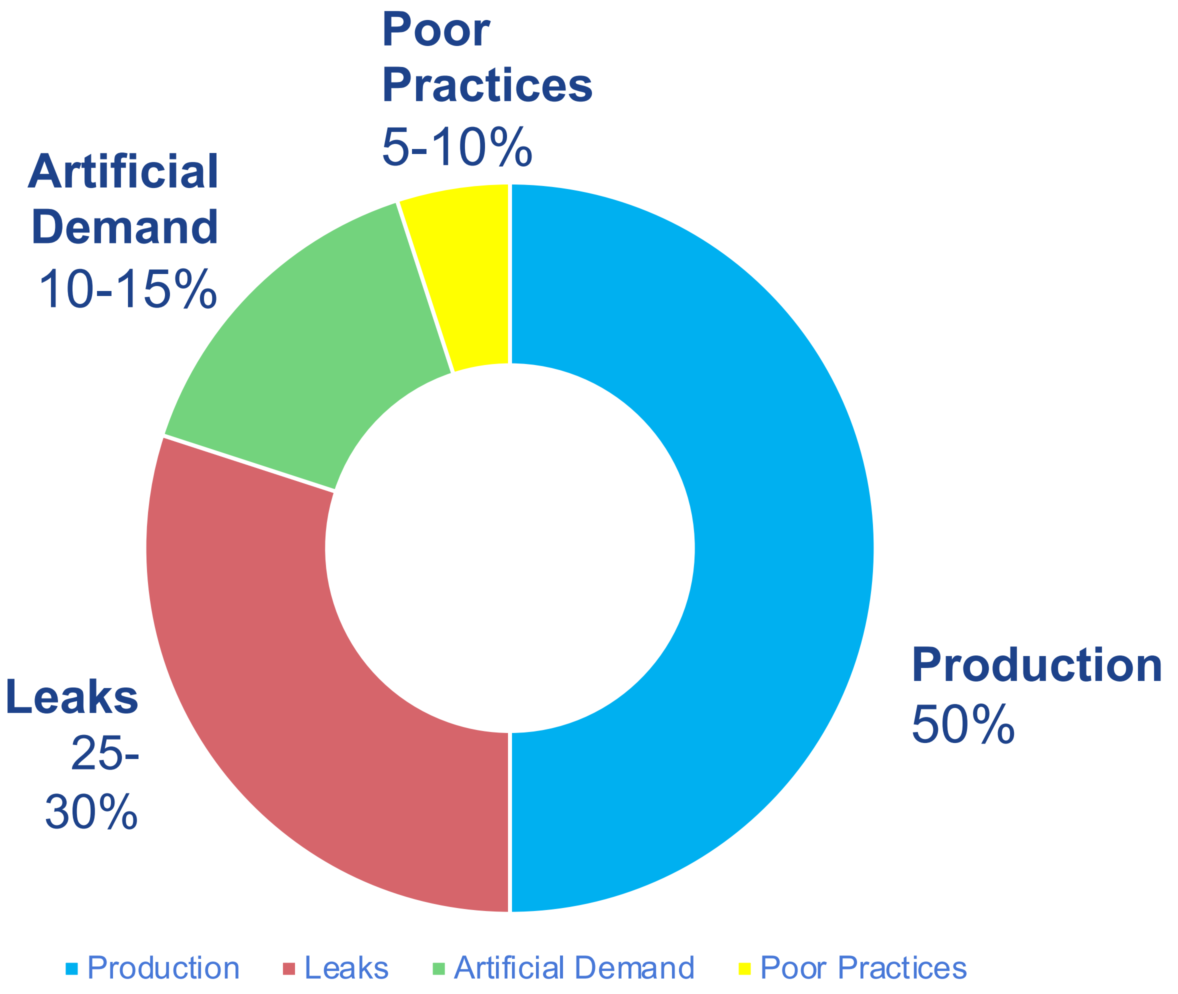
- Improve Compressor Control
- Discharge Pressure?

Use less compressed air

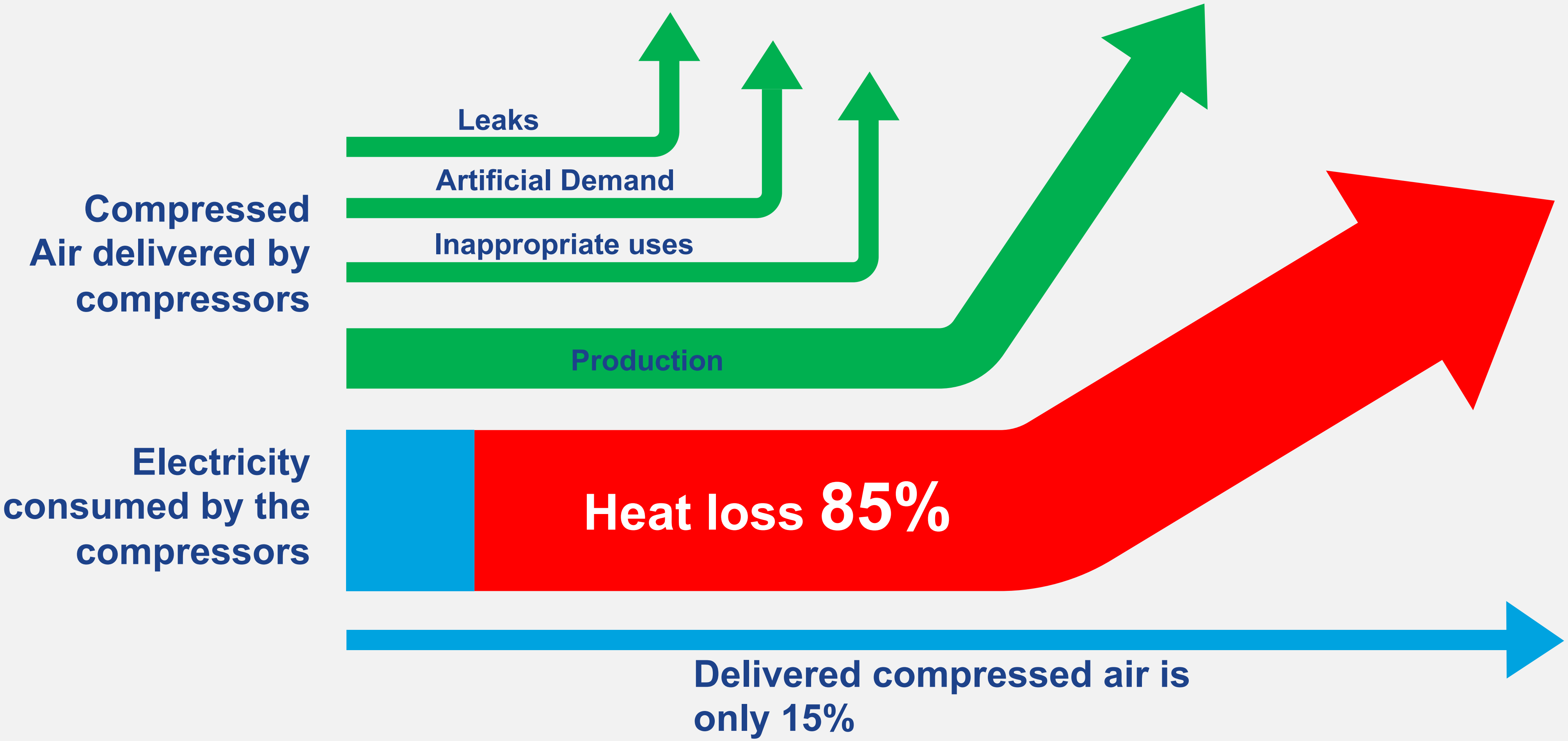
- Reduce Air Demand (Leaks, Inappropriate Uses, etc…)
- What is the Pressure at End Uses
- How does compressed air support production?

Understanding how compressed air is used is the single most important step to effective management.

Where does the air go?

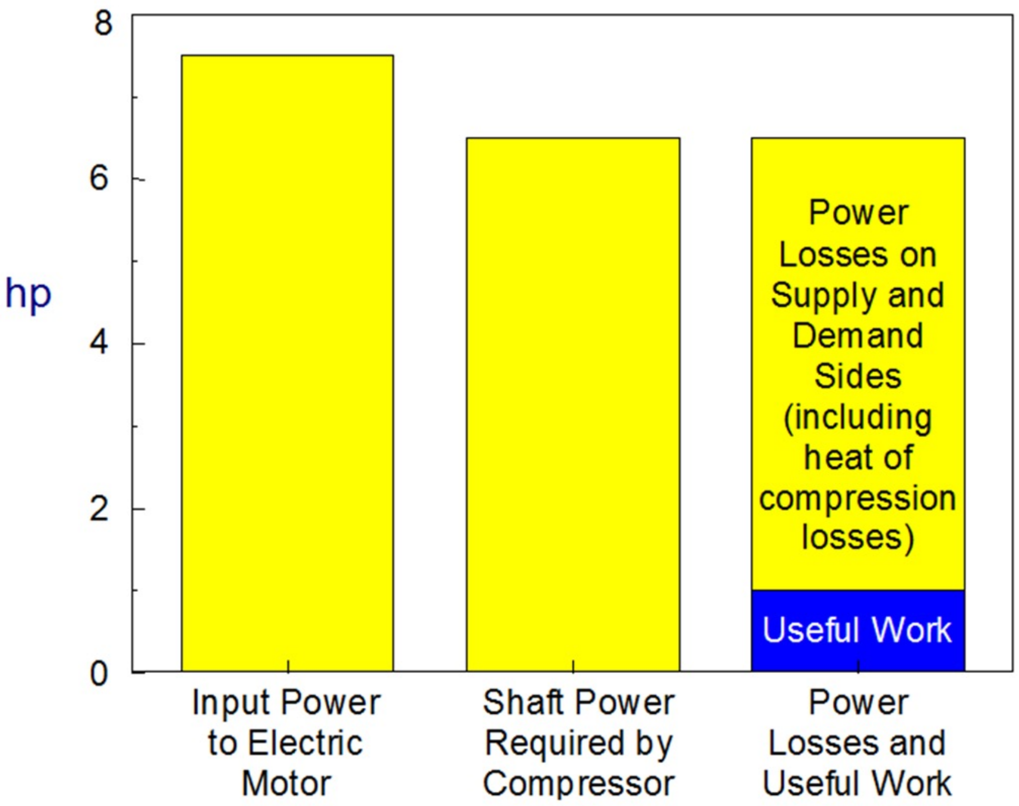


Not very efficient!



Compressed Air Versus Other Energy Sources

- 1 hp air motor = 7-8 hp of electrical power
  - 30 scfm @ 90 psig is required by the air motor
  - 6 - 7 bhp at compressor shaft required for 30 scfm
  - 7 - 8 hp electrical power required for this
- Annual energy cost for a 1 hp air motor versus a 1 hp electric motor, 5-day per week, 2 shift operation, $0.05/kWh
- **$ 1,164 vs. $ 194**



Week 2 we discussed:

Compressor Types
Maintenance
Compressor Room Best Practices and Ventilation

Ventilation

Heat Recovery Energy Savings Calculation

Annual energy savings (Btu/yr) =

0.80 **x** 0.85 **x** compressor bhp **x** 2,545 Btu/bhp-hour **x** hours of operation

$$\text{Cost Savings (\$/yr)} = \left(\left[\frac{\left(\frac{EnergySavingsBTU / Yr}{BTU / UnitFuel}\right)}{HeaterEfficiency}\right]\right) \times \$UnitFuel$$

1 therm = 100,000 BTU's

Example: 100 hp compressor running two shifts, 5 days per week

0.8 **x** 0.85 **x** 100 bhp **x** 2,545 Btu/bhp-hr **x** 4160 hr/yr = **719,929,600 Btu/yr**

In dollars:

$$\text{Cost Savings (\$/yr)} = \frac{\left(\frac{719{,}929{,}600 Btu / yr}{100{,}000 Btu / therm}\right)}{.85} \times \$0.40 / therm$$

$$\text{Cost Savings (\$/yr)} = \frac{7{,}199.296}{.85} \times \$0.40 / therm$$

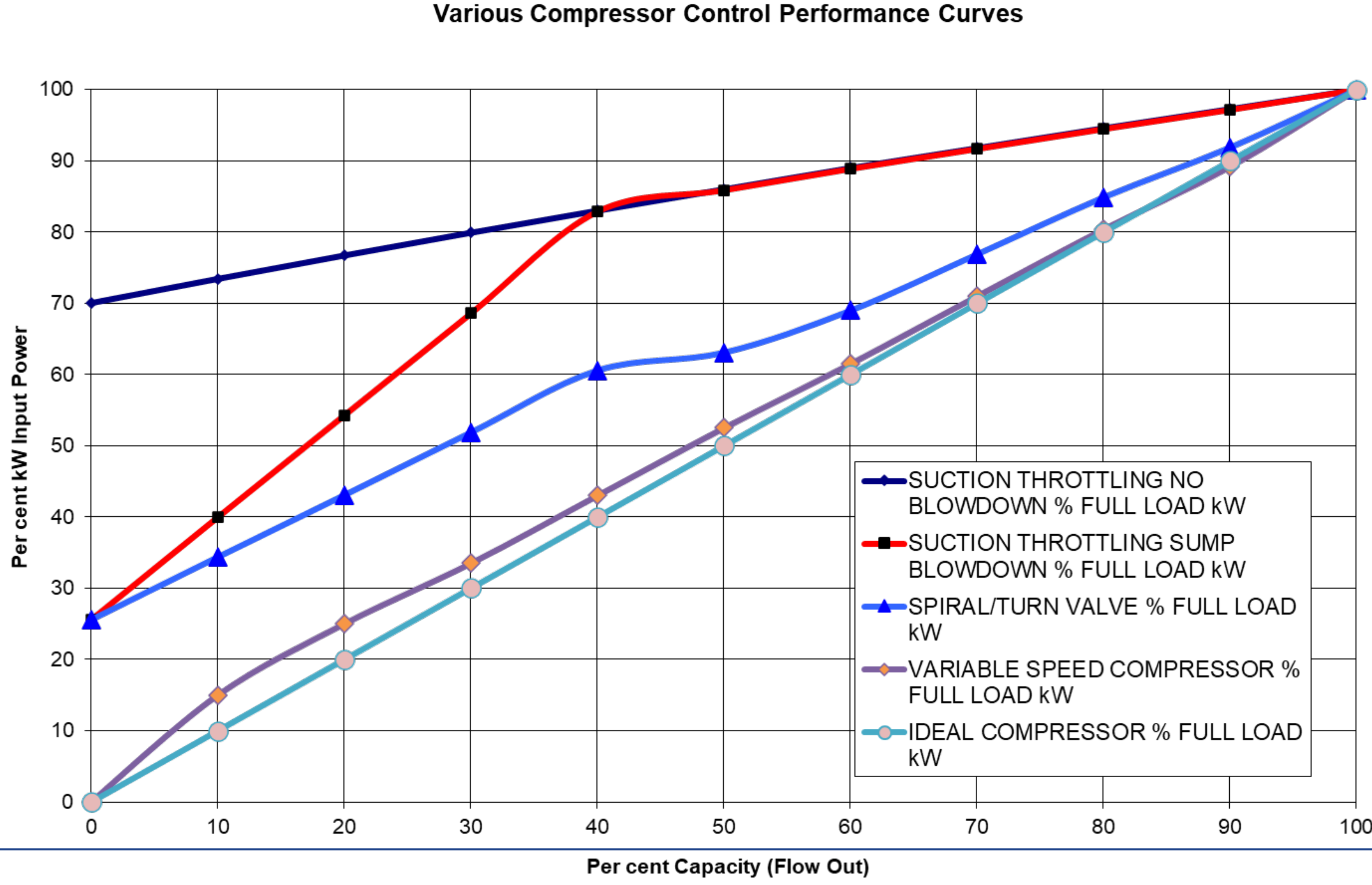
Cost Savings ($/yr) = $3,388

0.80 is the maximum theoretical recoverable heat as a percentage of the unit's output.
0.85 adjusted the maximum theoretical recoverable heat to what is available in typical applications.
2,545 converts bhp to Btu/hour

Session 3 – Week 3, we discussed:

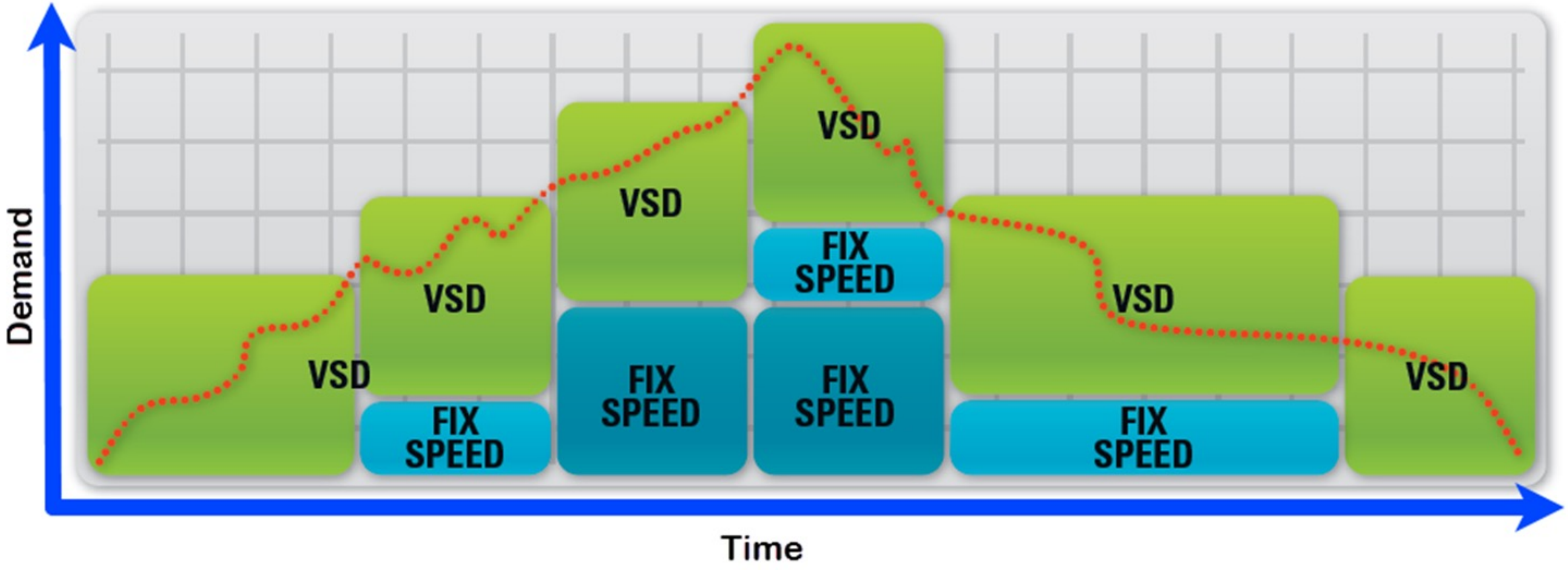
Compressor Controls
Intro to Airmaster+
Intro to LogTool
Intro to MEASUR

Inlet Valve Modulation

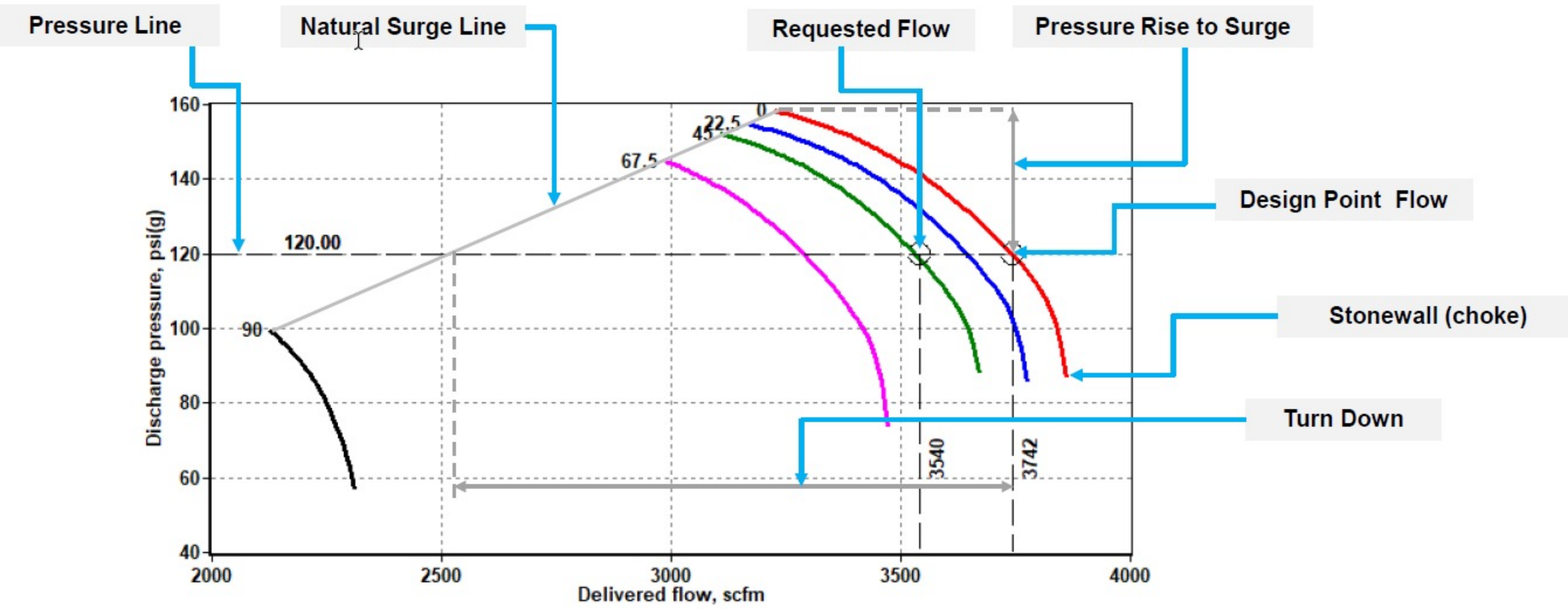


Variable Speed Compressors

- In order to provide efficient VSD regulation over the complete range of the customer's air profile, the range of the VSD from min to max needs to be sized greater than the load/no load machine

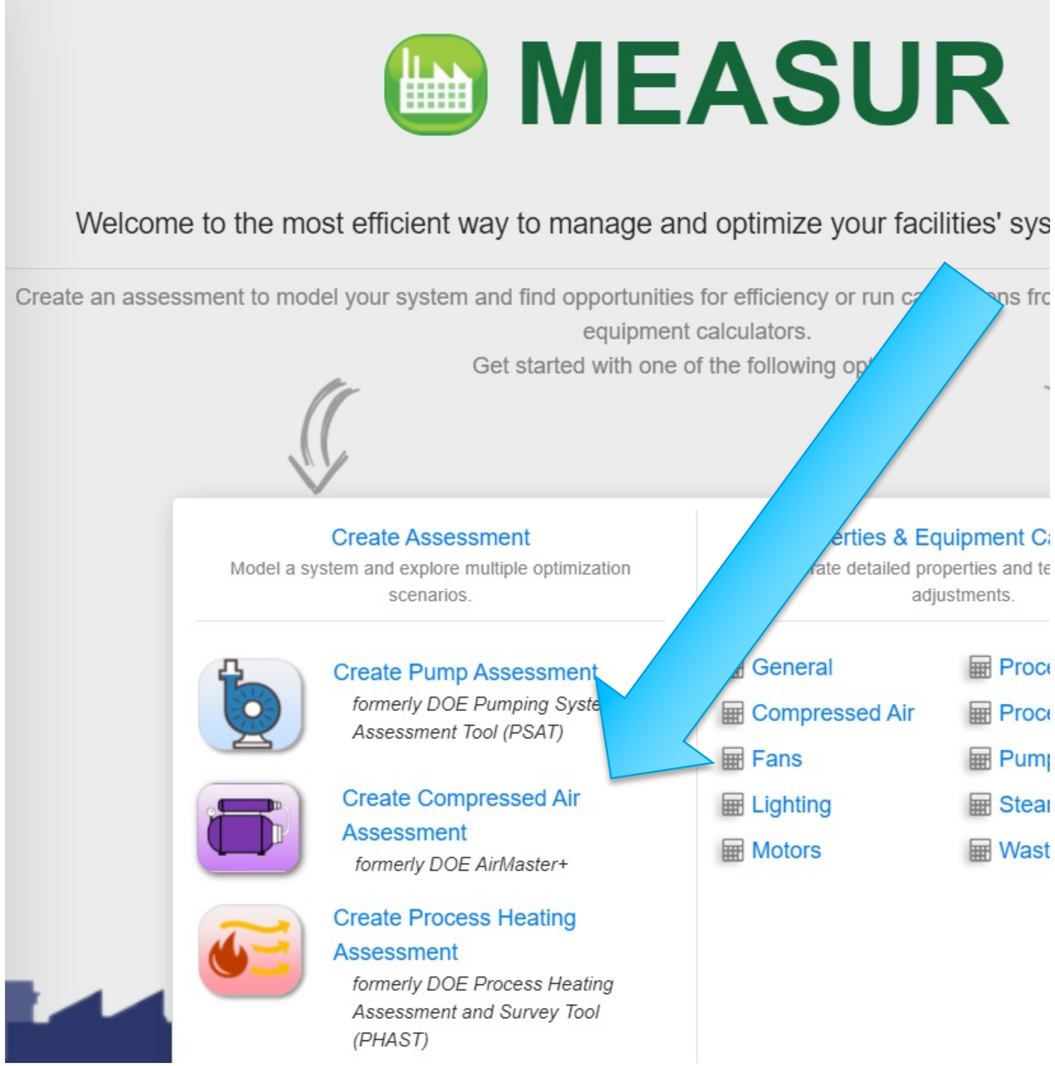


Centrifugal Performance



MEASUR: Compressed Air Assessment!

- Coming Soon!
- VINPLT participants will be notified upon release.
- We will offer a supplemental session to help you learn the new software.



Create Your Compressor Inventory

COMPRESSOR INVENTORY

Compressor Name	Compressor 1
Description	

Set Data From Existing Compressor

NAMEPLATE DATA

Compressor Type	Single stage lubricant-injected rotary screw
Motor Power	5 hp
Full Load Operating Pressure	100 psig
Rated Capacity at Full Load Pressure	18 acfm
Full Load Amps	7.5 amps
Total Package Input Power	4.6 kW

CONTROLS

INLET CONDITIONS

DESIGN DETAILS

PERFORMANCE POINTS

	Discharge Pressure	Airflow	Power
Full Load (cut-in)	100 psig	18 acfm	4.6 kW
Max Full Flow (cut-out)	110 psig	18 acfm	4.9 kW
No Load (unloaded)	15 psig	0 acfm	2.3 kW

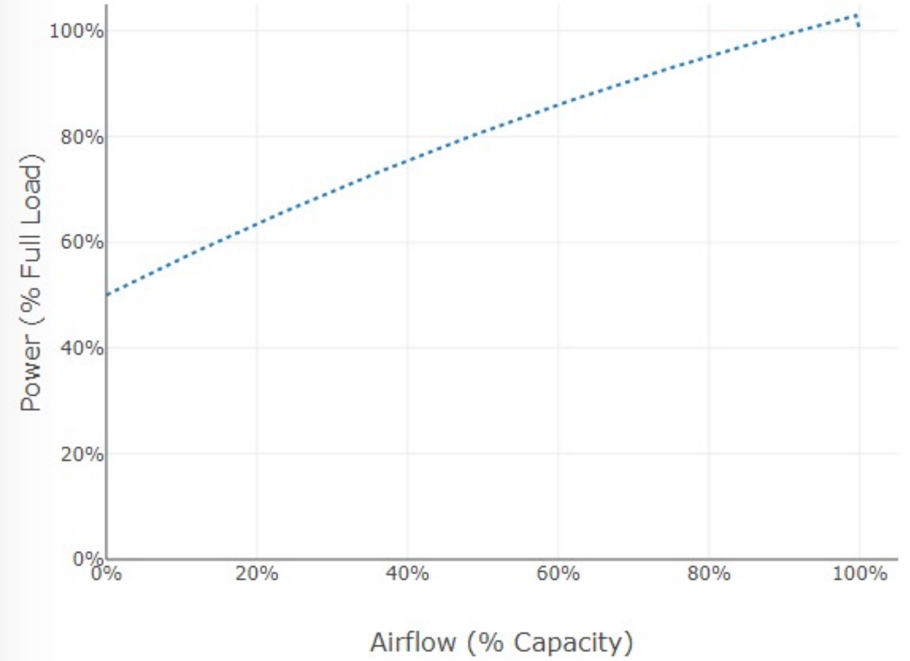
CURRENT INVENTORY | HELP

Name	Compressor Type	Control Type	Pressure Range
Compressor 1	Single stage lubricant-injected rotary screw	Load/unload	100 - 110 psig
Compressor 2	Single stage lubricant-injected rotary screw	Start/Stop	100 - 110 psig

+Add New Compressor

Compressor Profile (Compressor 1)

Graph All Compressors



Enter Your Operation Profile

1 Assessment Basics | 2 System Information | 3 Inventory | 4 Day Types | 5 **System Profile**

Setup Profile | Profile Summary | Graphs | Annual Summary

Select Day Type	Standard Day Type	Data Interval	1 hr
Profile Data Type	Airflow, % Capacity	Pressure Control Range	100 - 110 psig

Compressor Ordering (No Sequencer)

☐ Fill right on change | Turn All Off | Turn All On

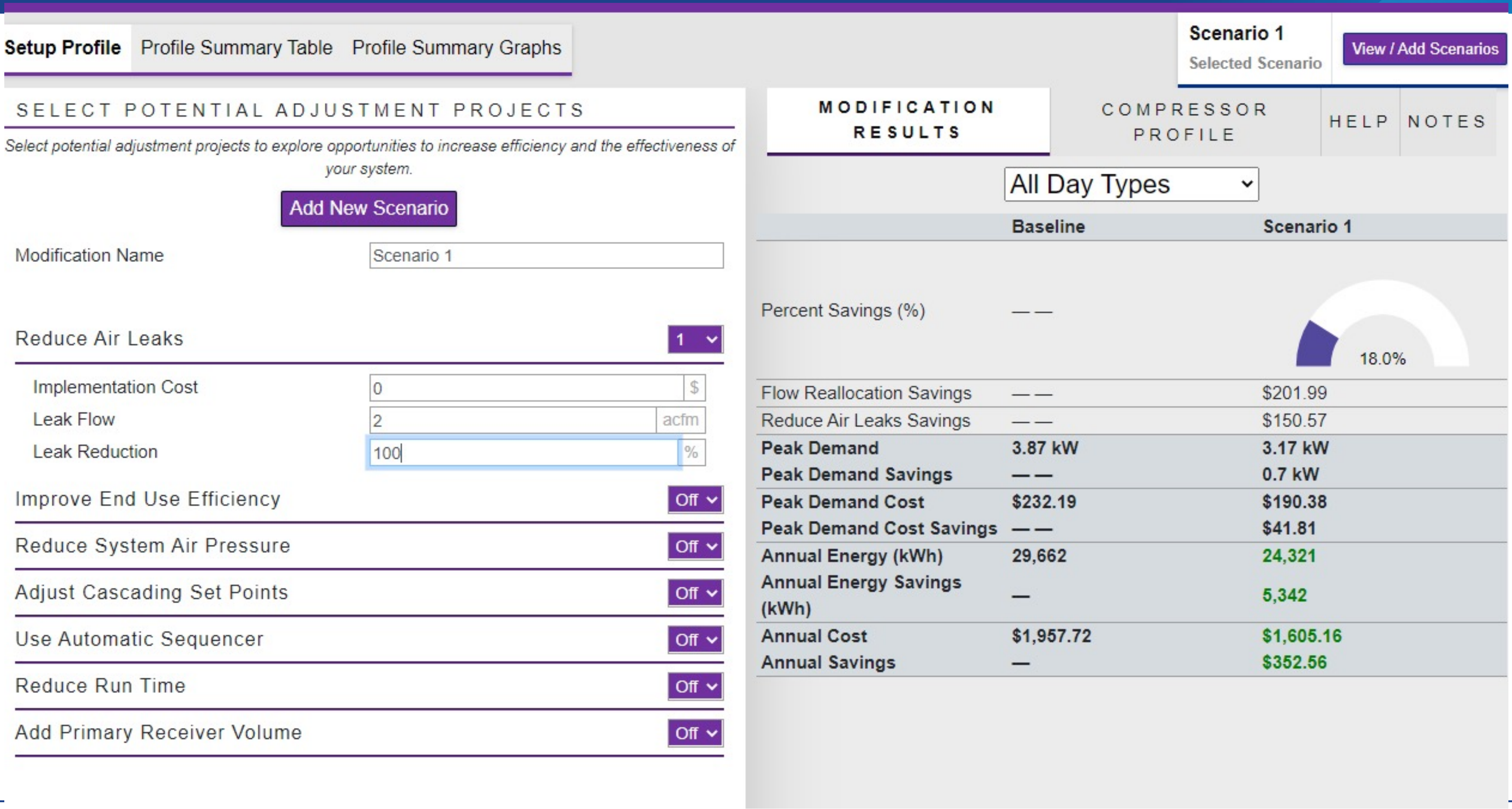
	FLP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Compressor 1	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Compressor 2	100	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Profile Data

☐ Fill right on change

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Compressor 1	% Capacity	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Compressor 2	% Capacity	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

Find Energy Savings!



Session 4 we discussed:

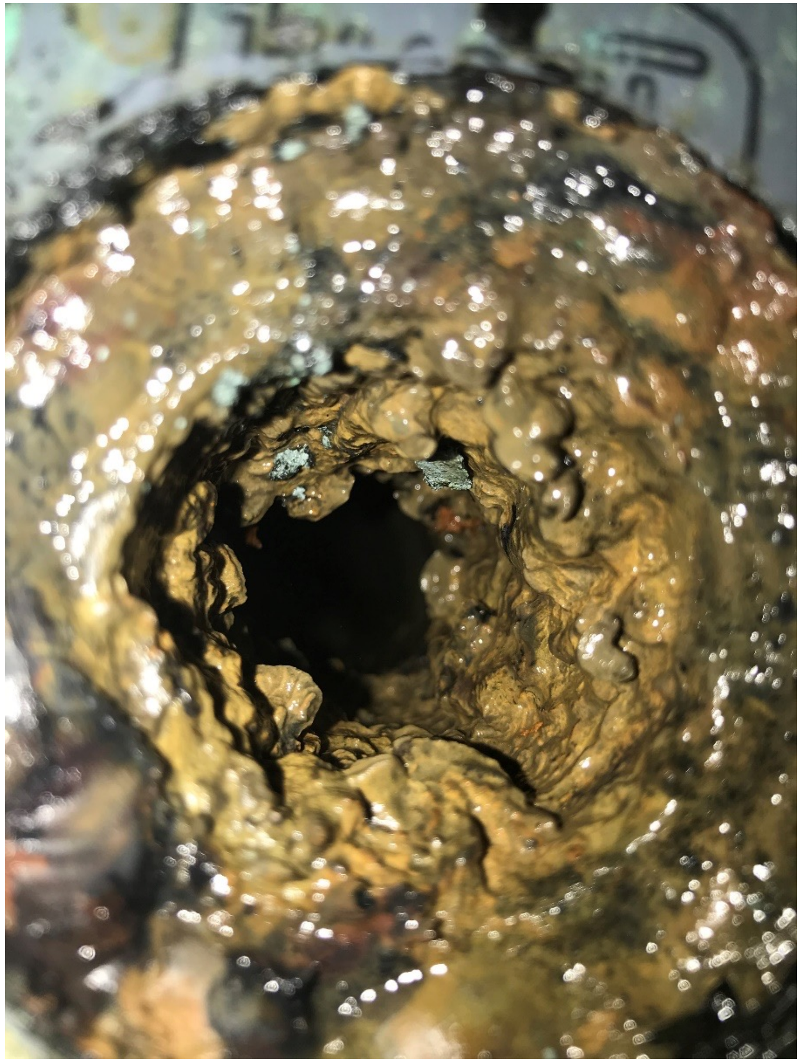
Air Treatment

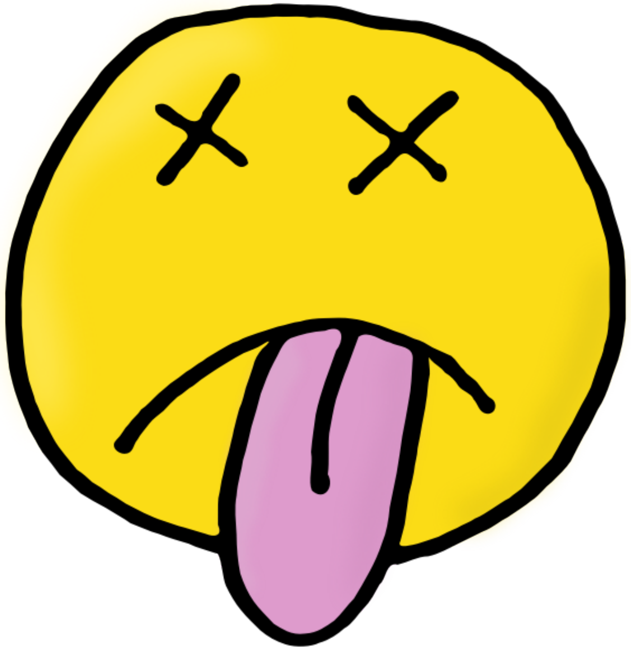
Dryers

Filters

Condensate Removal

EFFECTS OF WATER CONTAMINATION

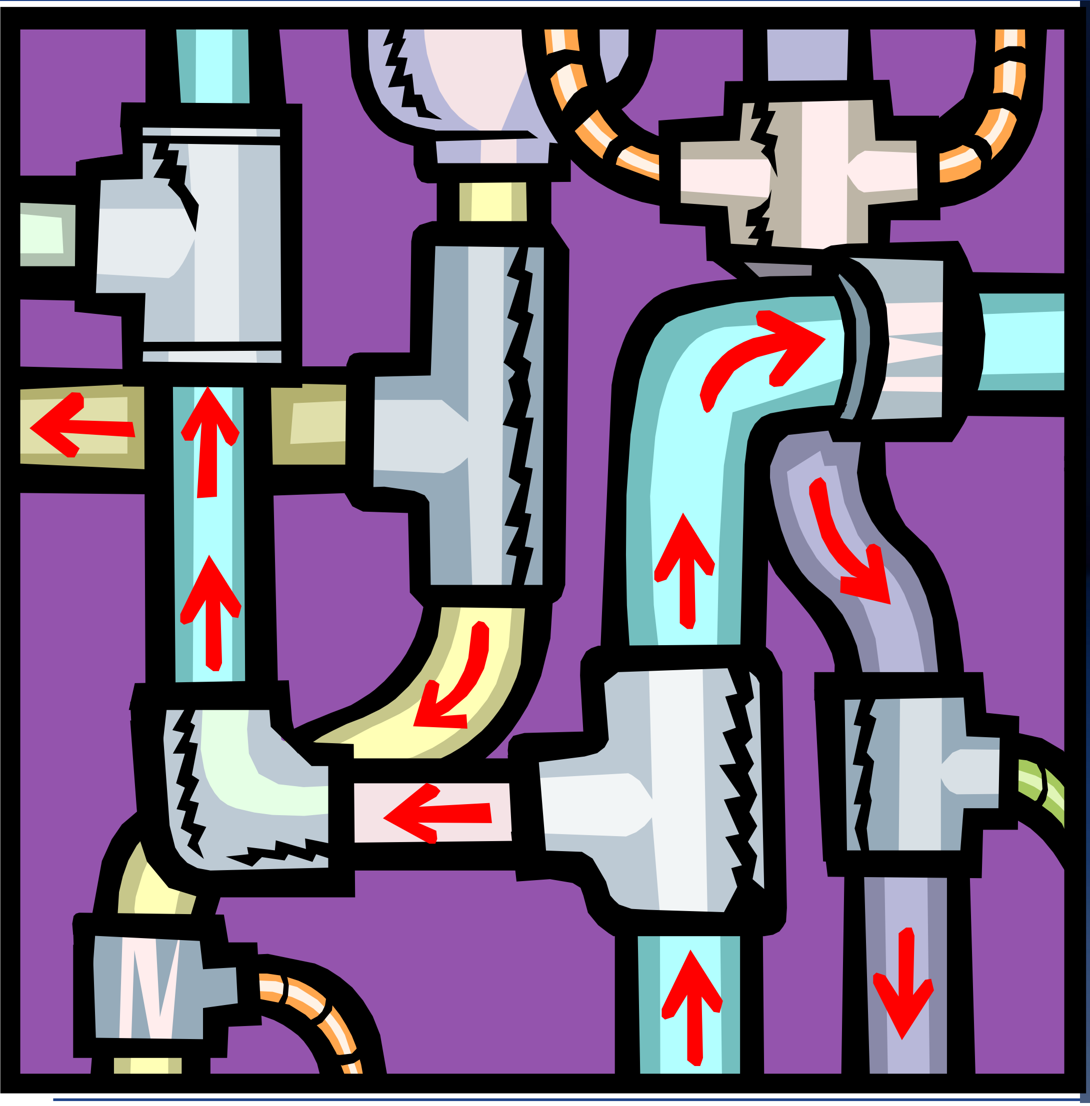


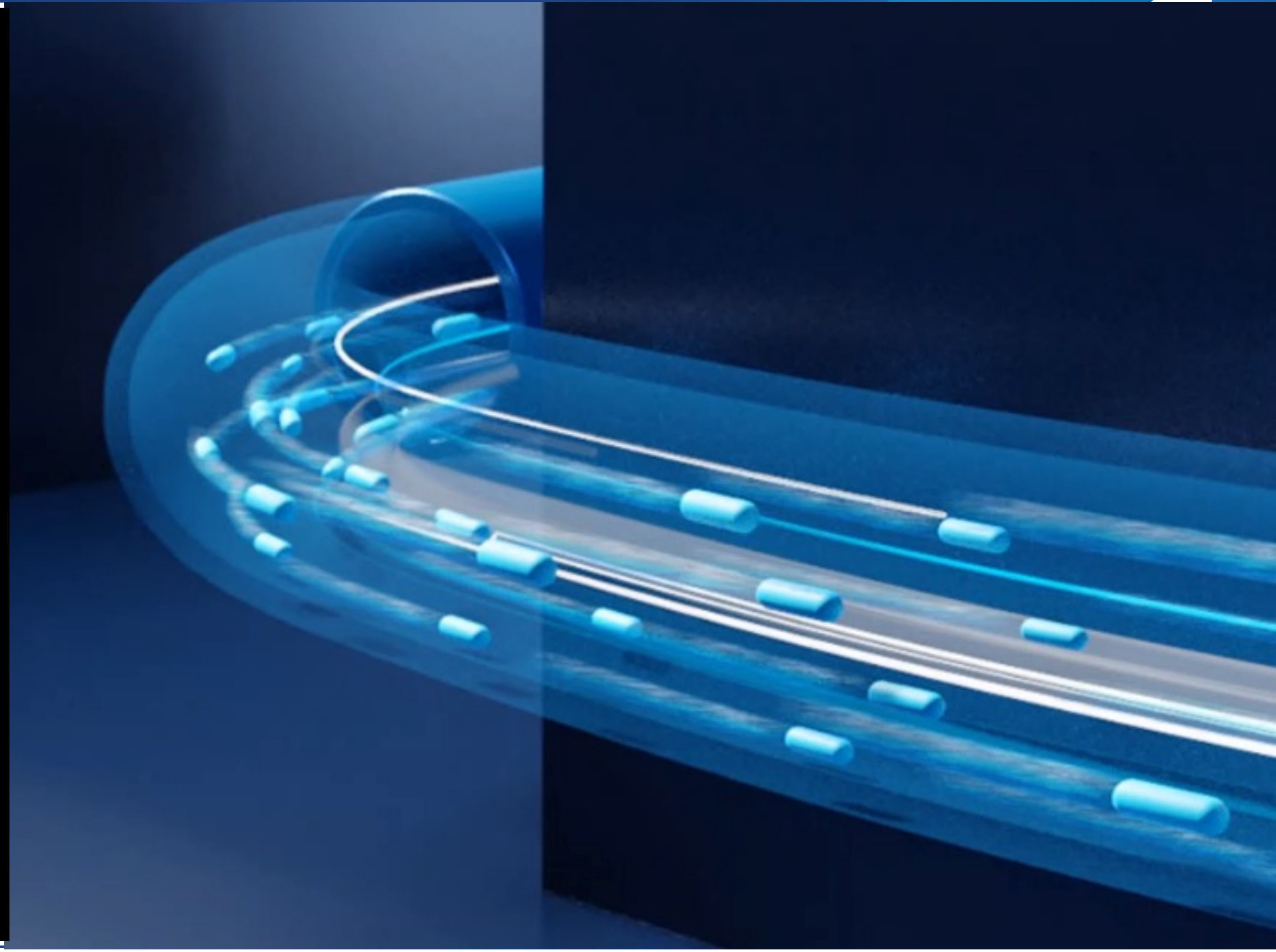


So How Do I Measure My Dewpoint?

- Maintaining the dew point of your air or gas system will prolong the lifetime of your equipment and reduce maintenance costs.
- For dew points related to production processes, guarding the dew point is critical for the end-product and key in preventing costly production losses.
- Permanent monitoring enables you to detect and prevent problems quickly and may provide visibility that a change in dew point is capacity or maintenance related.

Session 5 we discussed: **Distribution System**





Let's Not Forget Rubber Hose Losses

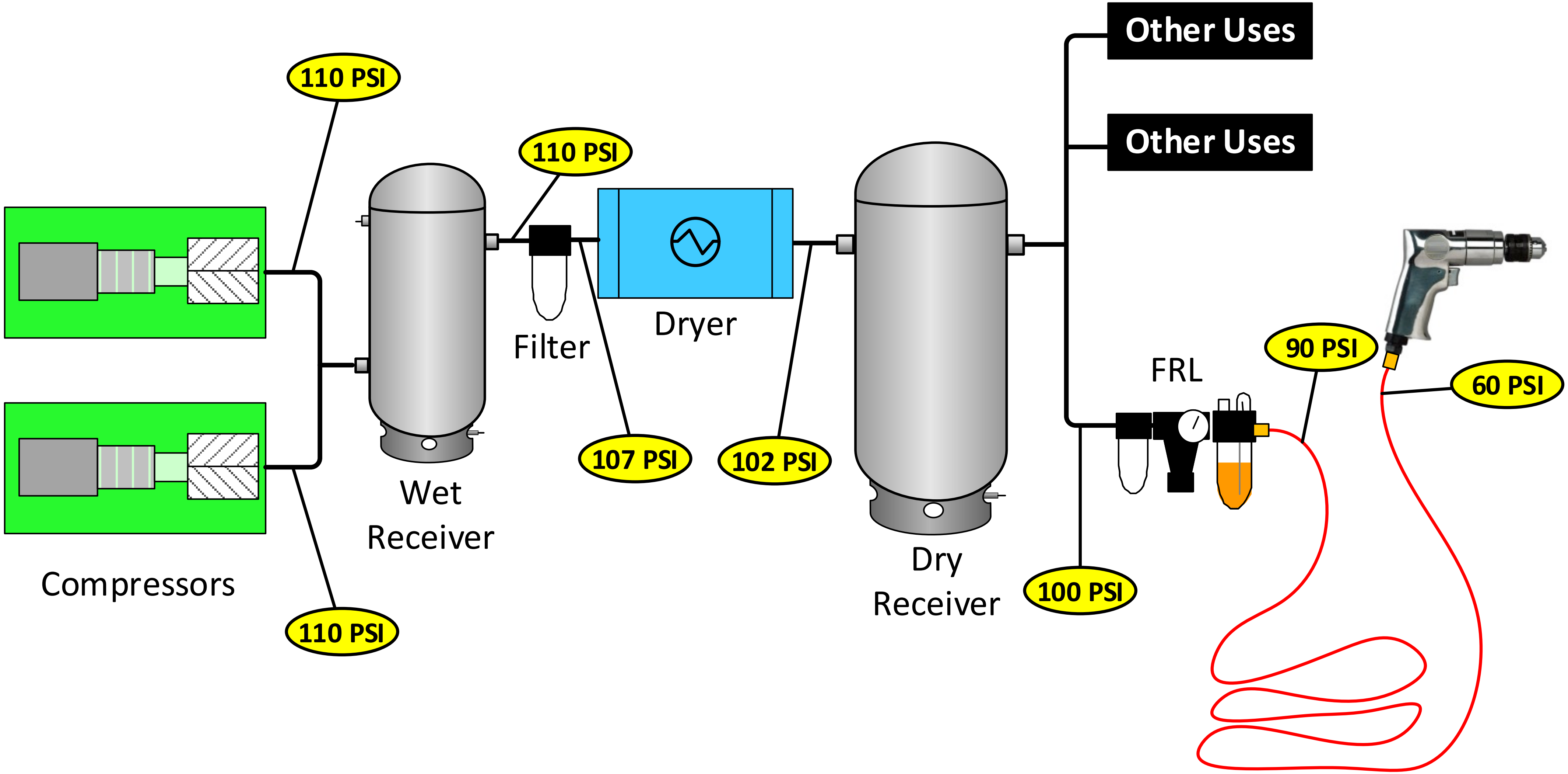
Air Flow CFM	Air Pressure Loss (PSI) in Standard power tool hoses Based on 100 psi Line Pressure — Hose Number and Size														
	1/4" x 10'	5/16" x 8'	3/8" x 10'	1/2" x 12 1/2	1/2" x 25'	1/2" x 50'	3/4" x 12.5'	3/4" x 25'	3/4" x 50'	1/2" x 50' + 1/4" x 10'	1/2" x 50' + 3/8" x 10'	1/2" x 50' + 5/16" x 10'	1/2/" x 50' + 1/2" x 12.5'	3/4" x 50' + 1/2" x 25'	3/4" x 50' + 3/4" x 12.5'
10 - 11	5.0	0.9								5.3	0.7	1.4			
11 - 12	5.9	1.0								6.2	0.8	1.6			
12 - 13	6.8	1.2	0.4							7.2	0.9	1.9			
13 - 14	8.0	1.4	0.5							8.4	1.1	2.2			
14 - 15	9.3	1.3	0.6							9.8	1.3	2.5			
15 - 16	11.0	1.9	0.7							11.6	1.5	2.9			
16 - 18	14.0	2.4	0.8							15.0	1.9	3.5	1.7		
18 - 20	19.6	3.0	1.0							21.4	2.4	4.5	2.0		
20 - 25		4.3	1.4	0.7	1.0	1.3					3.5	6.4	2.6	1.3	
25 - 30		6.6	2.1	1.0	1.5	2.3					5.2	9.8	3.8	1.9	
30 - 35		9.5	3.1	1.3	2.1	3.6					7.3	13.7	5.3	2.6	
35 - 40		12.8	4.2	1.7	2.8	5.2					9.6	18.4	7.1	3.5	
40 - 50		19.3	6.3	2.4	4.1	8.0					14.0		10.4	5.2	1.8
50 - 60			9.6	3.7	6.3	12.2					21.8		16.0	7.8	2.3
60 - 70			13.5	5.3	9.0	17.4	0.9	1.4	1.9				22.8	11.1	3.0
70 - 80			18.7	7.1	12.4		1.1	1.7	2.5					15.0	3.7
80 - 90			25.0	9.0	16.1		1.4	2.2	3.2					19.8	4.6
90 - 100				11.0			1.7	2.7	4.0						5.8
100 - 120							2.3	3.5	5.6						7.9
120 - 140							3.2	4.8	8.0						11.2
140 - 160							4.6	6.6	11.0						15.5
160 - 180							5.6	8.7	15.2						20.4
180 - 200							7.2	11.0							
200 - 220							9.0								

From

Table 4.7 Loss of Air Pressure Due to Friction @ 100 psig

Cu Ft Free Air Per Min	Equivalent Cu Ft Compressed Air Per Min	Nominal Diameter, In.											
		1/2	3/4	1	1 1/4	1 1/2	2	3	4	6	8	10	12
300	38.44	....	....	....	58.2	25.8	6.85	0.84	0.20				
350	44.80	....	....	....	....	35.1	9.36	1.14	0.27				
400	51.24	....	....	....	....	45.8	12.1	1.50	0.35				
450	57.65	....	....	....	....	58.0	15.4	1.89	0.46				
500	63.28	....	....	....	....	71.6	19.2	2.34	0.55				
600	76.88	....	....	....	....	....	27.6	3.36	0.79				
700	89.60	....	....	....	....	....	37.7	4.55	1.09				
800	102.5	....	....	....	....	....	49.0	5.89	1.42				
900	115.3	....	....	....	....	....	62.3	7.6	1.80				
1,000	128.1	....	....	....	....	....	76.9	9.3	2.21				
1,500	192.3	....	....	....	....	....	....	21.0	4.9	0.57			
2,000	256.2	....	....	....	....	....	....	37.4	8.8	0.99	0.24		
2,500	316.4	....	....	....	....	....	....	58.4	13.8	1.57	0.37		
3,000	384.6	....	....	....	....	....	....	84.1	20.0	2.26	0.53		
3,500	447.8	....	....	....	....	....	....	....	27.2	3.04	0.70	0.22	
4,000	512.4	....	....	....	....	....	....	....	35.5	4.01	0.94	0.28	
4,500	576.5	....	....	....	....	....	....	....	45.0	5.10	1.19	0.36	
5,000	632.8	....	....	....	....	....	....	....	55.6	6.3	1.47	0.44	0.17

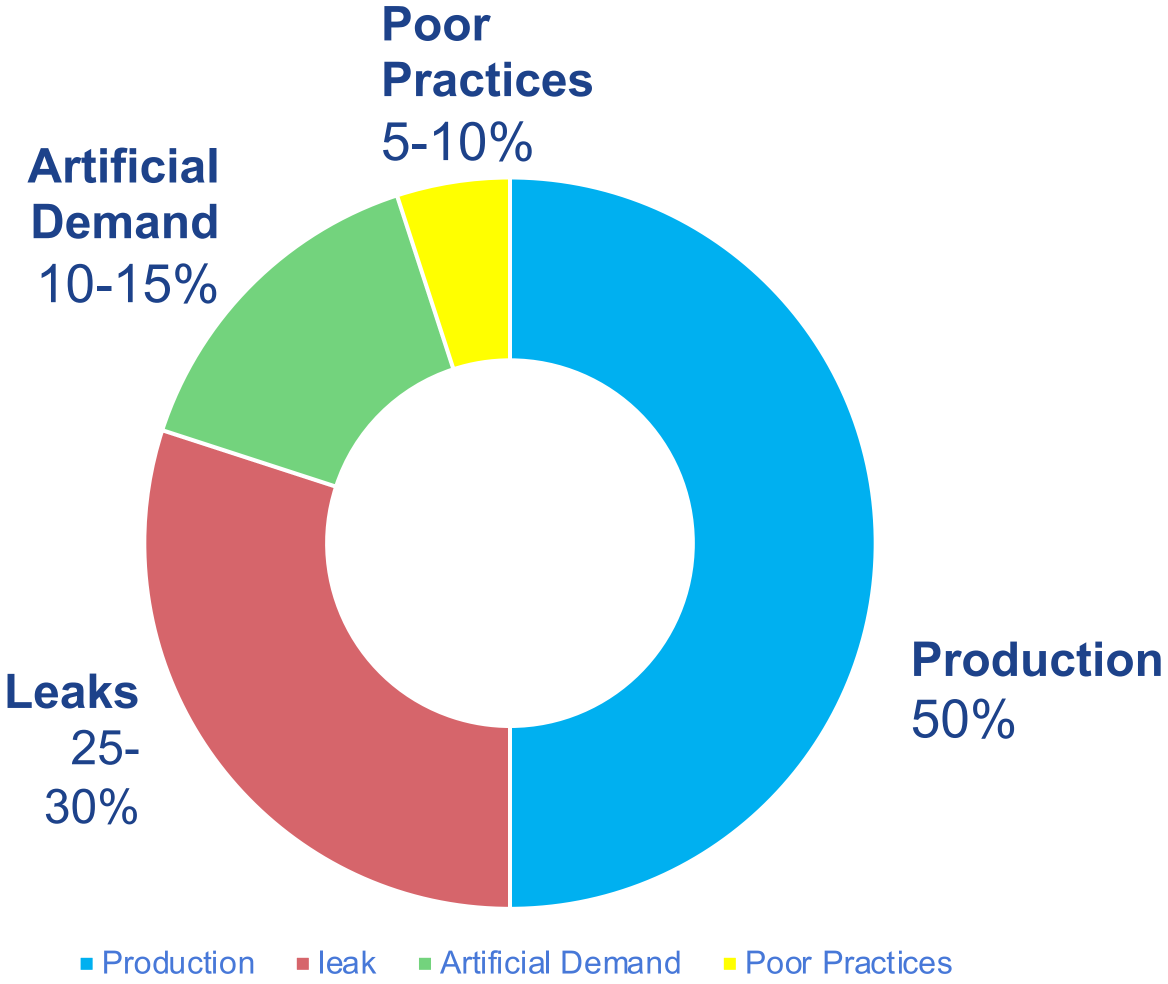
Developing a System Profile



Session 6 we discussed:

Demand Side

We looked at the waste



Potentially Inappropriate Applications

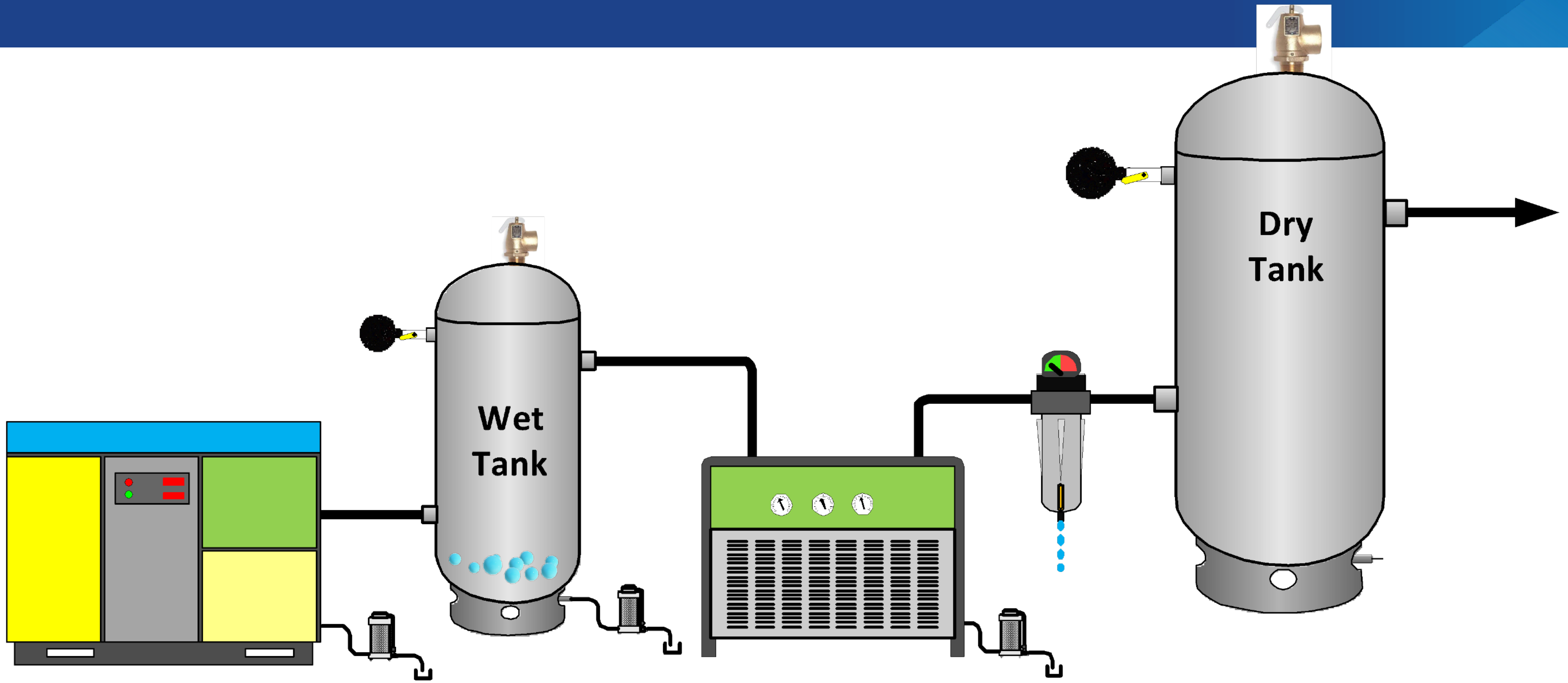
- Many applications can be served more efficiently by low pressure air from a fan, a blower; or by a vacuum pump, rather than by compressed air. Examples:

  - Open blowing
  - Sparging (agitating, aerating stirring, mixing)
  - Aspirating
  - Atomizing
  - Padding
  - Dilute phase transport
  - Dense phase transport
  - Vacuum generation
  - Personnel cooling
  - Open hand-held blow guns or lances
  - Cabinet cooling
  - Vacuum venturi
  - Diaphragm pumps
  - Timer drains/open drains
  - Air motors

Session 7 we discussed:

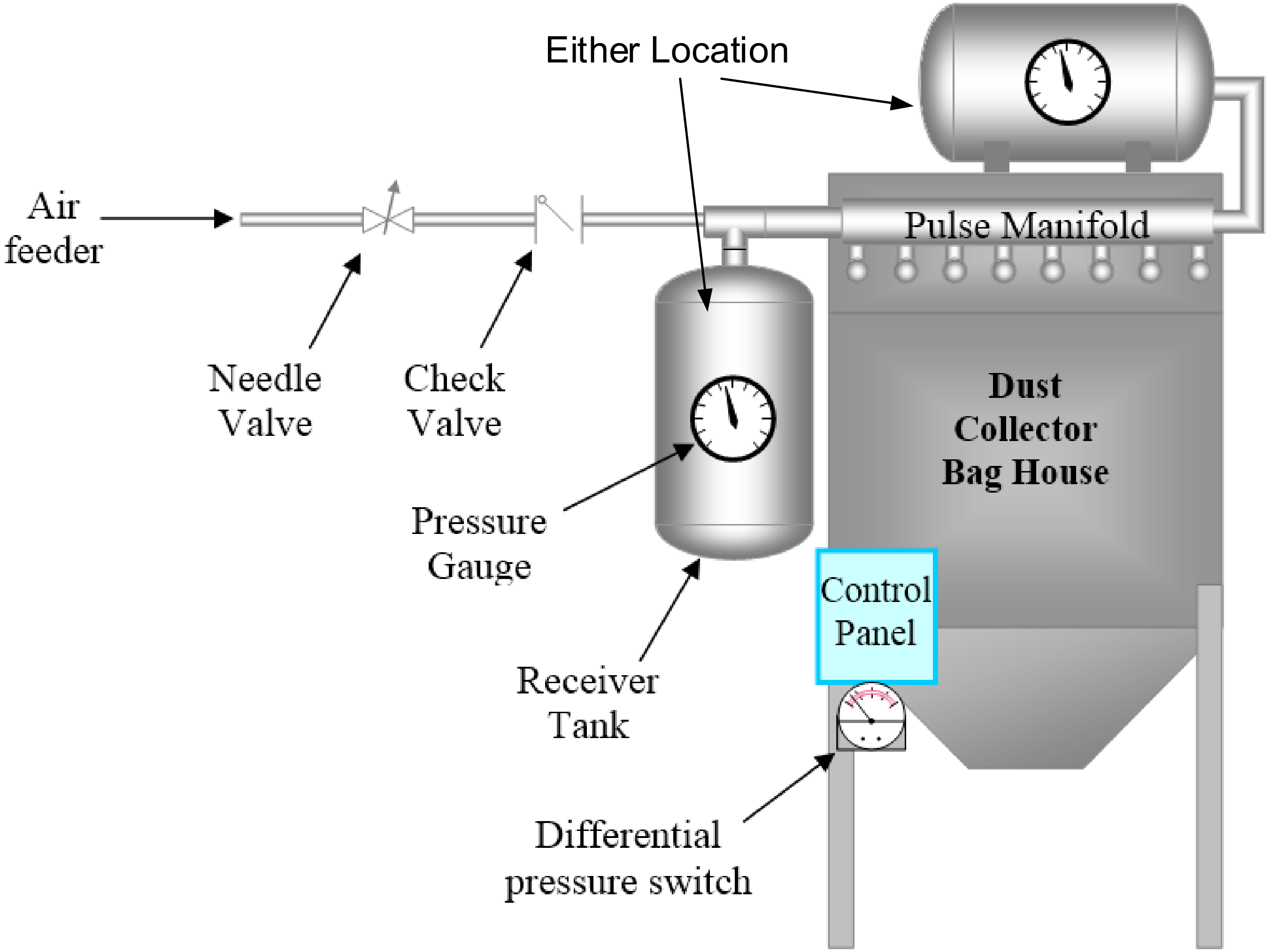
System Volume vs Storage

Best Practice



- A best practice is often to have two receivers at the supply side.
- One “wet” air receiver before the dryer to provide control storage and condensate drop out.
- And a second “dry” air receiver to meet sudden demands.
- Typical size ratio is 25% -30% wet and 70% - 75% dry.

Dedicated Storage to Shield the system from a high flow end use application



Example of Local Storage for Critical End Use Pressure

Example of Local Storage

Summary

- You need to be able to understand what is happening with your compressed air system - things are not always as they seem.
- Controls will help you to align supply with demand.
- Heat recovery can lead to substantial energy savings.
- Properly addressing air quality issues can greatly affect system performance (and economics).
- High pressure requirements should not drive your system.
- System profiles can help you understand what is happening.
- There are ways to effectively deal with high volume/intermittent needs.

Now let’s look at some of the close out presentations from our attendee's

U.S. DEPARTMENT OF ENERGY