Better Plants
U.S. DEPARTMENT OF ENERGY

In-Plant Trainings

Virtual Platform
Session 3 – Controls

Homework Questions

- What's the compression ratio of the single stage compressor below?
  - 13.5 psia inlet pressure
  - 113.5 discharge pressure
- Is discharge pressure psig or psia? If it is psig (assuming 1 atm=13.5 psi), $\frac{113.5gauge+13.5}{13.5a} = 9.4$
- If it is psia, $\frac{113.5}{13.5} = 8.4$

Homework Questions

- How can we find the compressor discharge pressure?
- I'd like to get feedback regarding dry air storage system in my facility. I have some doubts, that it is efficient. As for me, majority of air is going to consumers via two bypasses. If my thoughts are correct, do we need to keep all 6 dry tanks?
- How to calculate right size of dry (or wet tank)
- What material is best for compressed air lines – copper, steel, etc.?
- Pressure settings on Gardner Denver screw compressor –Robert Barrier
- Baseline unit for continuous operation, can these be on VFDs?

Homework Questions

- How do you know when you need additional wet or dry storage?
- How much moisture should an air dryer handle?
- Currently looking at installing another compressor in facility; question being which kind would be best for the space.
- Along with that; does it make sense to add a volume tank on the other side of the facility.
- What advantages do flow controllers have over the life of your compressor? Any situations when a controller would not help your overall system?

Homework Questions

- With the compressors in our mill, 2x centrifugal and 2x rotary screw, what would be the best operating strategy you would recommend? Run two centrifugal and trim with the rotary screw load/unloading? I can't seem to make the required ~7,000 CFM with the two centrifugals.
- How can I accurately measure the flow rate coming off the centrifugal compressors when there is less than 10 feet straight run of pipe after the compressor?
- what would be a good Kw/100CFM to aim for?
- During months with higher humidity, we have to leave the blowdown valves cracked open in order to keep the compressors from accumulating significant amounts of condensate. How could we reduce the amount of condensation without wasting air.

Homework Questions

- What are some determining factors on what works best to transport the air from the Air Compressor System to the End Users? For example, what type of piping is ideal?

Homework Questions

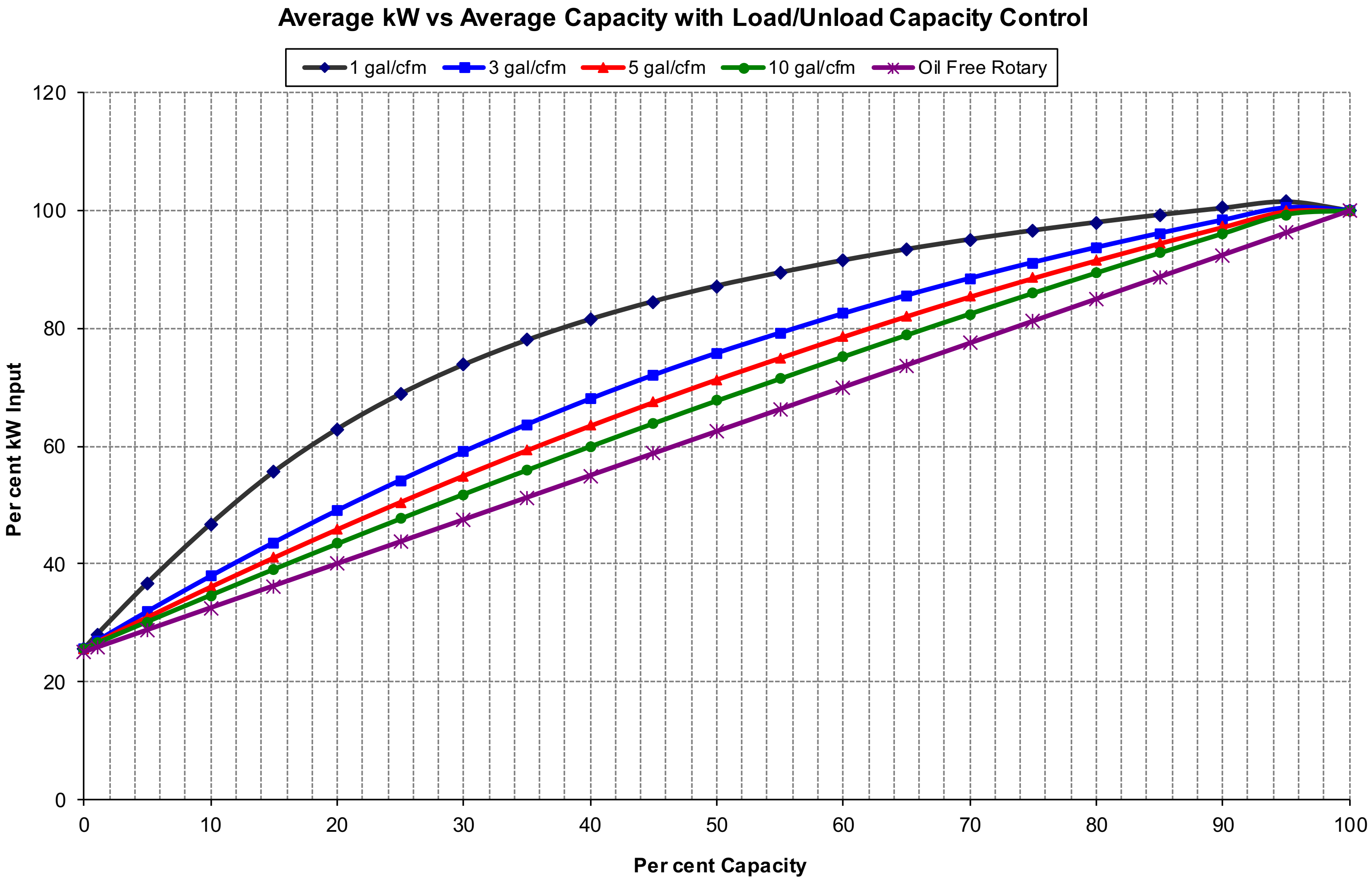
Name: Matt Kanuch

Company: Bendix

2. List your questions about the compressors in your facilities.

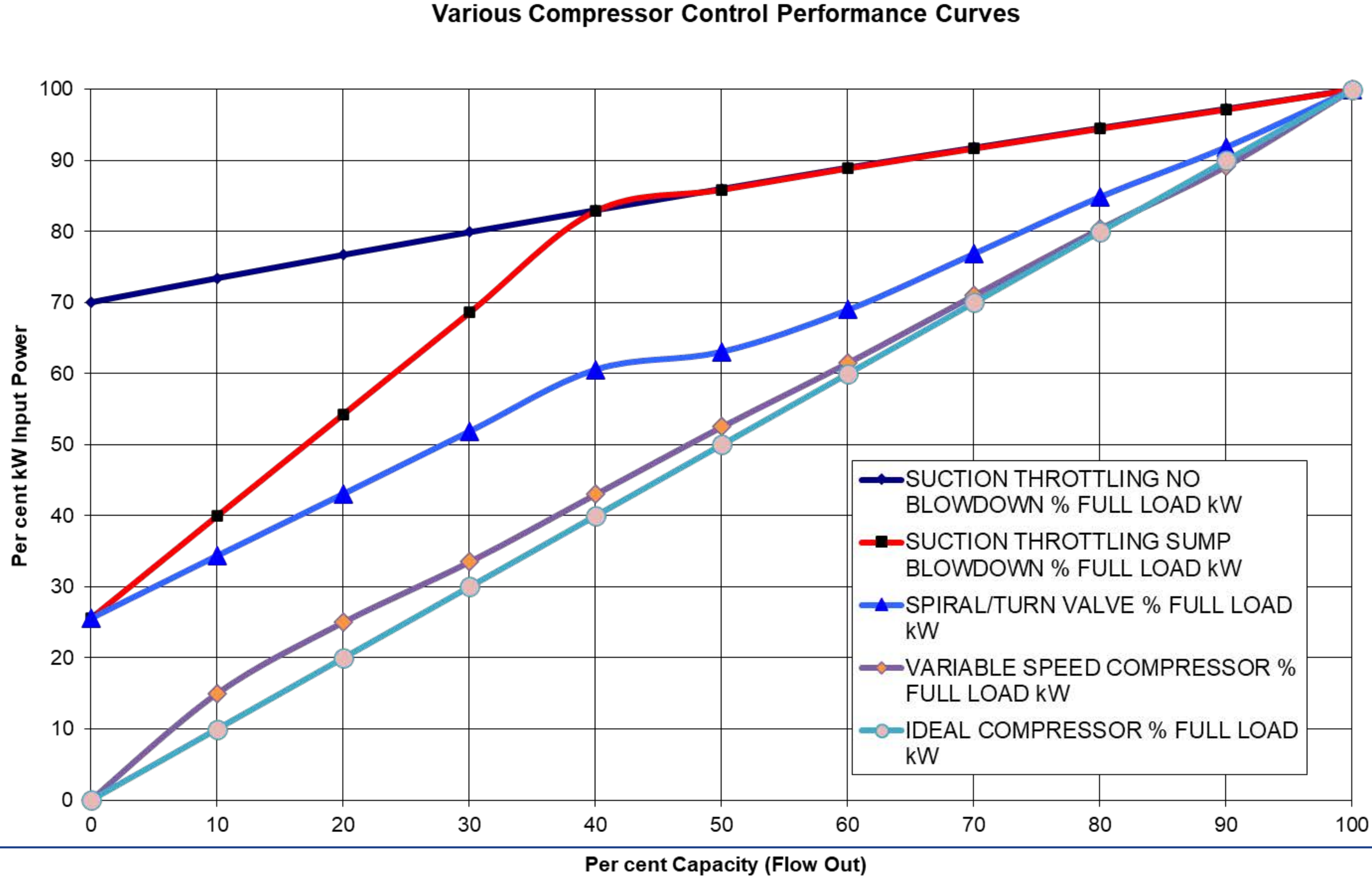
We have two rotary screw compressors, A VSD and a LOAD/UNLOAD. If our facility can be run off one 80-90% of the time, which type would you use as the lead compressor?

Load/No-load Control Curve



- This graph shows the effect of receiver size on the part load power of a lubricant injected rotary screw compressor with load/unload controls

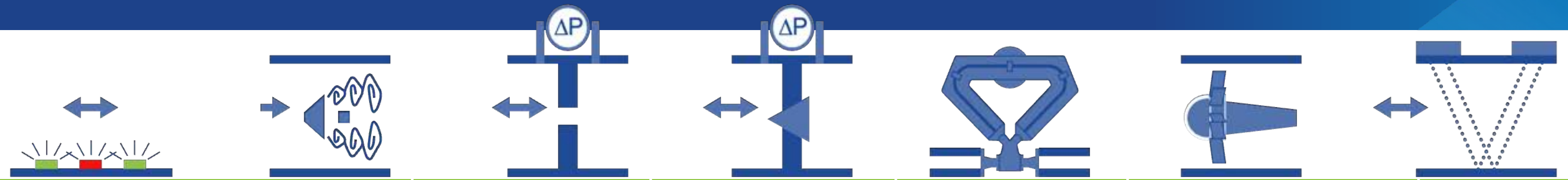
Performance Curves



Week 2

Quick Review on Flowmeters

Types of Meters - Comparisons



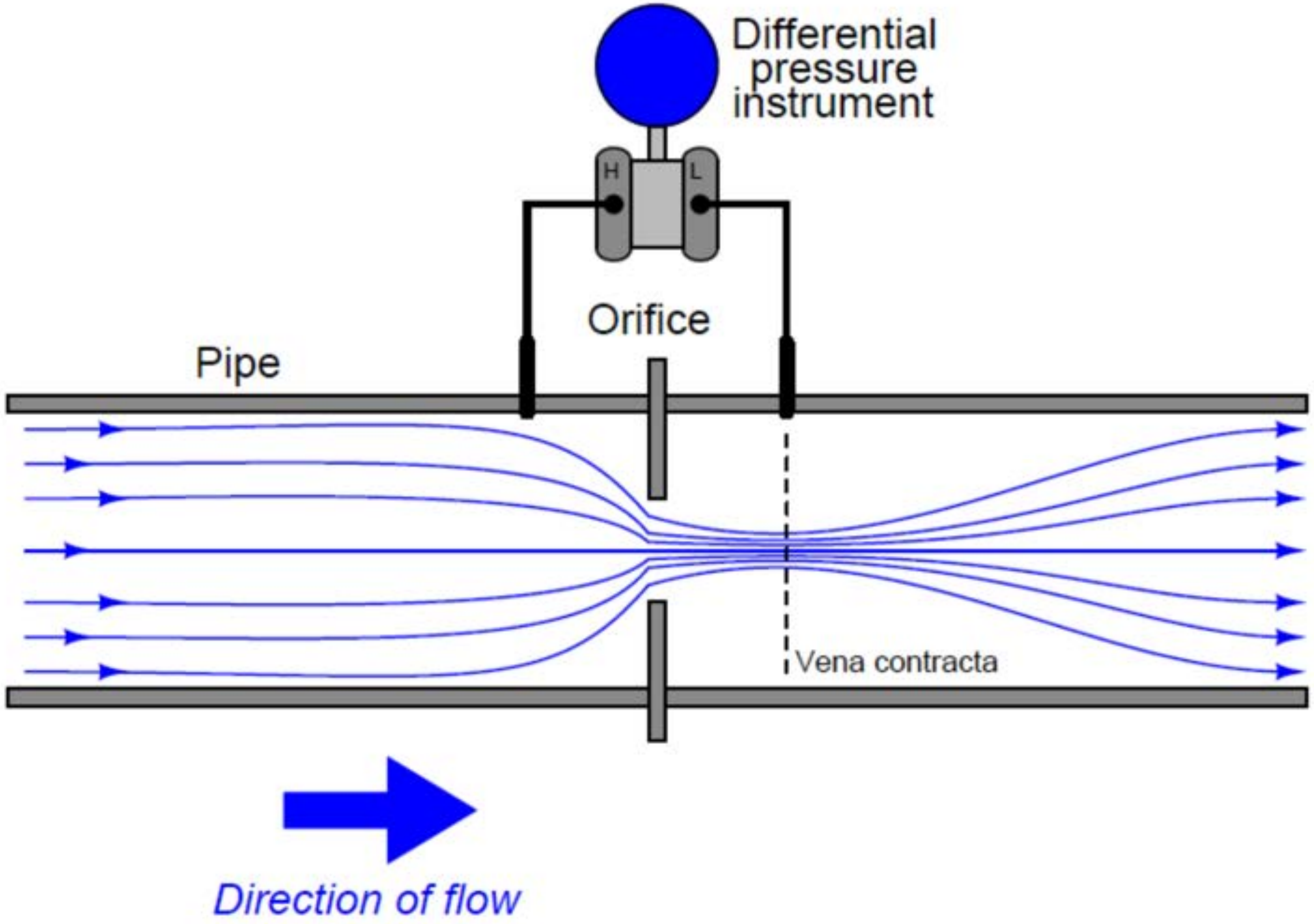
	Thermal	Vortex	DP – Orifice plate	DP – Insertion	Coriolis	Turbine/ rotary displacement	Clamp on ultrasonic
Mass flow	Yes	Optional	Optional	Optional	Yes	Optional	Optional
Meter run	20D	15D	15D	20D	0D	10D	20D
Pressure loss	Low	Medium/high	high	Low	Low	Low	Low
Dirty air	Fouling	OK	Clogging	Fouling/Clog	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

Orifice Plate Flow Meters

These meters are another carry over from fluid engineering.

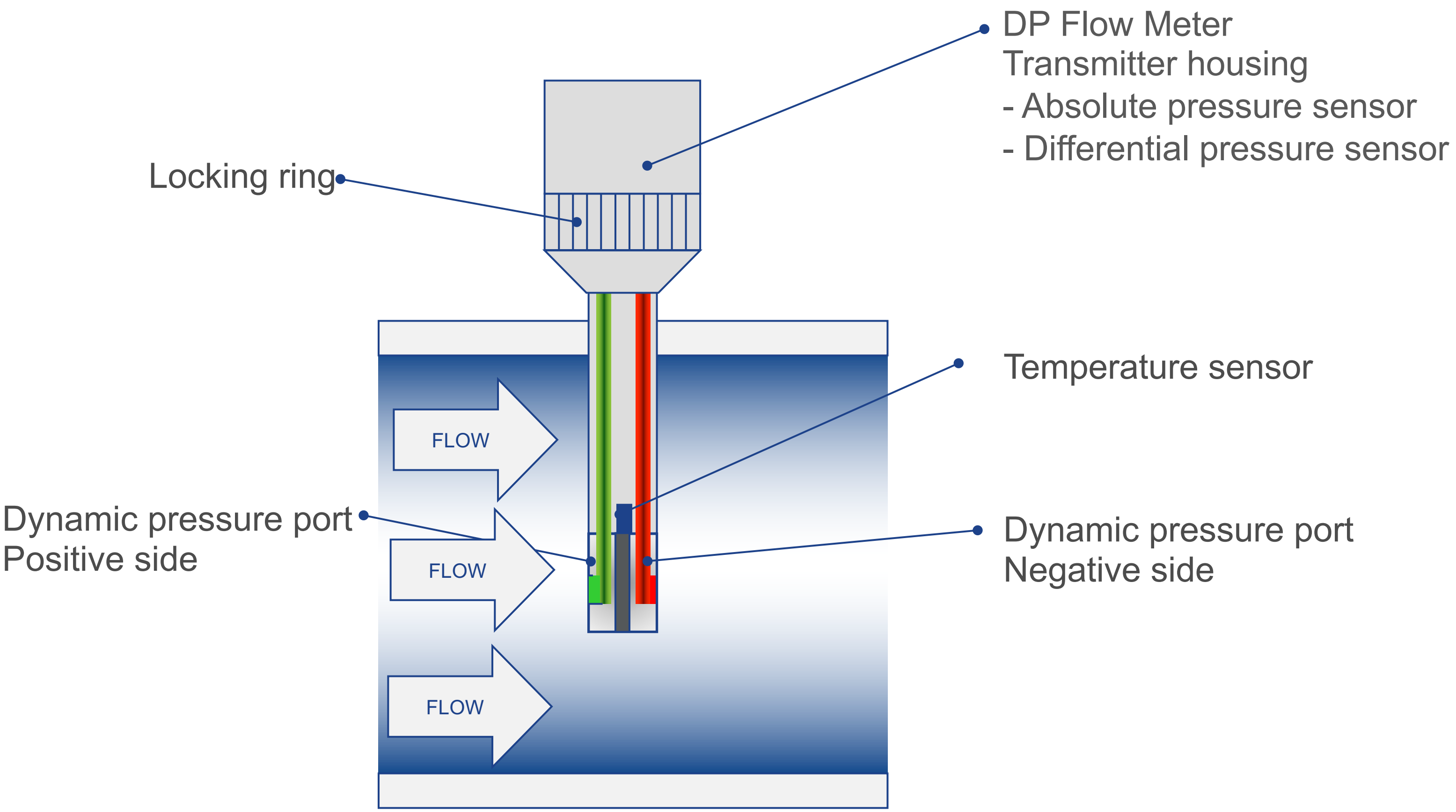
They operate on the physics of a pressure drop being created as a medium flows through an orifice.

The problem with these meters is just that; they, themselves are a pressure drop.



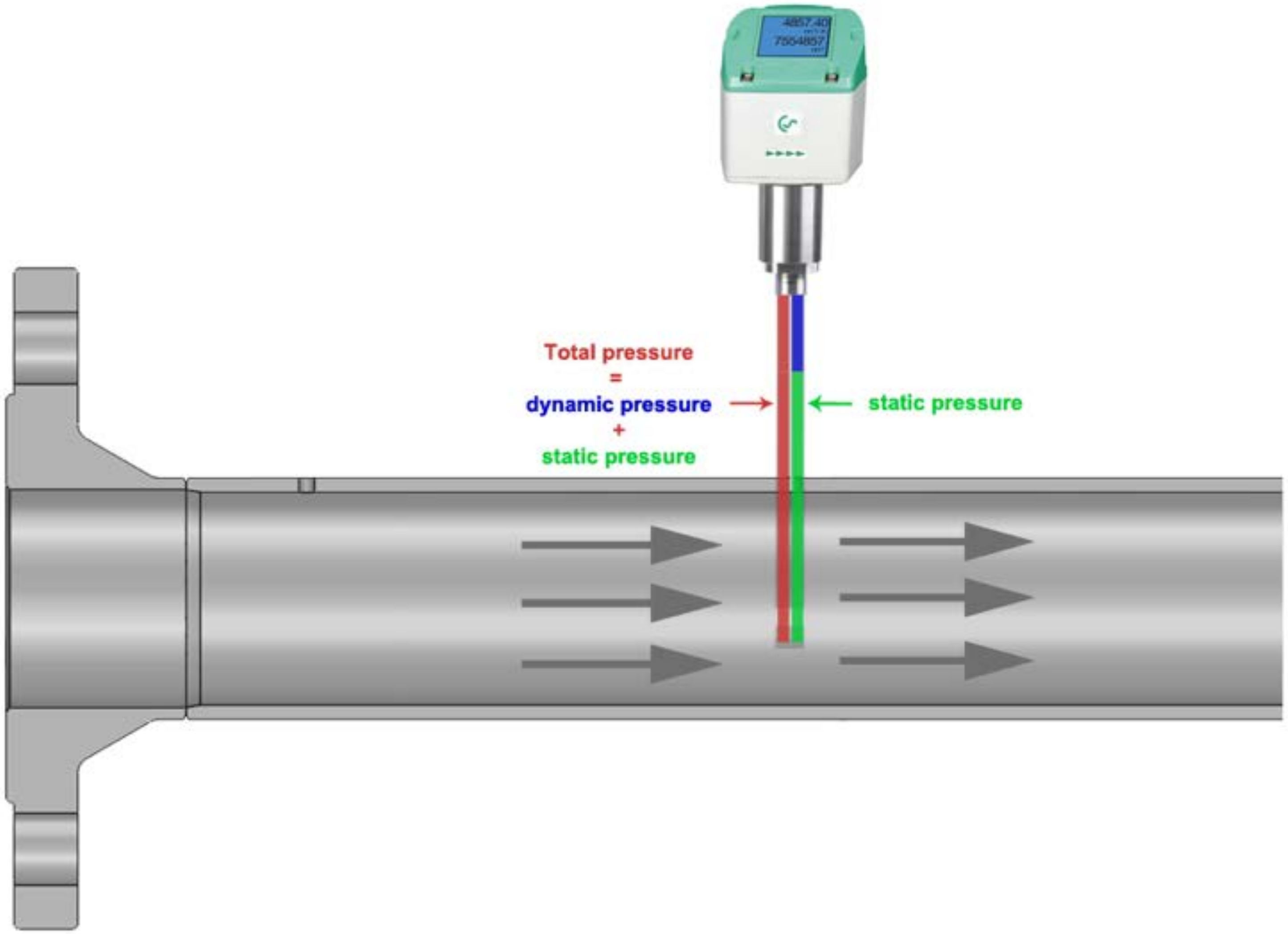
Differential Pressure Technology

- Speed of air creates differential pressure signal over the positive and negative port.
- Low speeds do not generate a stable Dif. Pressure.



Differential Pressure Technology

- Unique sensitivity in the lower measuring range: Measures from as little as 2 m/s and thus covers the complete operating range of variable speed drive (VSD) compressors
- Particularly suitable for extremely high flow rates
- Flow, total consumption, temperature and pressure
- Measurement at high temperatures, max. temperature 180 °C
- Installation via 1/2″ ball valve under pressure.



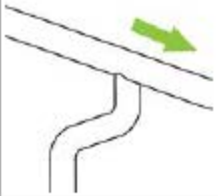
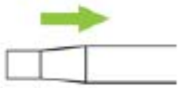
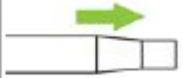
Min and Max Flow per Pipe Size

- DP flow meters have a min and max flow range. Below the minimum range the flow meter will read flaky or no flow, we call this the dead zone, 0 to 20 m/sec (0 to 65 ft/sec).
- In different pipe sizes this dead zone will have a different Q min, see the tables below.

Schedule 40 Standard Seamless Carbon Steel Pipe							
Size (inch)	*DN*	*ID (inch)*	*ID (mm)*	*Min flow (scfm)*	*Max flow (scfm)*	*Min flow (m^3_n/hr)*	*Max flow (m^3_n/hr)*
2	50	2,1	52,5	92	917	**156**	**1559**
3	80	3,1	77,9	202	2021	**343**	**3434**
4	100	4,0	102,3	348	3481	**591**	**5913**
6	150	6,1	154,1	790	7899	**1342**	**13420**
8	200	8,0	202,7	1368	13678	**2324**	**23238**
10	250	10,2	259,1	2234	22341	**3796**	**37957**
12	300	11,9	303,2	3060	30604	**5199**	**51994**
16	400	15,0	381,0	4832	48316	**8209**	**82087**
20	500	18,8	477,8	7599	75994	**12911**	**129110**

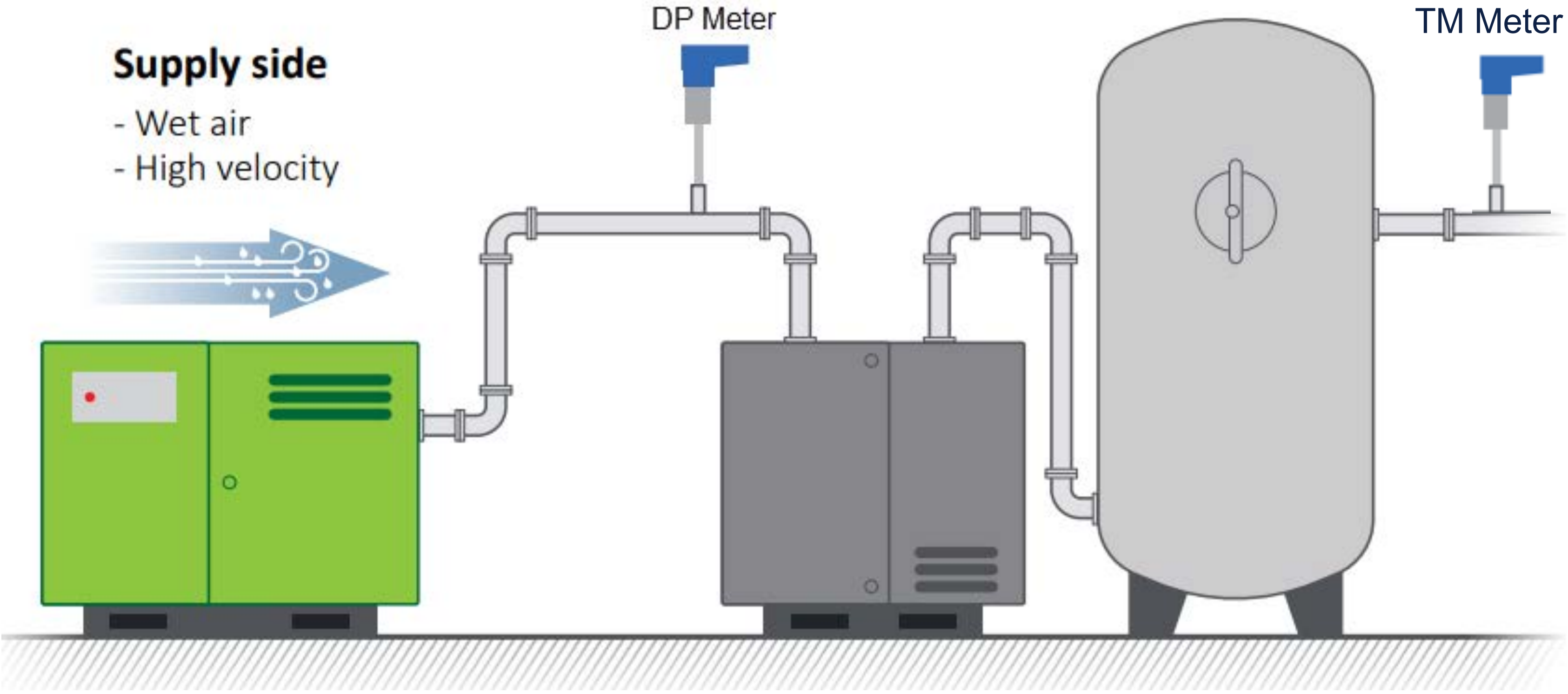
Schedule 10 Standard Seamless Carbon Steel Pipe					
ID (inch)	*ID (mm)*	*Min flow (scfm)*	*Max flow (scfm)*	*Min flow (m^3_n/hr)*	*Max flow (m^3_n/hr)*
2,2	54,8	100	999	**170**	**1697**
3,3	82,8	228	2282	**388**	**3877**
4,3	108,2	390	3897	**662**	**6621**
6,4	161,5	868	8678	**1474**	**14743**
8,3	211,6	1490	14897	**2531**	**25309**
10,4	264,7	2332	23316	**3961**	**39612**
12,4	314,7	3296	32965	**5601**	**56006**
15,6	396,8	5242	52420	**8906**	**89058**
19,6	496,9	8219	82191	**13964**	**139638**

Flow Meter Location

Picture	Description	Upstream length[2]	Downstream length[2]	Effect
	Single elbow	30 * D1	10 * D1	Distorted flow profile
	Complex feed-in situation (header)	40 * D1	10 * D1	Flow profile will be distorted
	Double elbow, multiple elbows following each other	40 * D1	10 * D1	Distorted profile + swirl
	Diameter change from small to large (gradual or instant)	40 * D1	5 *D1	Jet shaped flow
	Diameter change from large to small (gradual change, between 7 and 15 degrees)	10 * D1	5 * D1	Flattened flow profile

DP Insertion Flow Meters

- Insertion style Differential Pressure meter for saturated compressed air flow measurements.
- A differential pressure flow sensor measures bi-directional flow, pressure, temperature and total flow simultaneously.
- They are intended for use in high velocity applications where there is a continuous flow over a minimum value, such as compressor efficiency monitoring.

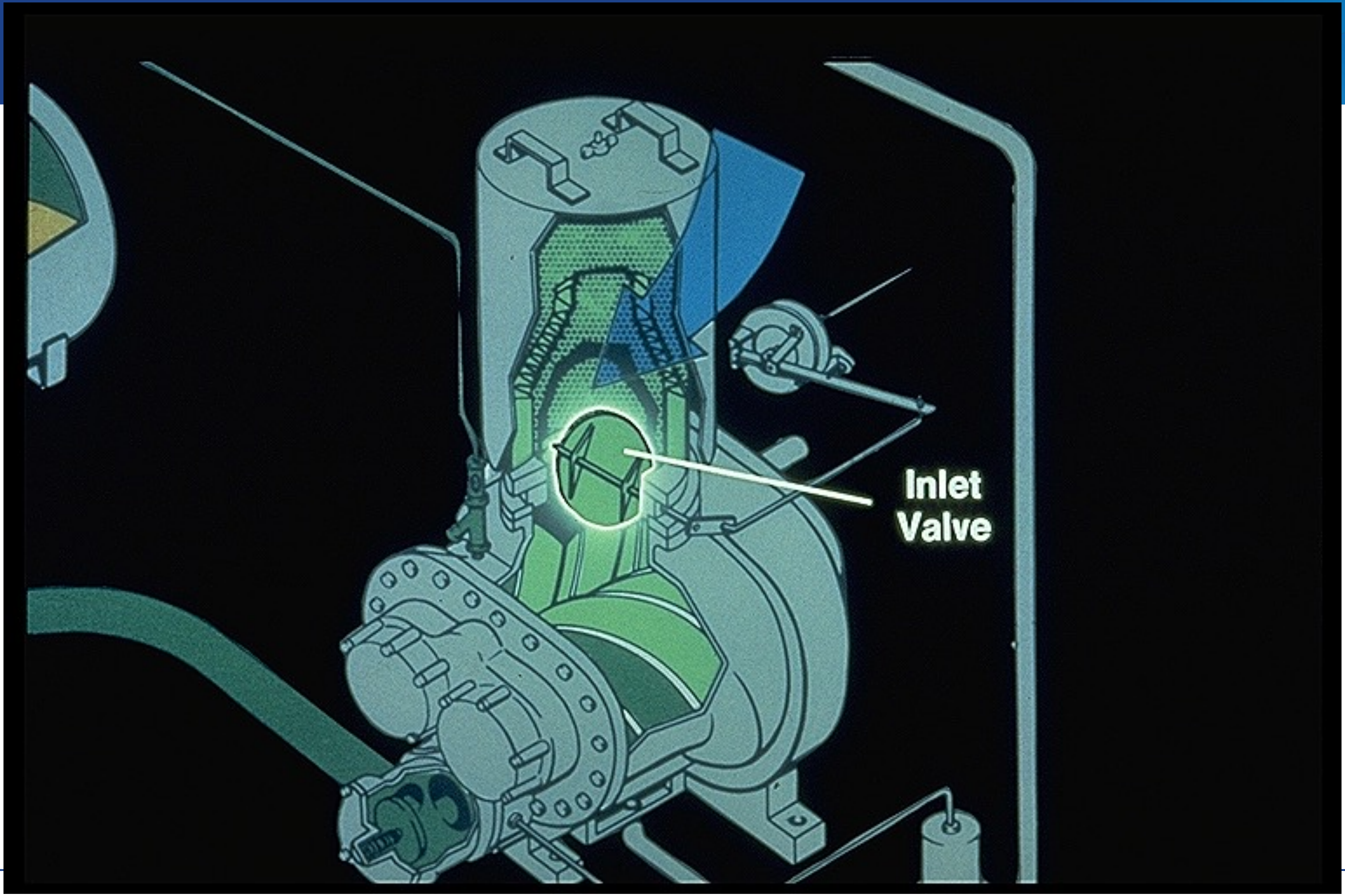


Session 3

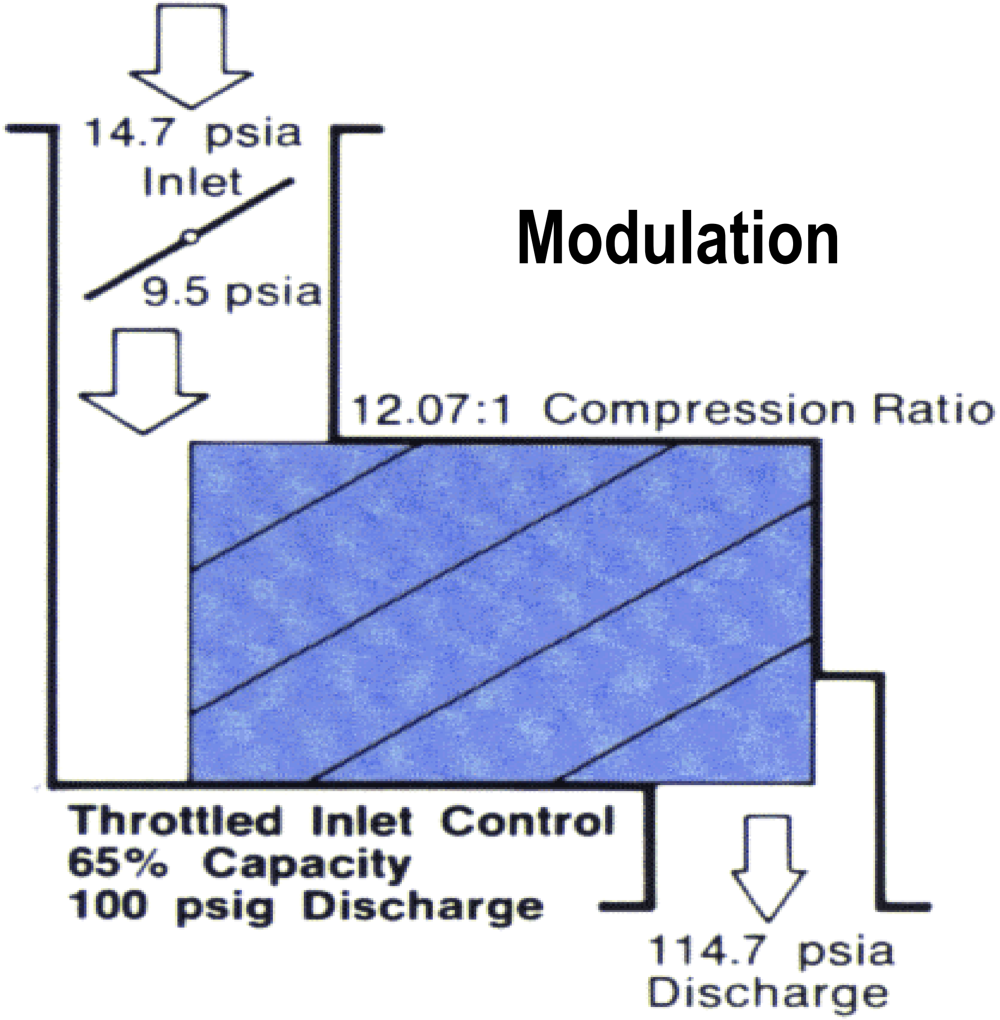
Compressor Controls

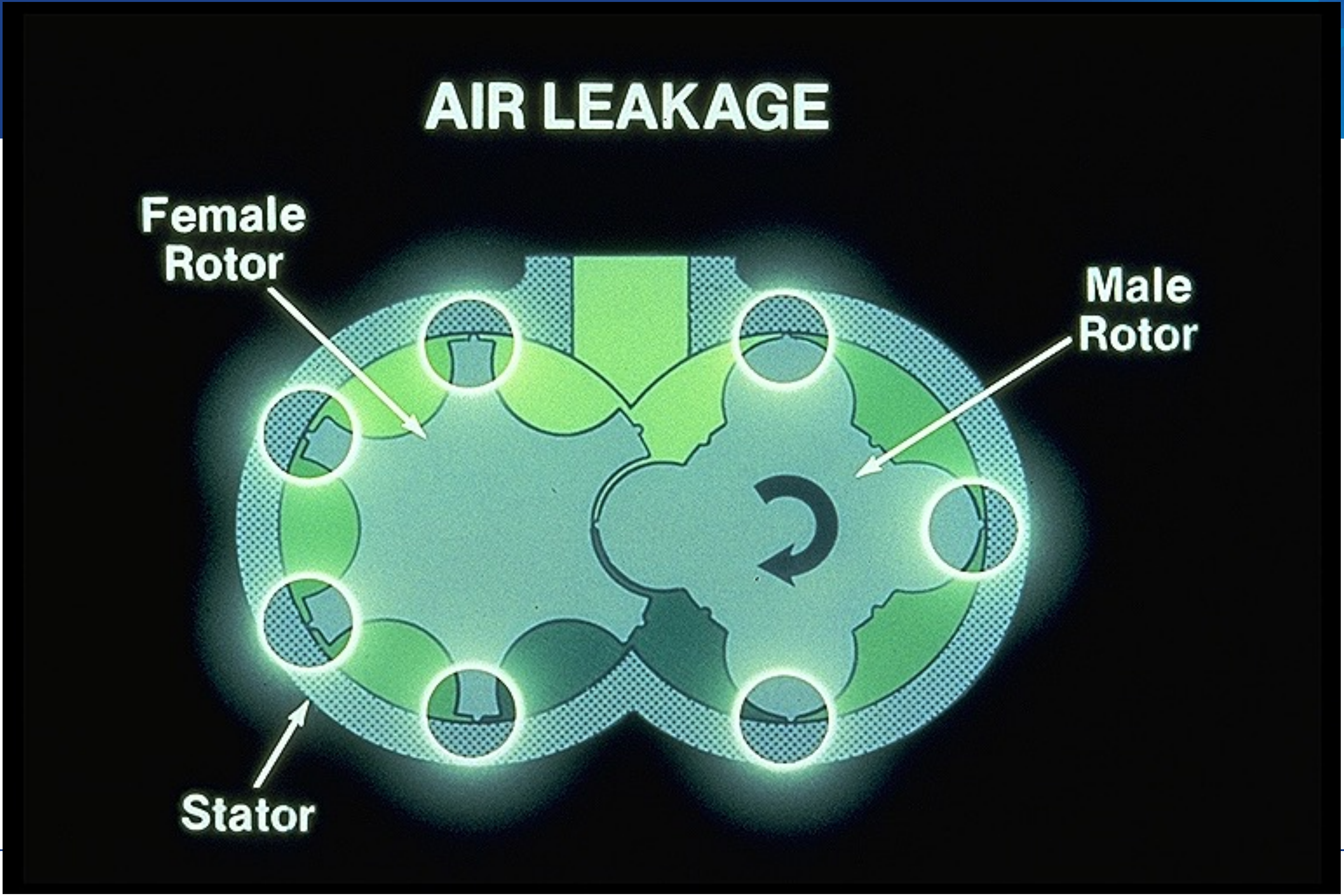
Compressor Control Types

- Start/Stop
- Load/Unload
- Modulating
- Variable Displacement
- Variable Speed

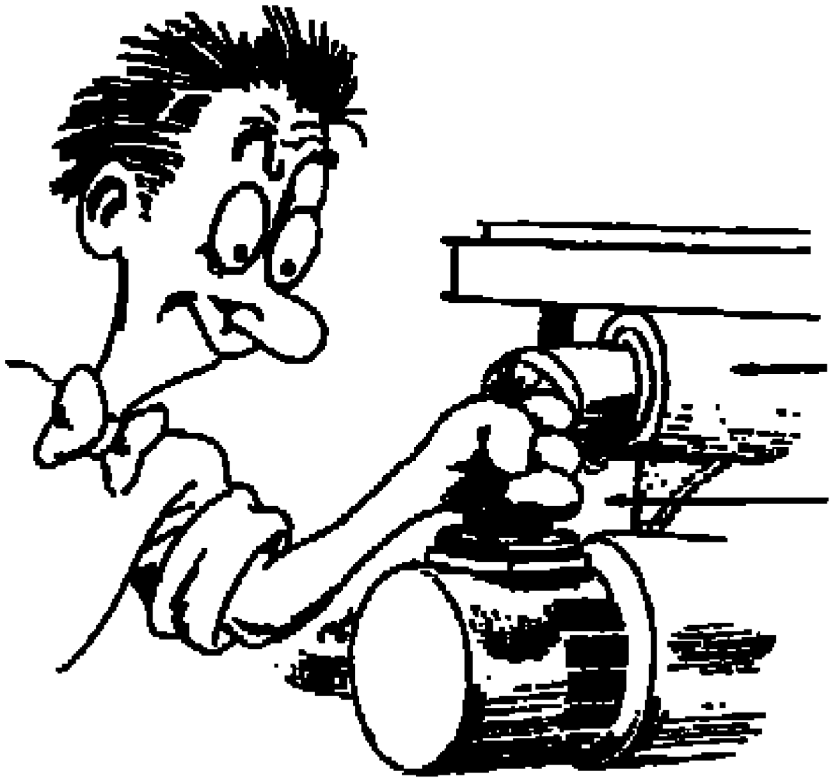

Inlet
Valve

Inlet Throttling



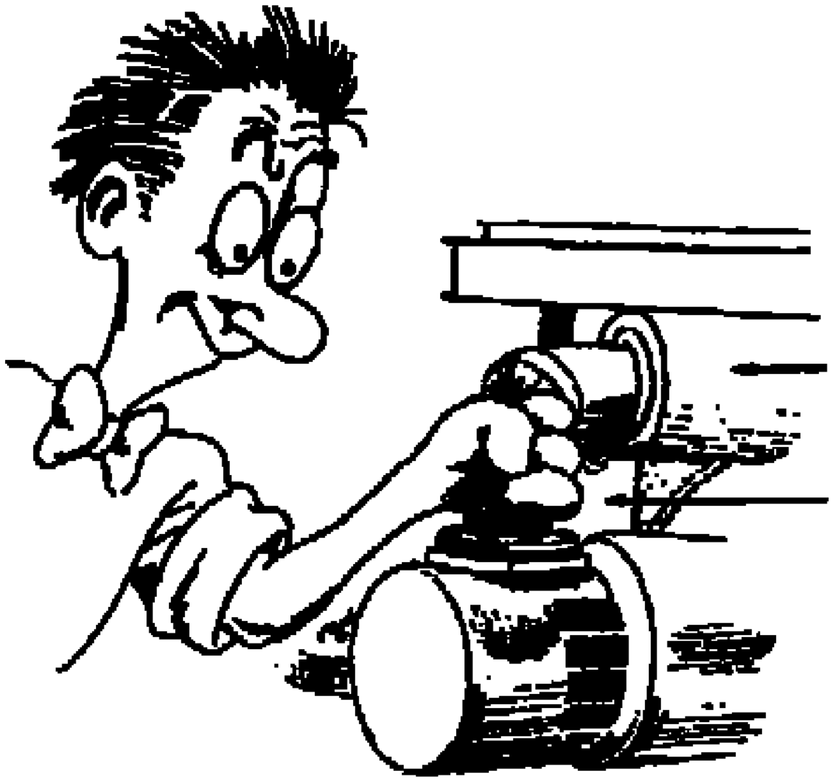

AIR LEAKAGE
Female Rotor
Male Rotor
Stator

Capacity Control by Inlet Throttling



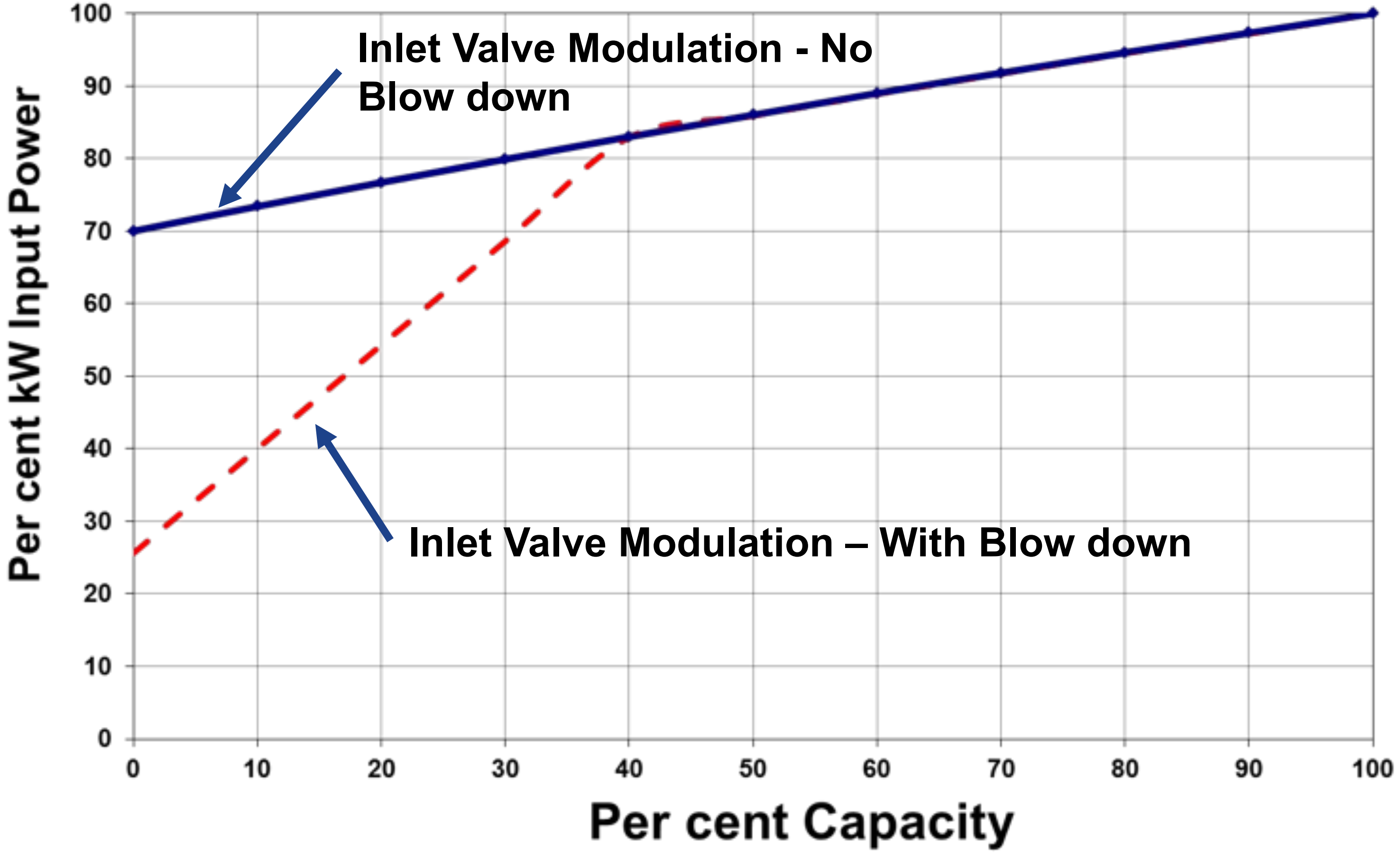
- Atmospheric pressure 14.7 psia
- Intake pressure 9.0 psia
- Discharge pressure 114.7
- Compression ratio: 114.7/9.0 = 12.7 to 1
- End Result?? Increased internal leakage due to a higher compression ratio

Capacity Control by Inlet Throttling



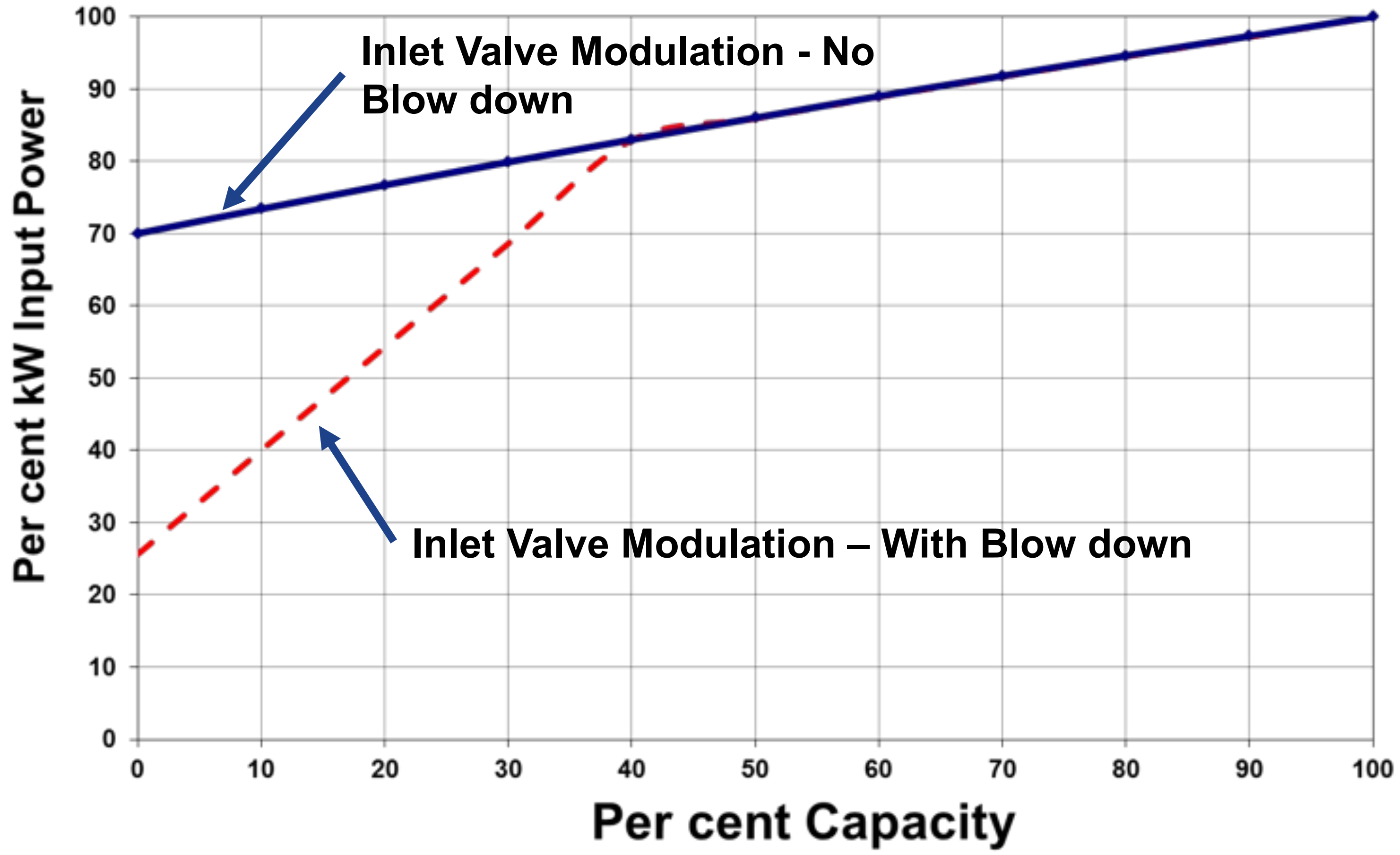
- Varies capacity by throttling (restricting) the inlet flow
- Provides a relatively stable output pressure
- Energy hog… least efficient
- Every 10% reduction in capacity yields only a 3% reduction in power(BHP)
- At zero capacity, power remains at 70% of full load power

Inlet Valve Modulation



- The example shows a discharge pressure range of 100 - 110 psig.
- As discharge pressure rises from 100 to 110 psig, a proportional pressure regulator provides a control pressure from 0 - 30 psig, to progressively close the inlet valve.
- As the inlet valve closes, the absolute pressure at the inlet of the air end is reduced.

Inlet Valve Modulation

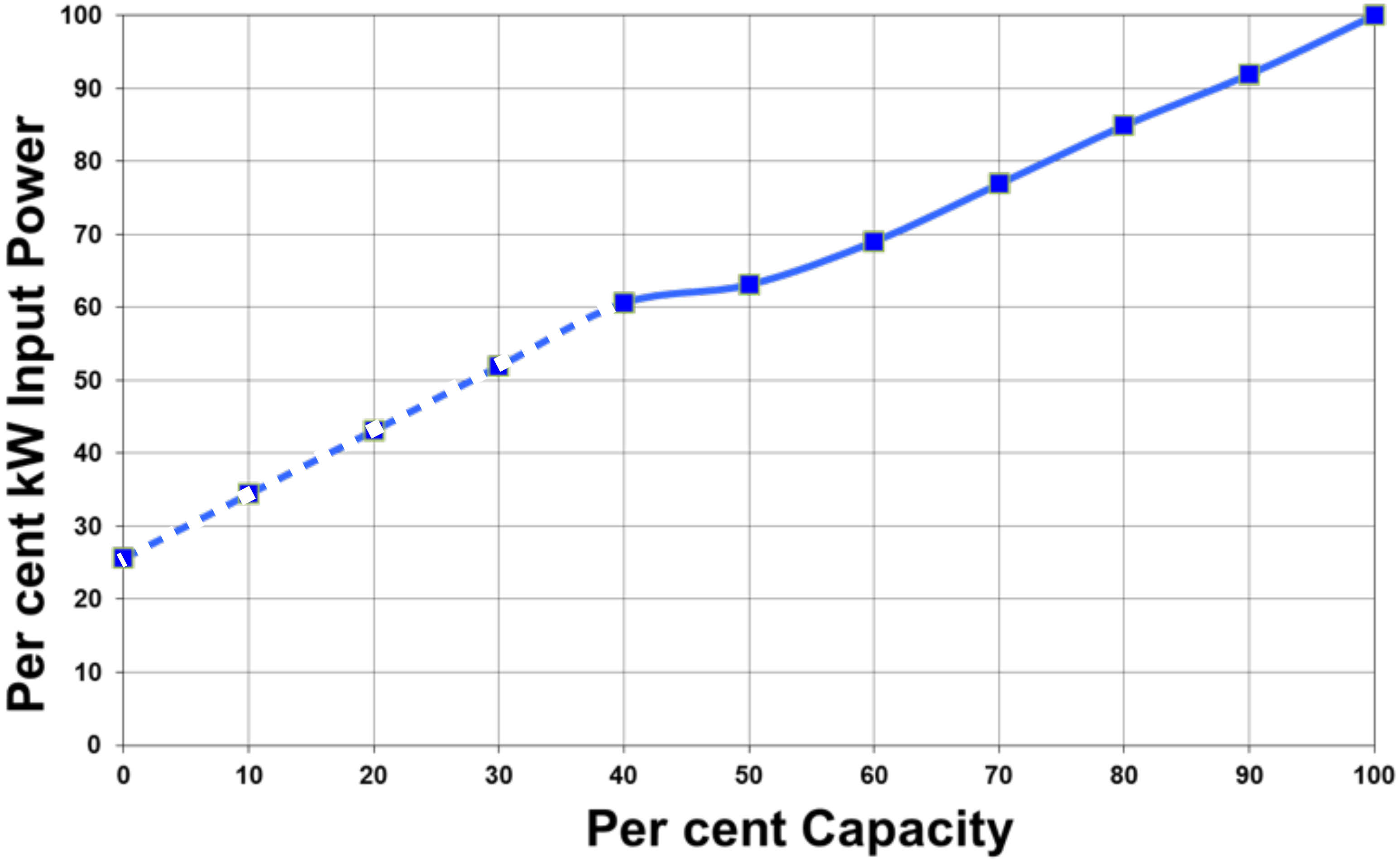


- This reduces the mass flow of air entering the air end in direct proportion to the absolute pressure.
- However, the reduced inlet pressure, with increasing discharge pressure, results in increasing pressure ratio.
- At 40% capacity the pressure ratio will be 124.7/5.88 = 21.21.
- This is why there is not much reduction in the power requirement.

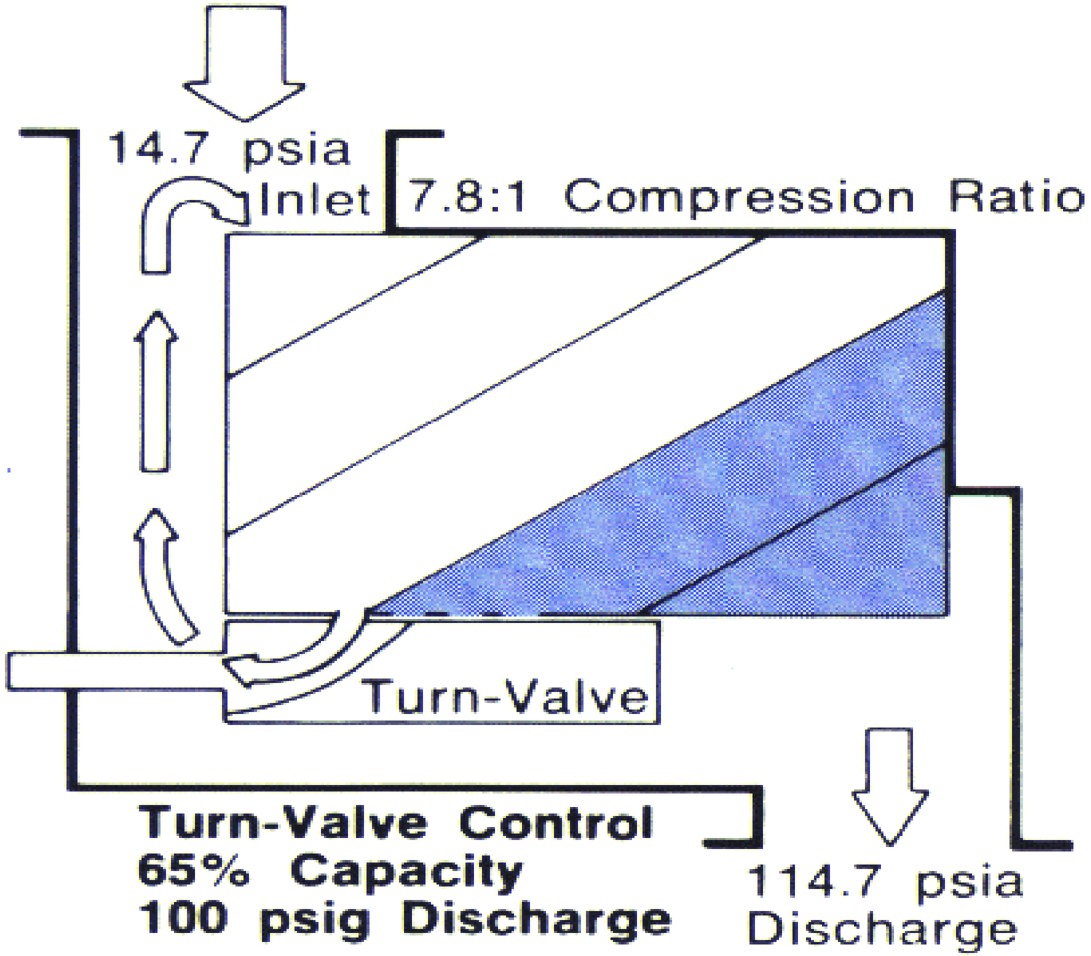
Variable Displacement

- Valves progressively opens ports connecting the compression chamber back to the compressor intake in response to rising discharge pressure. This allows some of the intake air to be returned to the compressor inlet before it gets compressed and uses power
- This progressive opening of by-pass ports has the effect of shortening the length of the rotors after the lobes seal without choking the intake and increasing the compression ratio

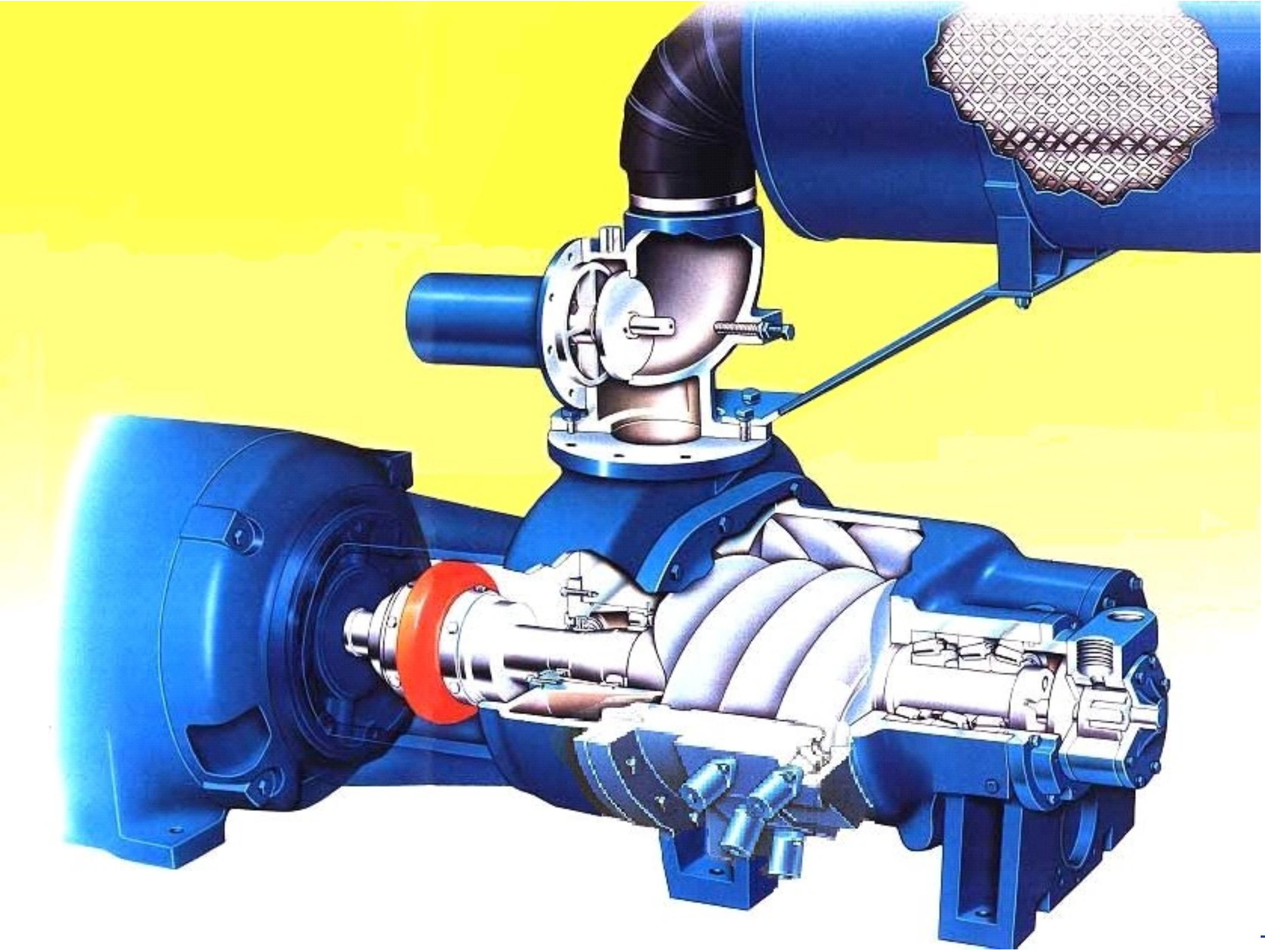
Variable Displacement



Variable Displacement

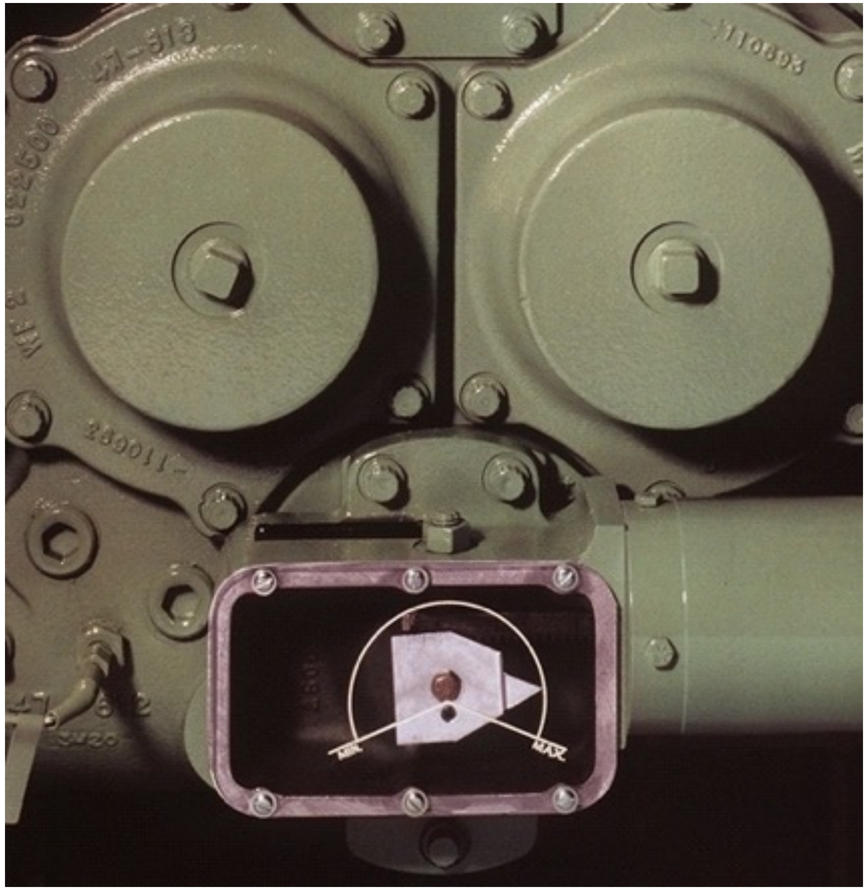


Variable Displacement



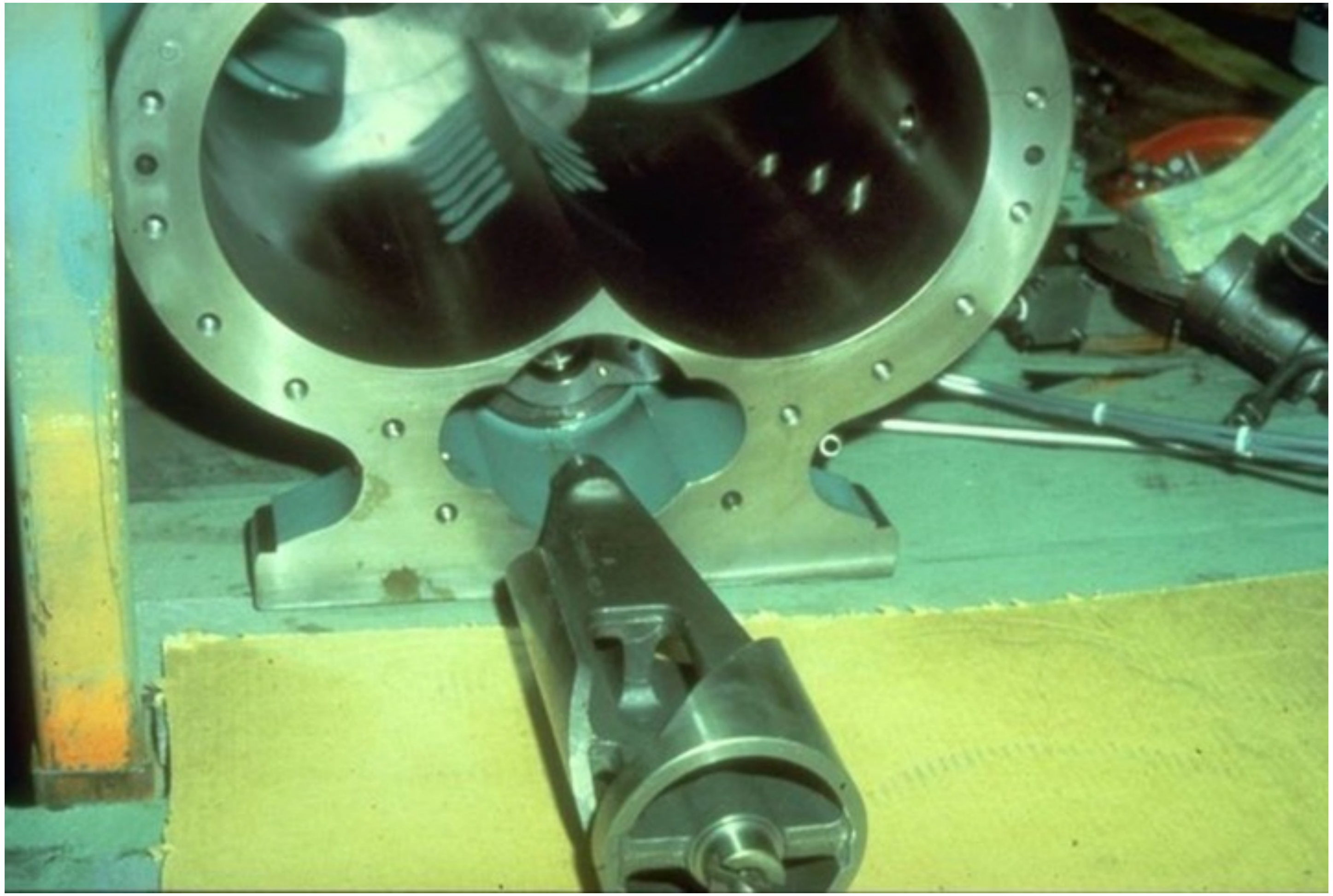
Variable Displacement

Original Version

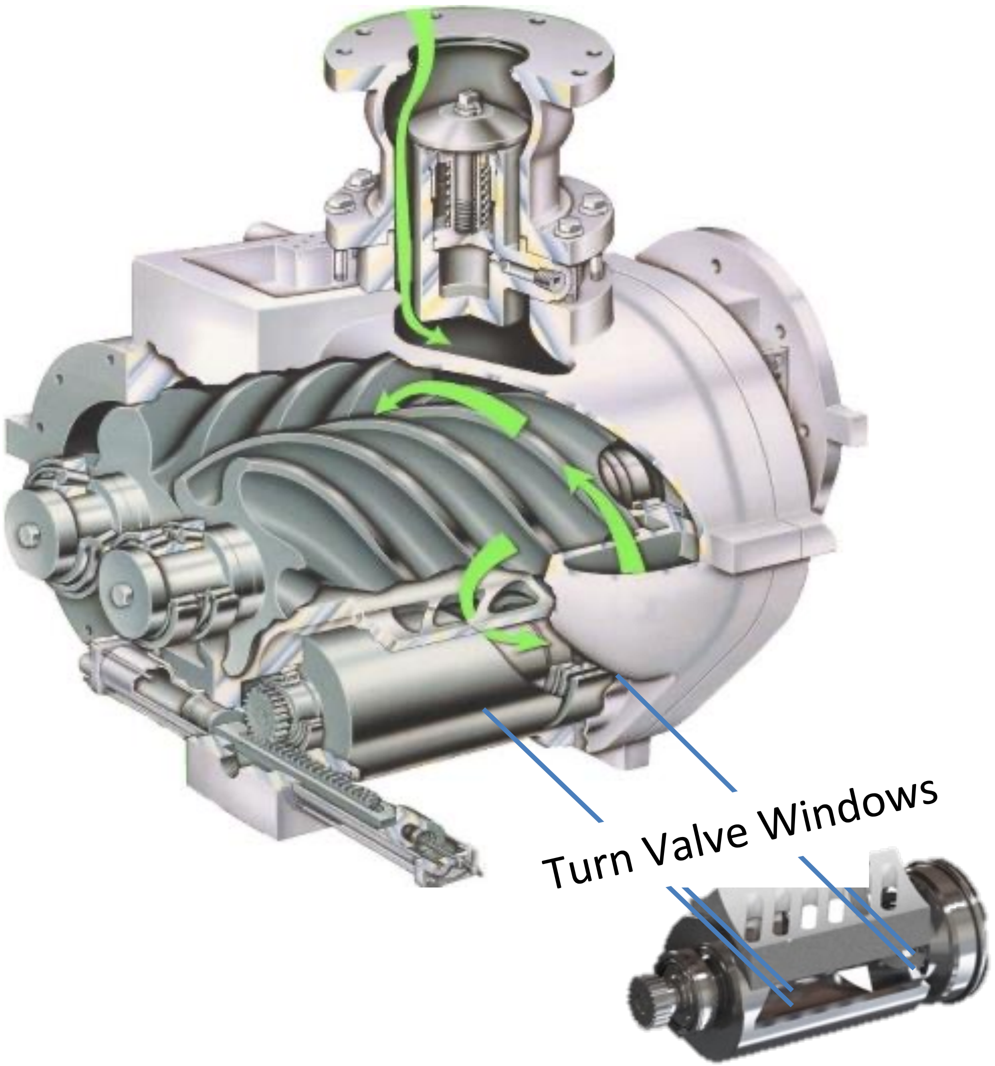


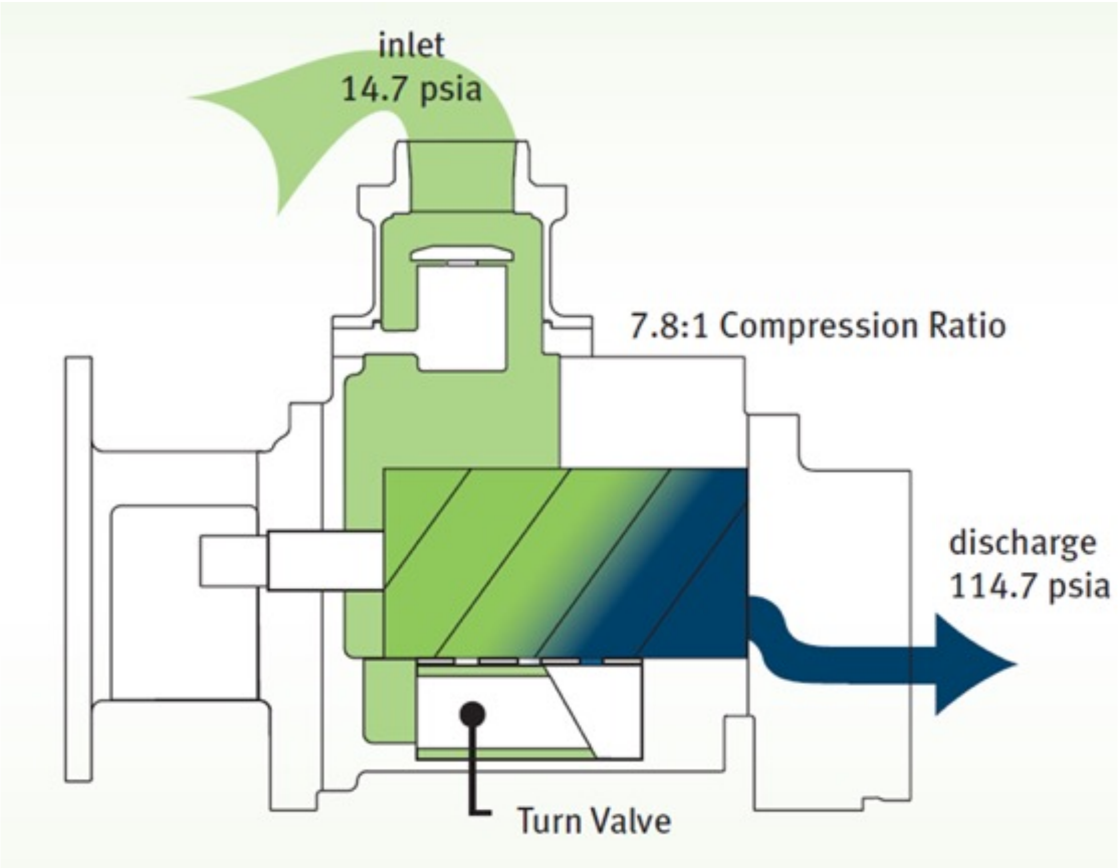
— UP TO 55% TURN DOWN

Variable Displacement

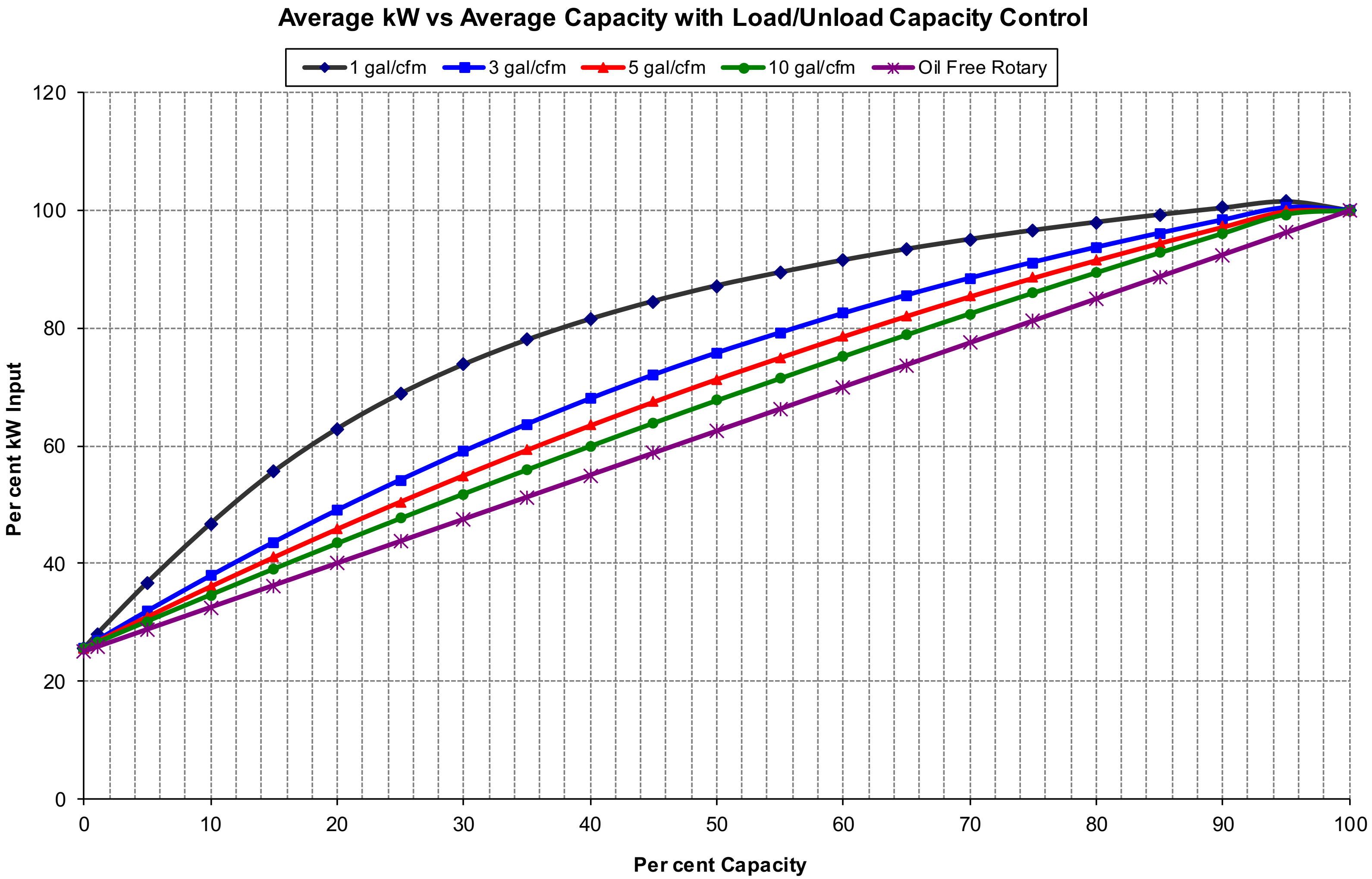


Variable Displacement





Load/No-load Control Curve

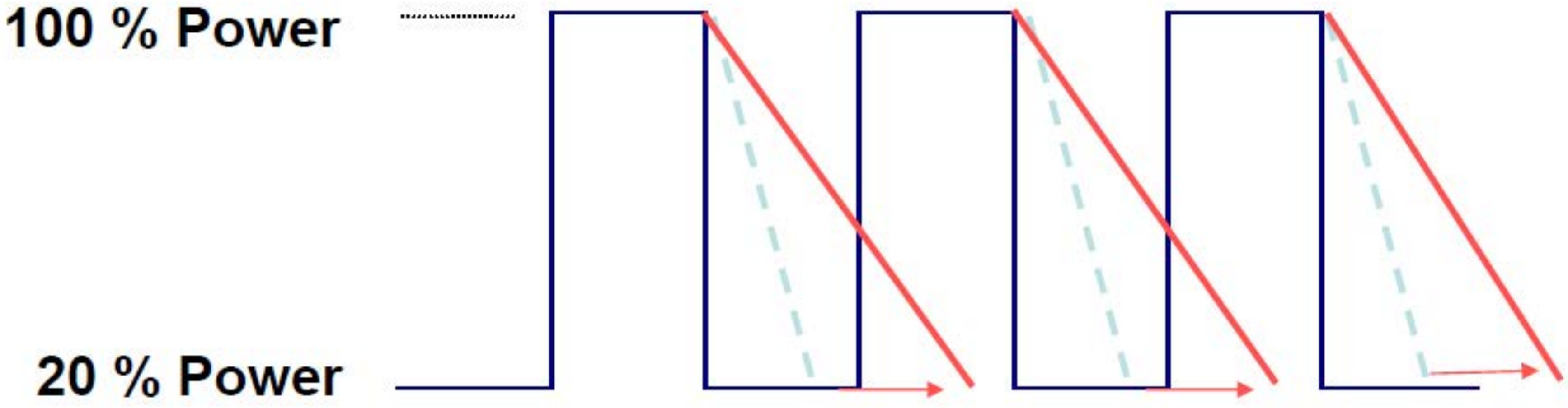


- This graph shows the effect of receiver size on the part load power of a lubricant injected rotary screw compressor with load/unload controls

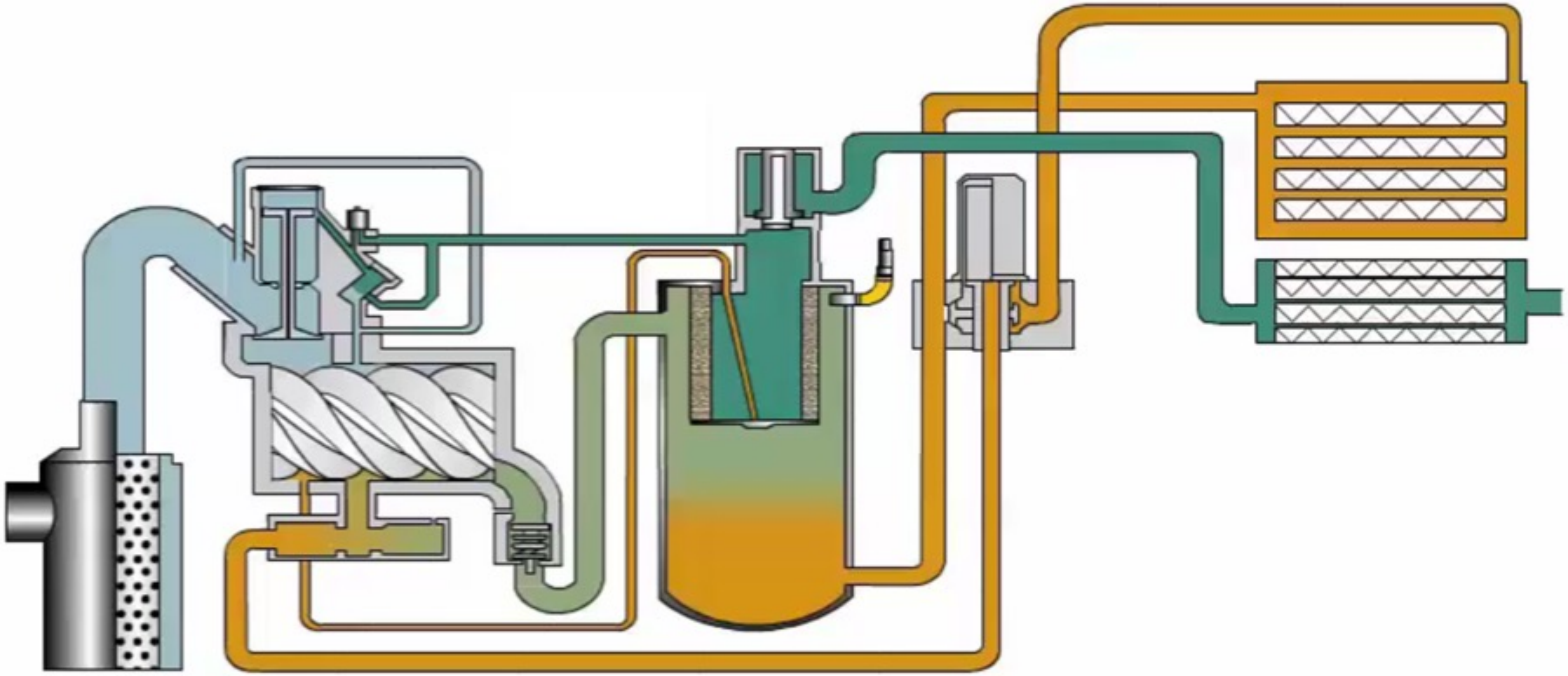
Load/Unload and Storage Size

- It is falsely assumed that a straight line, from full load bhp to unloaded bhp, represents the actual power requirement in this mode of operation.
- Sump blow down times will vary by machine size, but typically this takes in the range of 20 to 60 seconds to prevent foaming of the lubricant with the potential of excessive lubricant carry-over.
- In many cases, the system pressure will fall and the compressor will re-load before the fully unloaded power is realized.

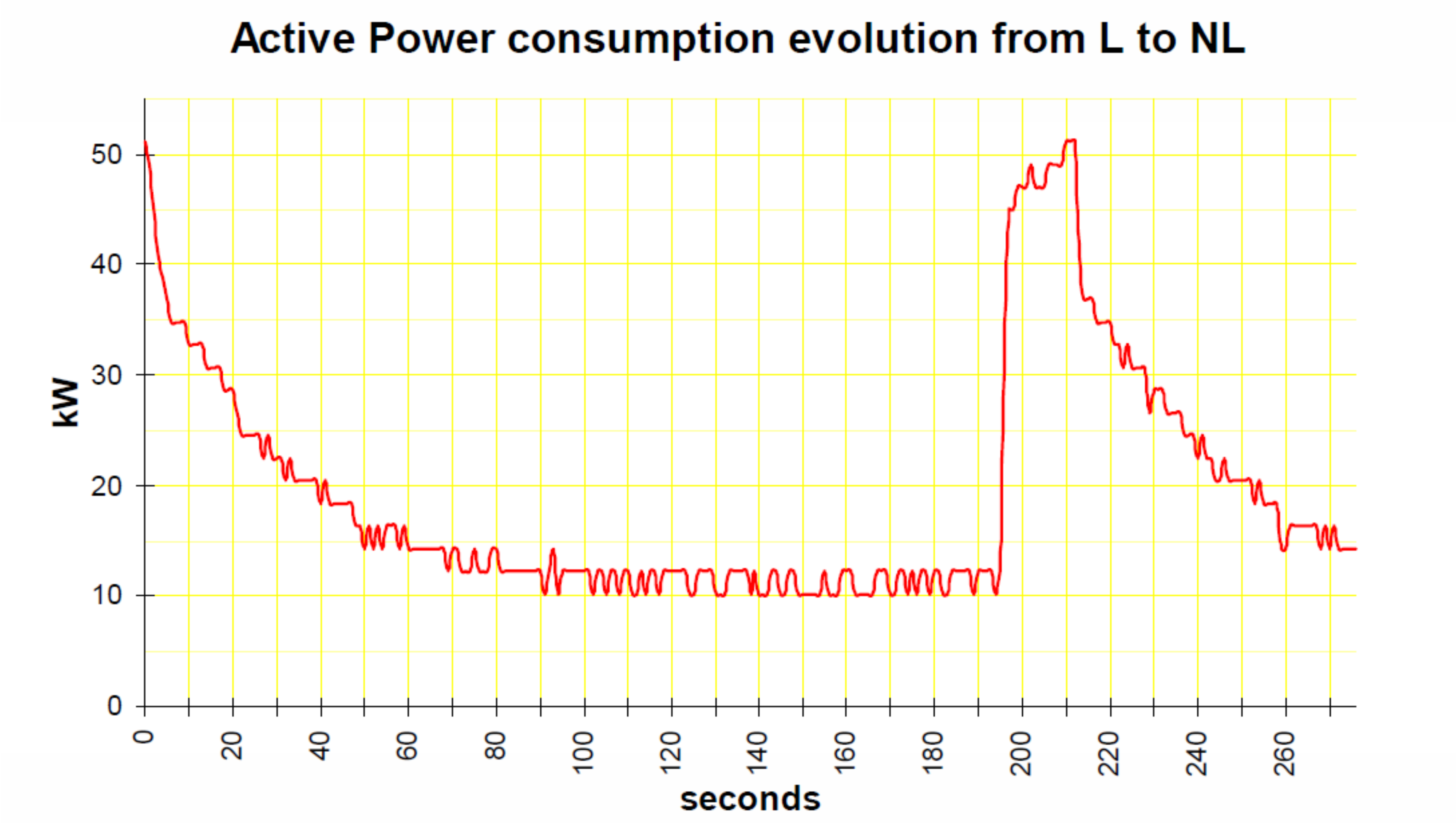
Capacity Control by Load/No-Load



- During blow-off, the compressor is still running against significant back pressure and consuming a lot of power
- Bigger sump vessels lead to longer blow-off times and more energy consumption



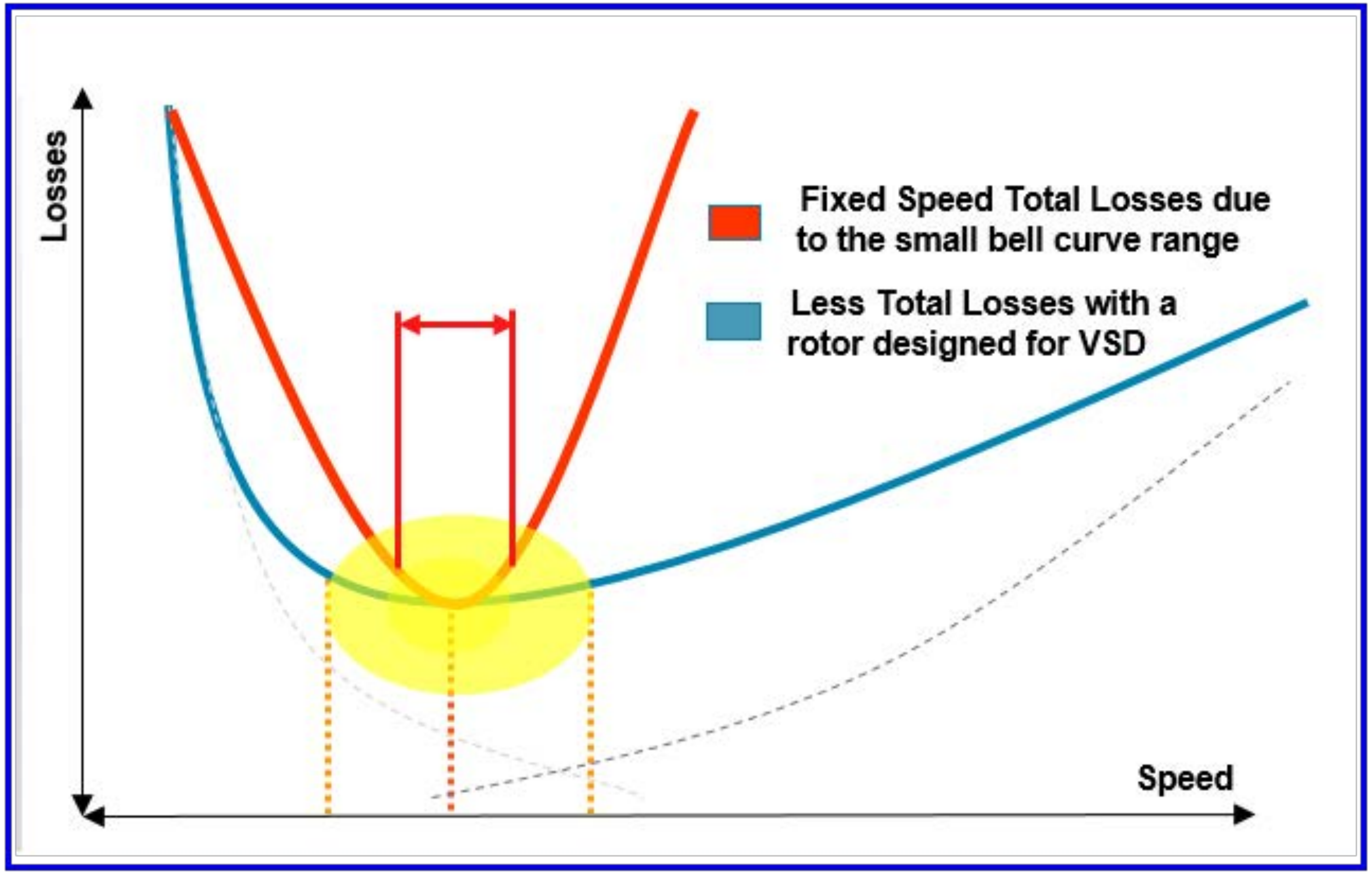
Capacity Control by Load/No-Load



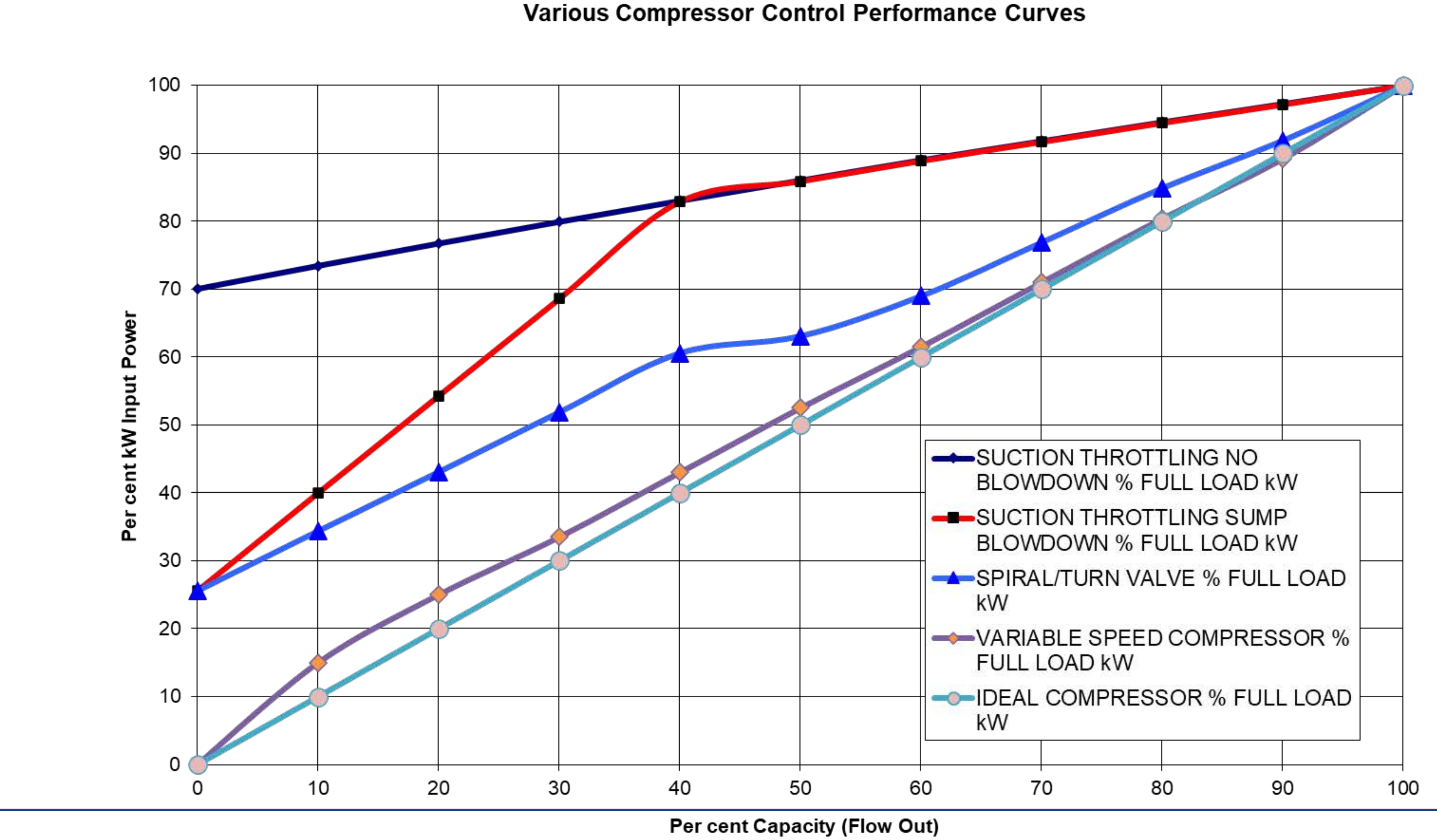
Variable Speed Compressors

- Efficient means of rotary compressor capacity control,
- Integrated variable frequency AC or
- Switched reluctance DC drives.
- Compressor discharge pressure can be held to within +/- 1
- In order to provide efficient VSD regulation over the complete range of the customer’s air profile, the VSD operational flow from min to max, needs to be sized so it will always be in its turndown range.

Variable Speed



Performance Curves



Variable Speed Compressors

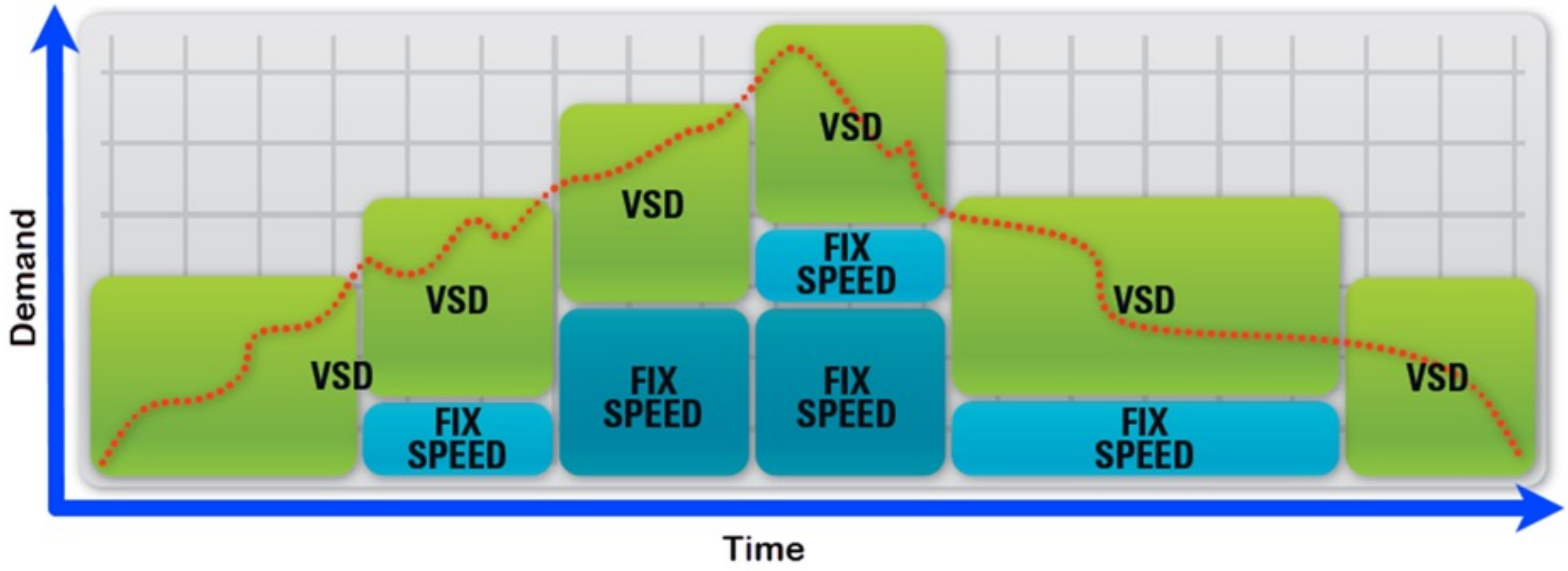
- The most common VSD is the variable frequency drive, which converts 60 Hz alternating current to direct current and then reconverts it to the proper frequency required to turn the drive motor at the desired speed.
- The variable frequency drive is less efficient at full load compared to modulation controls because the electrical conversions usually consume an additional two to four percent more energy.

Variable Speed Compressors

- VSD (variable speed drive) and VFD (variable frequency drive) are used interchangeably
- VFD is only one of the VSD technologies available.

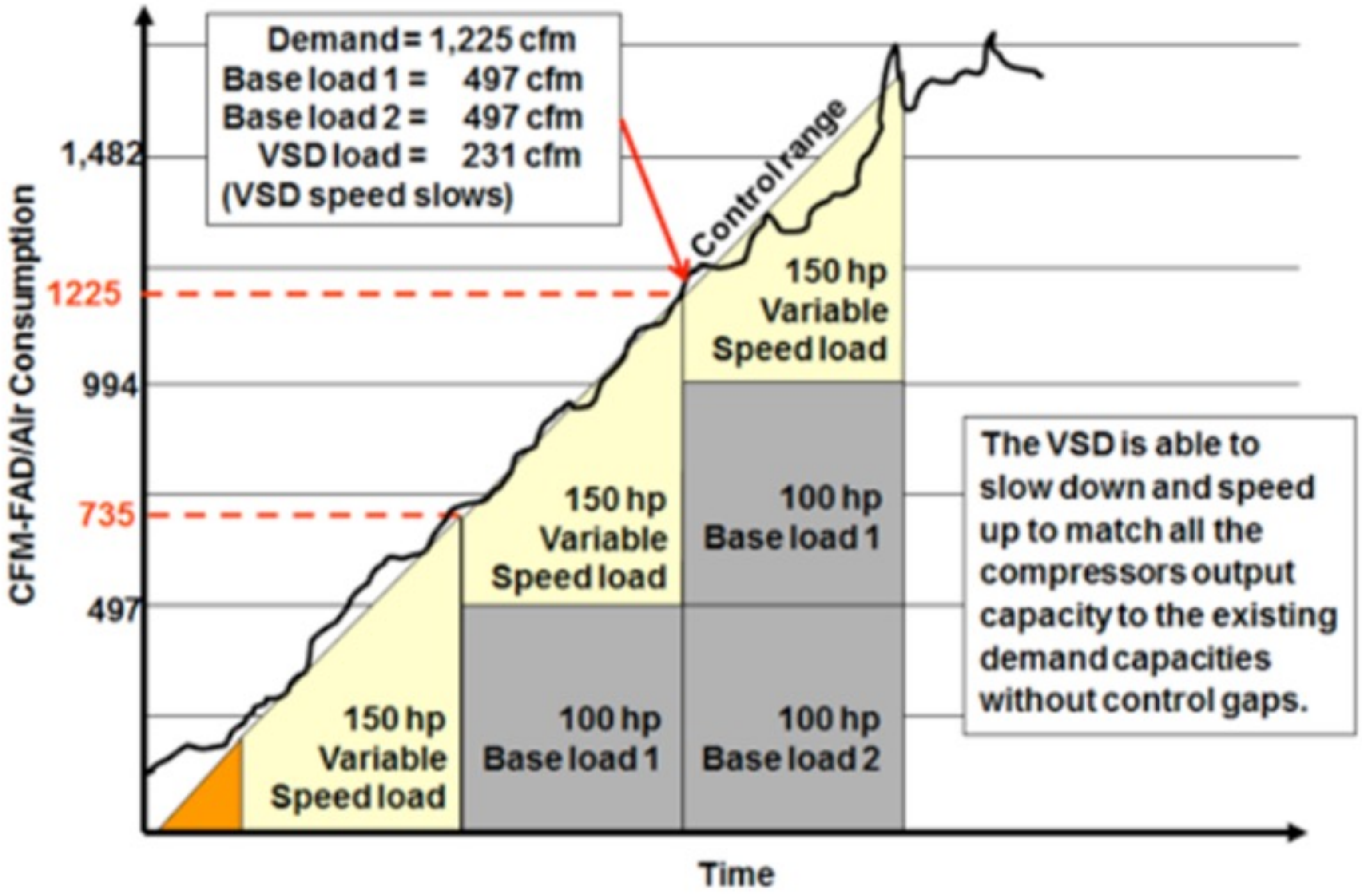
Variable Speed Compressors

- 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

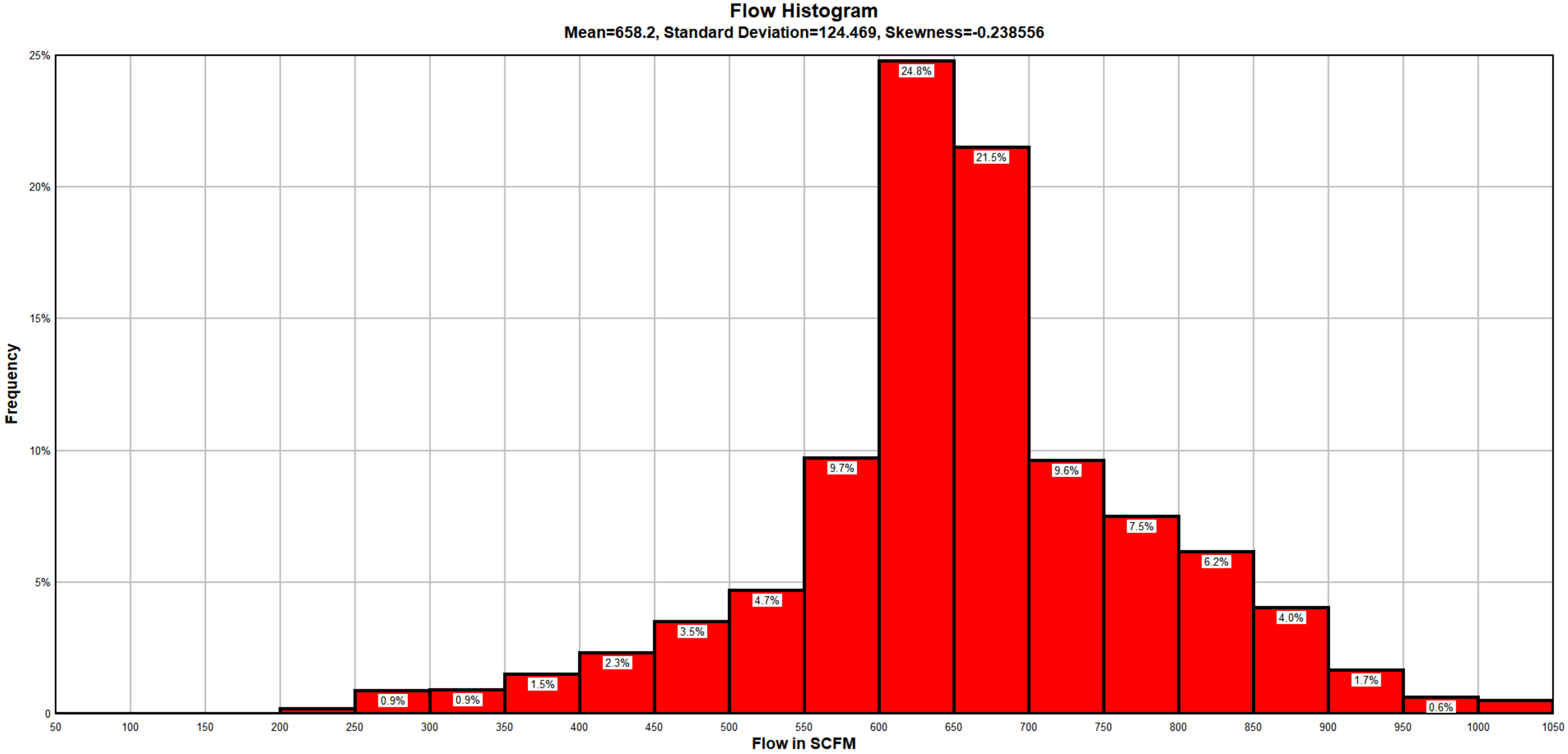


Variable Speed Compressors and Control Gap

This system can provide a steady operating pressure throughout the flow range of the system as long as the system is properly controlled with a master controller.



How do I know my flow patterns to size a VSD Correctly?



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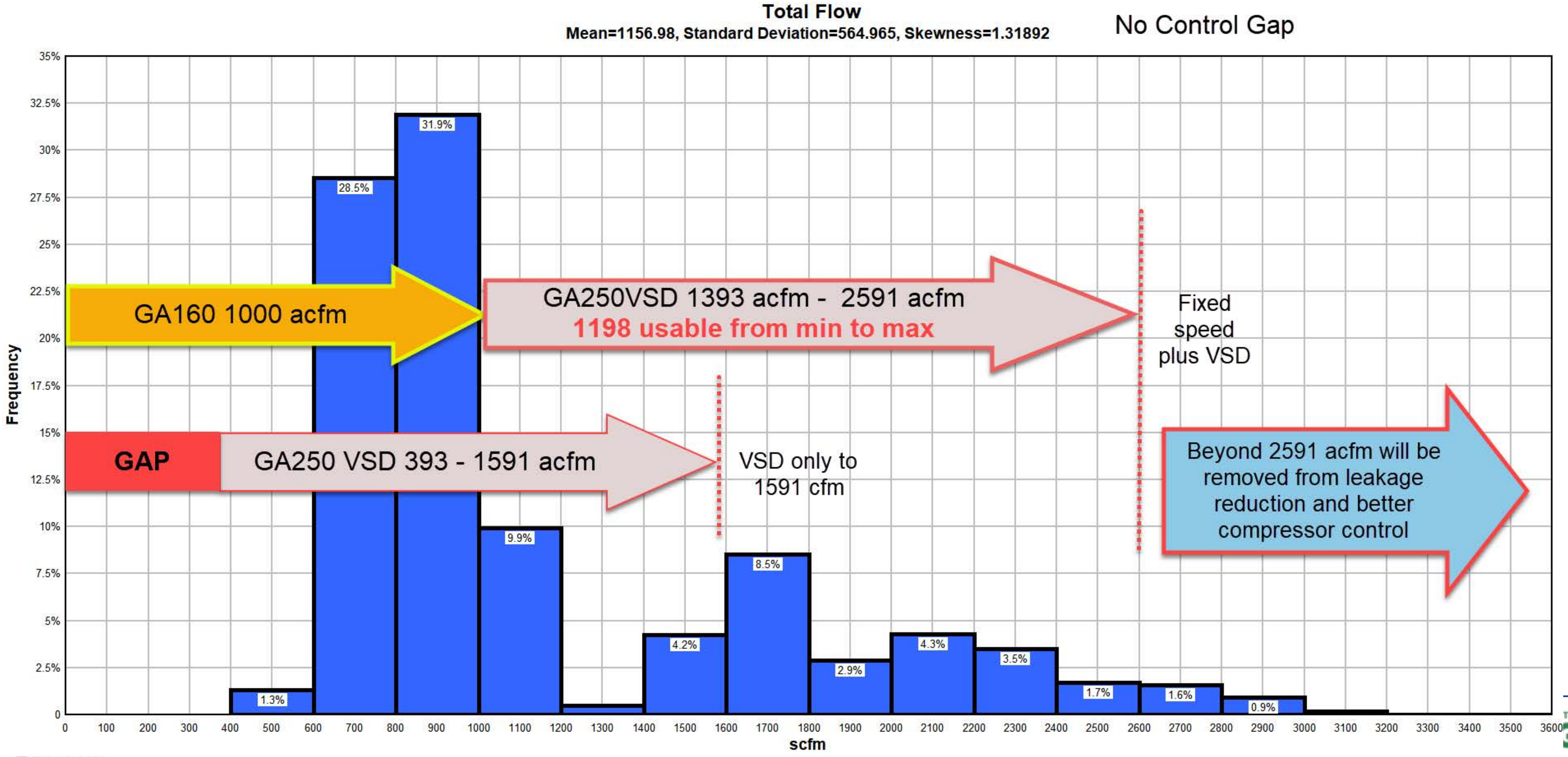

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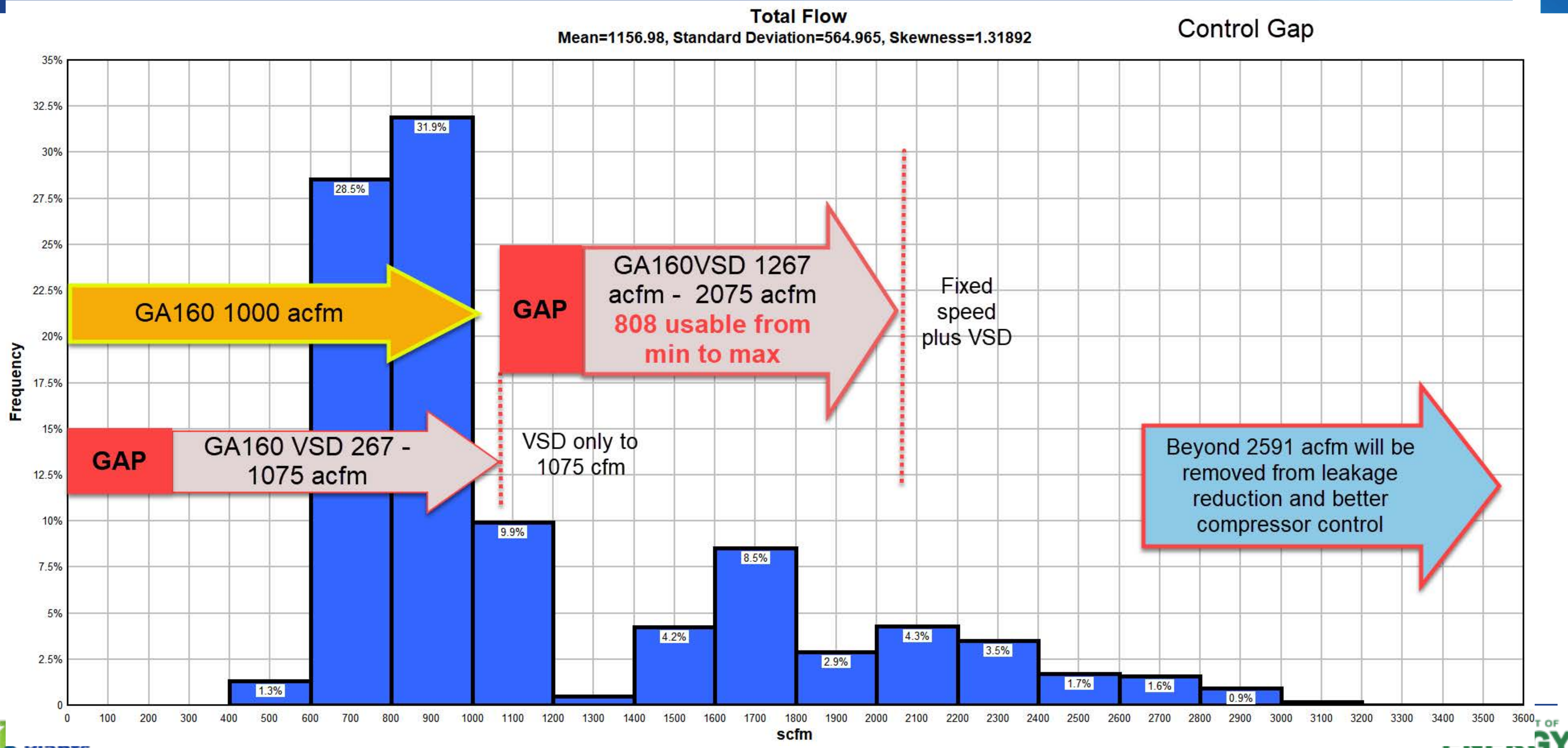

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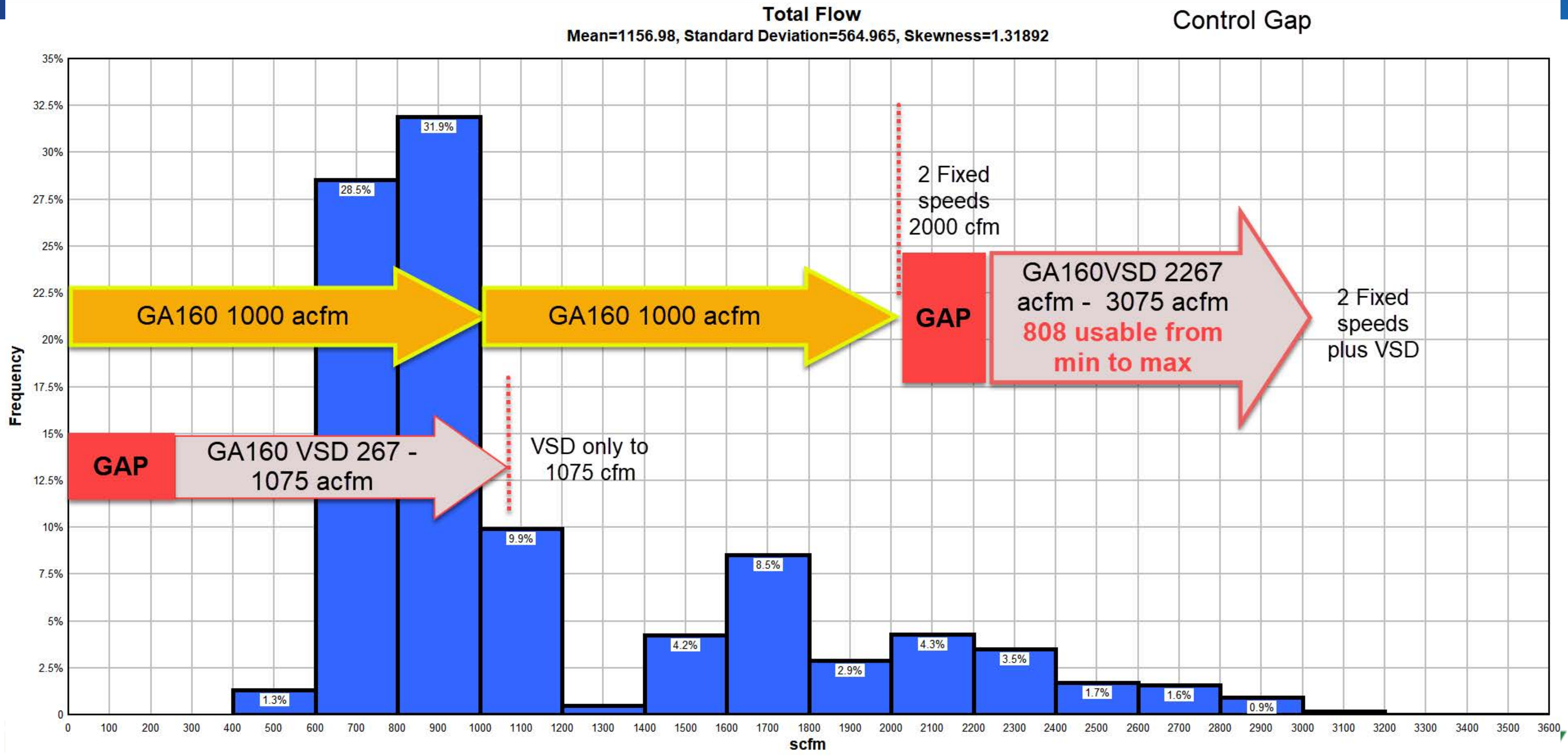
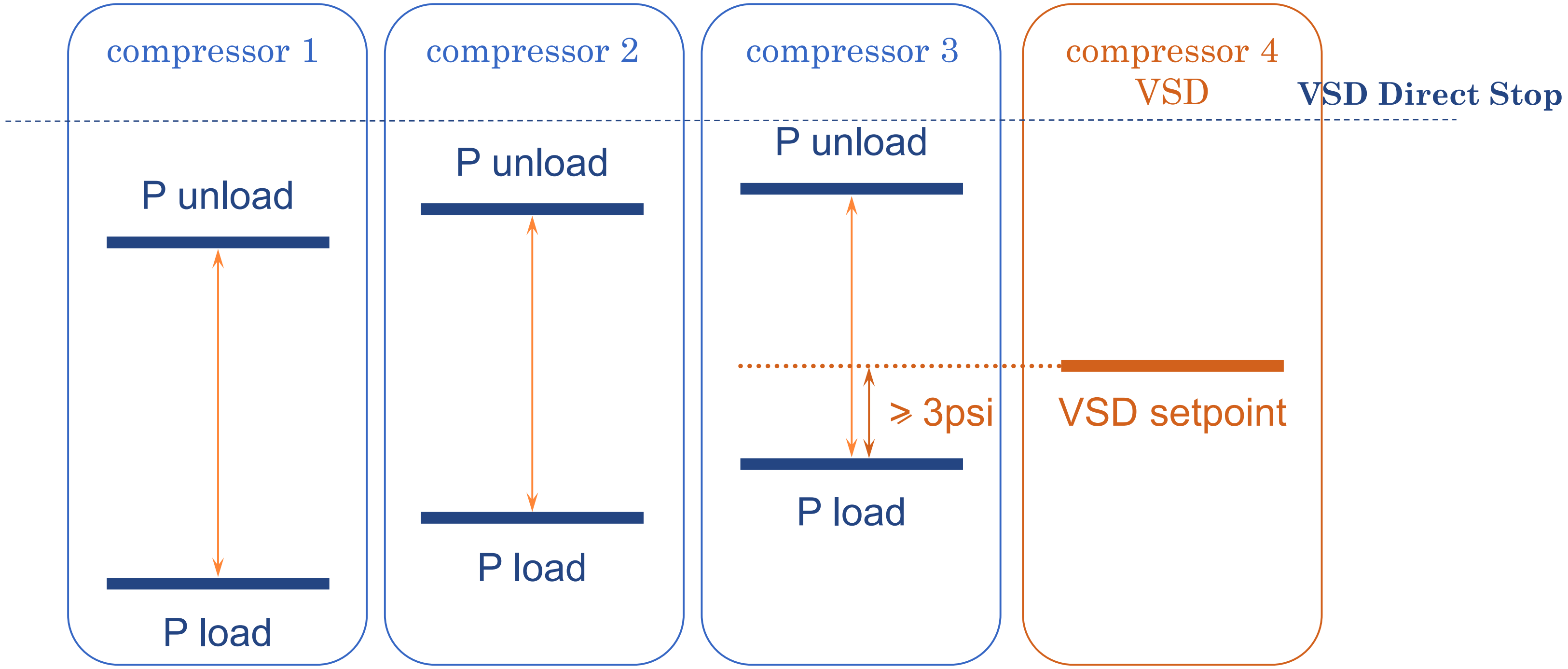


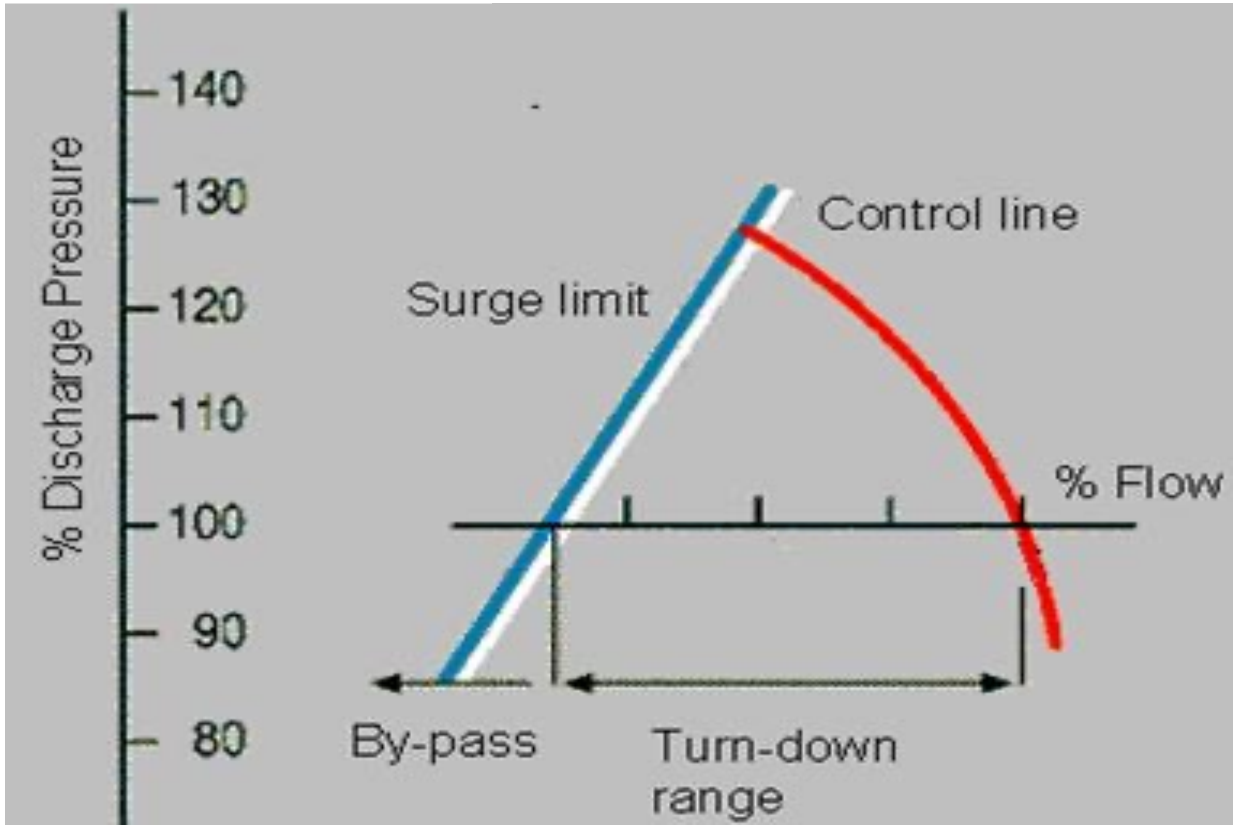
Control Gap and Position

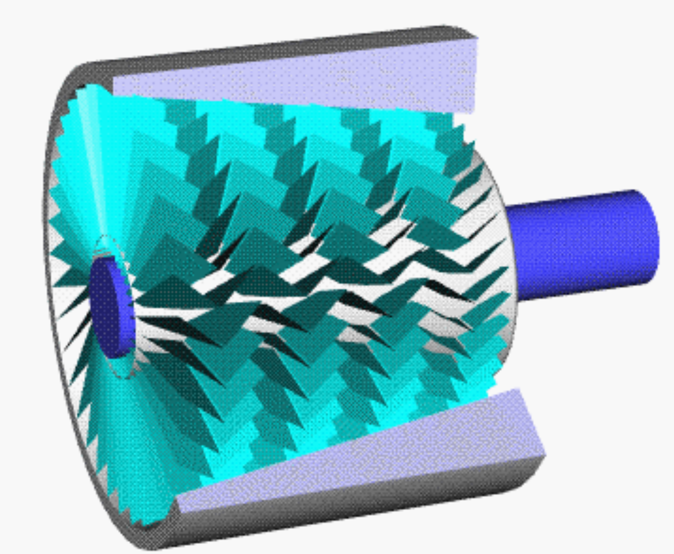
- In order to provide efficient VSD regulation over the complete range of the customer's air profile, the cfm of the VSD needs to be greater than the load/no load machine



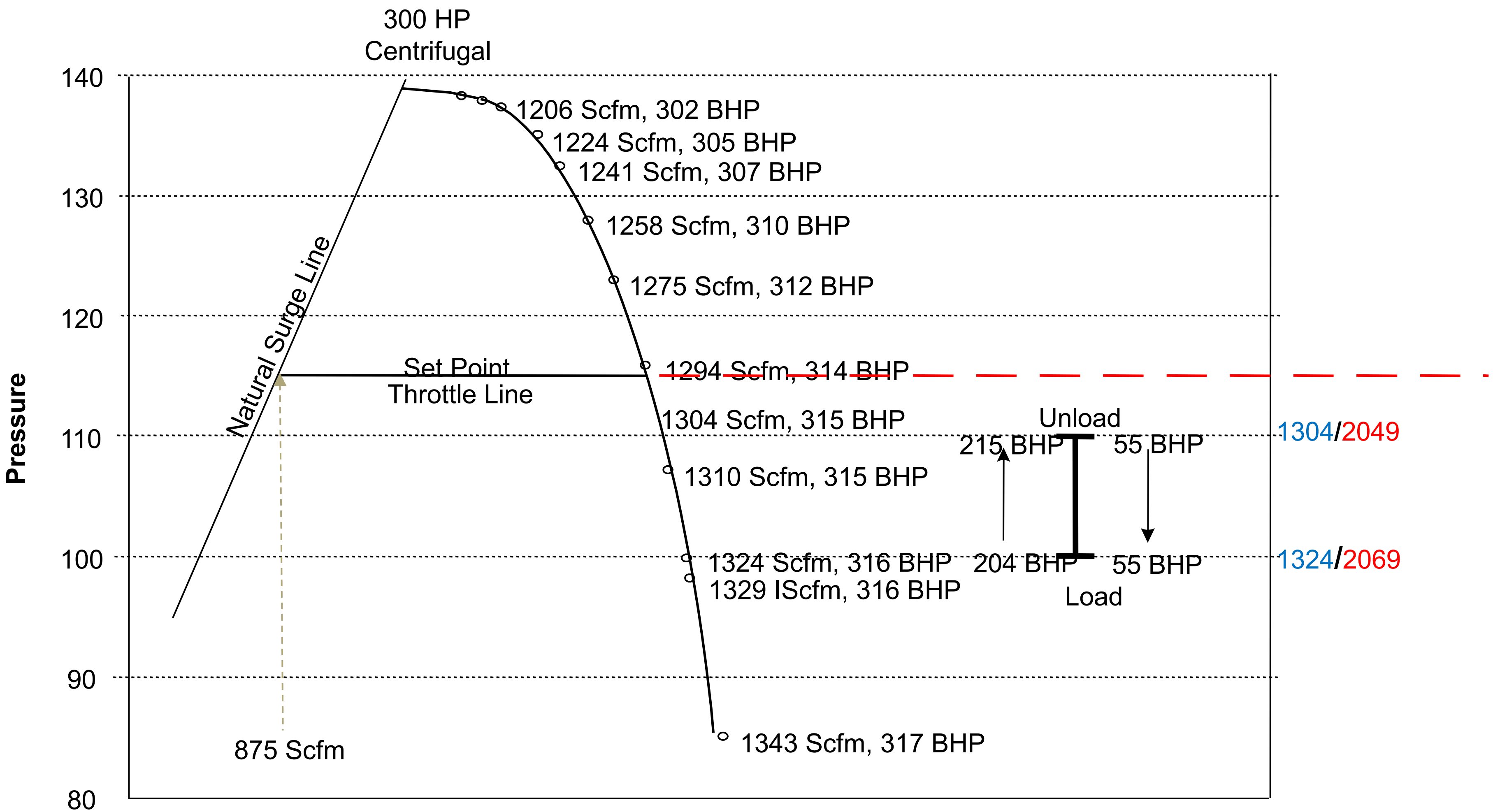
Centrifugal Compressor Control

- Performance is affected by inlet conditions and cooling water temperature
- Characteristic curve is determined by impeller design
- Two conditions should be avoided:
  - Surge (flow reversal)
  - Choke (excessive flow vs. frame design)
- Inlet throttle valves modulate the compressor to reduced flow and power but are limited by surge condition
- Blow-off valves control capacity below throttling limit

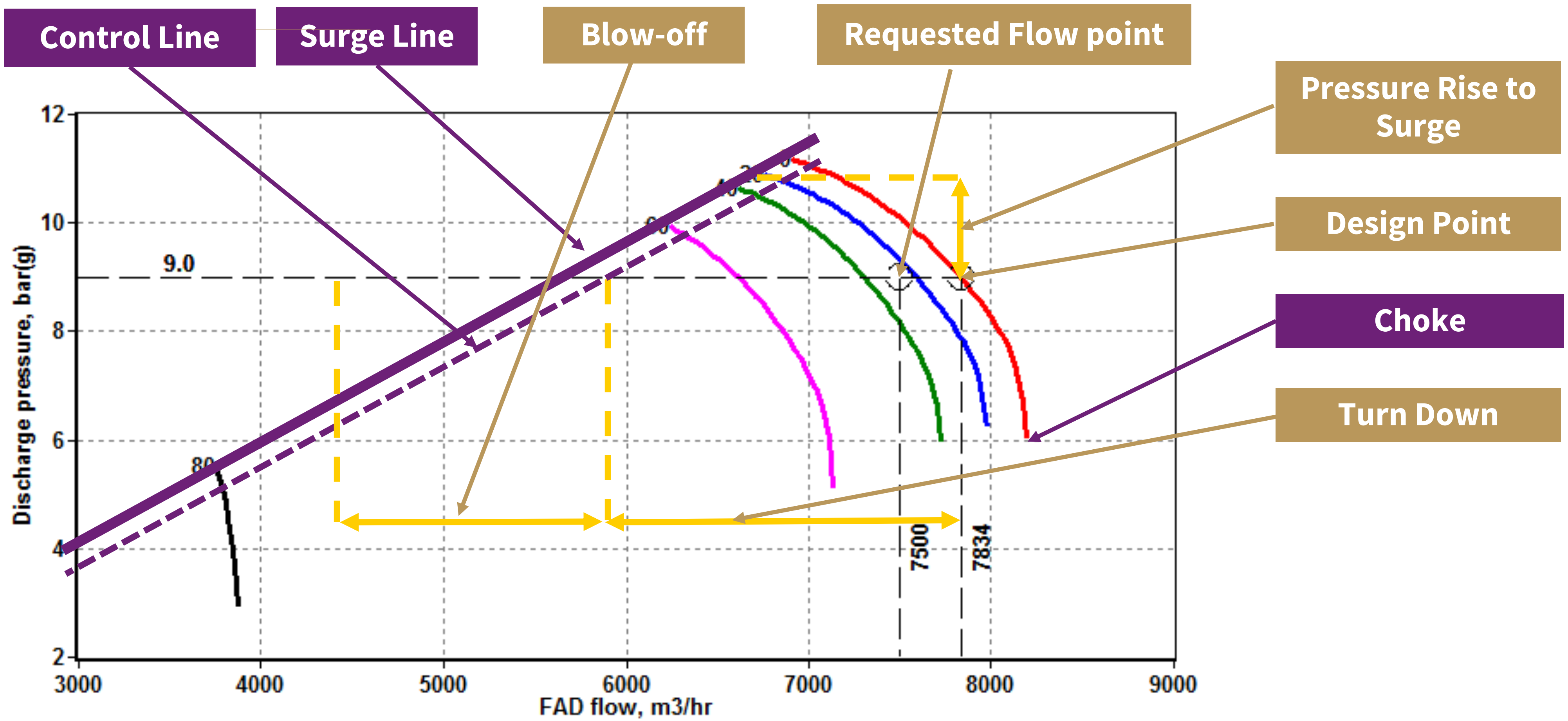

% Discharge Pressure
140
130
120
110
100
90
80
Control line
Surge limit
% Flow
By-pass
Turn-down
range



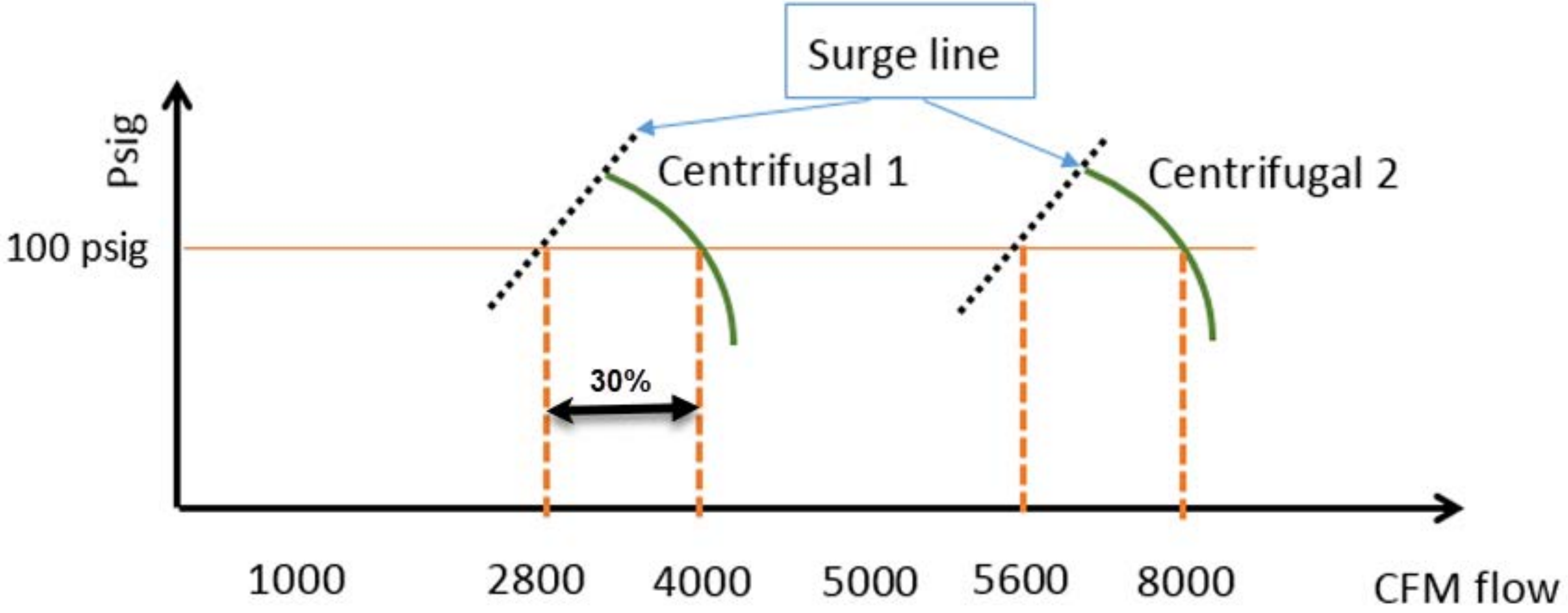
Building the Profile



Centrifugal Compressor Control Common Terms

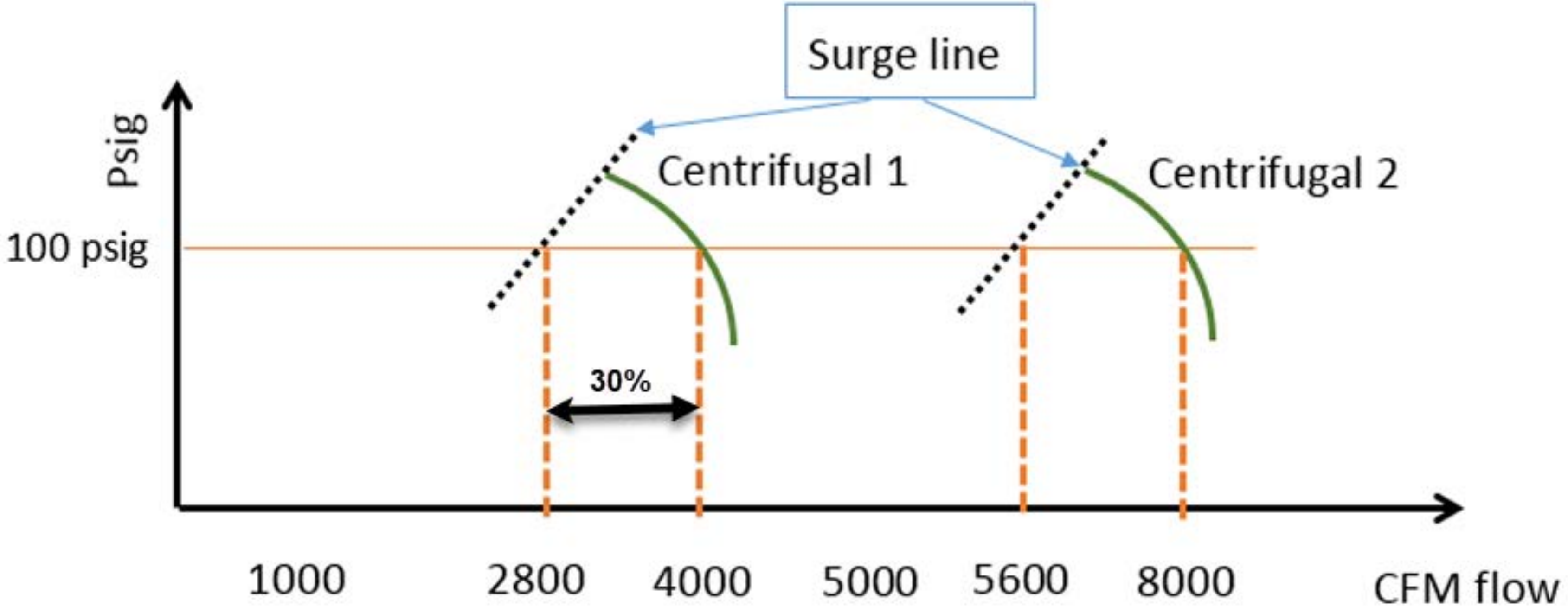


How do I know how to size Centrifugal to my flow Patterns?



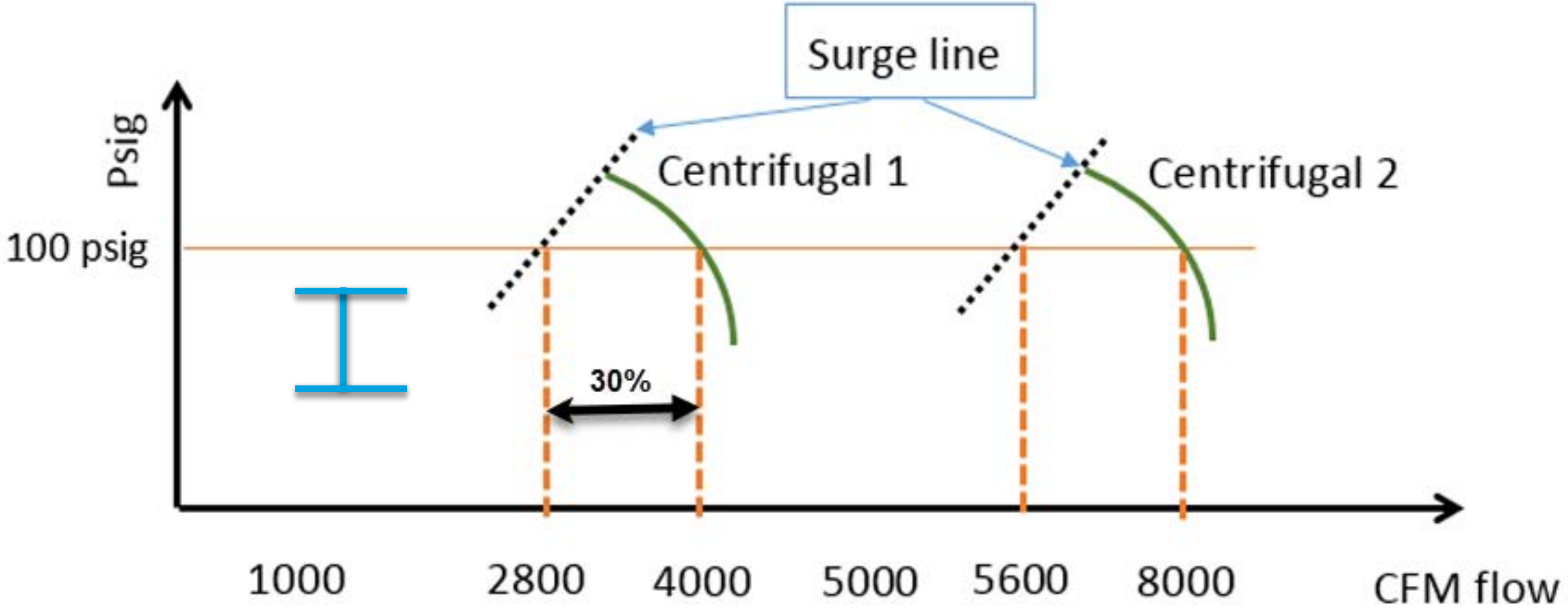
- Plant has 8000 cfm peak demand, 5800 cfm average demand, and 3000 cfm minimum demand during weekends at operating pressure of 100 psig.
- Two 4000 cfm centrifugals with a 30% turndown to 2800 cfm

How do I know how to size Centrifugal to my flow Patterns?



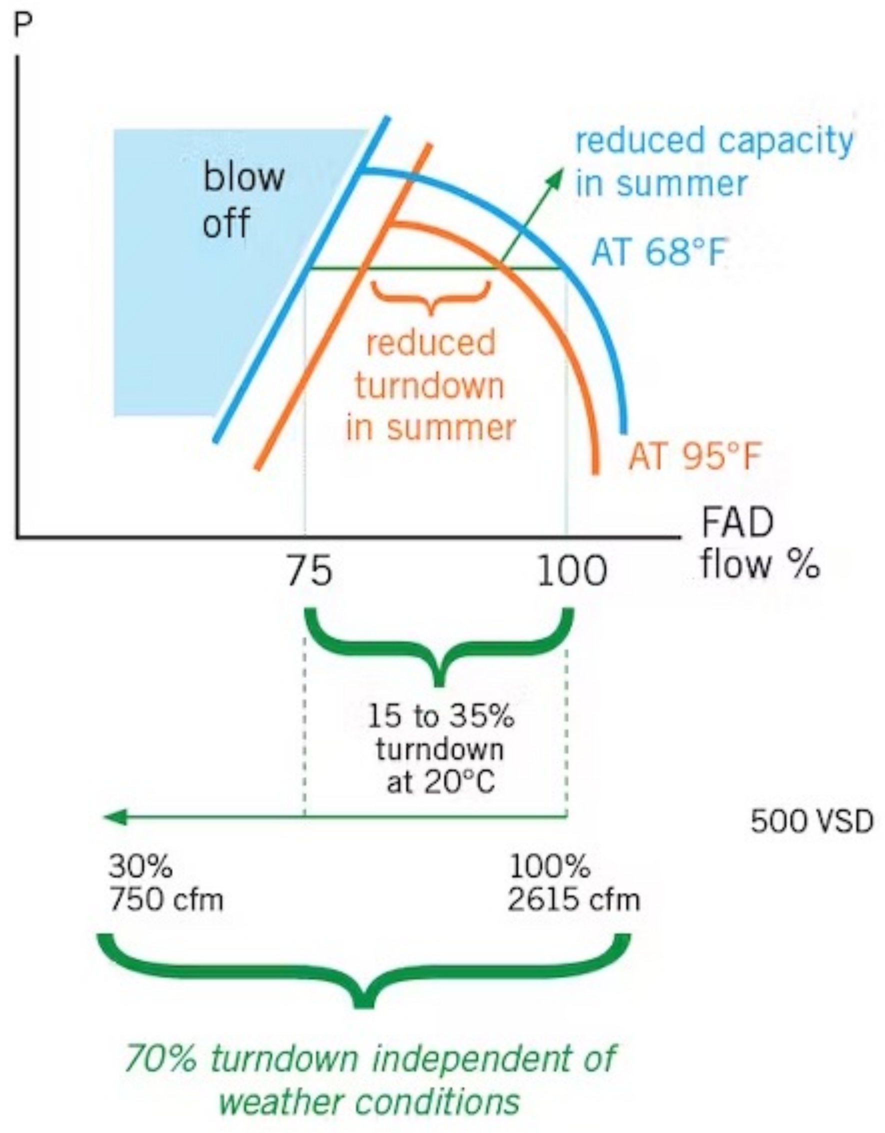
- During peak demand of 8000 cfm, both compressors will run at full load.
- When the flow demand is reduced to the average demand of 5800 cfm, the two centrifugal compressors will close the inlet guide valve and run in its turndown range without exhausting any compressed air to atmosphere.

How do I know how to size Centrifugal to my flow Patterns?



- During the weekend, when the demand reaches to minimum flow of 3000 cfm, one centrifugal compressor will stop and only one compressor will run in its turndown range.
- With this combination, the centrifugal compressors will work most efficiently and save a plant significant energy.
- If flow drops below min flow of the centrifugal, a rotary screw can be added to assist with keeping the plant operating and allowing the centrifugal to stay out of blow down.

How do I know how to size Centrifugal to my flow Patterns?

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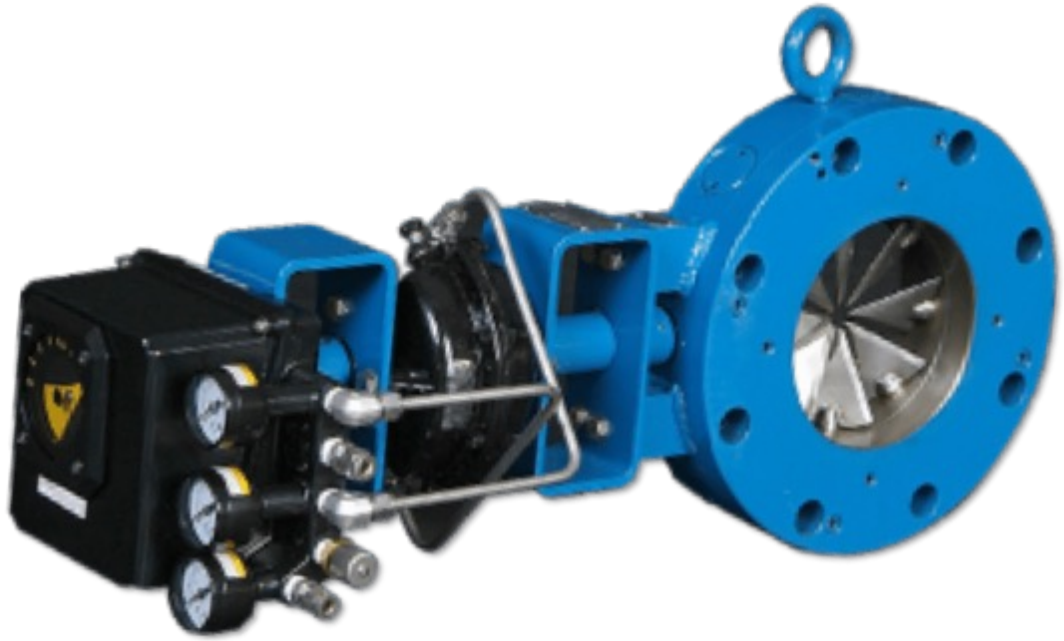
Inlet Guide Vanes - Open

Inlet Guide Vanes - Closed

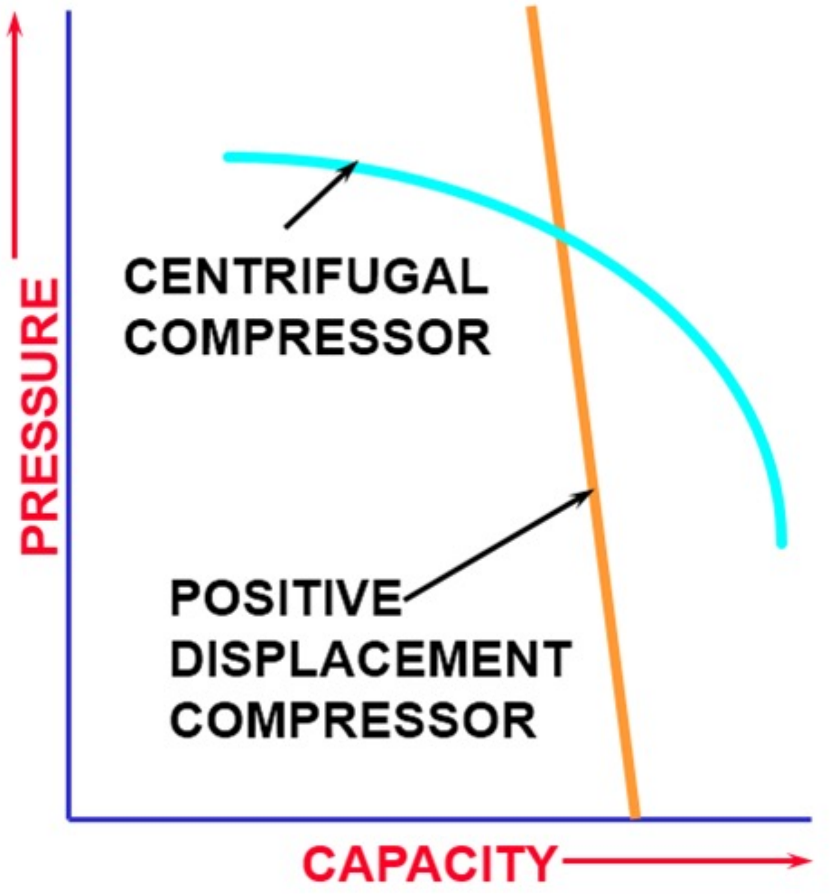
Inlet Guide Vanes



- This valve positioner consists of a common housing that contains a 4 – 20 mA current to pressure (I/P) transducer that controls the attached pilot valve operated air to actuator assembly.
- The positioner will output 0 to 65 psi (448 kPa) to the actuator from an air signal.
- The air signal provided by the positioner is proportional to the microcontroller 4 – 20 mA output.
- The actuator provides the power to drive the valve open or closed in proportion to the microprocessor output control signal.

Centrifugal Compressor Control

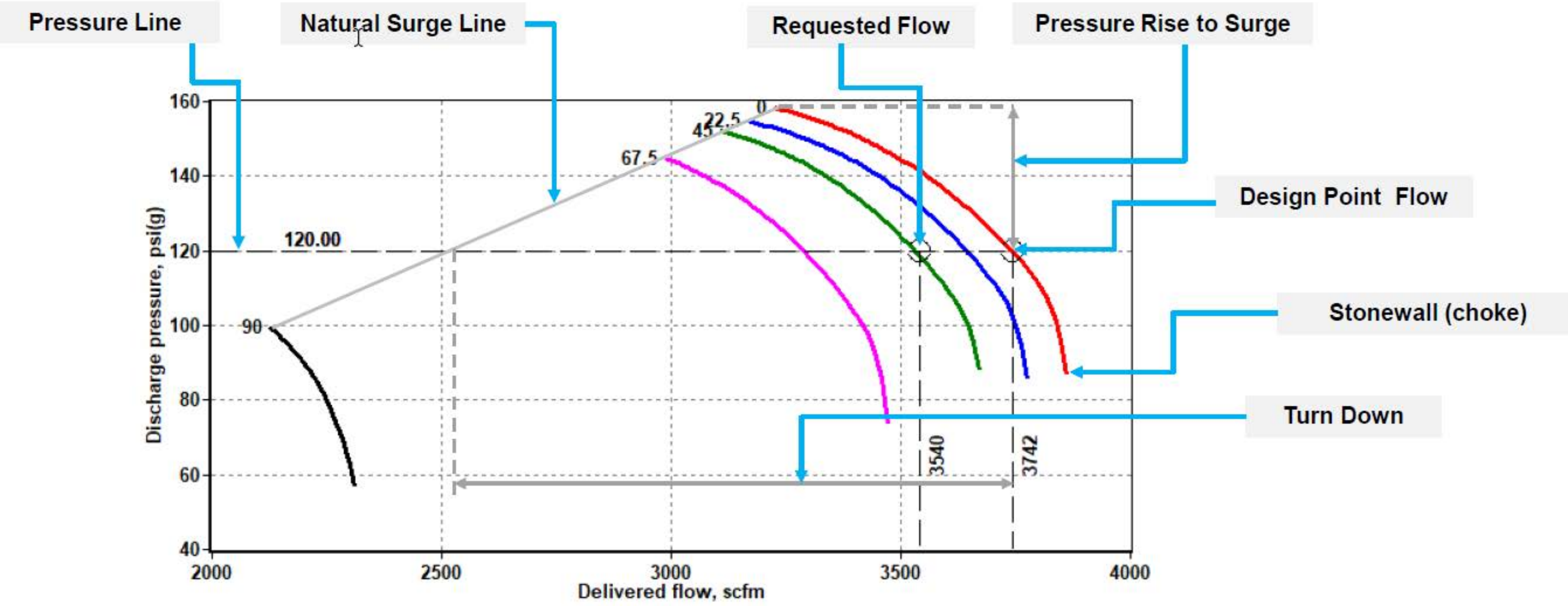
The relationship of flow and pressure for dynamic compressors is different from that of positive displacement machines.



Effects on dynamic compressor performance

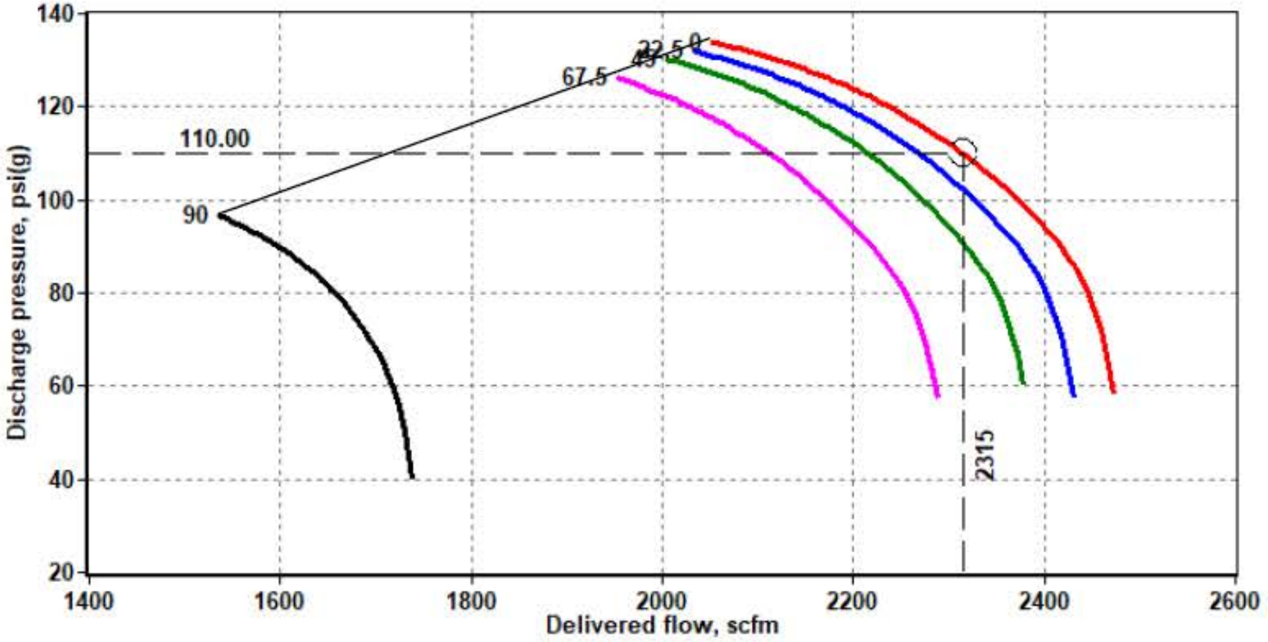
- Inlet pressure
- Inlet air temperature
- Cooling water temperature

Centrifugal Performance



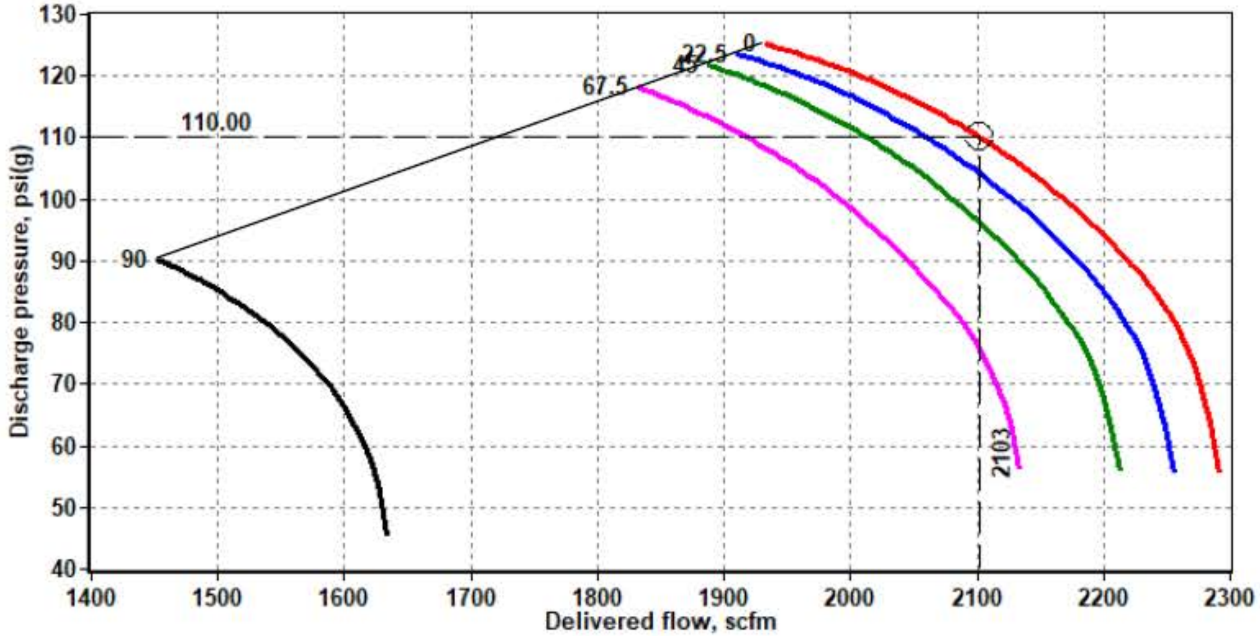
INLET TEMPERATURE CHANGE – EFFECT ON AIR OUTPUT

Capacity at 95⁰F inlet Temp



2,315 scfm, 497.75 HP, 24 psi rise to surge

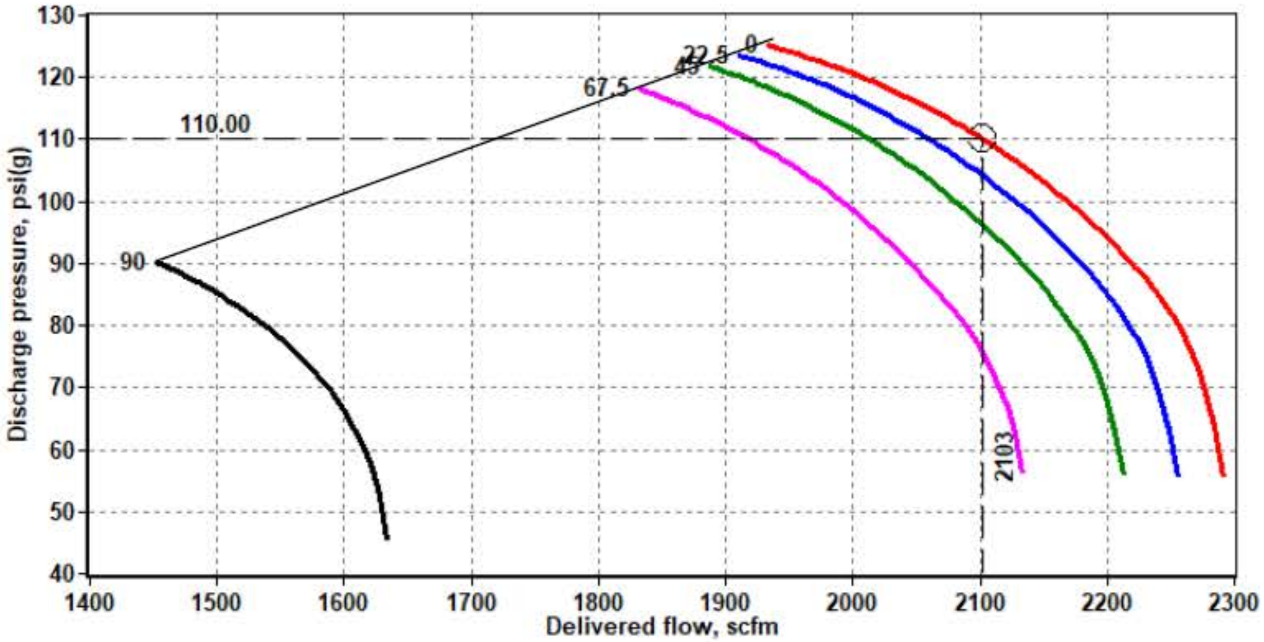
Capacity at 119⁰F inlet Temp



2,103 scfm, 467.74 HP, 15 psi rise to surge

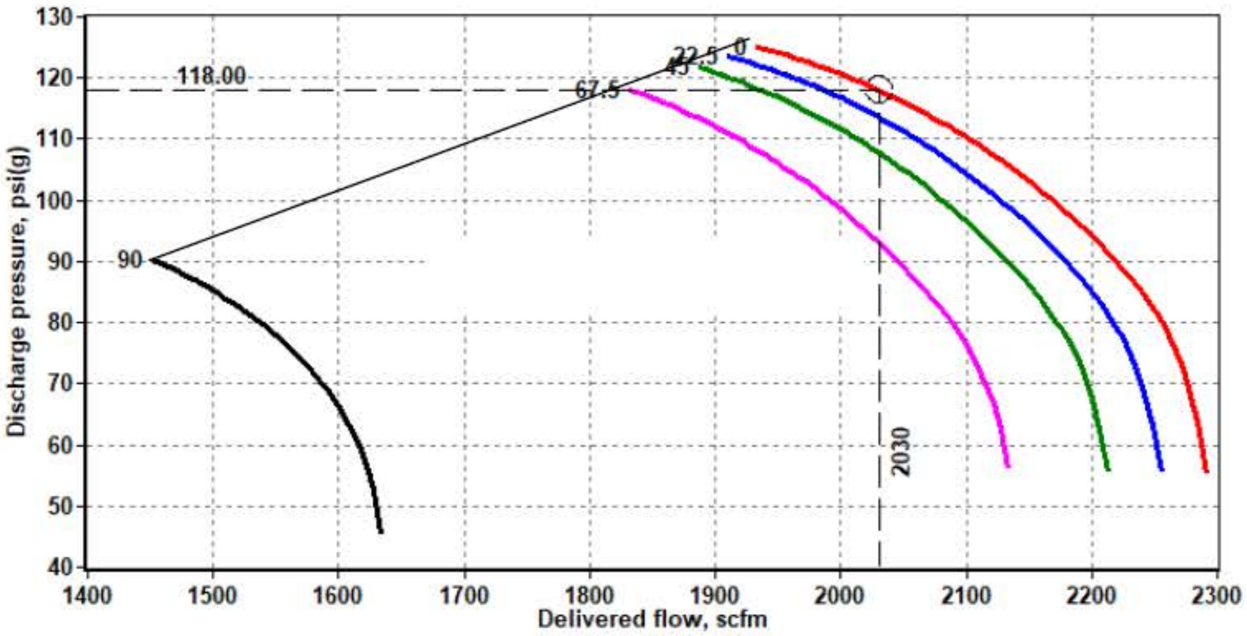
DISCHARGE PRESSURE CHANGE – EFFECT ON AIR OUTPUT

Capacity at 110 psig discharge pressure



2,103 scfm, 467.74 HP, 15 psi rise to surge

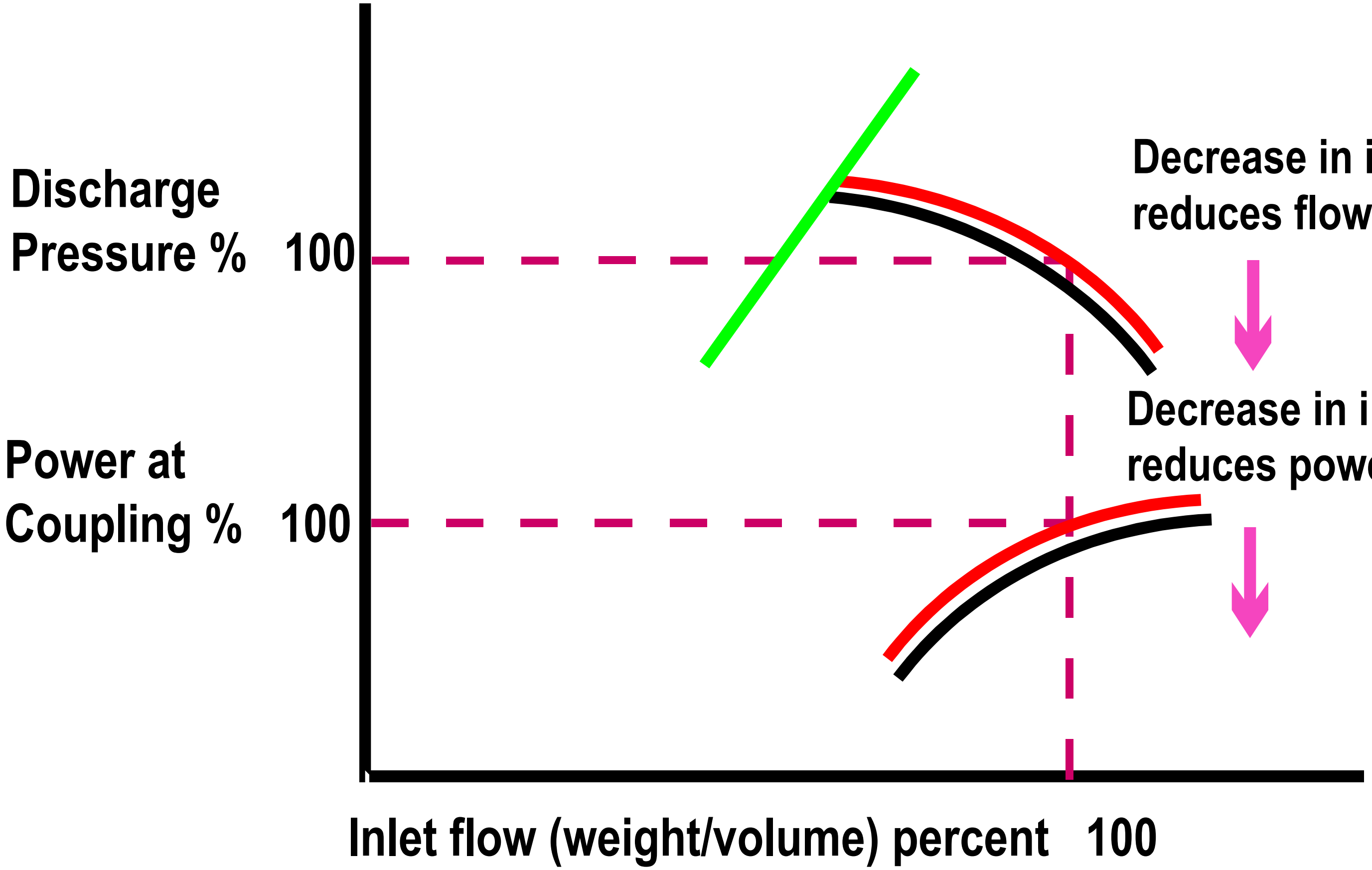
Capacity at 118 psig discharge pressure



2,030 scfm, 464.94 HP, 7 psi rise to surge

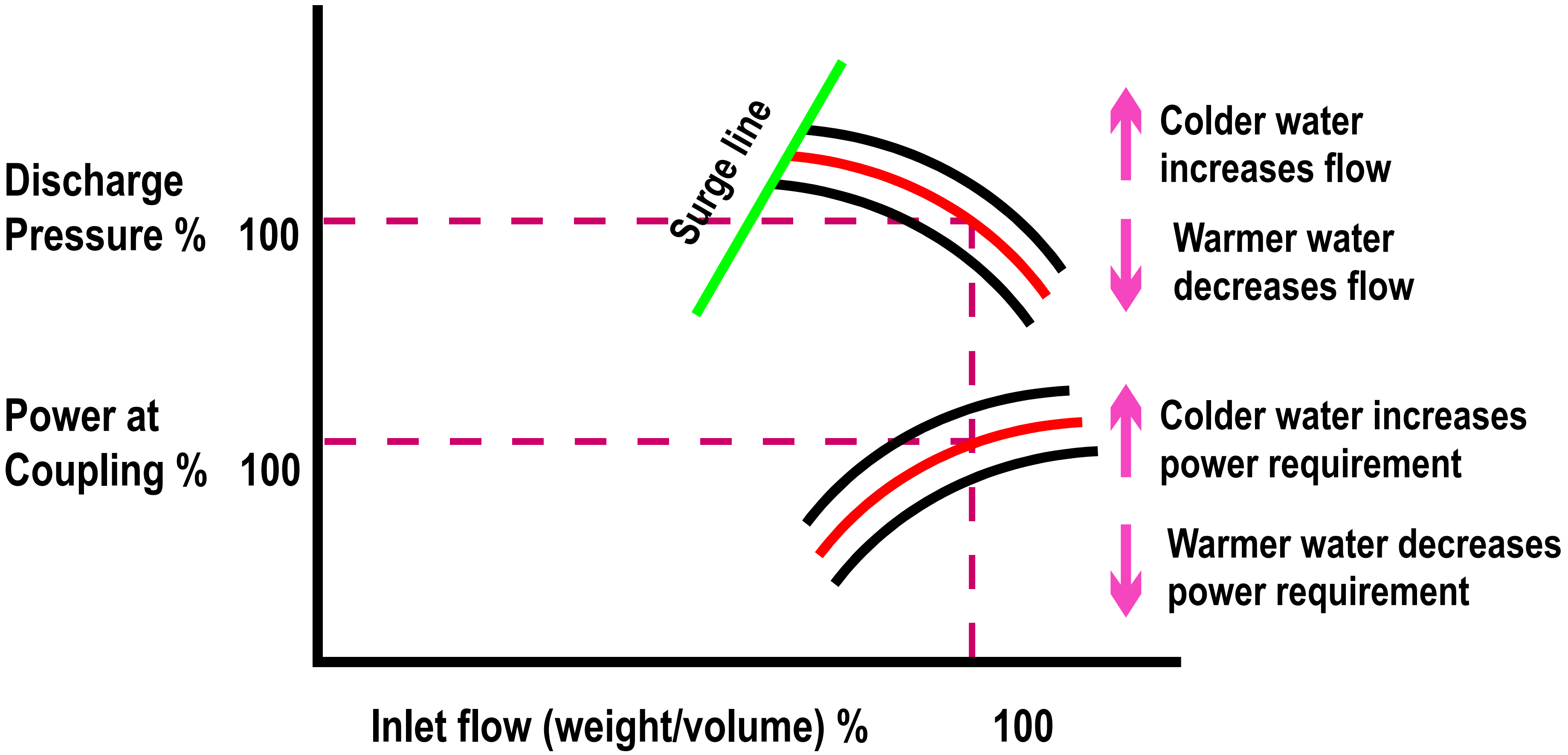
Inlet Pressure Effects On Dynamic Compressor Performance

Inlet pressure



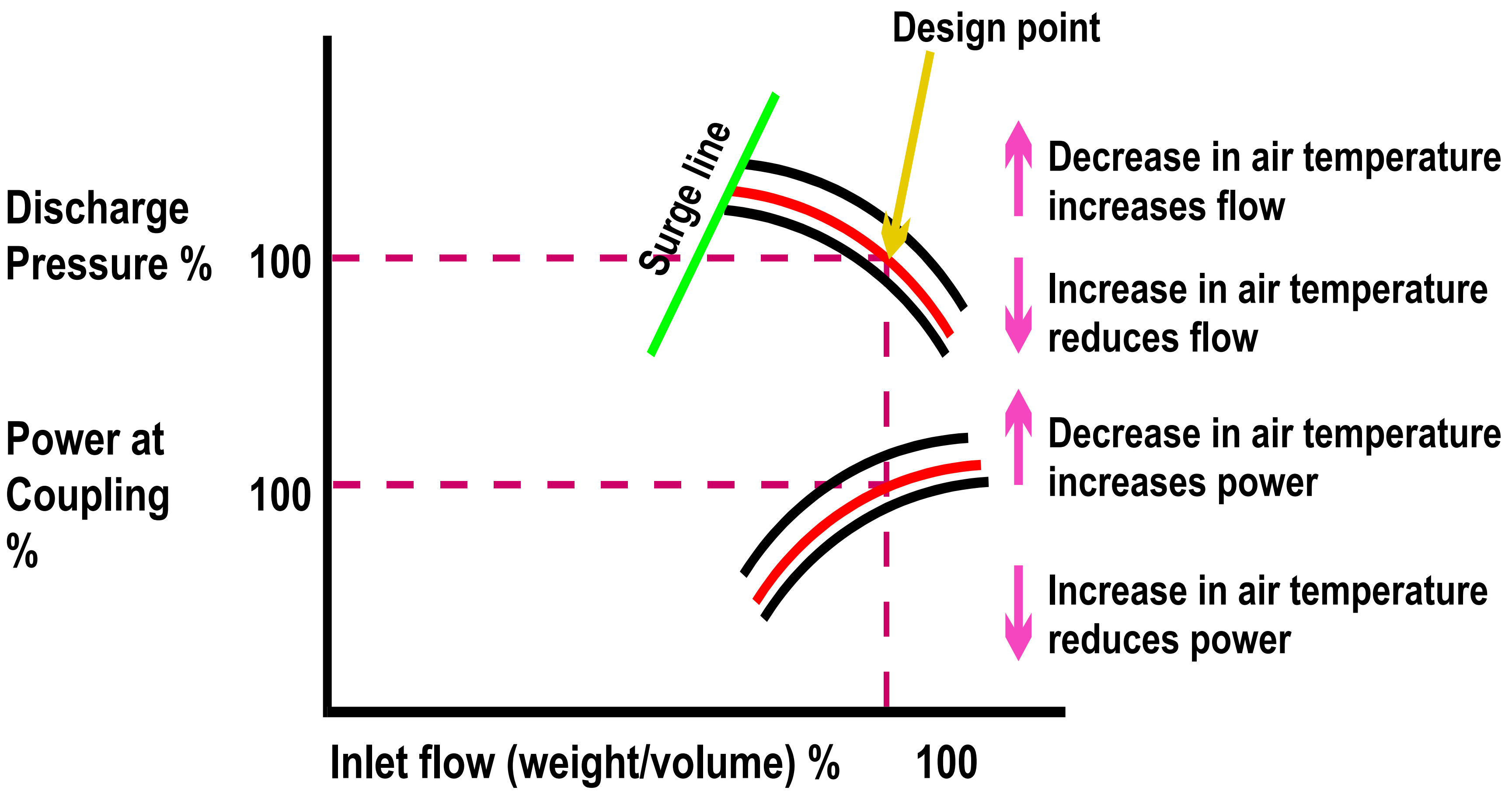
Cooling Water Effects On Dynamic Compressor Performance

Cooling water temperature

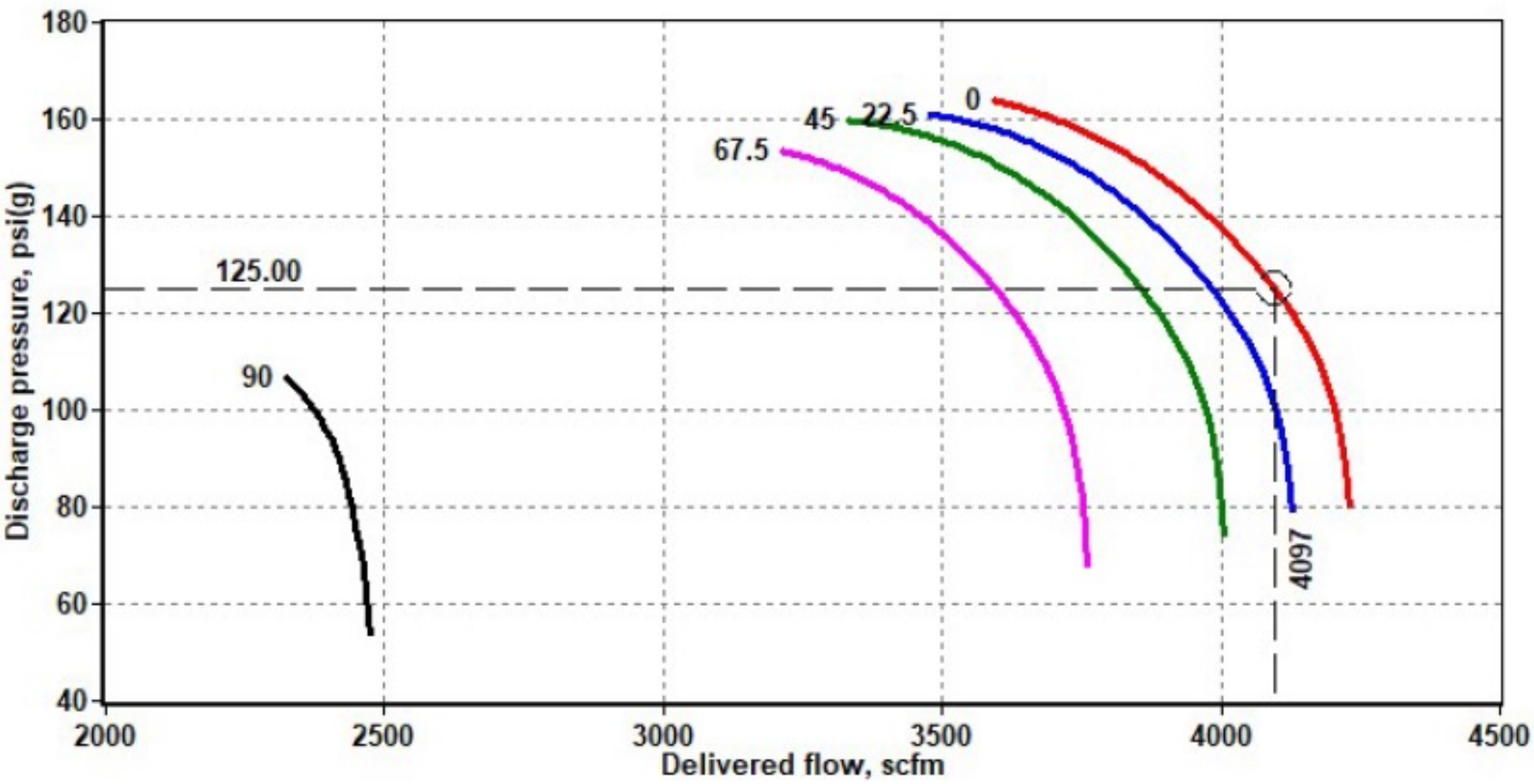


Inlet Air Temperature Effects On Dynamic Compressor Performance

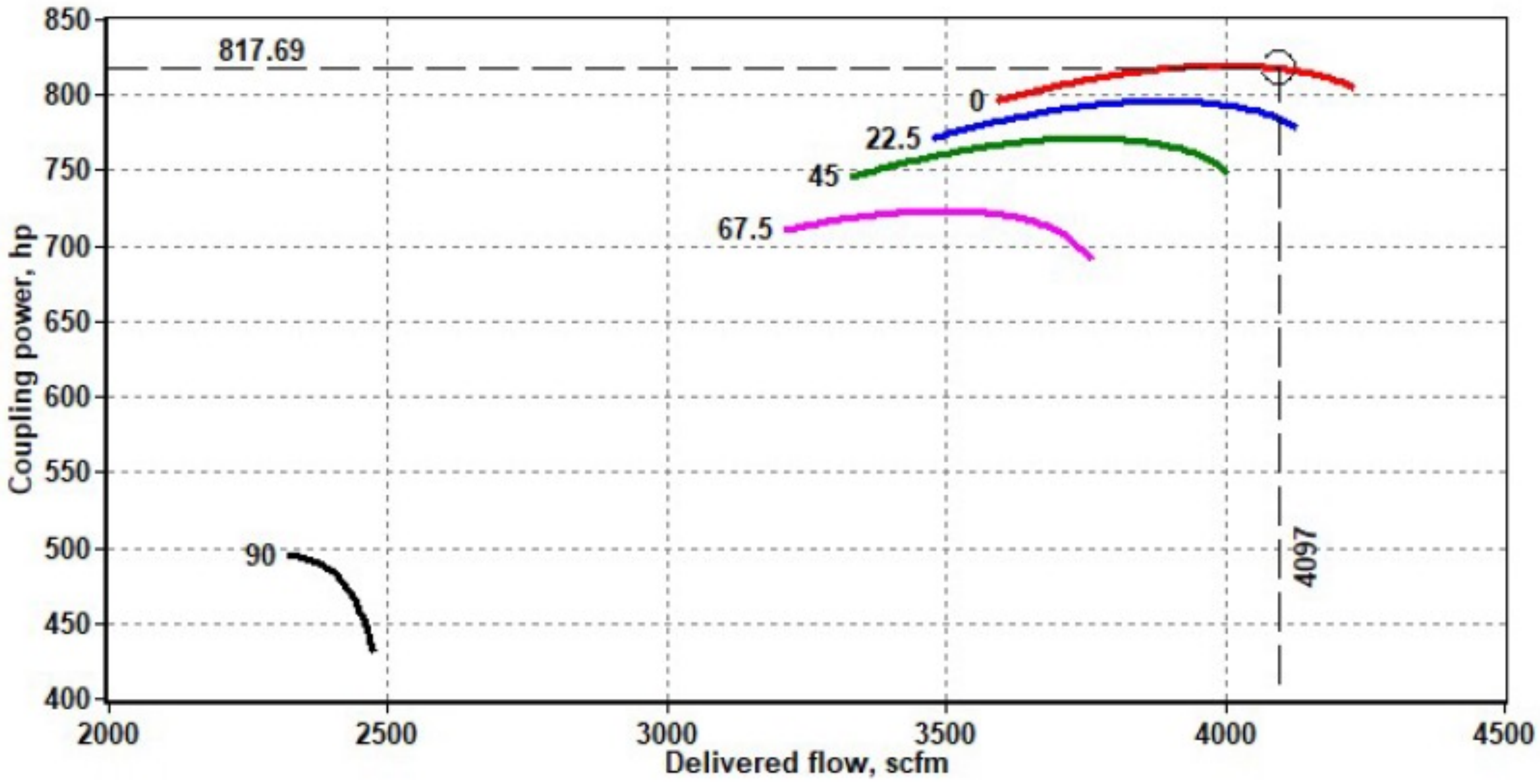
Inlet air temperature influence



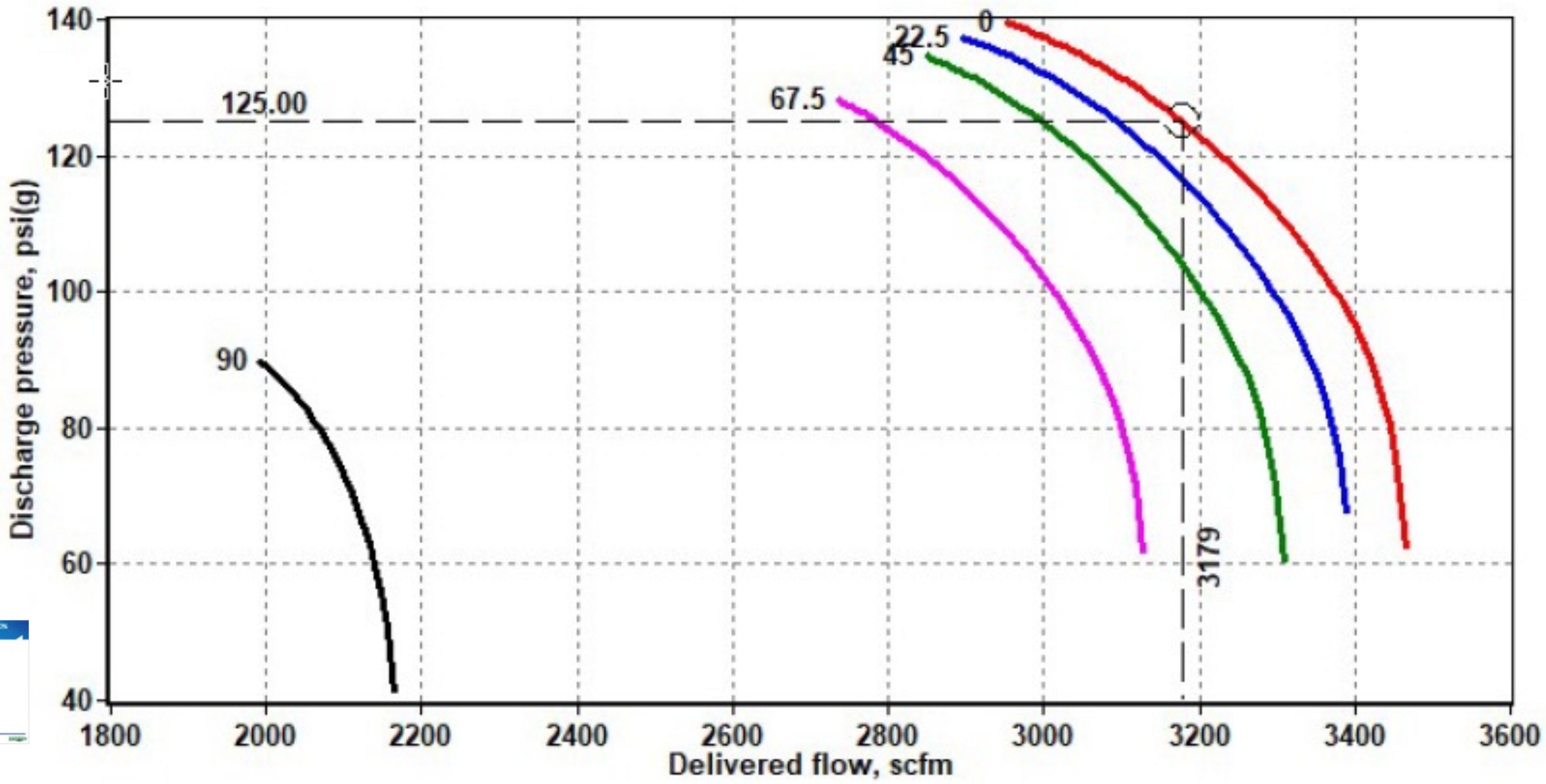
Curve showing air compressor performance at a 34°F inlet,60% RH, 77°F Coolant and 125 psig discharge pressure:

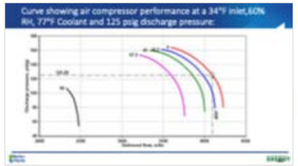


Curve showing air compressor horse power at a 34°F inlet,60% RH, 77°F Coolant and 125 psig discharge pressure:

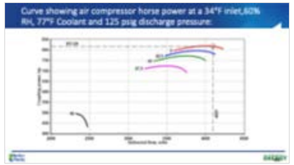


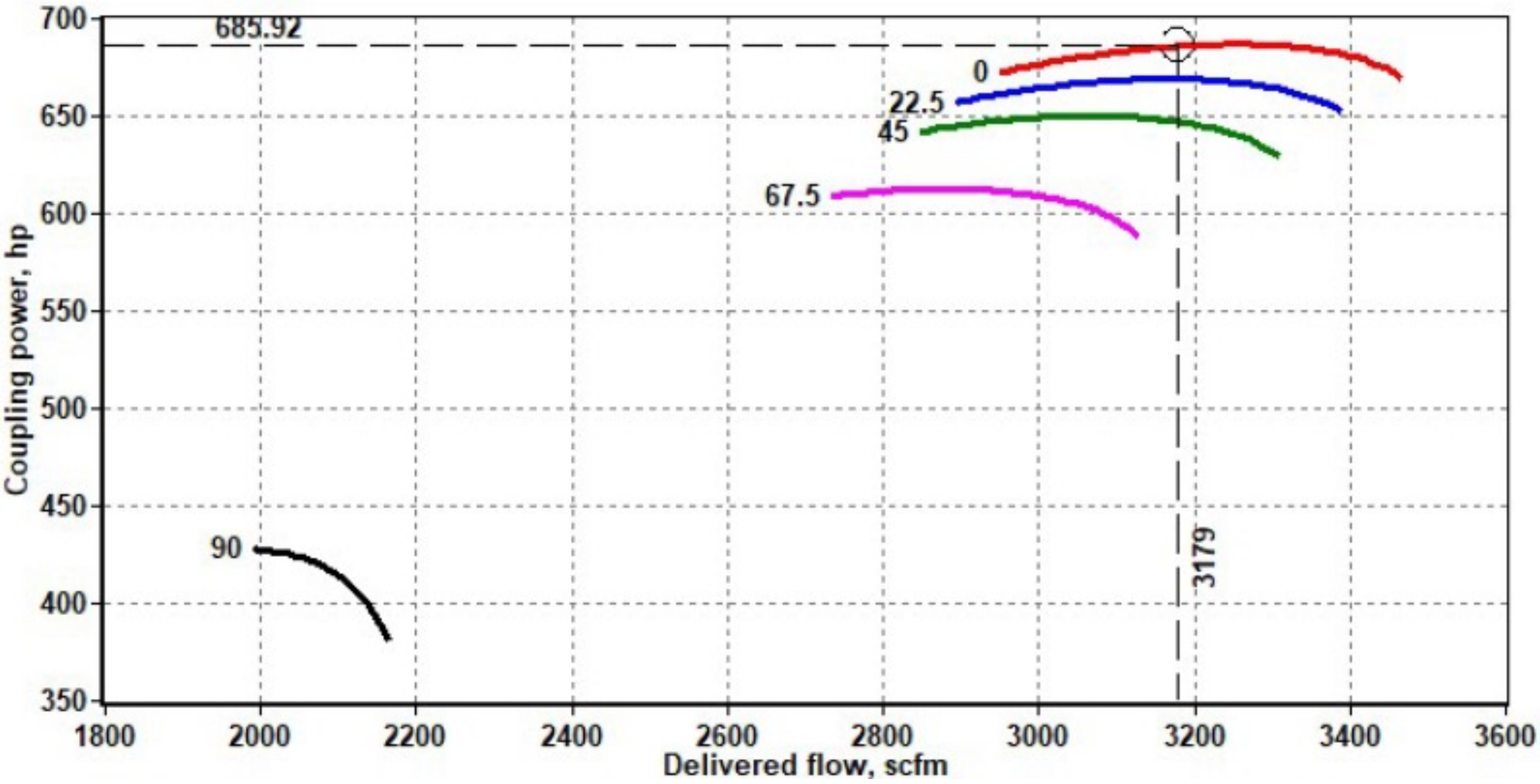
Curve showing air compressor performance at a 104°F inlet,100% RH, 77°F Coolant and 125 psig discharge pressure:





Curve showing air compressor horsepower at a 104°F inlet, 100% RH, 77°F Coolant and 125 psig discharge pressure:





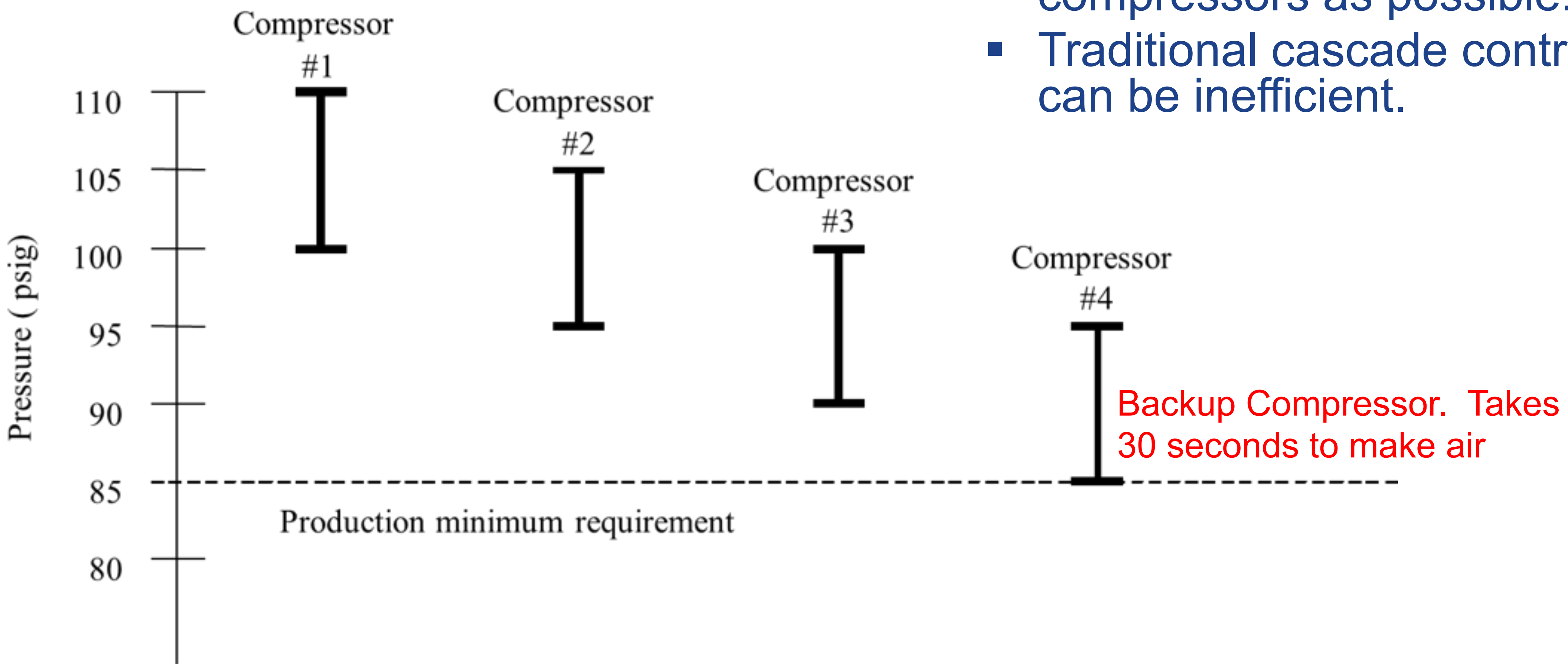
Multiple Compressor Control

- Holds a constant air pressure in the network within narrow limits.
- Easy to install.
- Connectable to all kinds of compressors.
- Optimisation of service intervals = lower service cost.
- Priority selection : old versus new machines.
- Delayed start : NEVER start two machines or more at the same time => high current peaks are avoided.
- Base load compressors can fill a net in advance to avoid load peaks.

Multiple Compressor Control

- Very simple user interface = minimum user training.
- Machines are used more efficiently.
- Energy reduction = immediately saves money.
- Full compressor & network status feed- back.
- Programmable pressure schedule.
- PC monitoring & analysing possibilities.

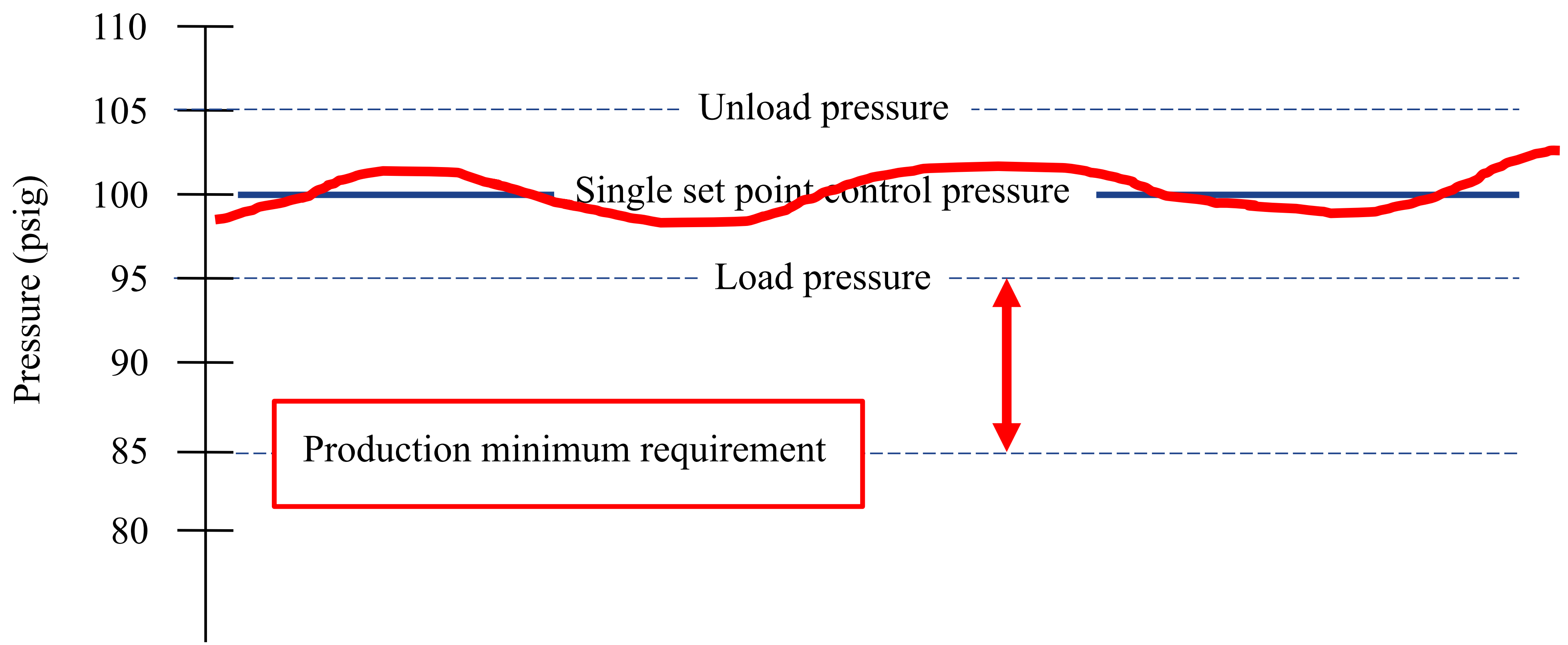
Cascade Compressor Control



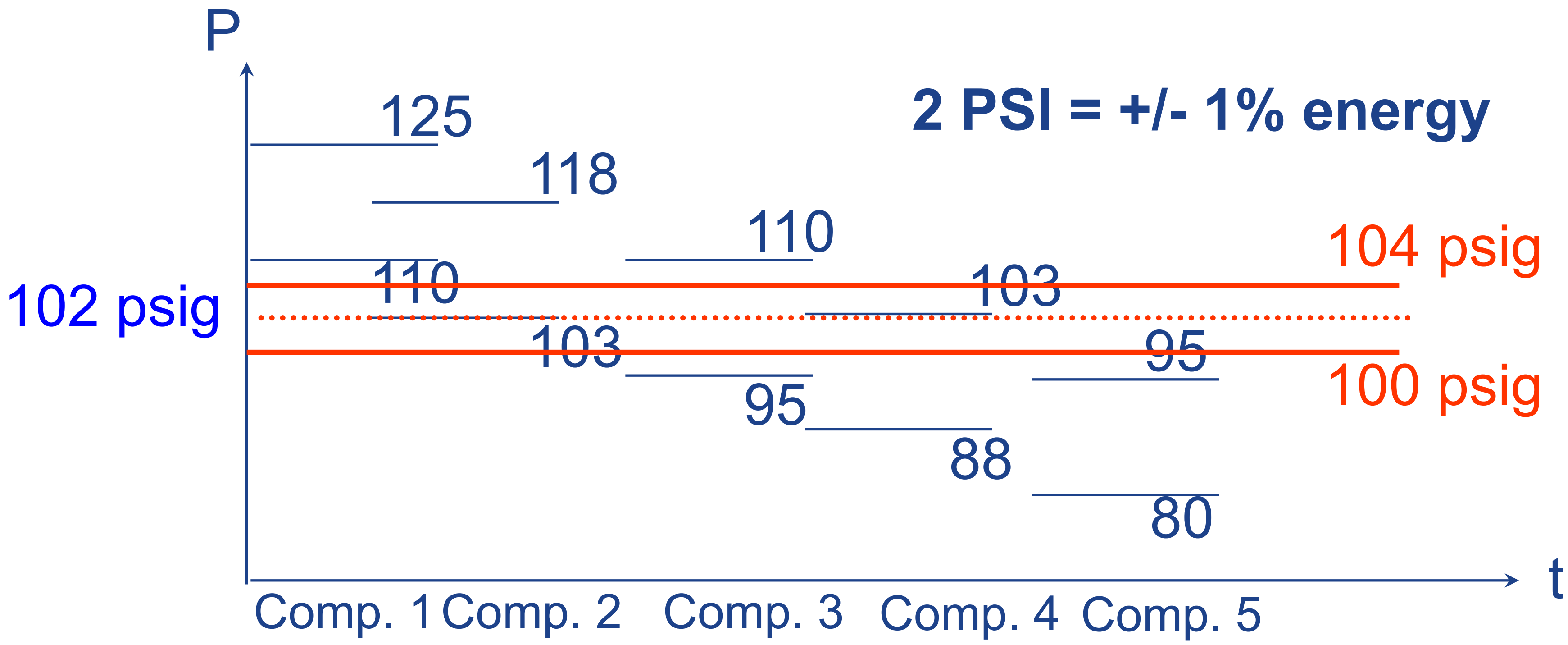
- Base load as many compressors as possible.
- Traditional cascade control can be inefficient.

Master Controls

- Basic single set point control scheme



Master Control Basics

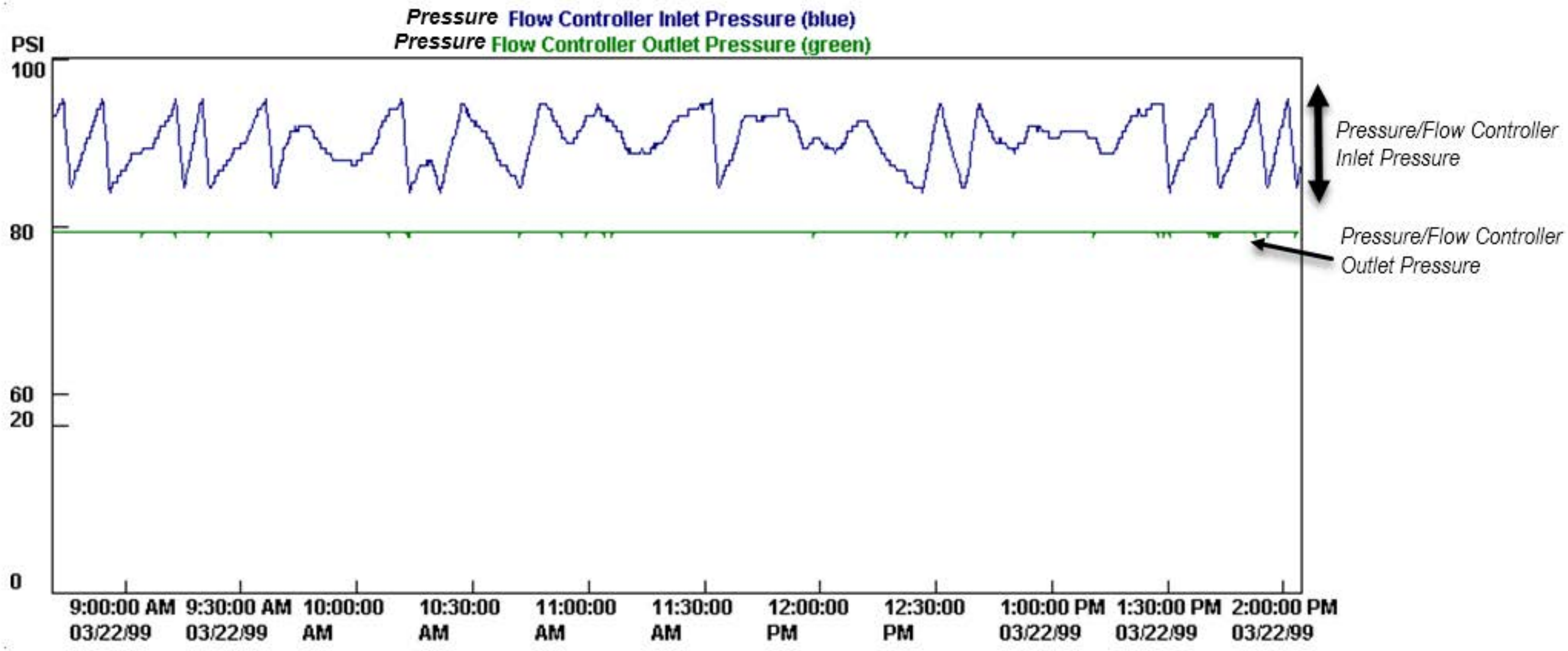


Cascaded Pressure Switches Vs Master

Pressure/Flow Controllers

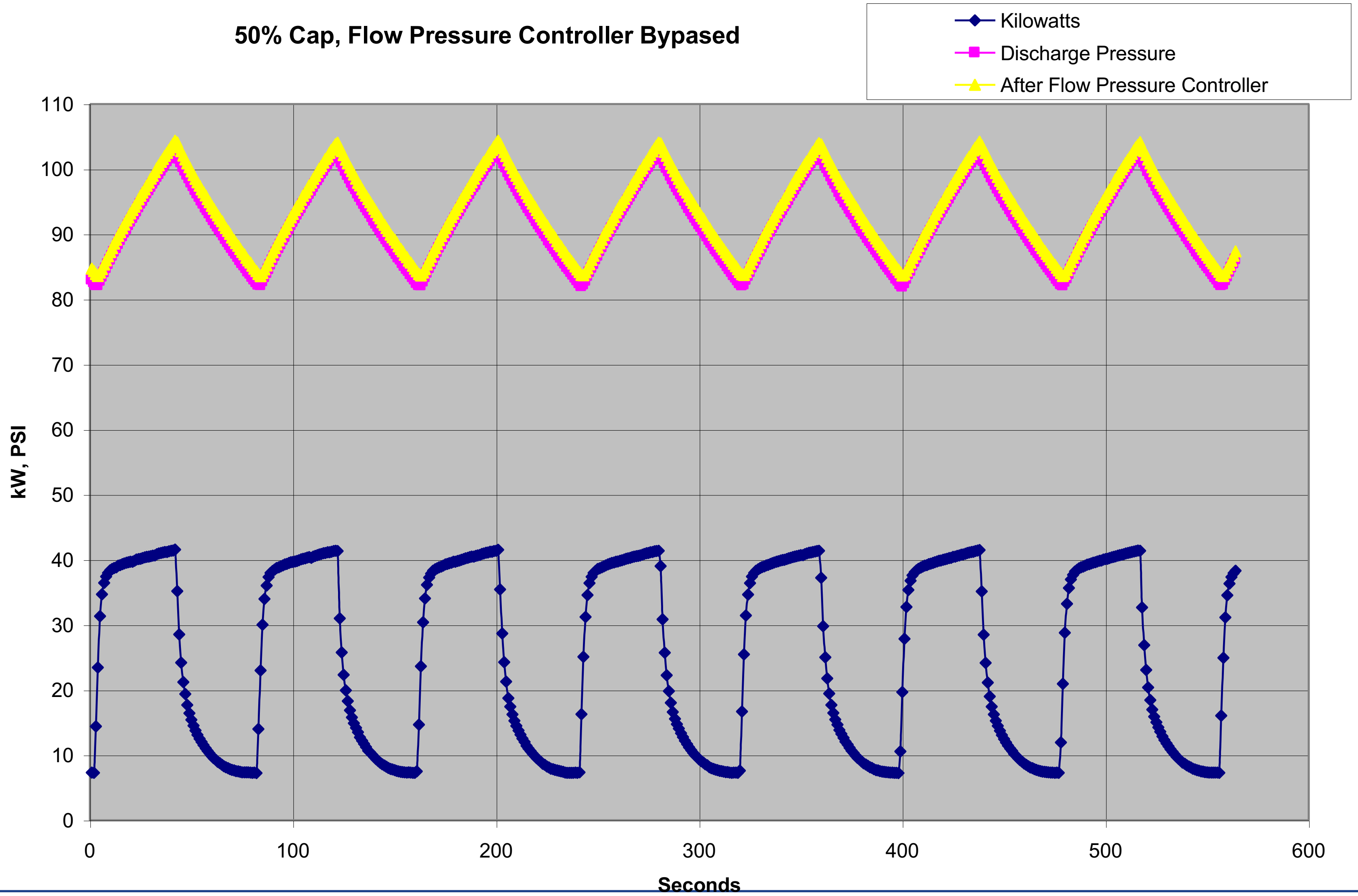
- Primary function: Stabilize pressure regardless of demand
- Most compressor controls cause 3-10 psi swings
- Multiple compressors can compound the system pressure swings
- Pressure/flow controllers typically hold pressure to production within ± 1% of set point
- The following graph is from a system with 9 compressors totaling over 6,000 hp – pressure is set at 79 psig

Pressure/Flow Controllers

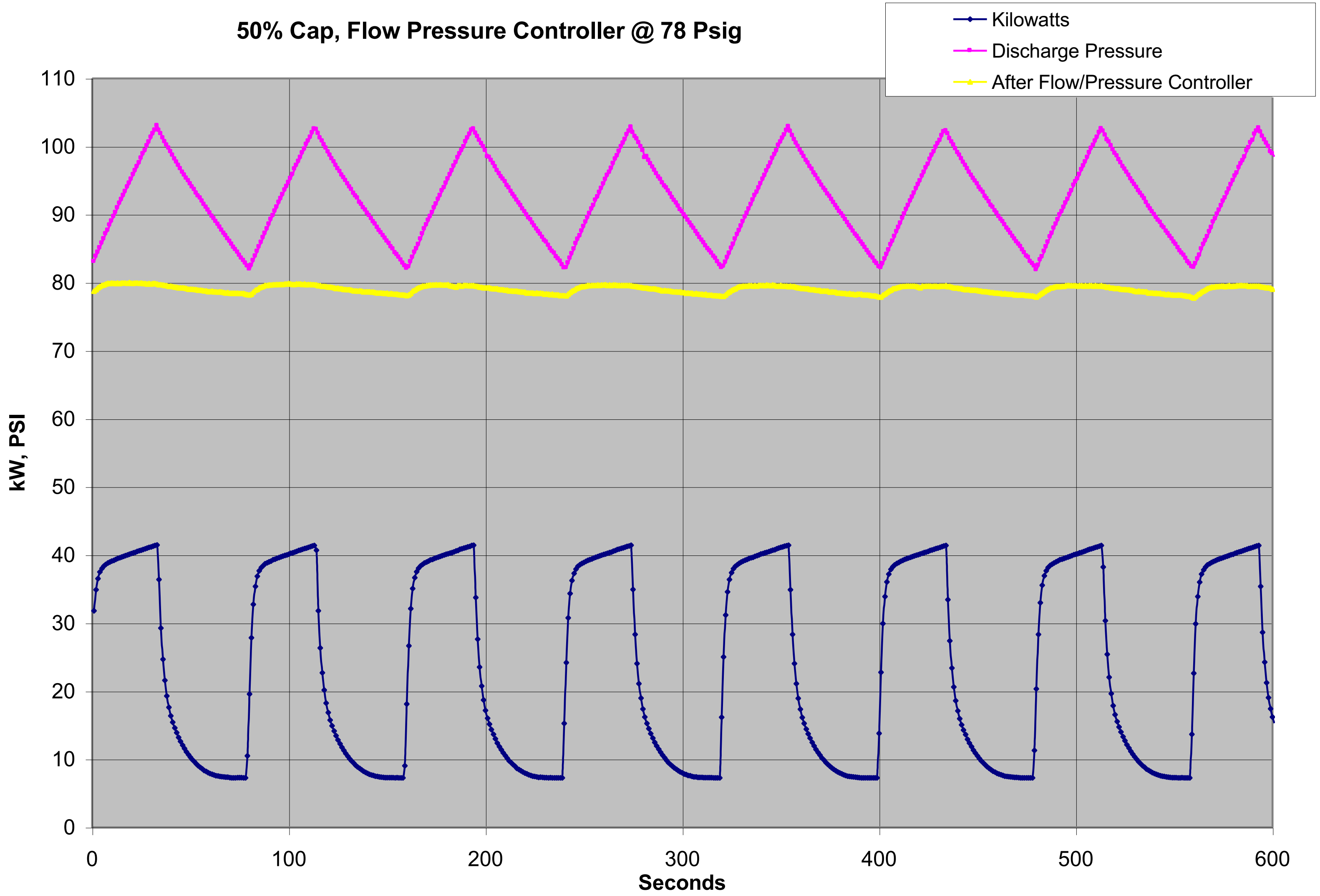


- The compressor discharge pressure varies about 10 psi as the trim compressor loads and unloads to meet plant demand.
- The pressure to the plant is kept at a constant 79 psig.

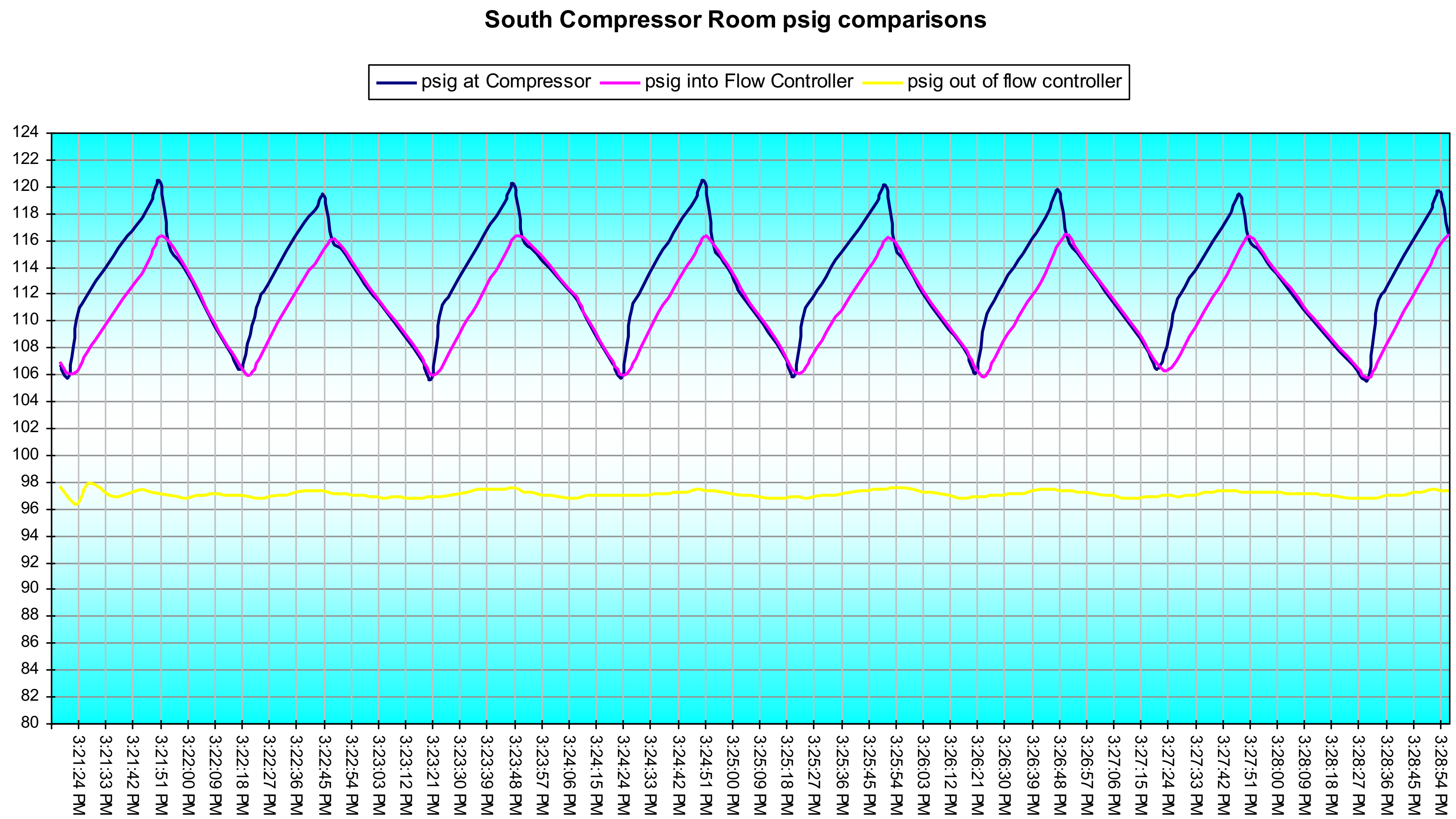
Pressure/Flow Controllers



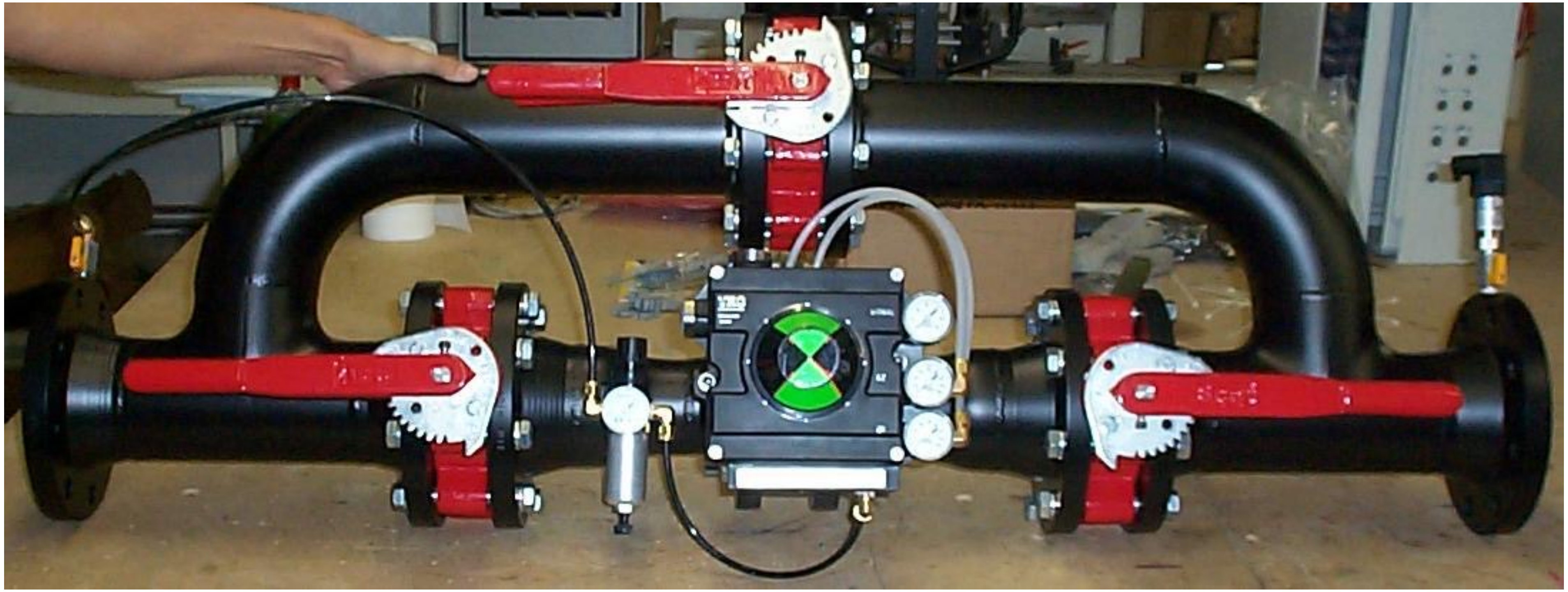
Pressure/Flow Controllers



Pressure/Flow Controllers

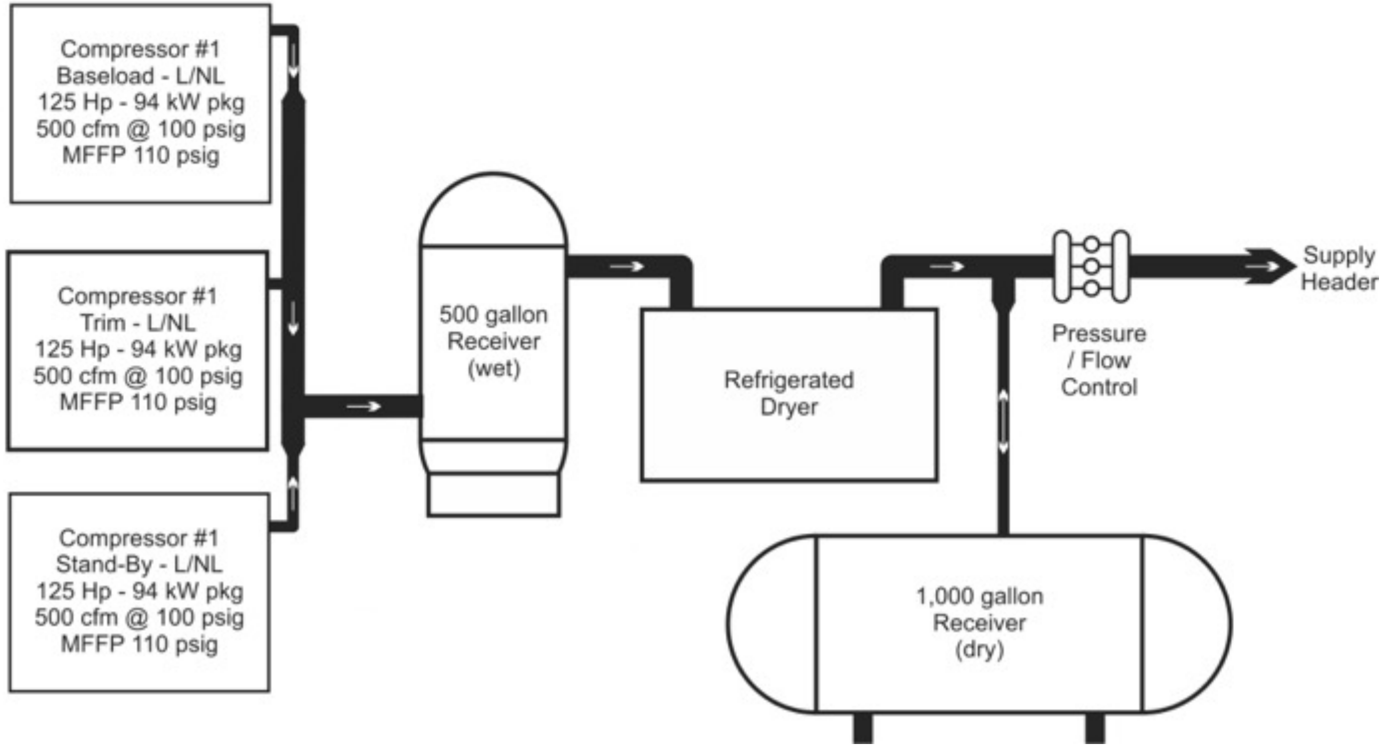


Pressure/Flow Controllers



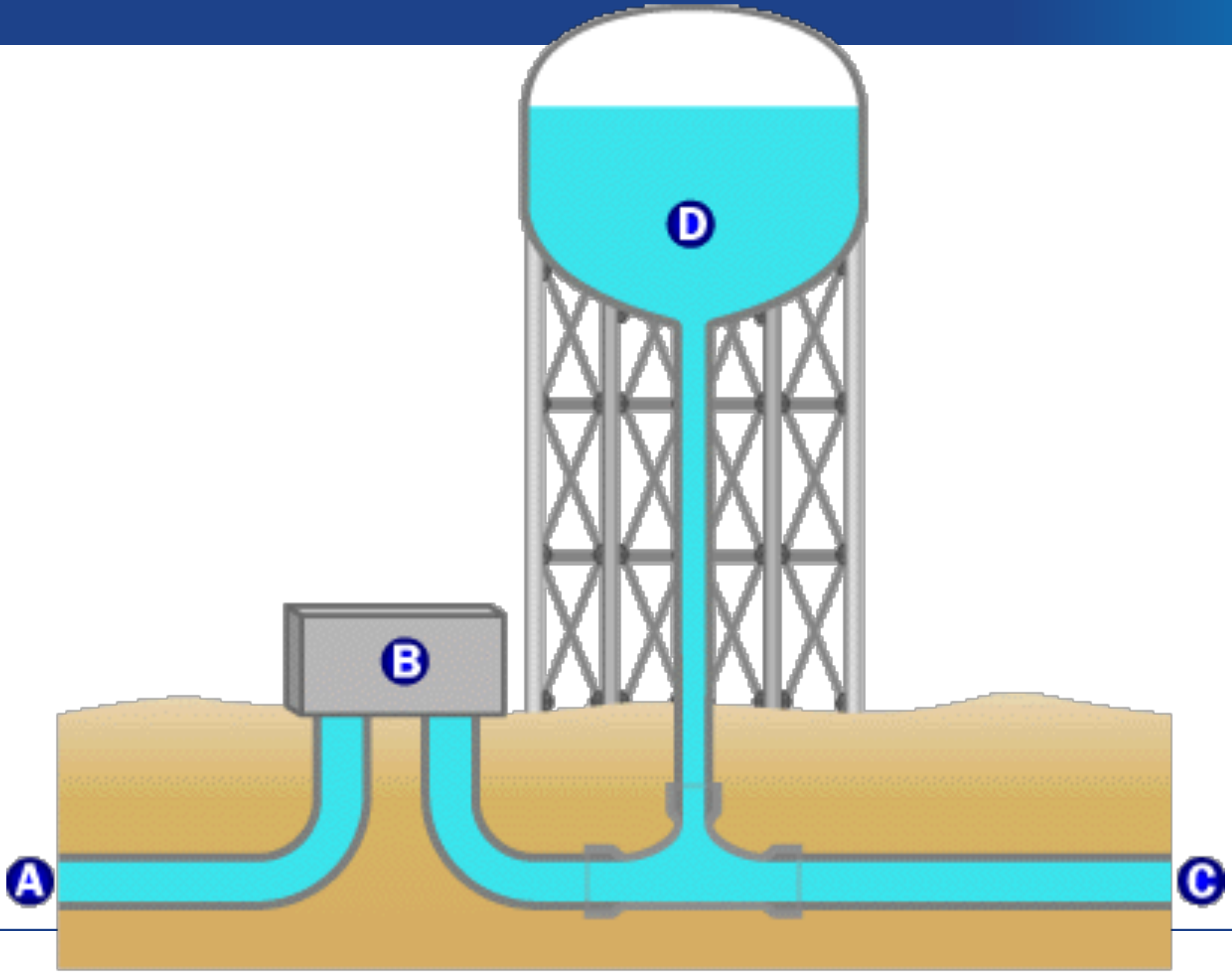
Pressure/Flow Controllers

Pressure/Flow Controllers

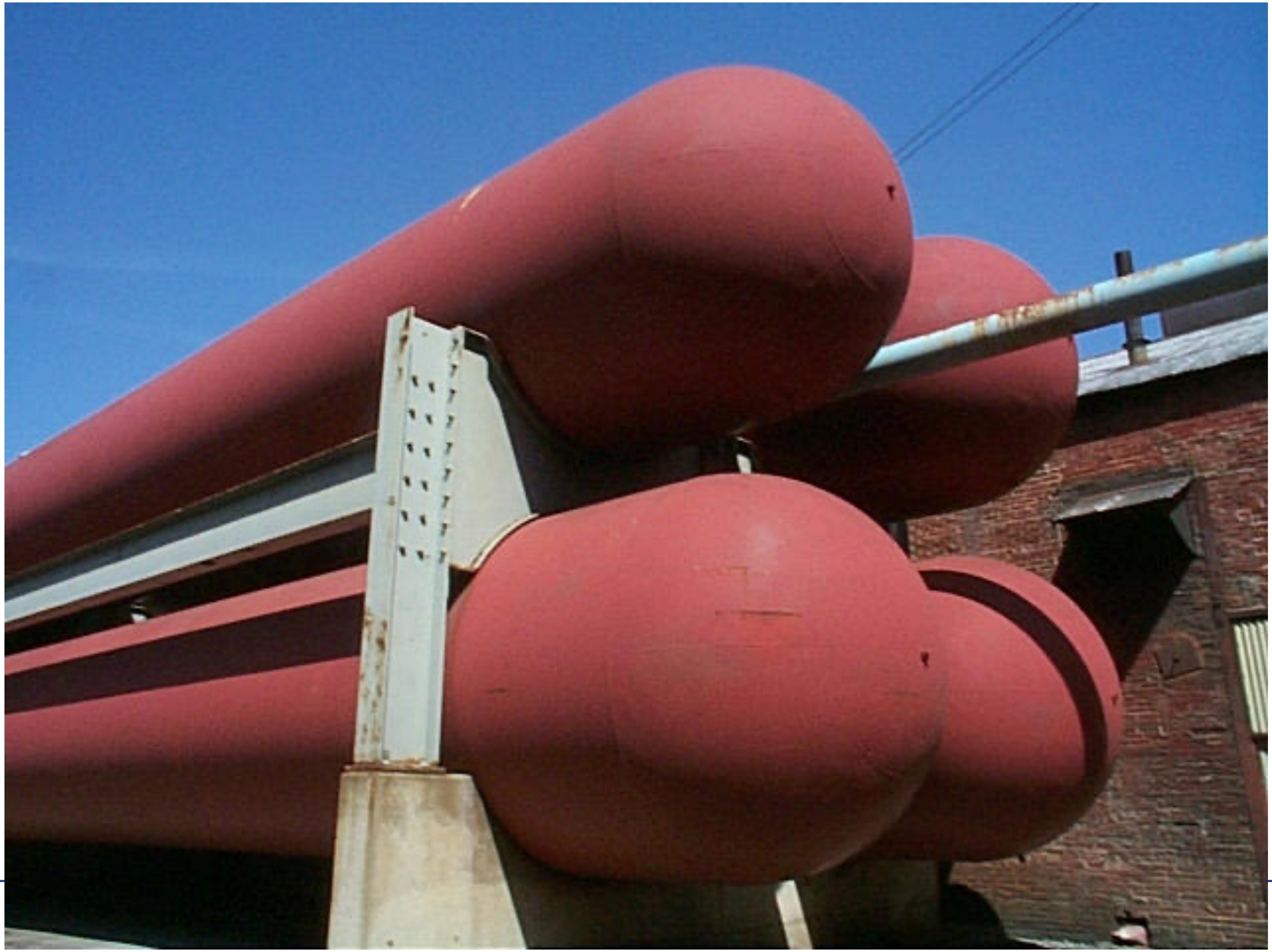


- A typical block diagram of a pressure/flow controller in a compressed air system with one point of entry (single compressor room)

Pressure/Flow Controllers

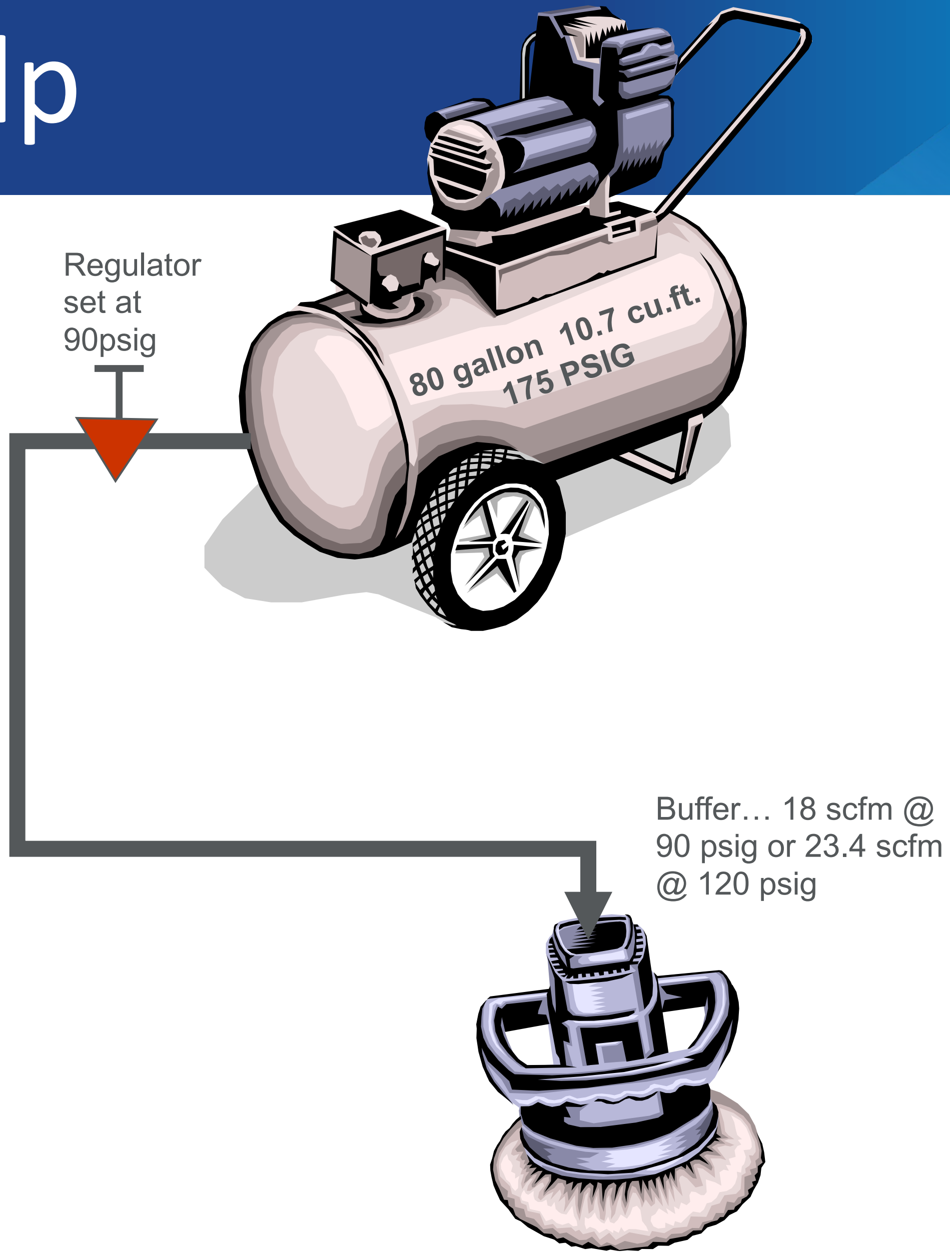


Primary Storage

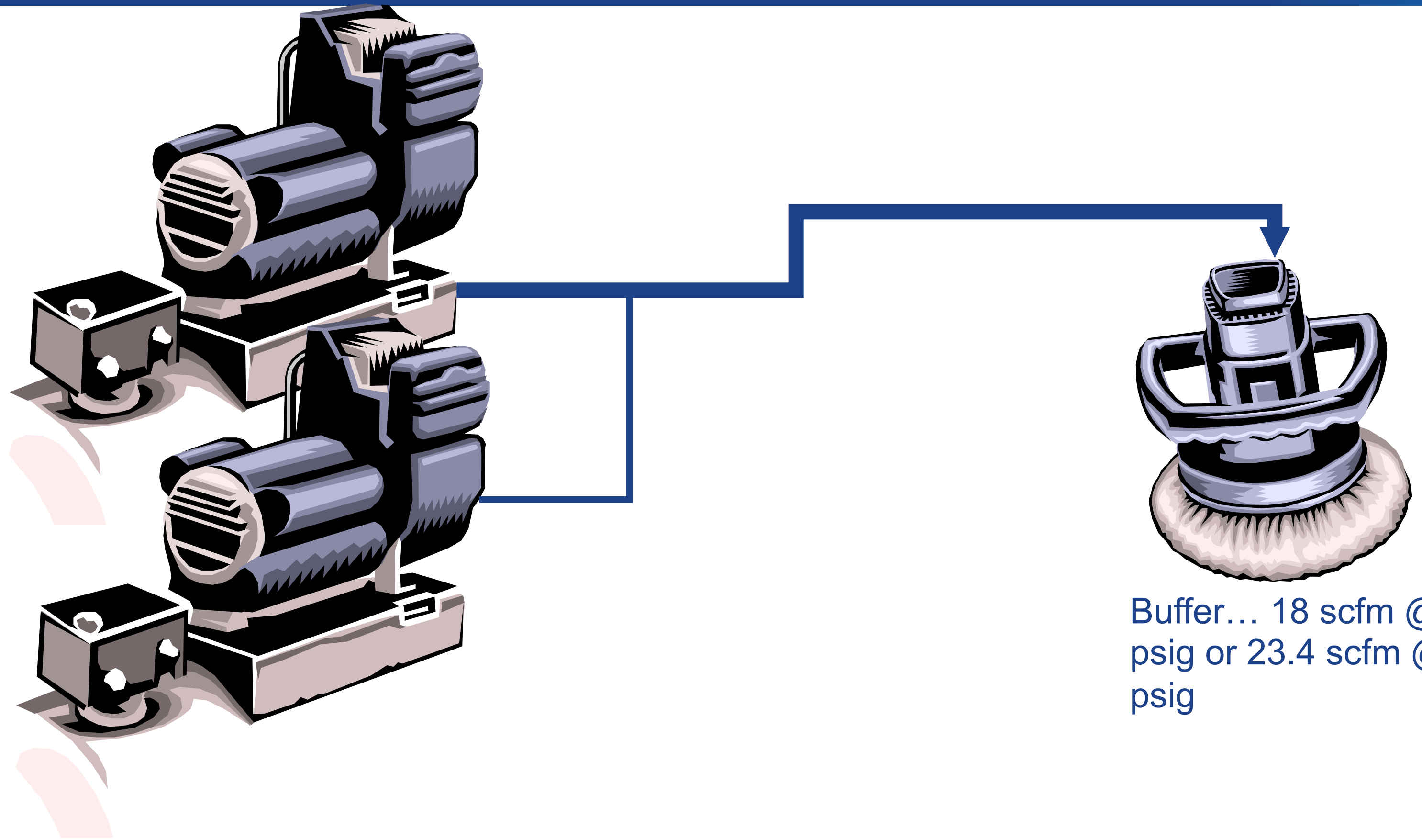


How does Volume Help

- A paint area in a body shop has a 5 HP compressor mounted on an 80-gallon air receiver. This receiver is pumped up to 175 psig. The air flow to the buffer which uses 18 SCFM at 90 PSIG, is regulated to 90 PSIG outflow from the regulator.
- The compressor delivers 12-13 SCFM at 90 psig but yet it runs the 18 SCFM sander just fine.
- How can this work???
- The buffer uses more volume(scfm) than the compressor can deliver !!
- If there were no regulation and receiver, you can be sure that the compressor would not be able to run the tool



How does Volume Help



Buffer… 18 scfm @ 90 psig or 23.4 scfm @ 120 psig

With no receiver, the painter must install a second 5 hp compressor and therefore use twice the energy as before

Controls Summary

- Create a control strategy:
  - ✓ Know how your controls work
  - ✓ Realize the pros and cons of different controls
  - ✓ Recognize how controls affect part load efficiency
  - ✓ Understand how storage affects the effectiveness of control strategies

Session 3

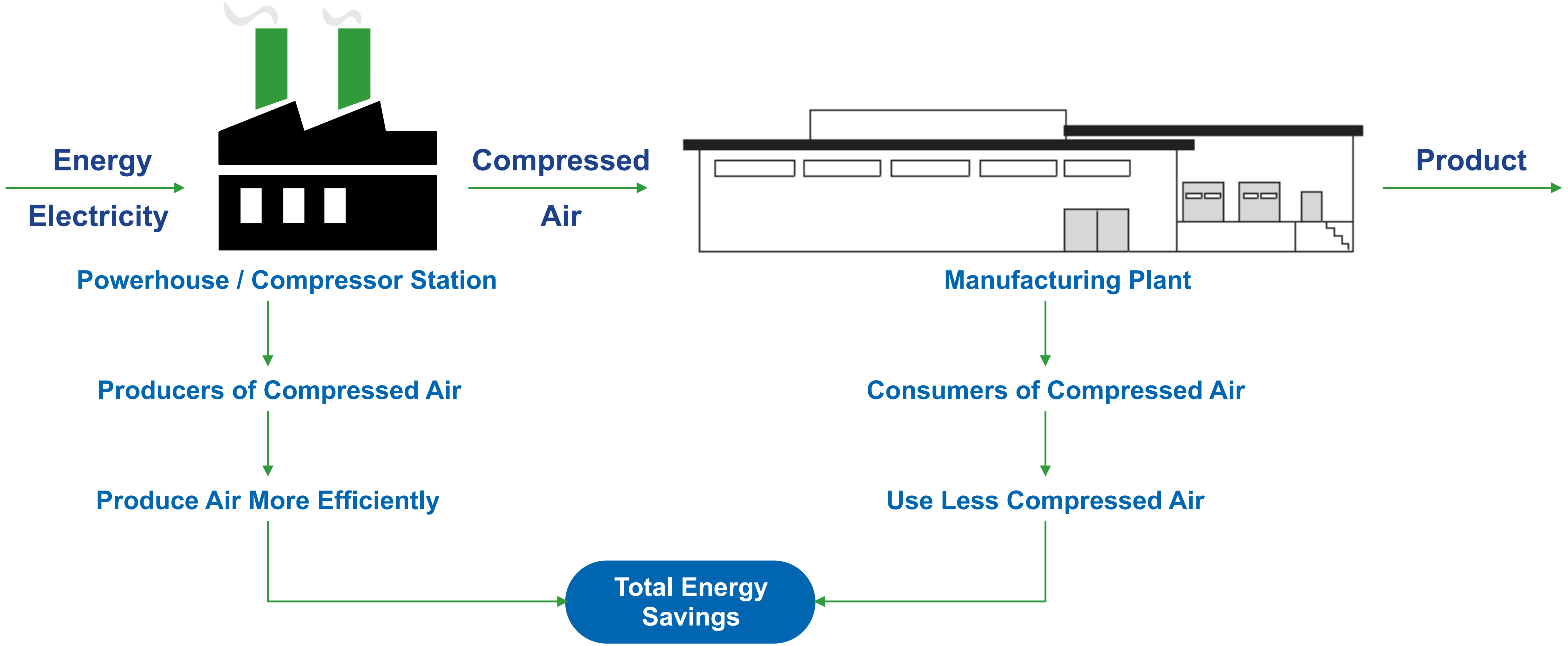
Logtool, AirMaster+ and the MEASUR Tool

Why AIRMaster+?

- ~90% of energy input to compressor never reaches tools (waste heat, drying, etc.)
- Leaks +pressure drops remove air energy before reaching tools--sometimes >50%
- Poor or improperly adjusted controls leave several compressors operating a part load
- System assessments can be an arduous task using spreadsheets that must be modified for each job
- AIRMaster+ provides a systematic approach to assessing compressed air systems, analyzing collected data, and reporting results

What Can This Tool Help Me With?

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.

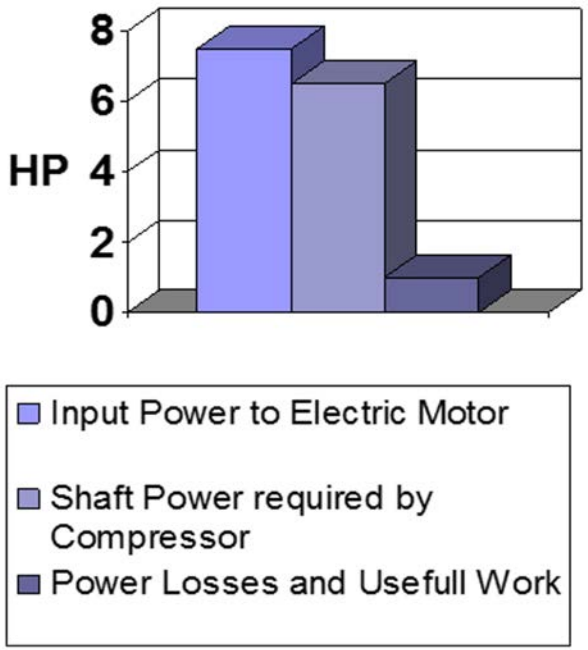


What Can This Tool Help Me With?

- Produce more efficiently
  - Improve Compressor Control
  - Type of Compressor Control
- Use less compressed air
  - Reduce System Pressure
  - Reduce Air Demand
  - How does compressed air support production?

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



AIRMaster+ Features

- AIRMaster+ is a Windows-based software tool used to analyze industrial compressed air systems:
- Simulates existing and modified compressed air system operation
- Models part load system operation
- Assigns electrical utility energy schedules
- Enters 24-hour metered airflow or power data
- Is not a substitute for an experienced auditor!

Energy Efficiency Measures

1. Reduce Air Leaks
2. Improve End Use Efficiency
3. Reduce System Air Pressure
4. Use Unloading Controls
5. Adjust Cascading Set Points
6. Use Automatic Sequencer
7. Reduce Run Time
8. Add Primary Receiver Volume

Why LogTool?

- LogTool is a public domain tool developed by SBW Consulting with support from the Compressed Air Challenge™.
- It is designed to assist in the analysis of compressed air system performance measurements.
- It is a companion tool for Airmaster+ available from the US DOE and CAC.

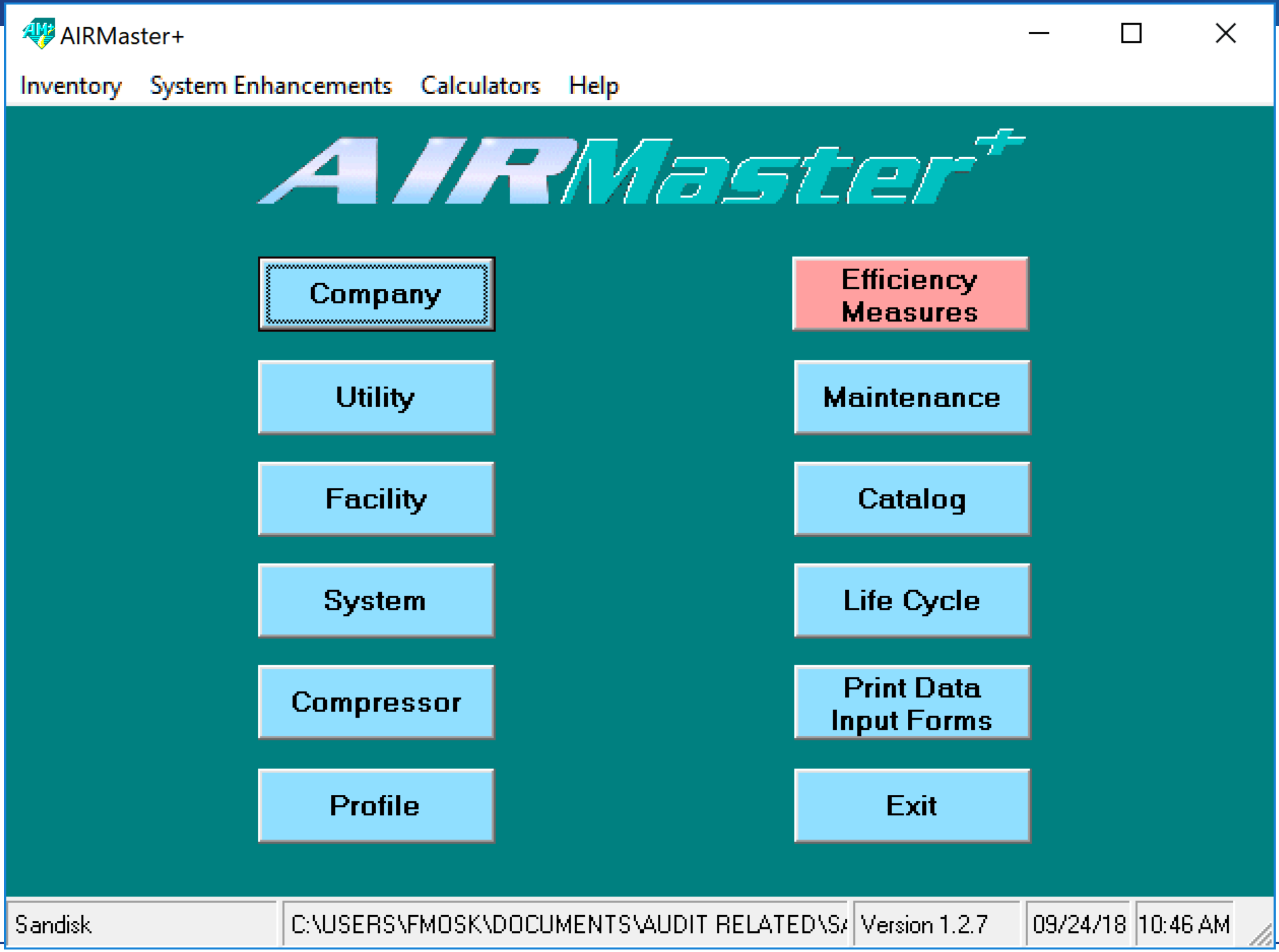
LogTool is Designed To:

- Import data which is exported from different types of data loggers.
- Select logger data channels and modify their properties.
  - e.g., name, type, units, etc.
- View data values for one or more logger channels.
- Display trend plots on one or two Y axis.
- Display scatter plots.
- Display daytype plots in the format that is needed for AIRMaster+

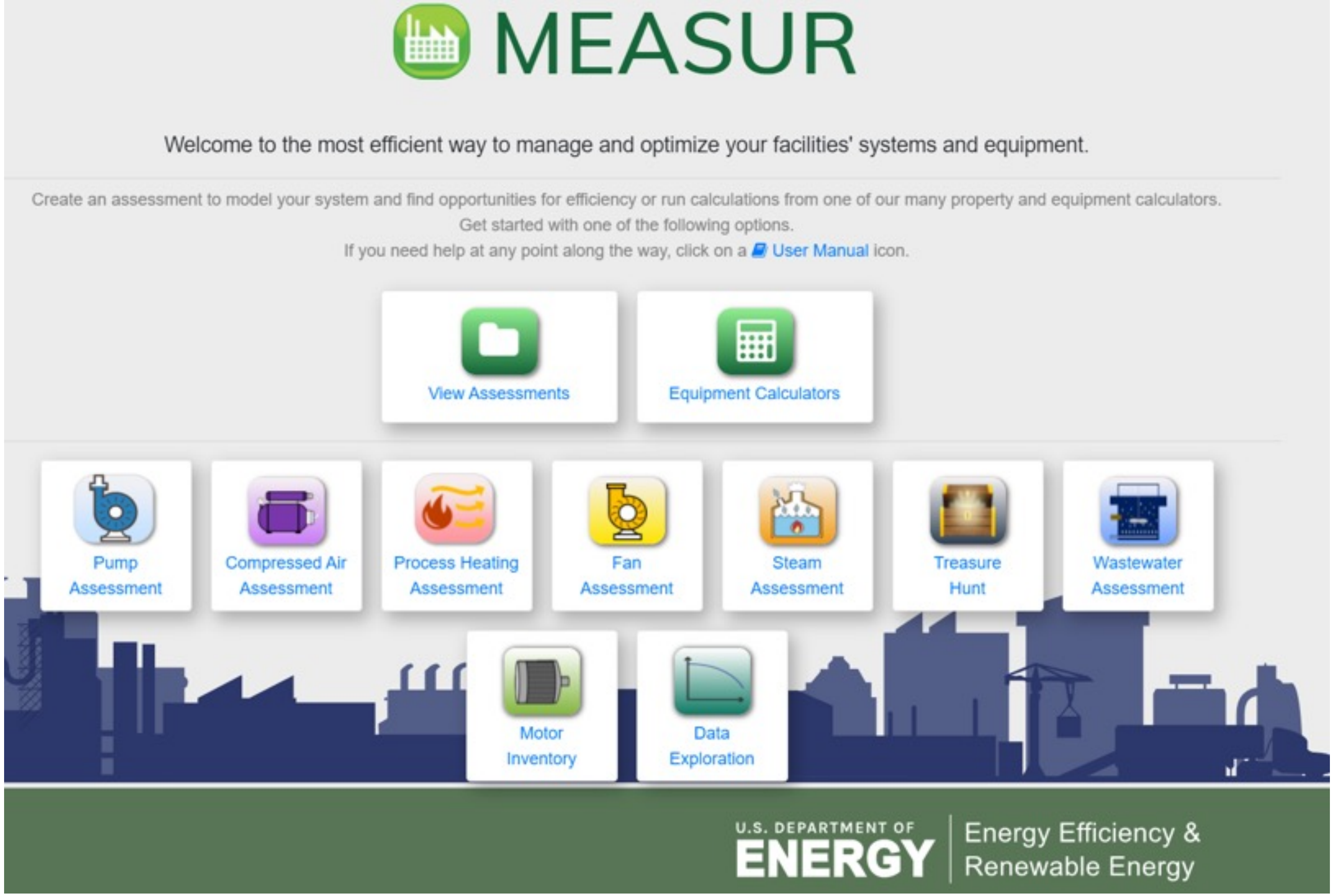
Enter LogTool Data Into AIRMaster

- Enter Utility and rate information
- Enter System information including Day Types
- Enter compressor Information
- Enter recorded data to establish the baseline
  - This data comes from LogTool
- Experiment with different EEM's

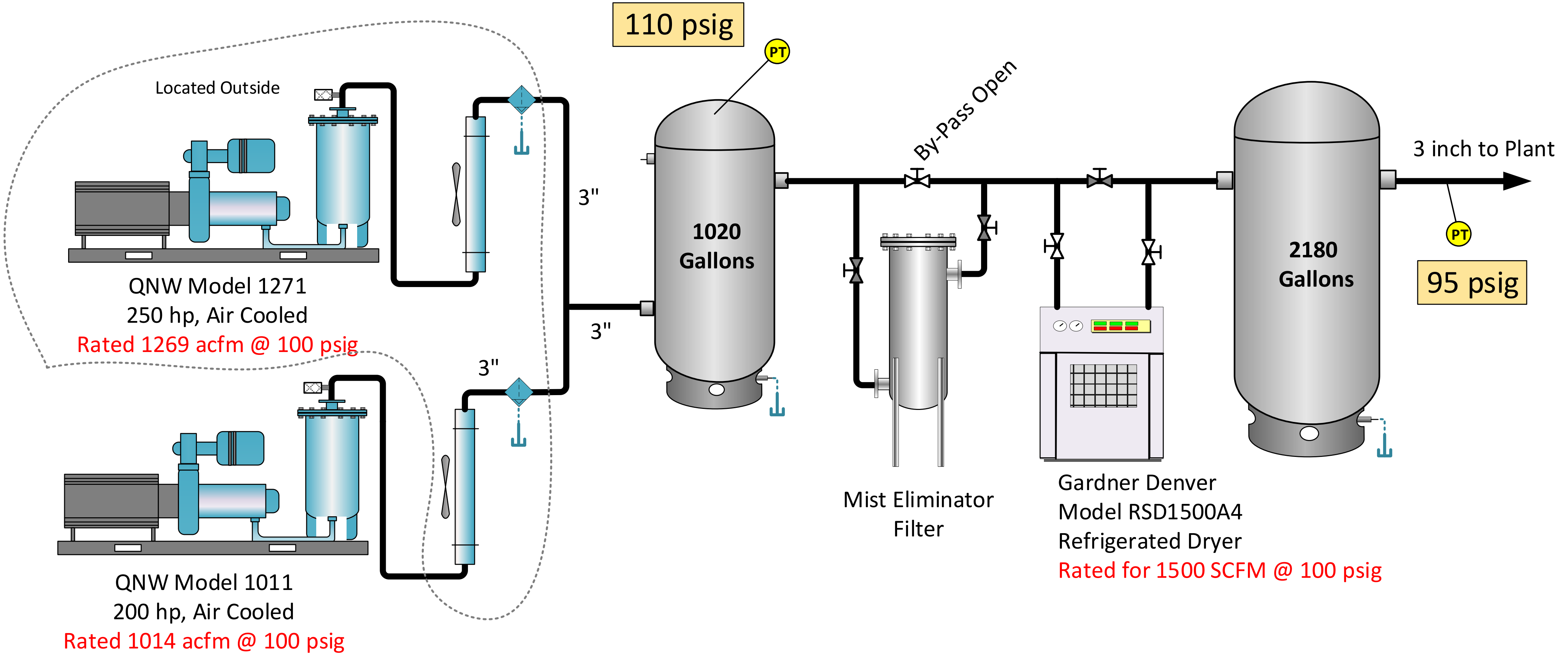
AIRMaster+ Main Menu



MEASUR Main Menu



Box Plant Company Example



Baseline Info

- 200 hp baseloaded compressor rated 1014 acfm using modulated inlet control
- 250 hp trim compressor rated 1269 acfm using modulated inlet control operating at 40% output
- Production is 24/6 with Sundays off
- Average flow during Monday to Saturday is 1500 cfm
- Baseline energy is 2,587,516 kWh or $174,657 using $.0675/kWh
- Leakage is estimated to be about 600 cfm based on leak down test

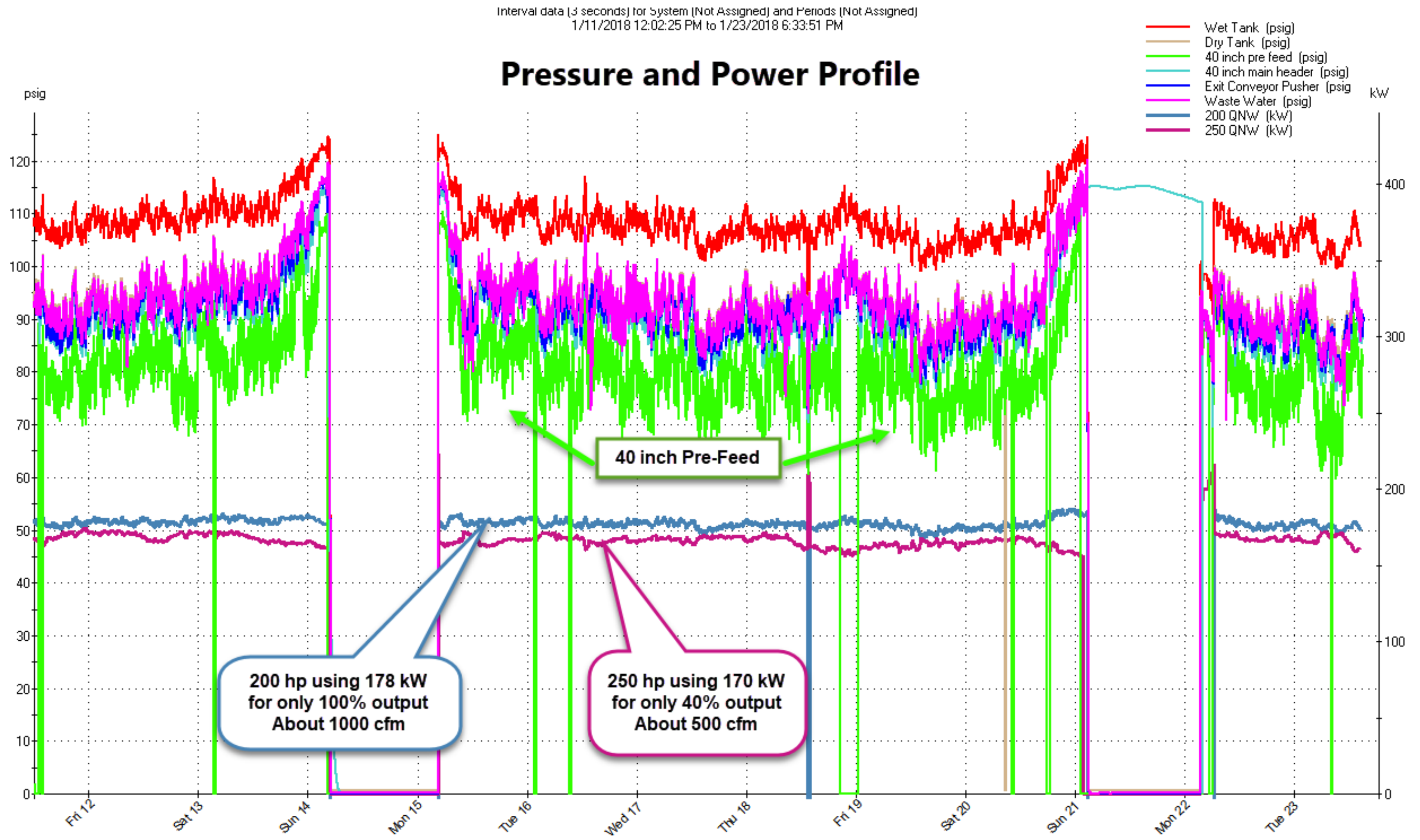
Baseline Info

- Air Operated Diaphragm Pumps (AOD) are in use and can be replaced with electric driven pumps made to pump heavy viscous fluids such as glue
- 3-inch pipe is used in the compressor room to handle almost 1500 scfm of flow. This is borderline undersized and is creating additional pressure drop.
- Both compressors must run to support production. Neither one by itself can run production. There is no redundancy at this plant for compressed air.

Table 4.7 Loss of Air Pressure Due to Friction

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
10	1.28	6.50	.99	0.28									
20	2.56	25.9	3.90	1.11	0.25	0.11							
30	3.84	58.5	9.01	2.51	0.57	0.26							
40	5.12	....	16.0	4.45	1.03	0.46							
50	6.41	....	25.1	9.96	1.61	0.71	0.19						
60	7.68	....	36.2	10.0	2.32	1.02	0.28						
70	8.96	....	49.3	13.7	3.16	1.40	0.37						
80	10.24	....	64.5.	17.8	4.14	1.83	0.49						
90	11.52	....	82.8	22.6	5.23	2.32	0.62						
100	12.81	....	....	27.9	6.47	2.86	0.77						
125	15.82	....	....	48.6	10.2	4.49	1.19						
150	19.23	....	....	62.8	14.6	6.43	1.72	0.21					
175	22.40	....	....	....	19.8	8.72	2.36	0.28					
200	25.62	....	....	....	25.9	11.4	3.06	0.37					
250	31.64	....	....	....	40.4	17.9	4.78	0.58					
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		

LogTool Trend Plot



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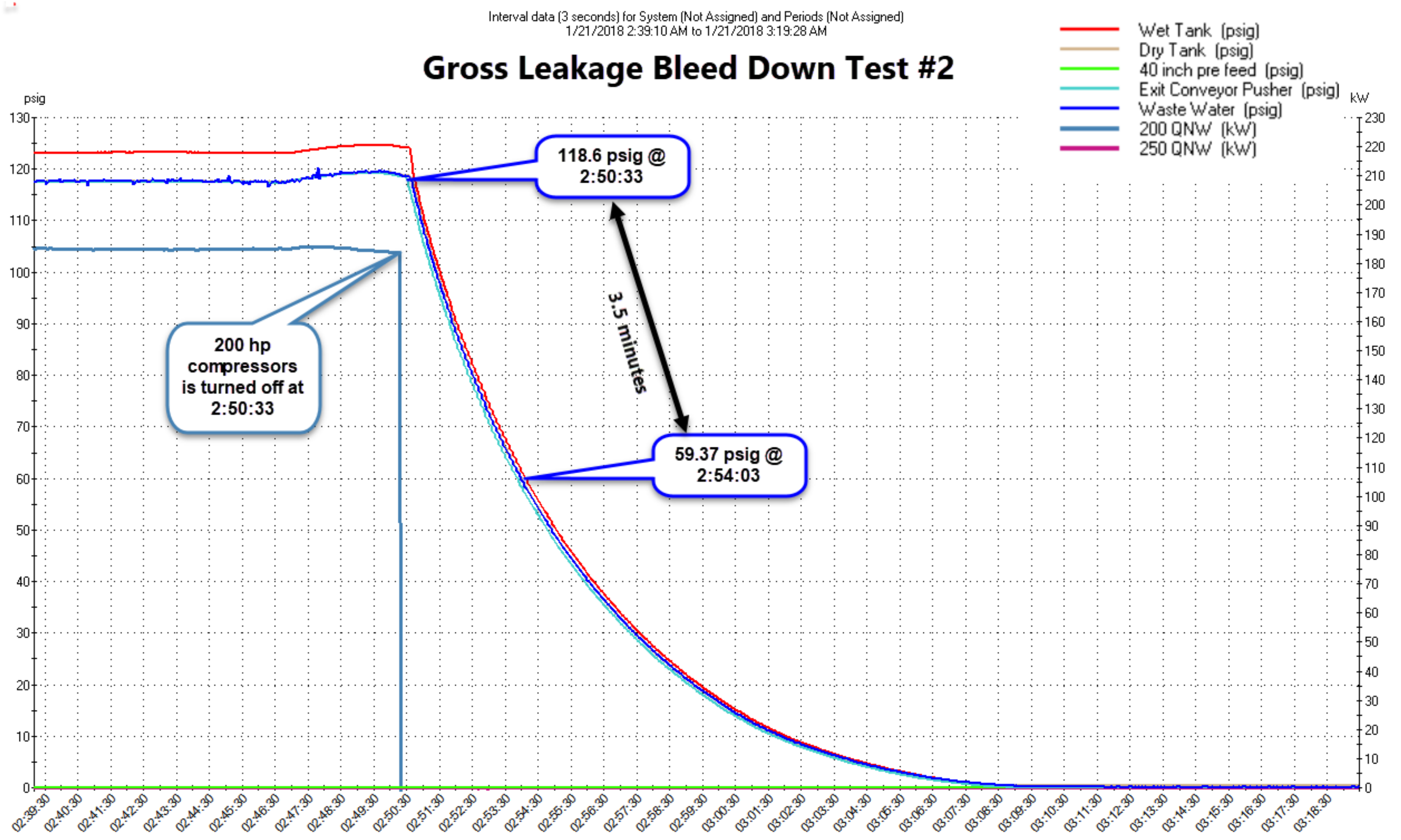
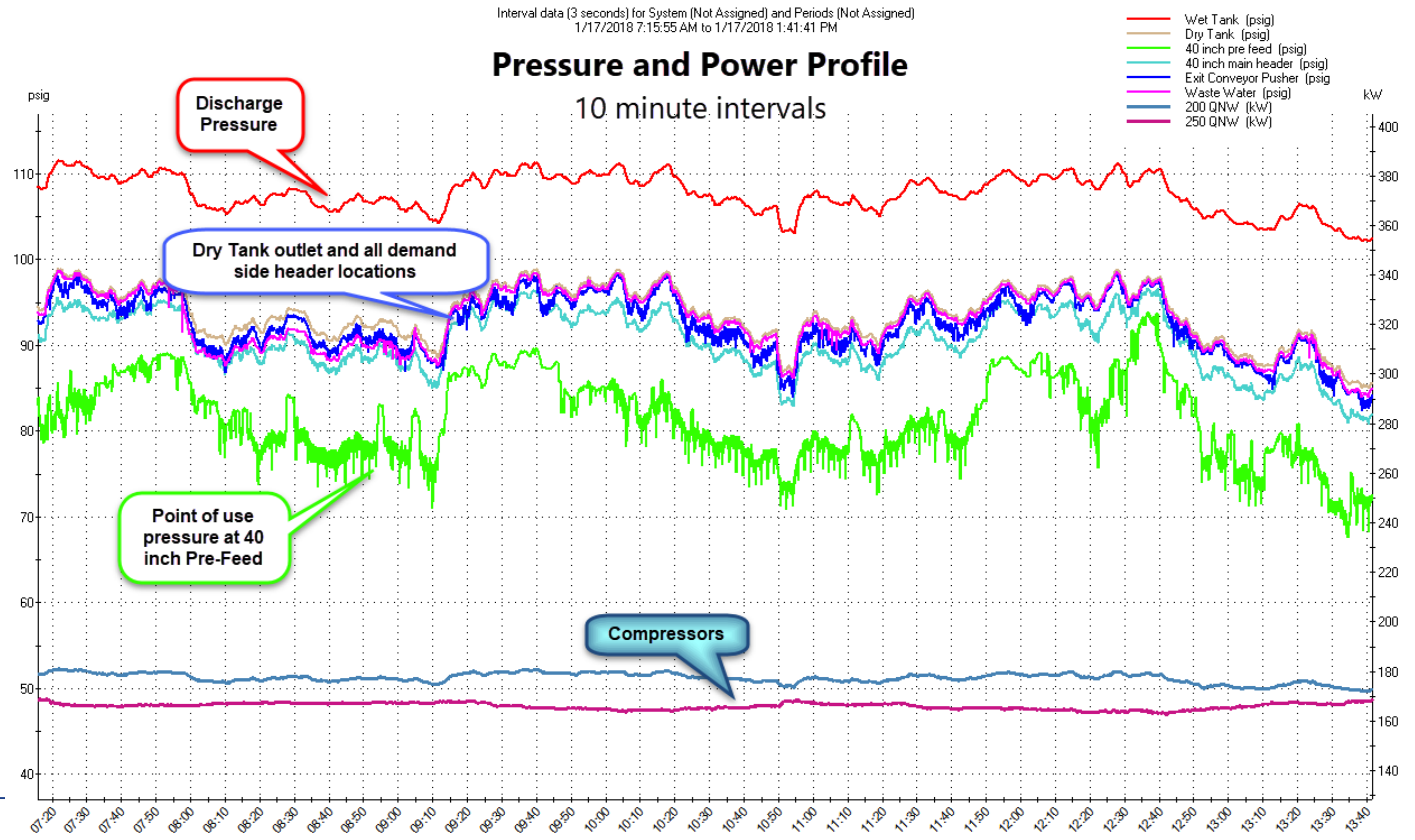
LogTool Trend Plot



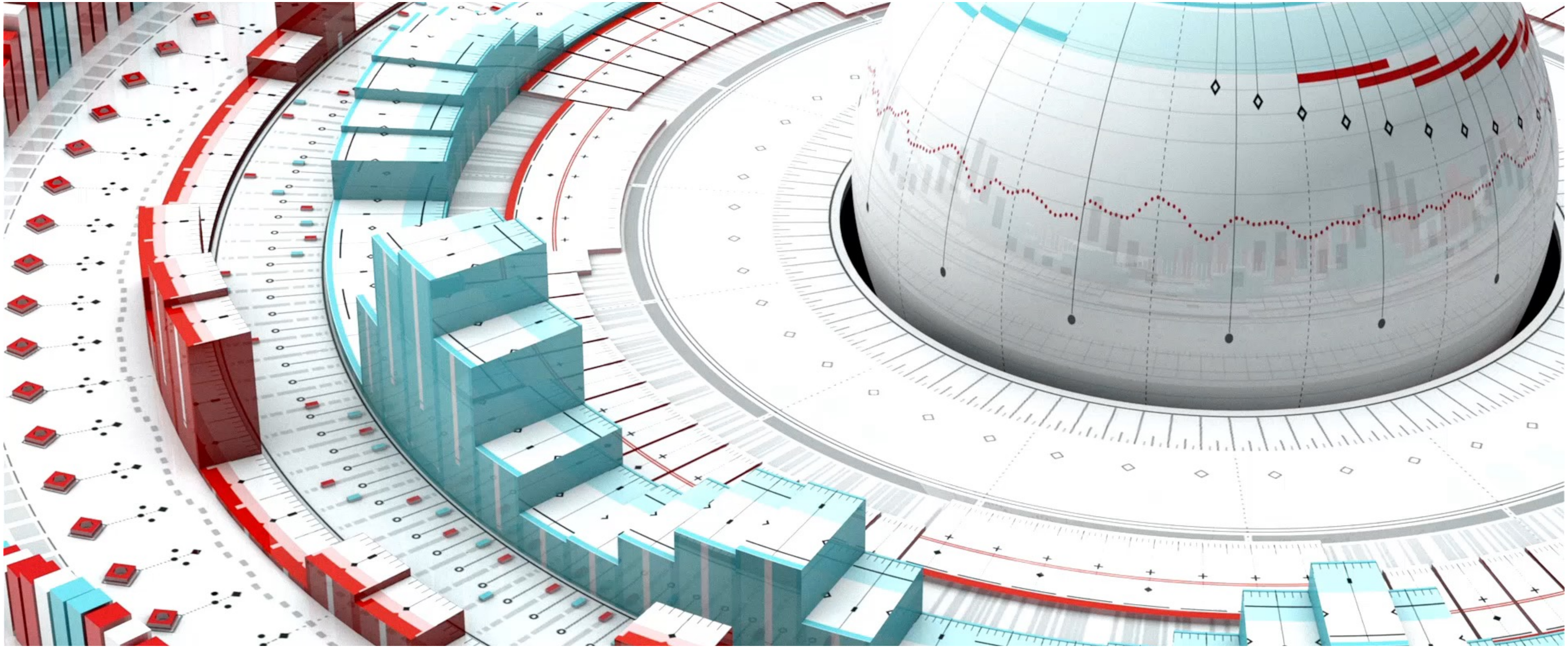
Bleed Down Test Calculation

Cfm Leakage =	[V x (P1 - P2) x 1.25]/(T x 14.7)						
Where	V=	453.9	Cu ft				
	P1=	118.66	Psig				
	P2 =	59.33	Psig				
	T =	3.50	Minute				
Cfm Leakage =	654.34						
% Leakage =	Measured cfm leakage/total cfm output of plant compressors						
% Leakage =	**32.3%**	Assuming 4cfm/hp and total HP of 450					

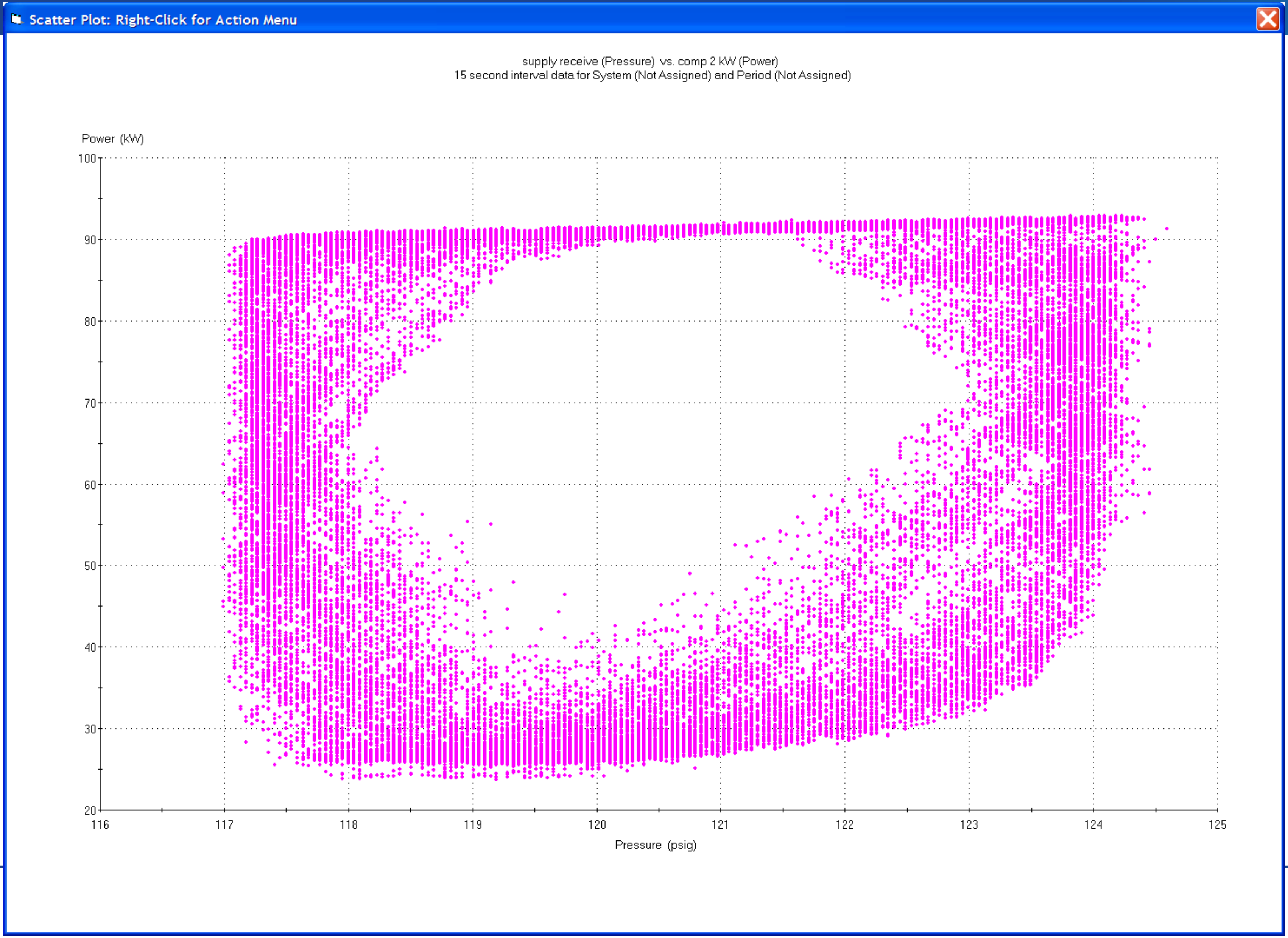
LogTool Trend Plot

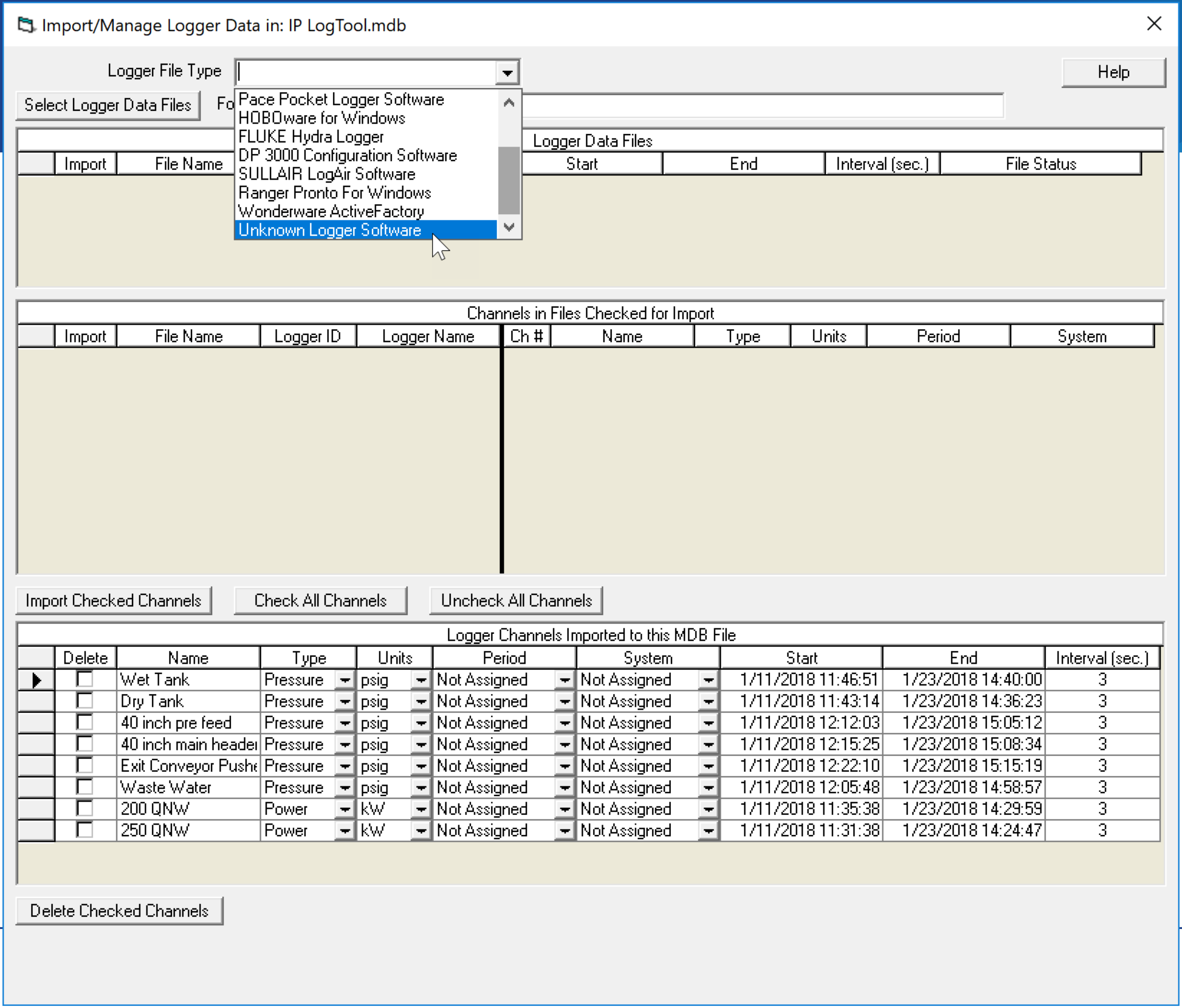


LogTool Scatter Plot



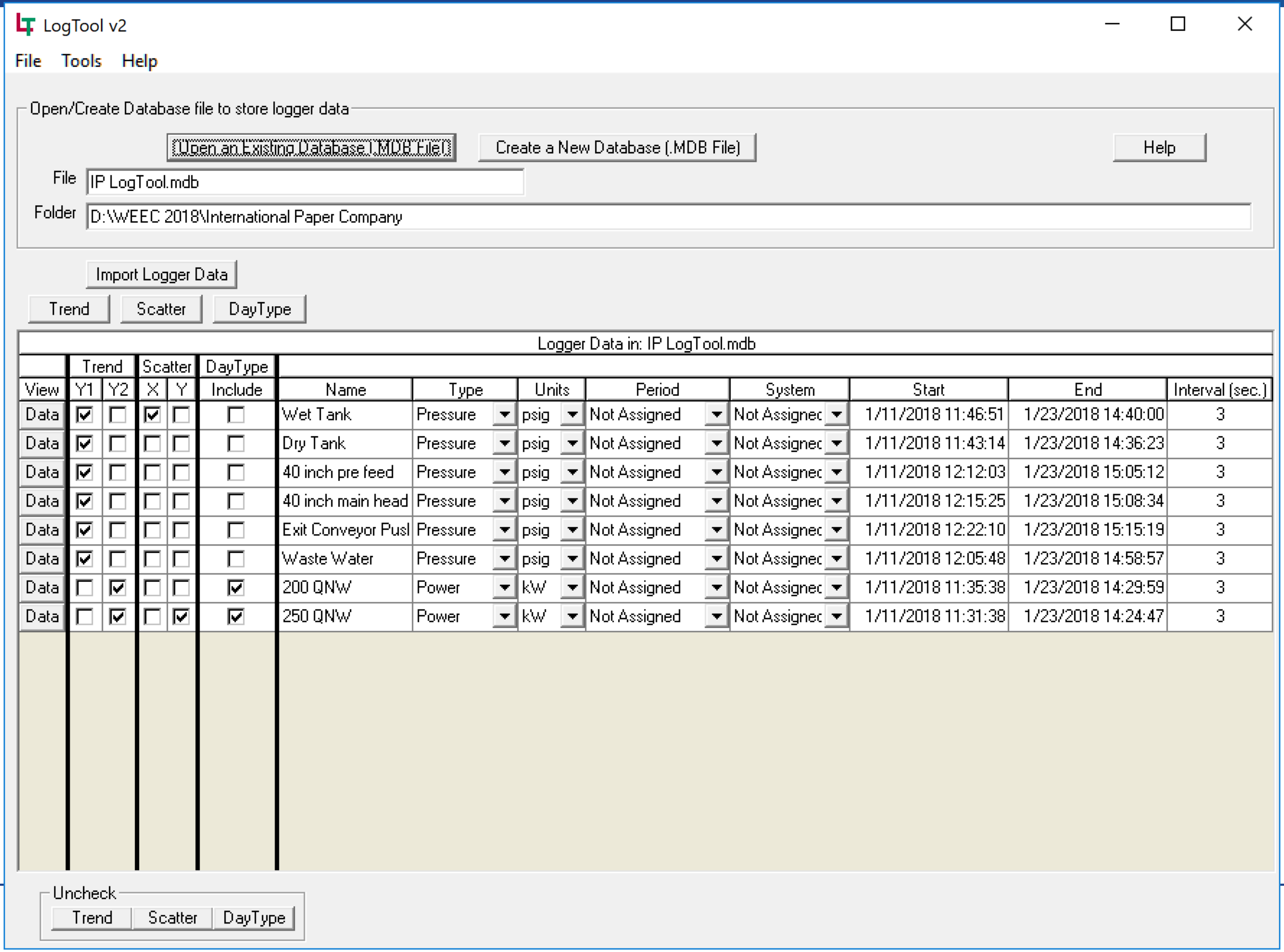
LogTool Scatter Plot





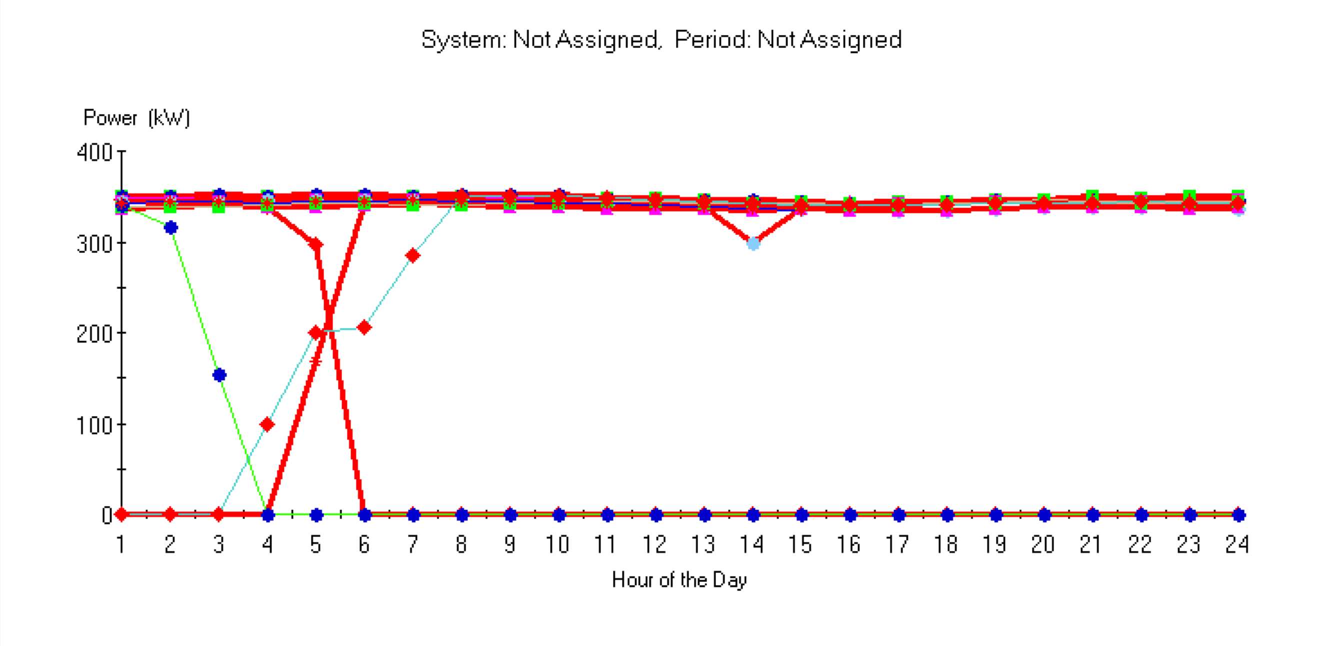
Delete	Name	Type	Units	Period	System	Start	End	Interval (sec.)
☐	Wet Tank	Pressure	psig	Not Assigned	Not Assigned	1/11/2018 11:46:51	1/23/2018 14:40:00	3
☐	Dry Tank	Pressure	psig	Not Assigned	Not Assigned	1/11/2018 11:43:14	1/23/2018 14:36:23	3
☐	40 inch pre feed	Pressure	psig	Not Assigned	Not Assigned	1/11/2018 12:12:03	1/23/2018 15:05:12	3
☐	40 inch main heade	Pressure	psig	Not Assigned	Not Assigned	1/11/2018 12:15:25	1/23/2018 15:08:34	3
☐	Exit Conveyor Pushe	Pressure	psig	Not Assigned	Not Assigned	1/11/2018 12:22:10	1/23/2018 15:15:19	3
☐	Waste Water	Pressure	psig	Not Assigned	Not Assigned	1/11/2018 12:05:48	1/23/2018 14:58:57	3
☐	200 QNW	Power	kW	Not Assigned	Not Assigned	1/11/2018 11:35:38	1/23/2018 14:29:59	3
☐	250 QNW	Power	kW	Not Assigned	Not Assigned	1/11/2018 11:31:38	1/23/2018 14:24:47	3

LogTool Main Menu



Enter LogTool Data Into AIRMaster

DayType Analysis



Right click on data points to select day type. Left click to highlight the trace.

Click a date to highlight profile in graph.

Date	Day	Day Type
Jan-11-2018	Thu	Excluded Days
Jan-12-2018	Fri	Production
Jan-13-2018	Sat	Production
Jan-14-2018	Sun	Sunday
Jan-15-2018	Mon	Monday
Jan-16-2018	Tue	Production
Jan-17-2018	Wed	Production
Jan-18-2018	Thu	Production
Jan-19-2018	Fri	Production
Jan-20-2018	Sat	Production
Jan-21-2018	Sun	Excluded Days
Jan-22-2018	Mon	Excluded Days
Jan-23-2018	Tue	Excluded Days

Plot Day Type ... All Days

Remove Day Type...

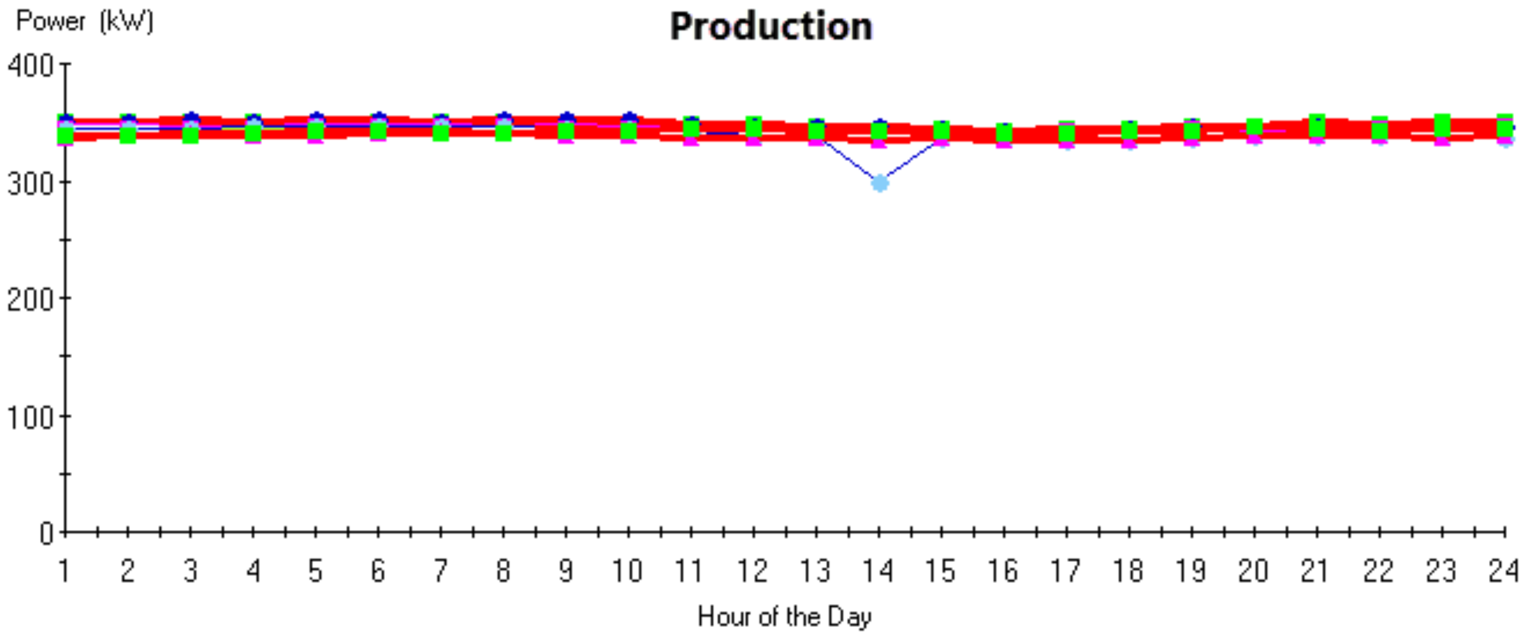
Caution: Day profiles can be similar even though different equipment, e.g., compressors, is operating. Use Trend Plots to examine the details of equipment operation before determining whether days should be assigned to the same daytype.

Create System DayType Profiles | Copy Plot to ClipBoard | Copy Profiles to ClipBoard | Help

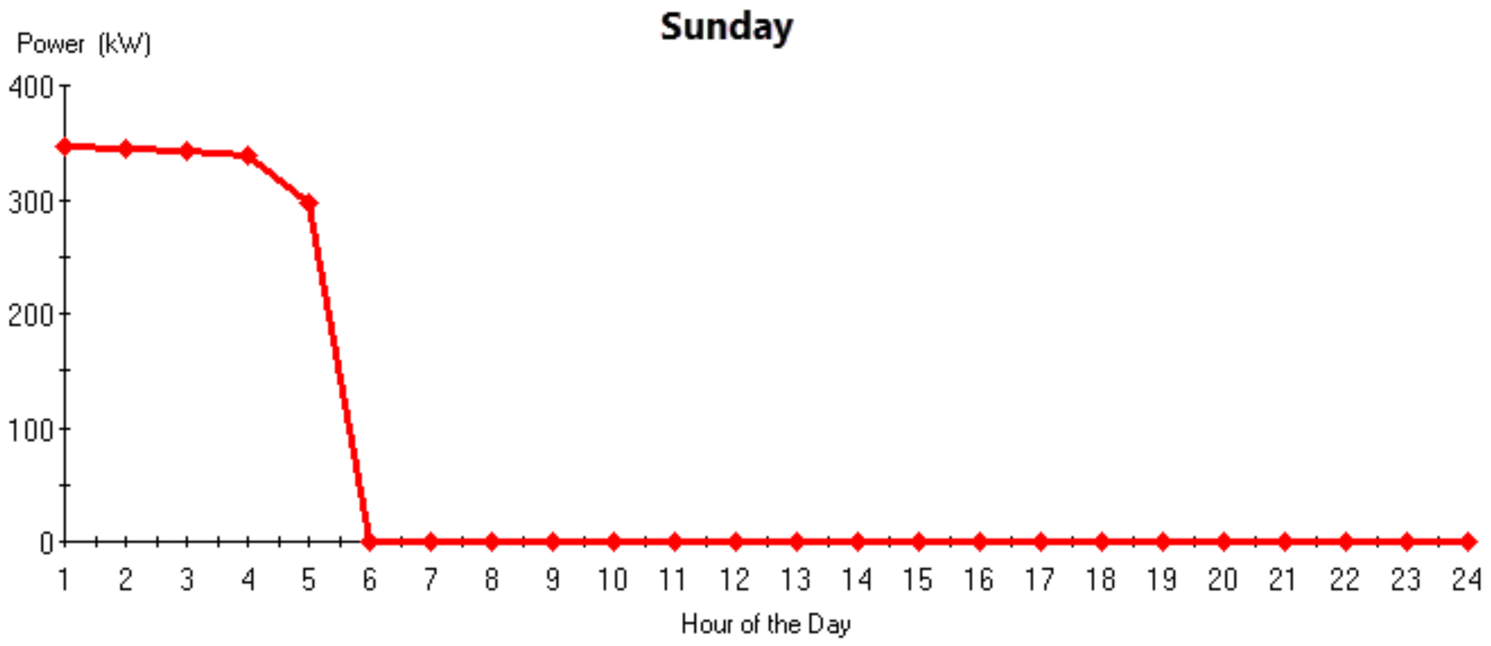
System DayType Profiles

DayTypeName	ChannelName	Hr_01	Hr_02	Hr_03	Hr_04	Hr_05	Hr_06	Hr_07
Monday	200 QNW	0.00	0.00	0.00	0.00	84.55	175.88	177.13
Monday	250 QNW	0.00	0.00	0.00	0.00	83.80	164.18	163.56
Production	200 QNW	178.12	178.25	177.86	177.11	177.67	178.09	177.97
Production	250 QNW	166.54	166.81	167.49	168.31	168.50	168.50	168.40
Sunday	200 QNW	181.76	180.51	179.20	176.98	154.17	0.00	0.00
Sunday	250 QNW	165.56	163.78	162.43	161.83	143.08	0.00	0.00

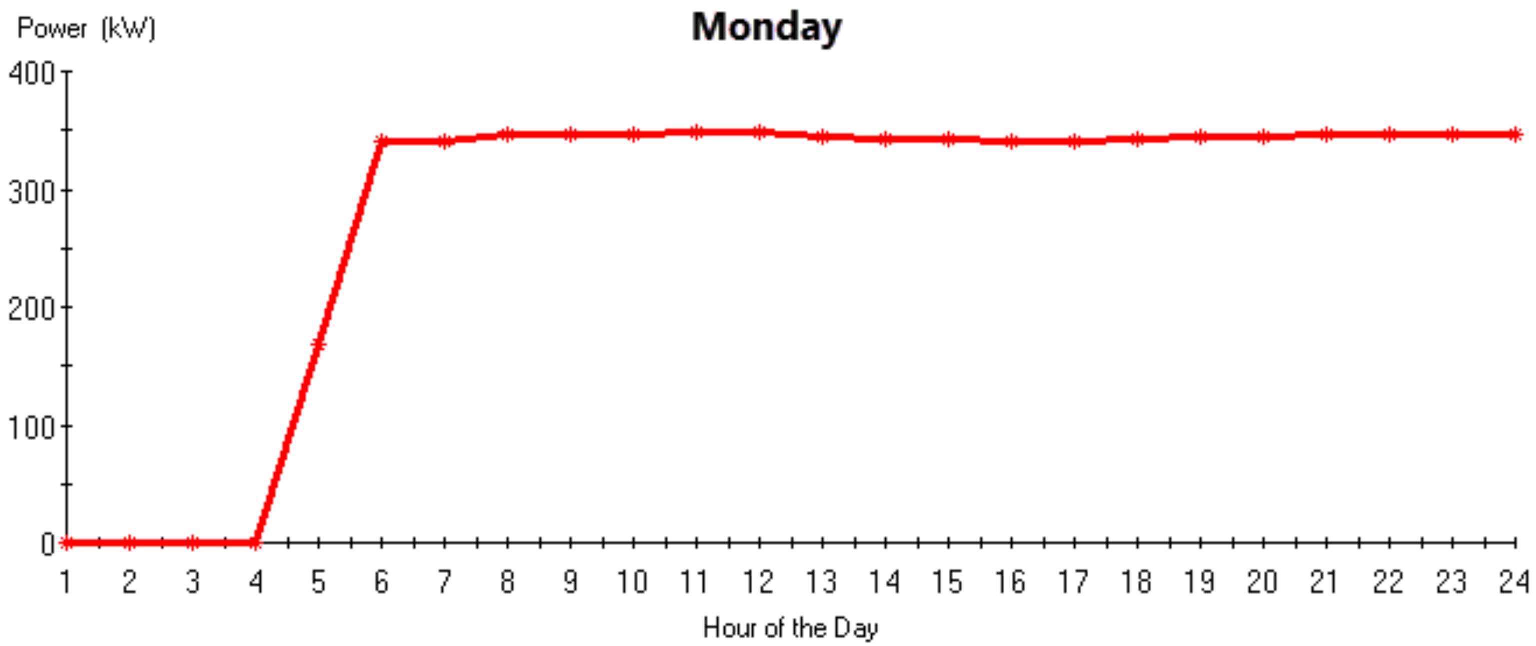
DayType Profiles



DayType Profiles



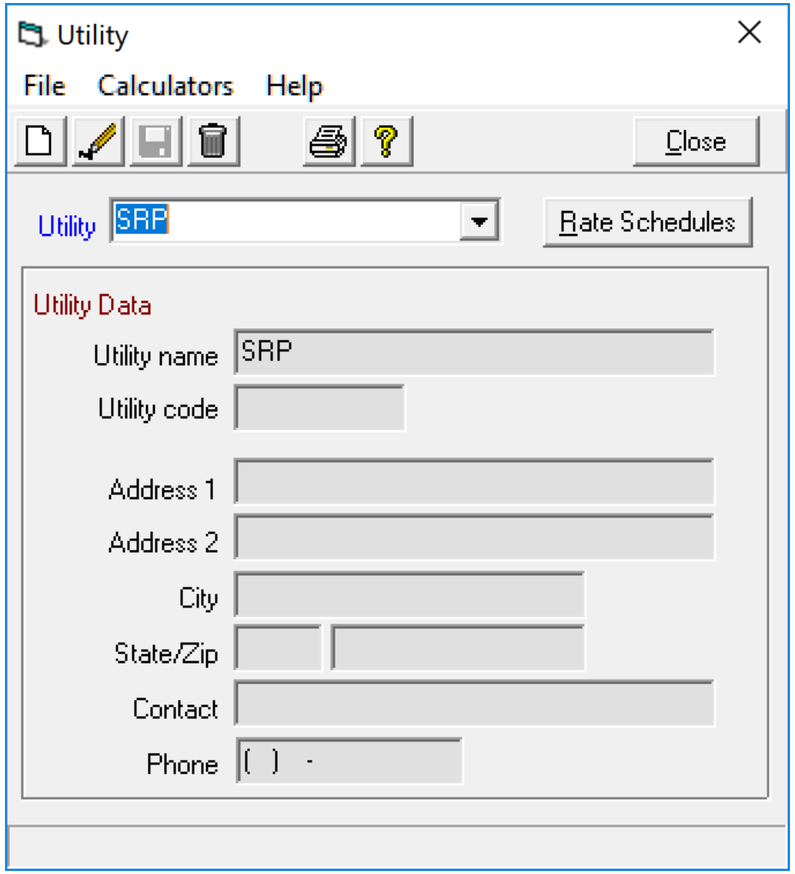
DayType Profiles

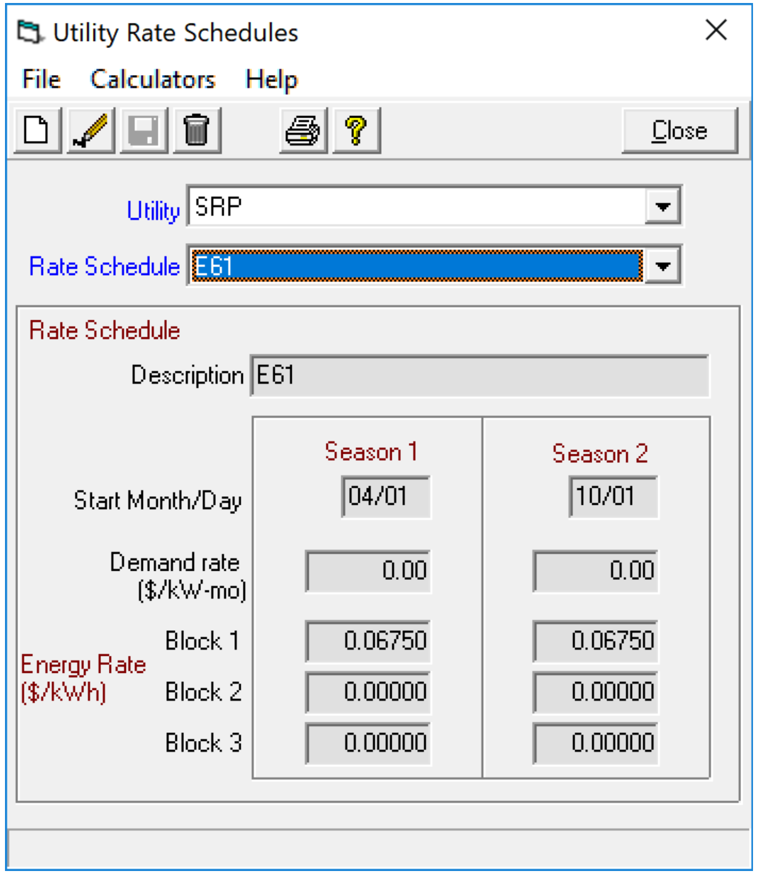


Enter LogTool Data Into AIRMaster

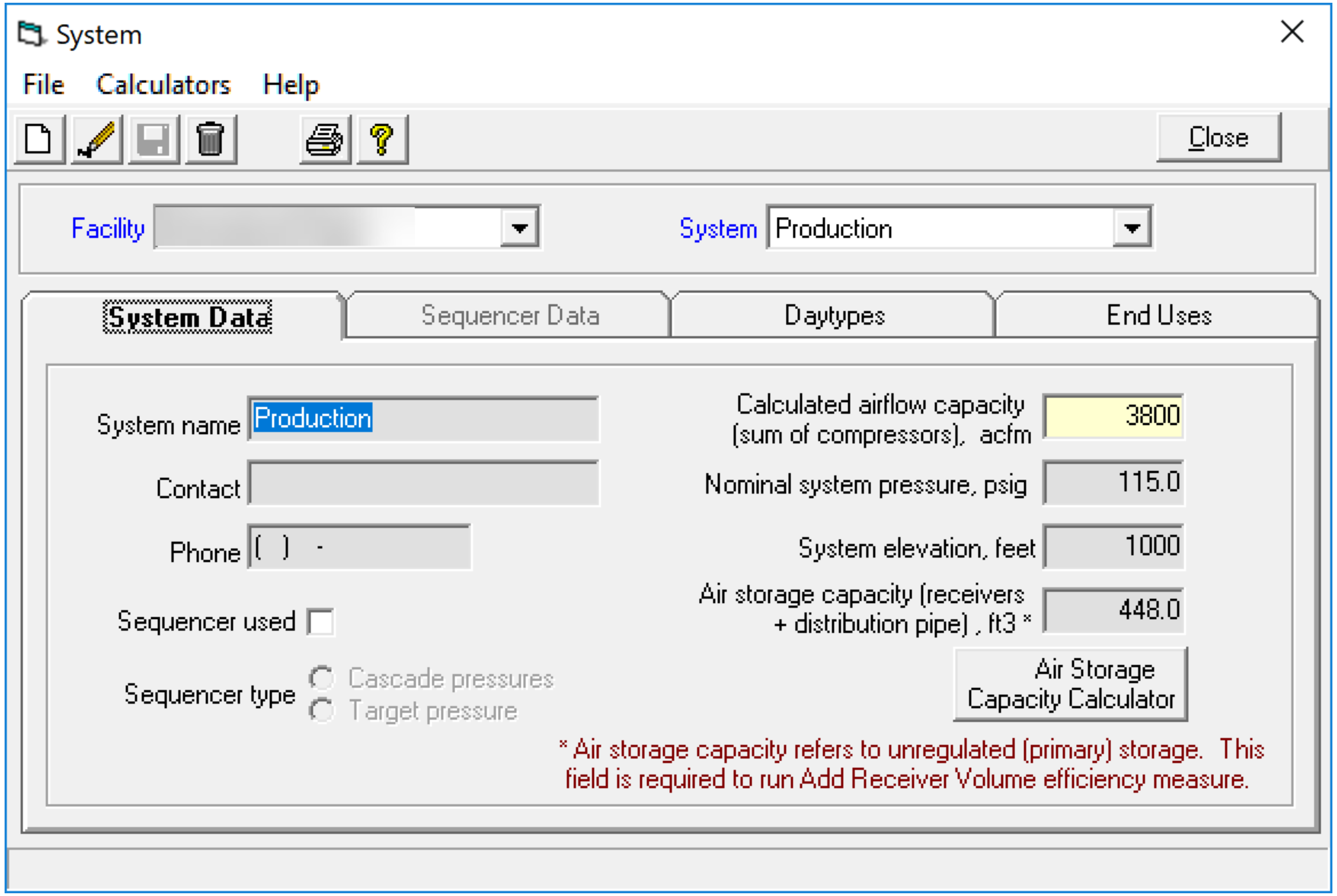
- Enter Utility and rate information
- Enter System information including Day Types
- Enter compressor Information
- Enter recorded data to establish the baseline
  - This data comes from LogTool
- Experiment with different EEM's

Utility and Rate Information

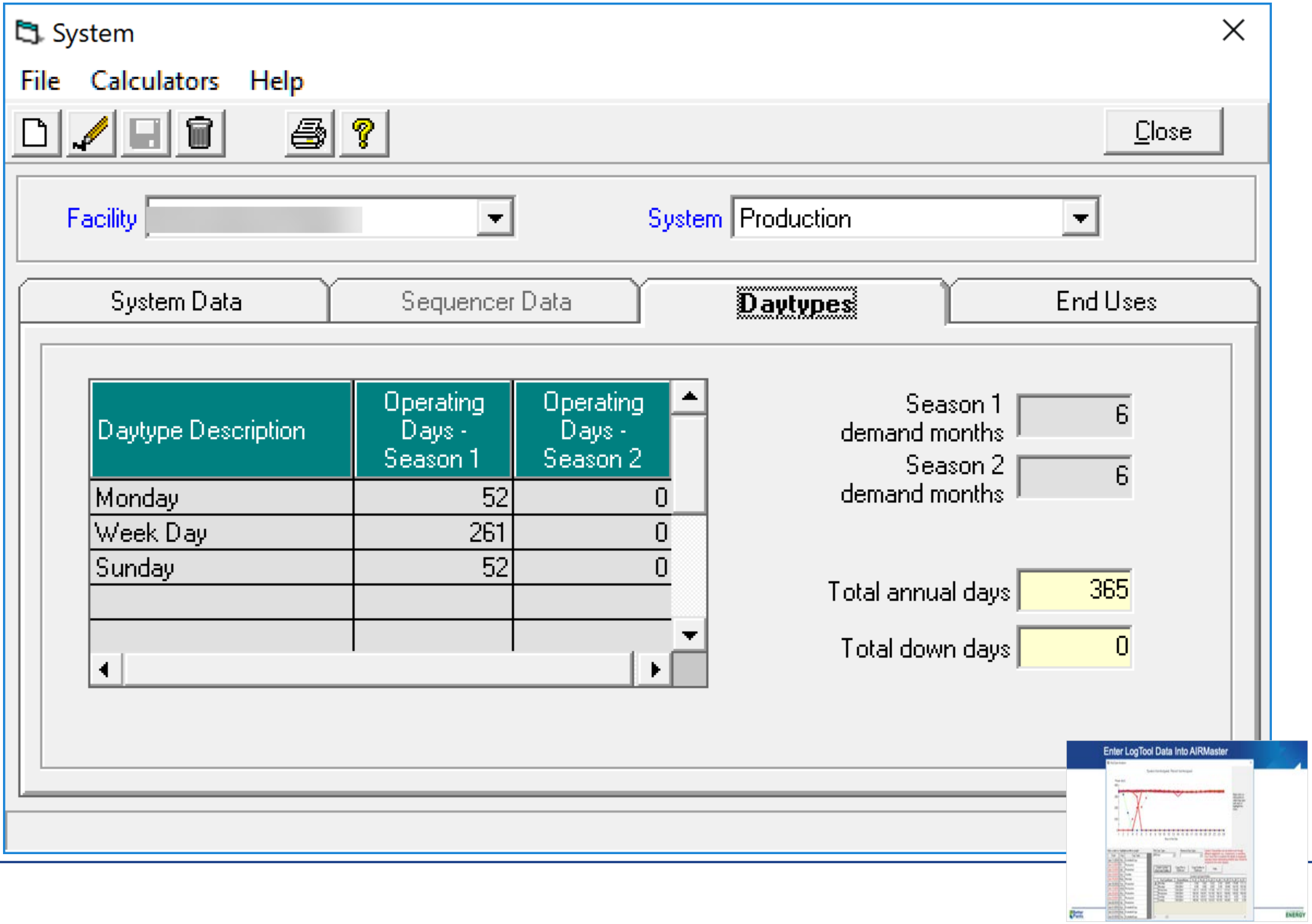




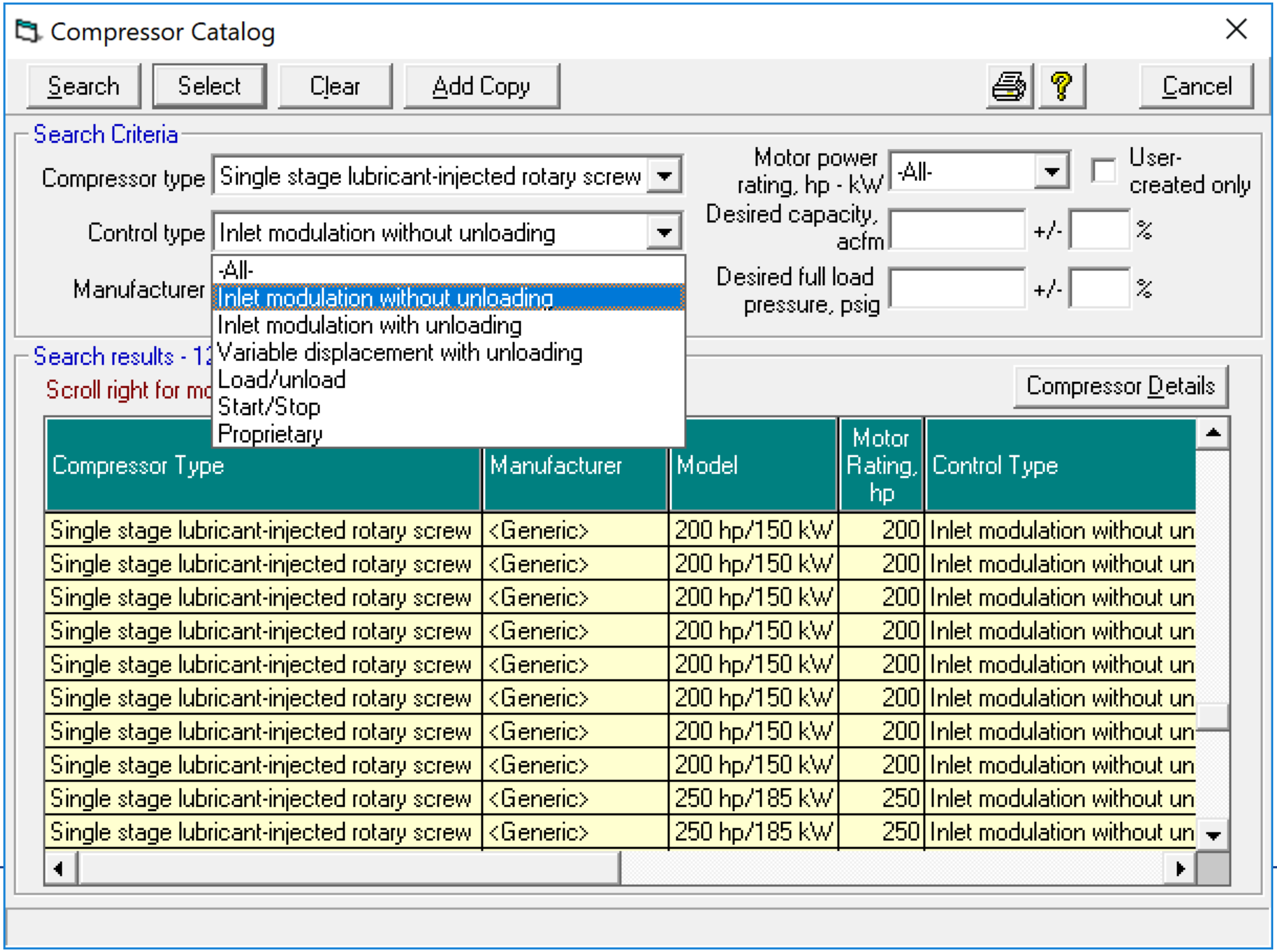
System Information



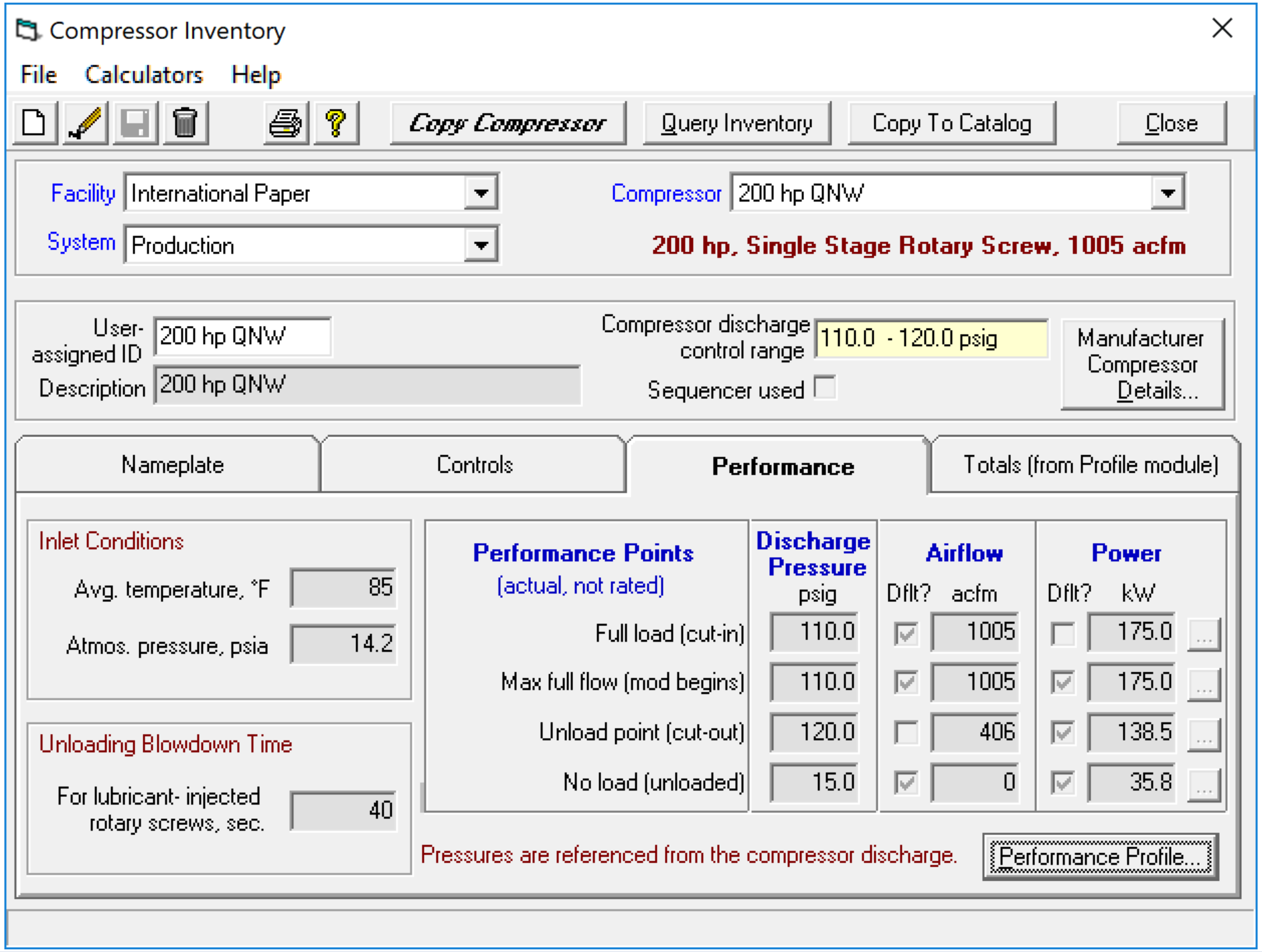
System Information Day Types



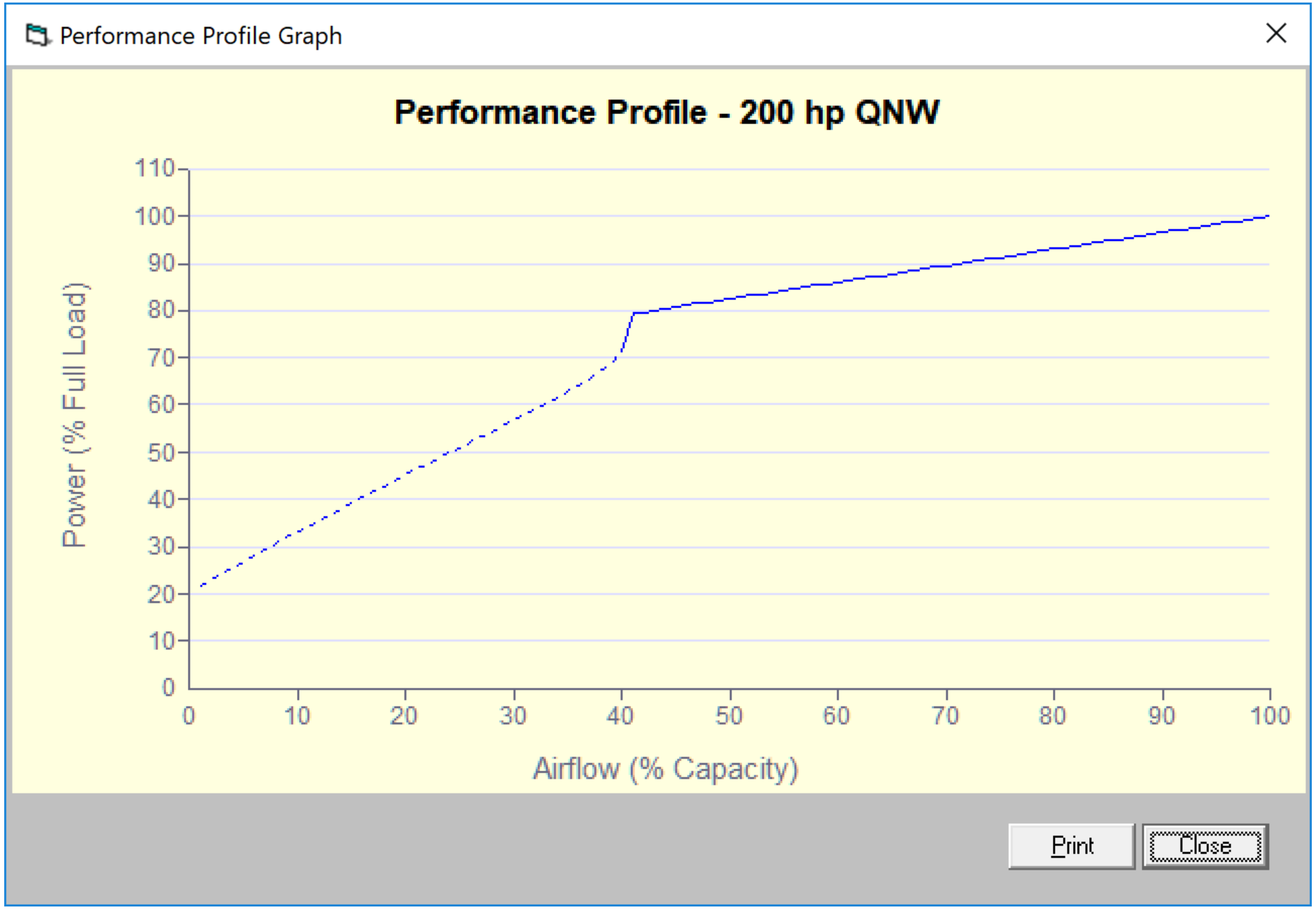
Compressor Information



Compressor Information



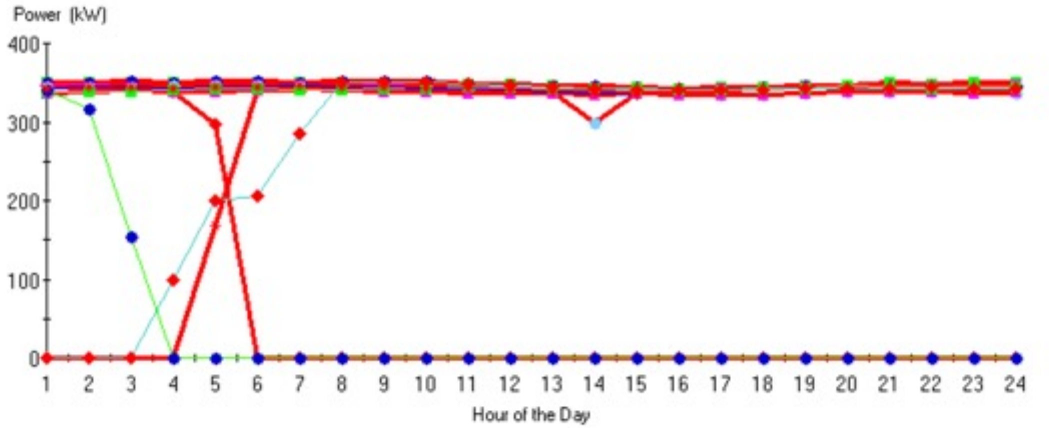
Compressor Information



Create the baseline from the Data

DayType Analysis

System: Not Assigned, Period: Not Assigned



Right click on data points to select day type. Left click to highlight the trace.

Click a date to highlight profile in graph.

Date	Day	Day Type
Jan-11-2018	Thu	Excluded Days
Jan-12-2018	Fri	Production
Jan-13-2018	Sat	Production
Jan-14-2018	Sun	Sunday
Jan-15-2018	Mon	Monday
Jan-16-2018	Tue	Production
Jan-17-2018	Wed	Production
Jan-18-2018	Thu	Production
Jan-19-2018	Fri	Production
Jan-20-2018	Sat	Production
Jan-21-2018	Sun	Excluded Days
Jan-22-2018	Mon	Excluded Days
Jan-23-2018	Tue	Excluded Days

Plot Day Type ... All Days

Remove Day Type...

Caution: Day profiles can be similar even though different equipment, e.g., compressors, is operating. Use Trend Plots to examine the details of equipment operation before determining whether days should be assigned to the same daytype.

Create System DayType Profiles | Copy Plot to ClipBoard | Copy Profiles to ClipBoard | Help

System DayType Profiles

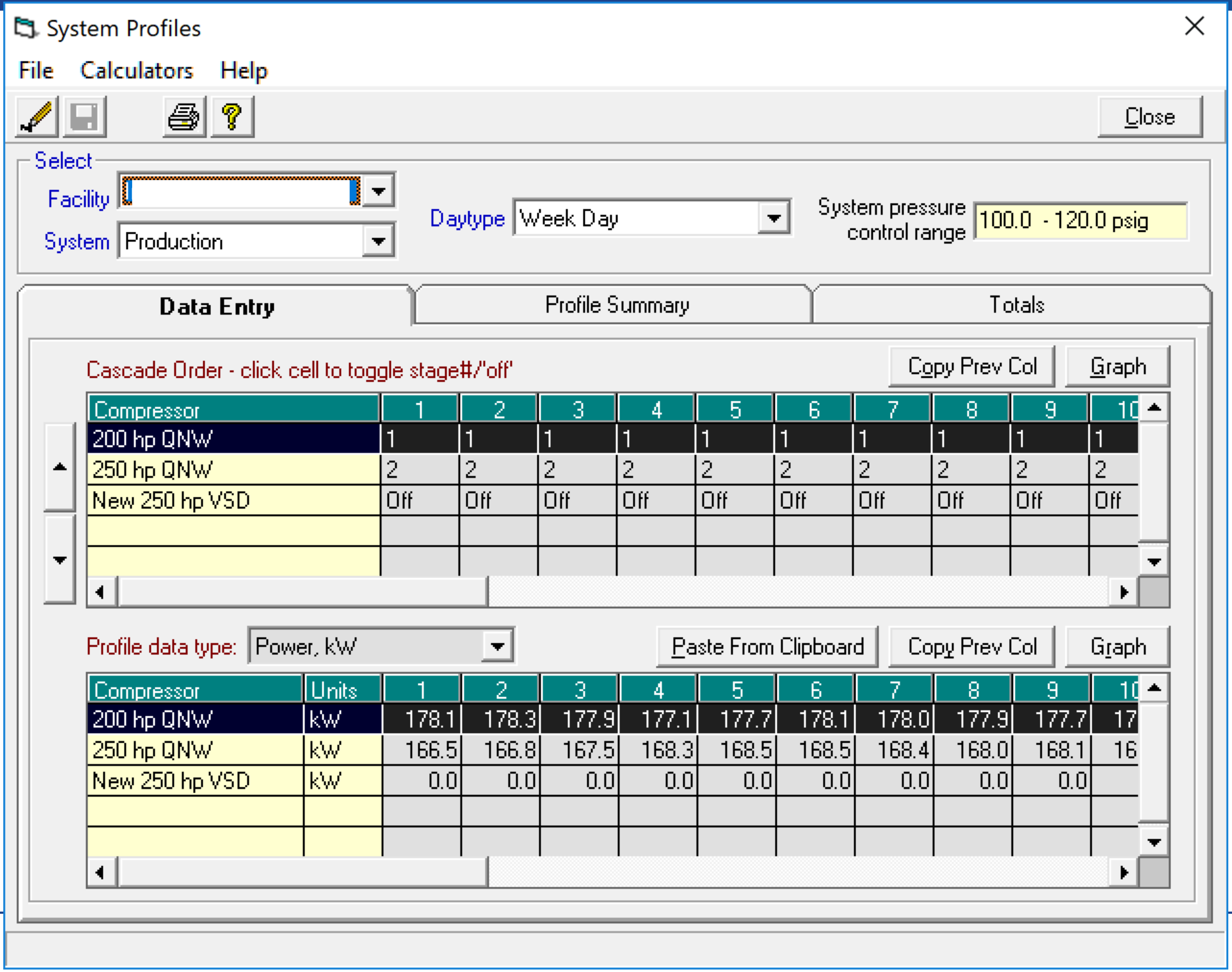
DayTypeName	ChannelName	Hr_01	Hr_02	Hr_03	Hr_04	Hr_05	Hr_06	Hr_07
Monday	200 QNW	0.00	0.00	0.00	0.00	84.55	175.88	177.13
Monday	250 QNW	0.00	0.00	0.00	0.00	83.80	164.18	163.56
Production	200 QNW	178.12	178.25	177.86	177.11	177.67	178.09	177.97
Production	250 QNW	166.54	166.81	167.49	168.31	168.50	168.50	168.40
Sunday	200 QNW	181.76	180.51	179.20	176.98	154.17	0.00	0.00
Sunday	250 QNW	165.56	163.78	162.43	161.83	143.08	0.00	0.00

Enter LogTool Data Into AIRMaster

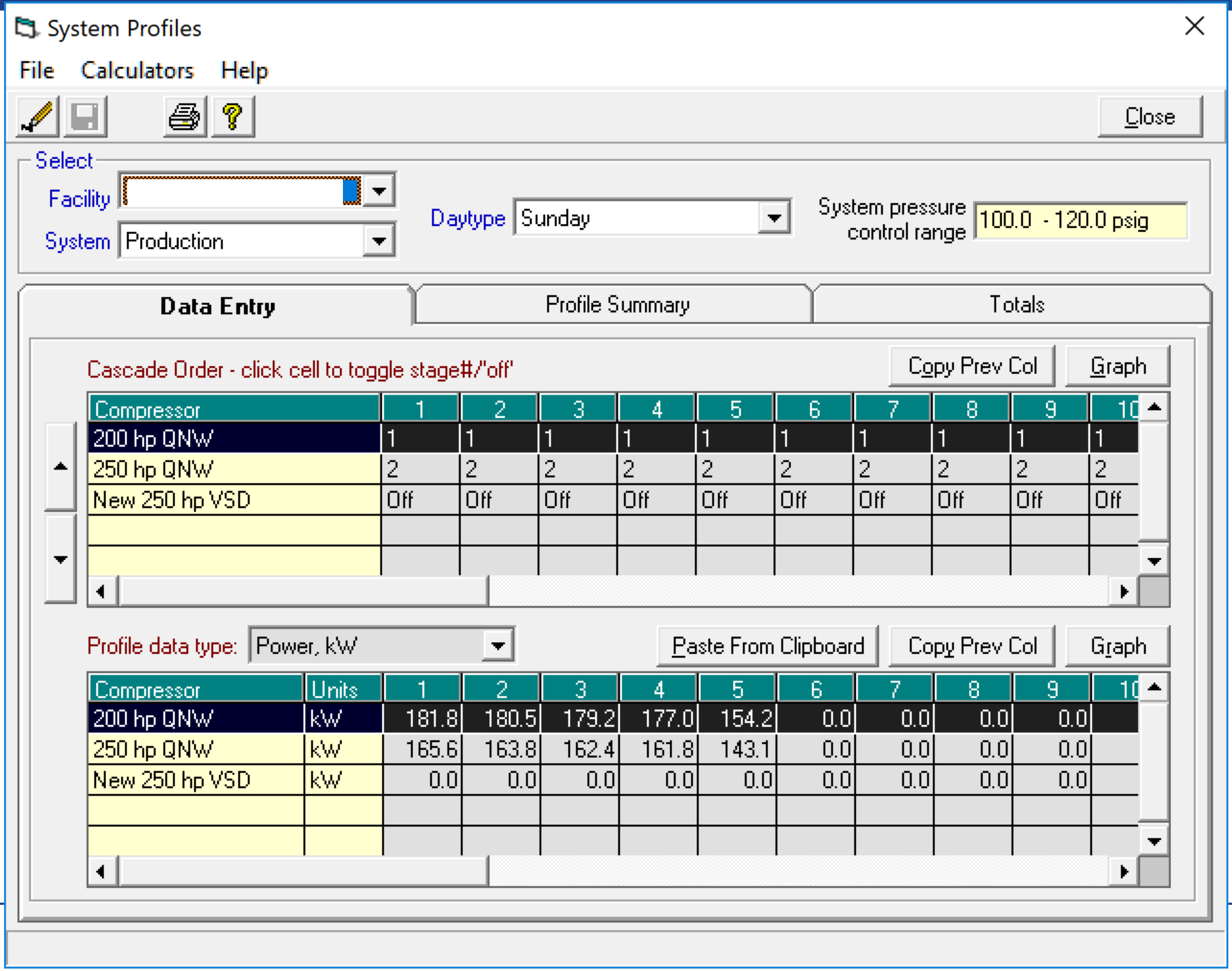
System	Type	Period	DayTypeNa	ChannelName	Hr_01	Hr_02	Hr_03	Hr_04	Hr_05	Hr_06	Hr_07	Hr_08	Hr_09	Hr_10	Hr_11	Hr_12	Hr_13	Hr_14	Hr_15	Hr_16	Hr_17	Hr_18	Hr_19	Hr_20	Hr_21	Hr_22	Hr_23	Hr_24
Not Assigne	Power	Not Assigne	Monday	200 QNW	0.0	0.0	0.0	0.0	84.6	175.9	177.1	181.6	182.2	180.8	177.2	177.7	177.0	178.6	178.7	178.7	176.9	177.0	178.2	177.2	178.7	179.6	180.1	179.3
Not Assigne	Power	Not Assigne	Monday	250 QNW	0.0	0.0	0.0	0.0	83.8	164.2	163.6	164.5	165.0	166.7	171.6	169.9	168.1	164.9	163.3	162.5	163.6	164.8	165.6	167.1	167.1	167.0	166.2	166.9
Not Assigne	Power	Not Assigne	Production	200 QNW	178.1	178.3	177.9	177.1	177.7	178.1	178.0	177.9	177.7	178.1	177.3	177.2	177.2	168.0	174.9	175.7	175.7	175.8	177.5	177.4	178.4	179.0	179.1	179.8
Not Assigne	Power	Not Assigne	Production	250 QNW	166.5	166.8	167.5	168.3	168.5	168.5	168.4	168.0	168.1	167.1	166.4	166.1	165.0	167.1	165.9	164.7	164.5	165.2	165.0	165.8	165.3	164.5	164.2	164.4
Not Assigne	Power	Not Assigne	Sunday	200 QNW	181.8	180.5	179.2	177.0	154.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Not Assigne	Power	Not Assigne	Sunday	250 QNW	165.6	163.8	162.4	161.8	143.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Date	Day	Day Type
Jan-11-201	Thu	Excluded Days
Jan-12-201	Fri	Production
Jan-13-201	Sat	Production
Jan-14-201	Sun	Sunday
Jan-15-201	Mon	Monday
Jan-16-201	Tue	Production
Jan-17-201	Wed	Production
Jan-18-201	Thu	Production
Jan-19-201	Fri	Production
Jan-20-201	Sat	Production
Jan-21-201	Sun	Excluded Days
Jan-22-201	Mon	Excluded Days
Jan-23-201	Tue	Excluded Days

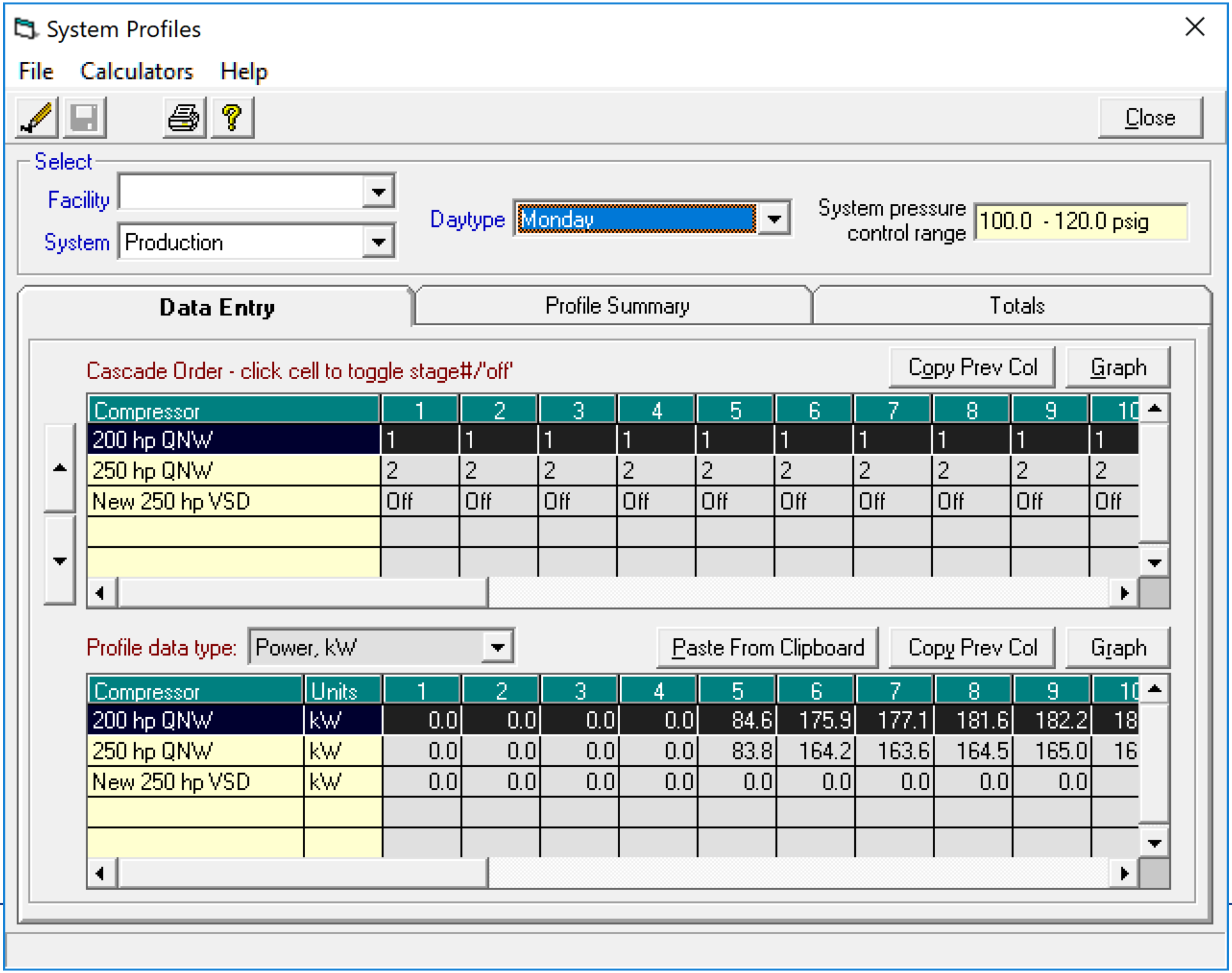
Enter LogTool Data Into AIRMaster



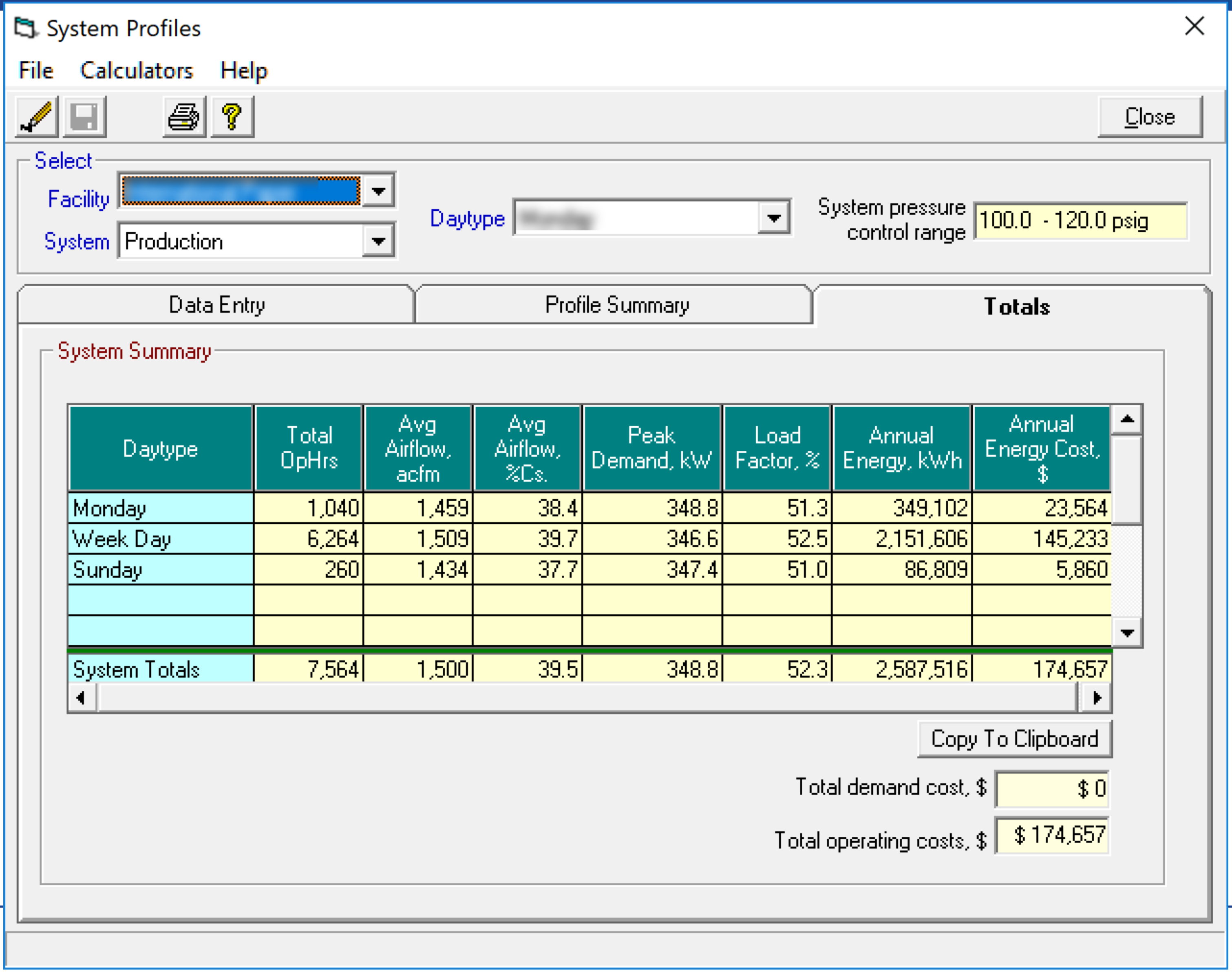
Enter LogTool Data Into AIRMaster



Enter LogTool Data Into AIRMaster

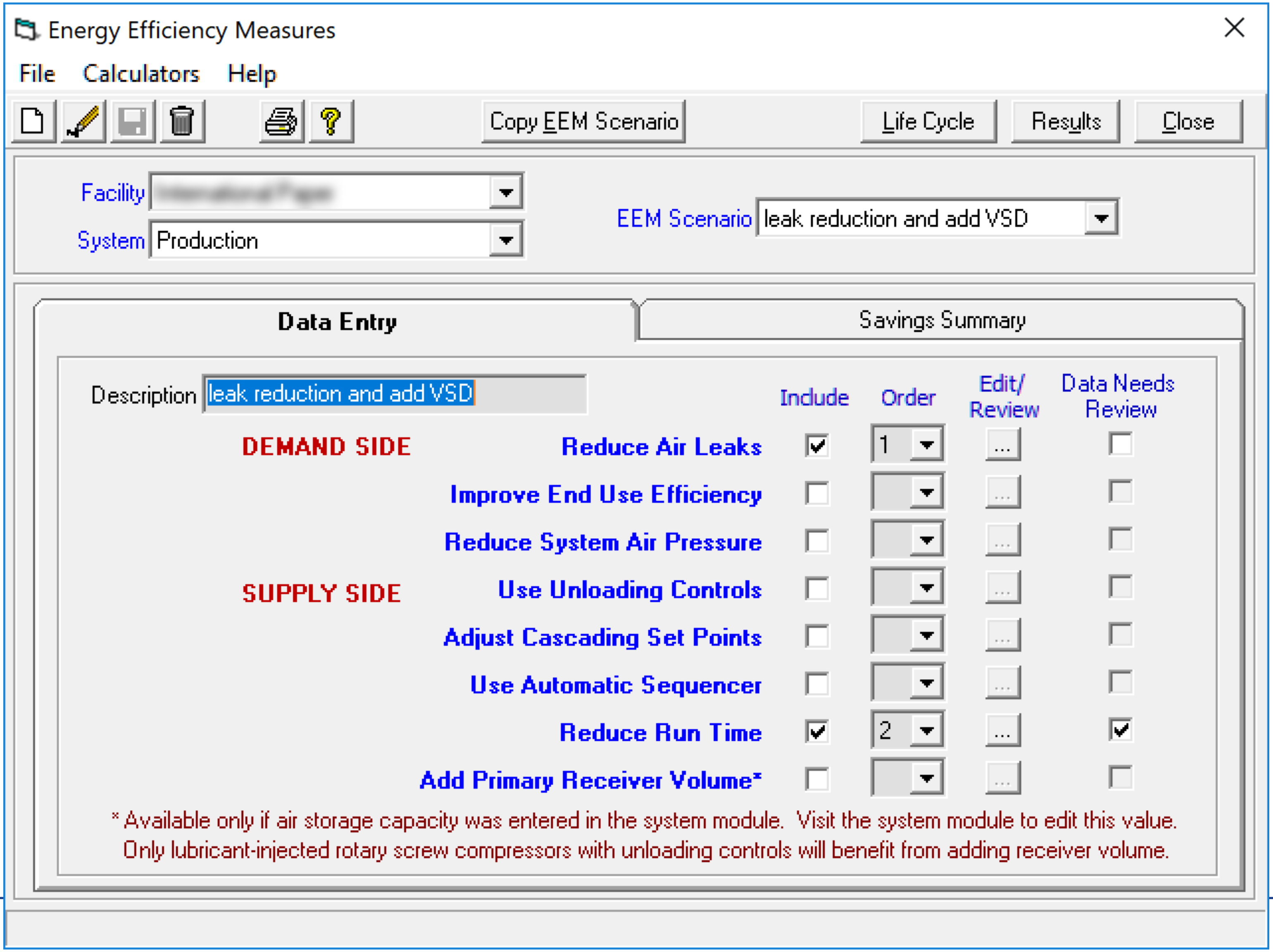


The Baseline

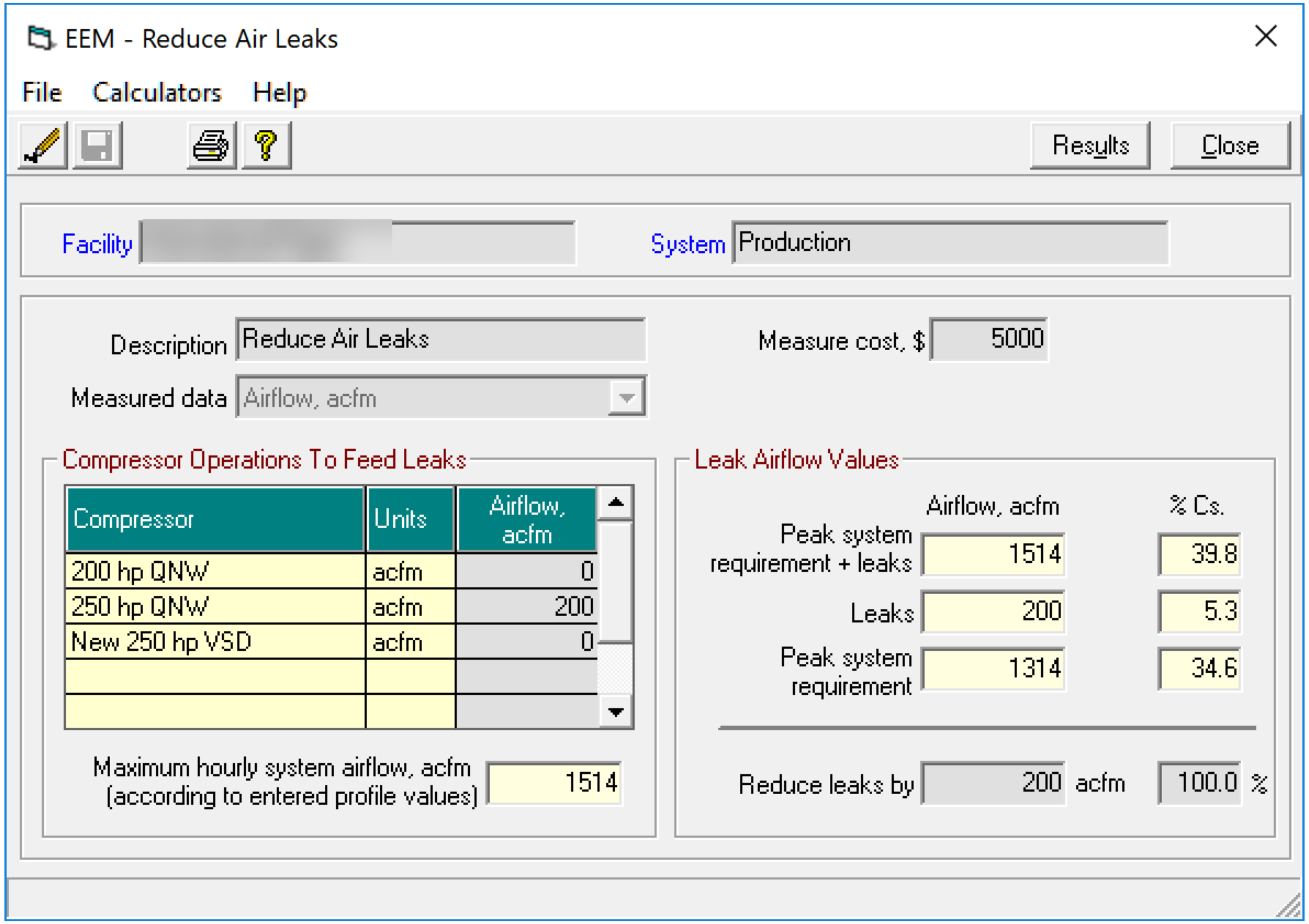


Daytype	Total OpHrs	Avg Airflow, acfm	Avg Airflow, %Cs.	Peak Demand, kW	Load Factor, %	Annual Energy, kWh	Annual Energy Cost, $
Monday	1,040	1,459	38.4	348.8	51.3	349,102	23,564
Week Day	6,264	1,509	39.7	346.6	52.5	2,151,606	145,233
Sunday	260	1,434	37.7	347.4	51.0	86,809	5,860
System Totals	7,564	1,500	39.5	348.8	52.3	2,587,516	174,657

EEM's

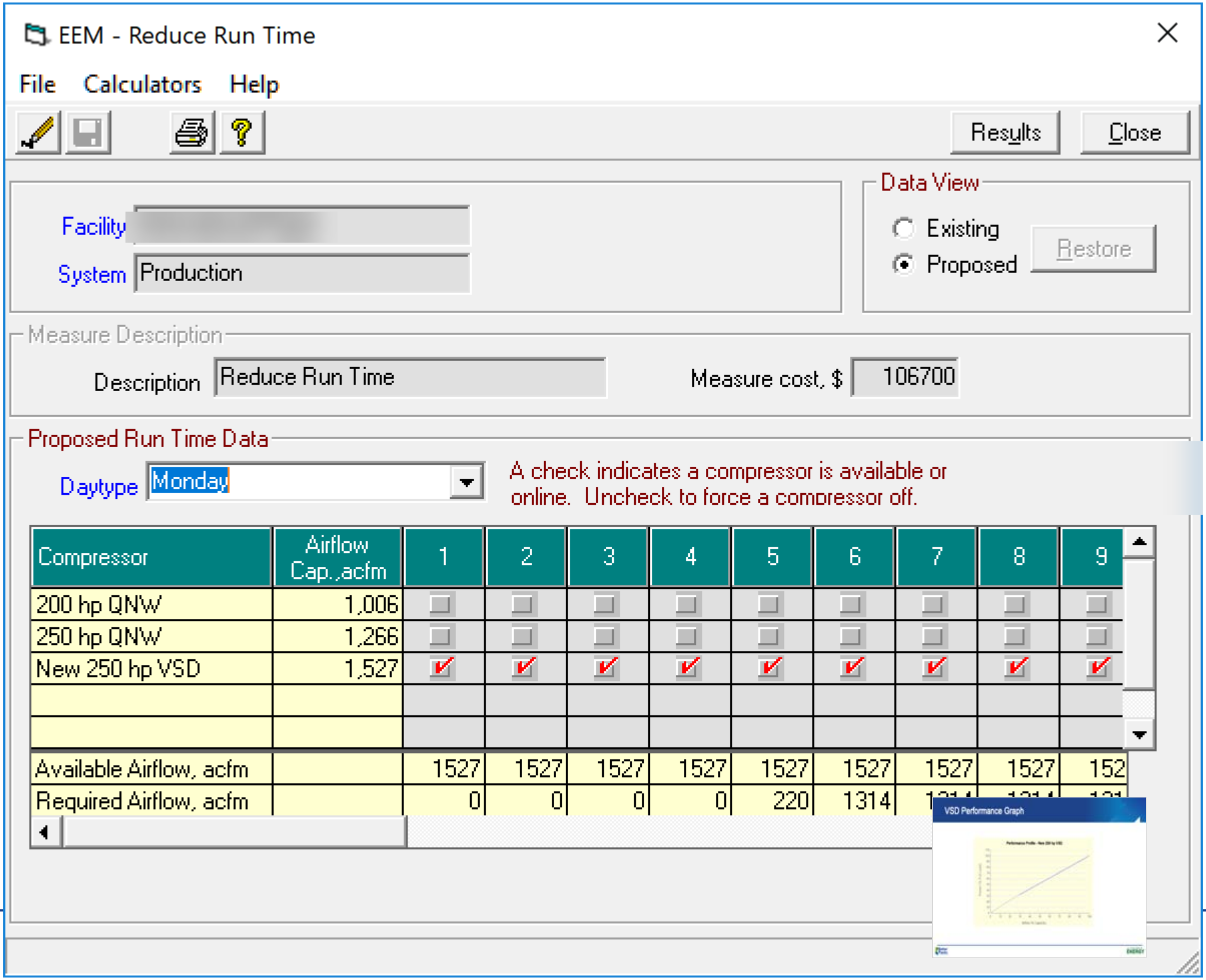

Energy Efficiency Measures
File
Calculators
Help
Copy EEM Scenario
Life Cycle
Results
Close
Facility
System
Production
EEM Scenario
leak reduction and add VSD
Data Entry
Savings Summary
Description
leak reduction and add VSD
Include
Order
Edit/ Review
Data Needs Review
DEMAND SIDE
Reduce Air Leaks
1
Improve End Use Efficiency
Reduce System Air Pressure
SUPPLY SIDE
Use Unloading Controls
Adjust Cascading Set Points
Use Automatic Sequencer
Reduce Run Time
2
Add Primary Receiver Volume*
* Available only if air storage capacity was entered in the system module. Visit the system module to edit this value.
Only lubricant-injected rotary screw compressors with unloading controls will benefit from adding receiver volume.

EEM’s



EEM - Reduce Air Leaks
File
Calculators
Help
Results
Close
Facility
System
Production
Description
Reduce Air Leaks
Measure cost, $
5000
Measured data
Airflow, acfm
Compressor Operations To Feed Leaks
Compressor
Units
Airflow, acfm
200 hp QNW
acfm
0
250 hp QNW
acfm
200
New 250 hp VSD
acfm
0
Maximum hourly system airflow, acfm (according to entered profile values)
1514
Leak Airflow Values
Airflow, acfm
% Cs.
Peak system requirement + leaks
1514
39.8
Leaks
200
5.3
Peak system requirement
1314
34.6
Reduce leaks by
200
acfm
100.0
%

EEM's


EEM - Reduce Run Time
File
Calculators
Help
Results
Close
Data View
Existing
Proposed
Restore
Facility
System
Production
Measure Description
Description
Reduce Run Time
Measure cost, $
106700
Proposed Run Time Data
Daytype
Monday
A check indicates a compressor is available or online. Uncheck to force a compressor off.
Compressor
Airflow Cap.,acfm
1
2
3
4
5
6
7
8
9
200 hp QNW
1,006
250 hp QNW
1,266
New 250 hp VSD
1,527
Available Airflow, acfm
1527
1527
1527
1527
1527
1527
1527
1527
Required Airflow, acfm
0
0
0
0
220
1314
VSD Performance Graph

EEM's

Energy Efficiency Measures

File Calculators Help

Copy EEM Scenario | Life Cycle | Results | Close

Facility: International Paper

System: Production

EEM Scenario: leak reduction and add VSD

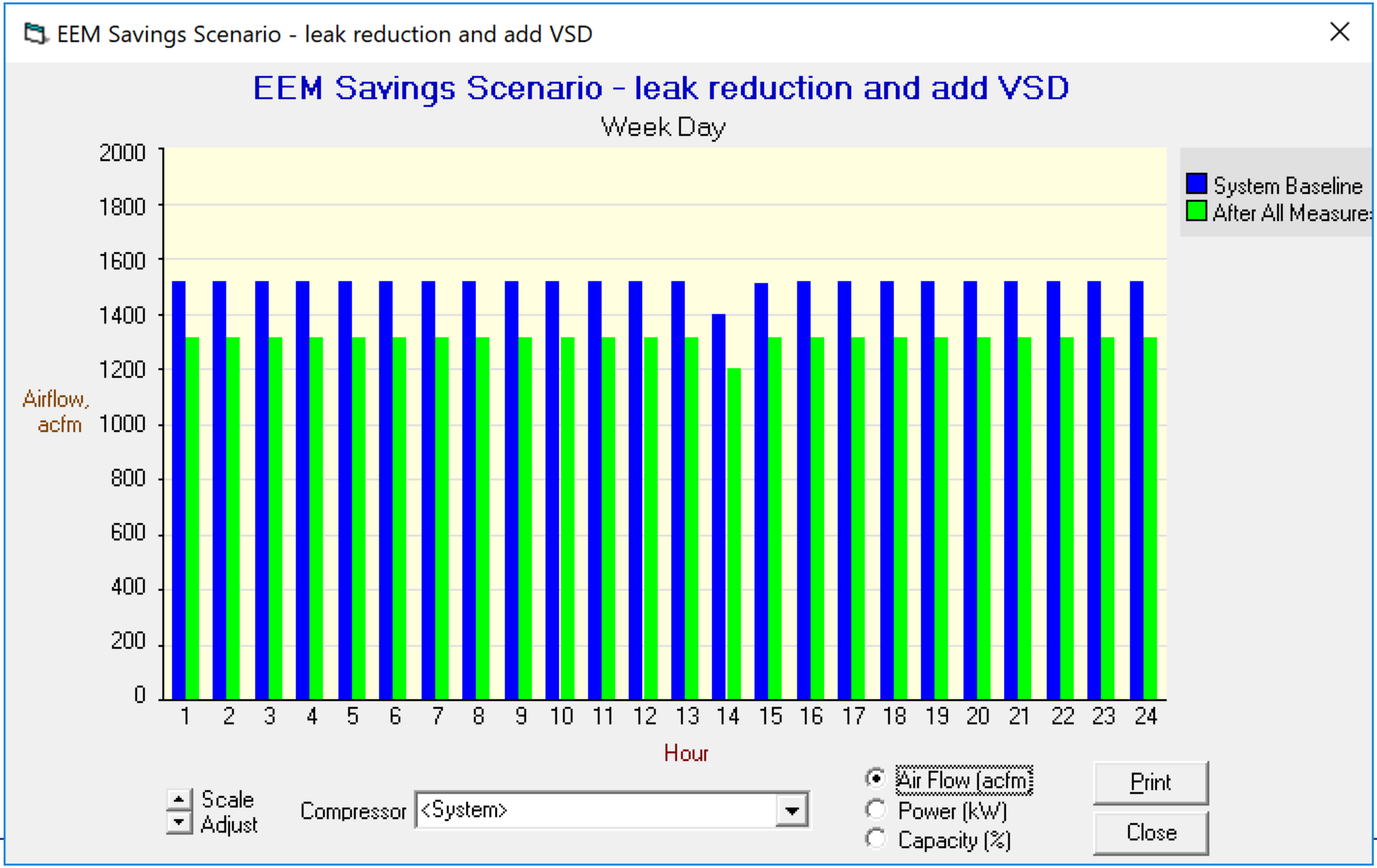
Data Entry | **Savings Summary**

Description	Energy Savings, kWh	Energy Savings, $	Energy Savings, %	Demand Savings, kW	Demand Savings, $	Installed Cost, $	Total Savings, $	Simple Payback, years
Reduce Air Leaks	457,487	30,880	17.7	64.1	0	5,000	30,880	0.2
Reduce Run Time	484,848	32,727	18.7	64.9	0	106,700	32,727	3.3
TOTALS	942,335	63,608	36.4	129.0	0	111,700	63,608	1.8

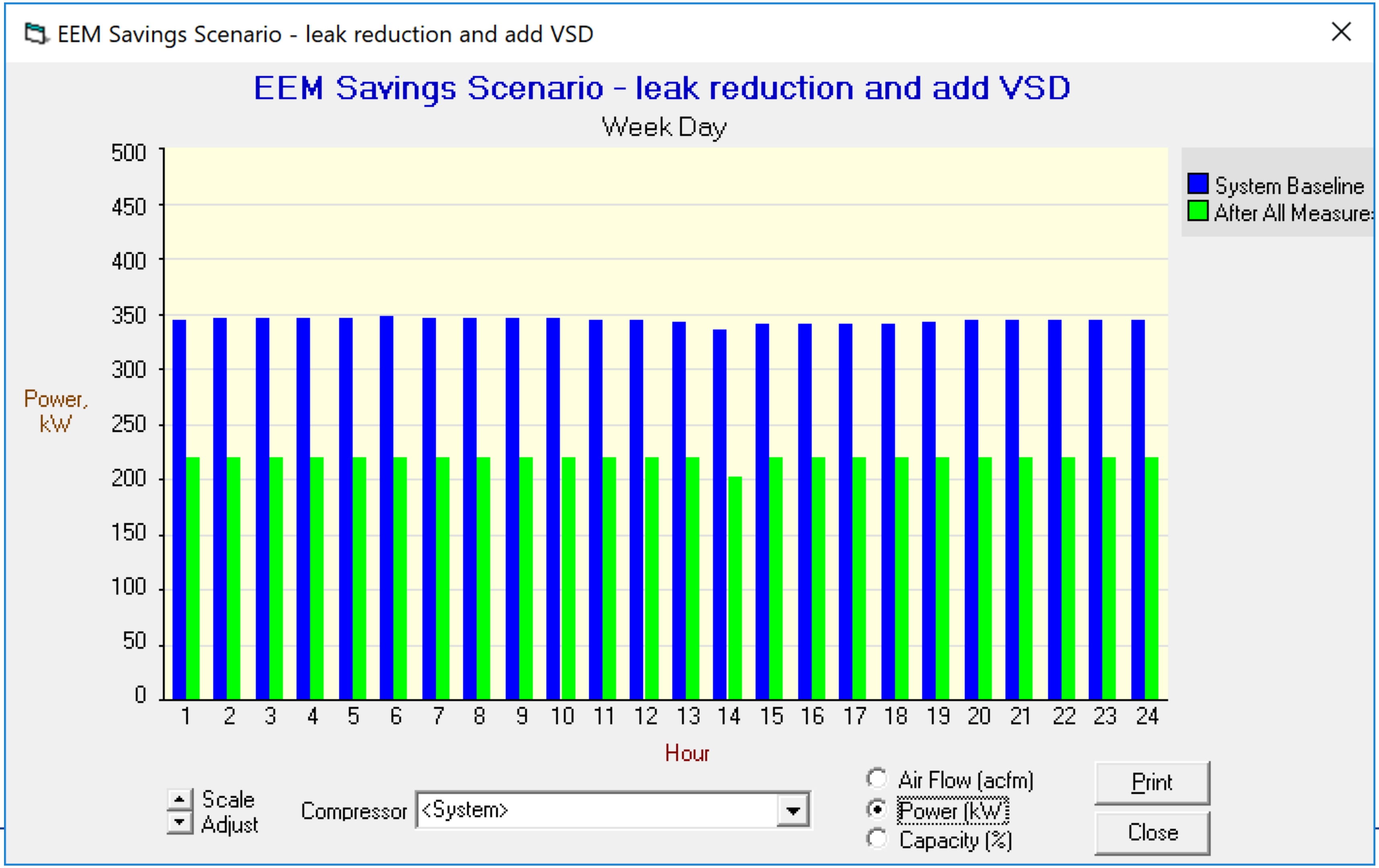
Double-click row to view corresponding measure input data

Copy To Clipboard

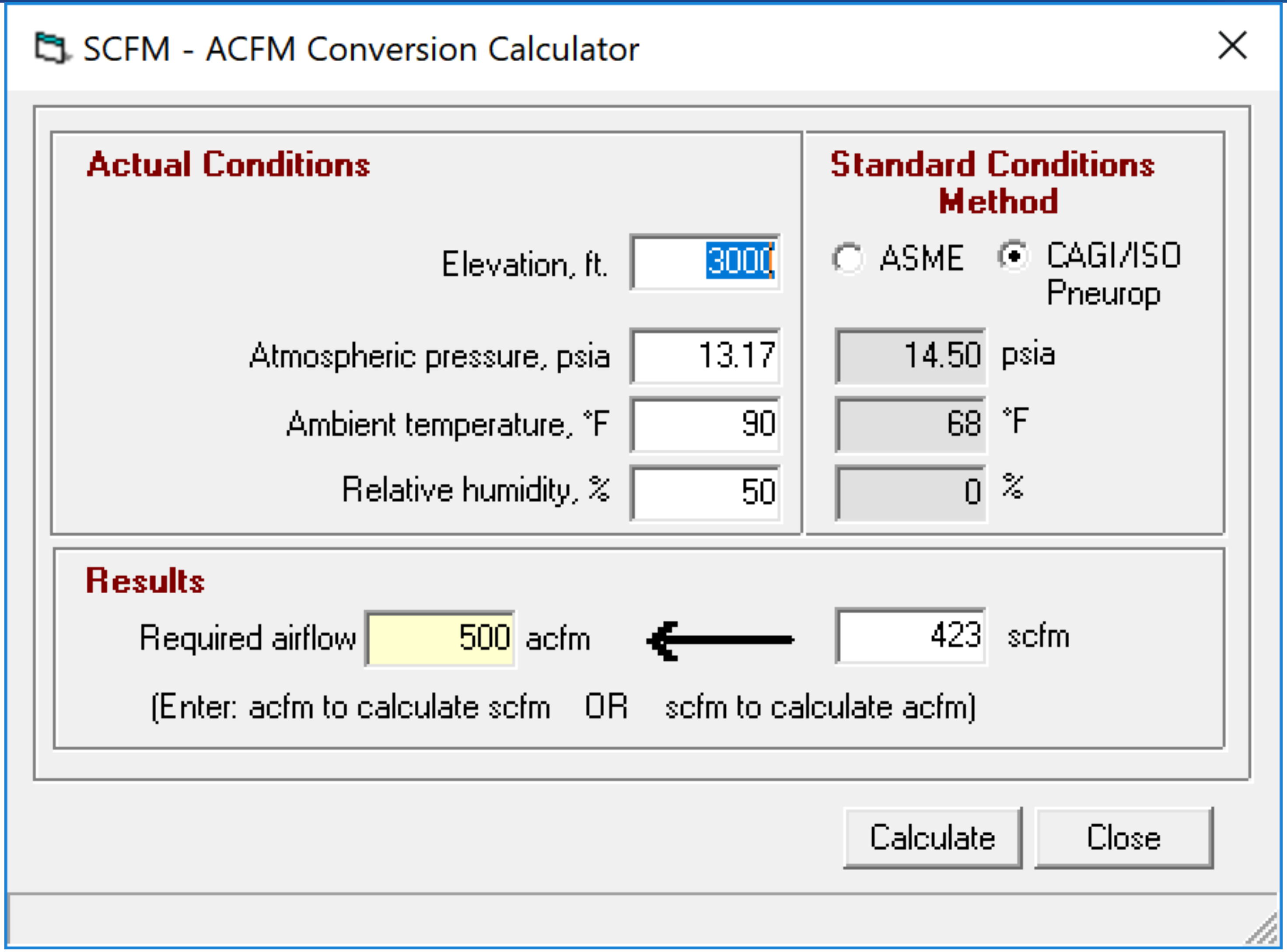
Bar Graphs


EEM Savings Scenario - leak reduction and add VSD
EEM Savings Scenario - leak reduction and add VSD
Week Day
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Airflow, acfm
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
System Baseline
After All Measure
Scale Adjust
Compressor
<System>
Air Flow (acfm)
Power (kW)
Capacity (%)
Print
Close

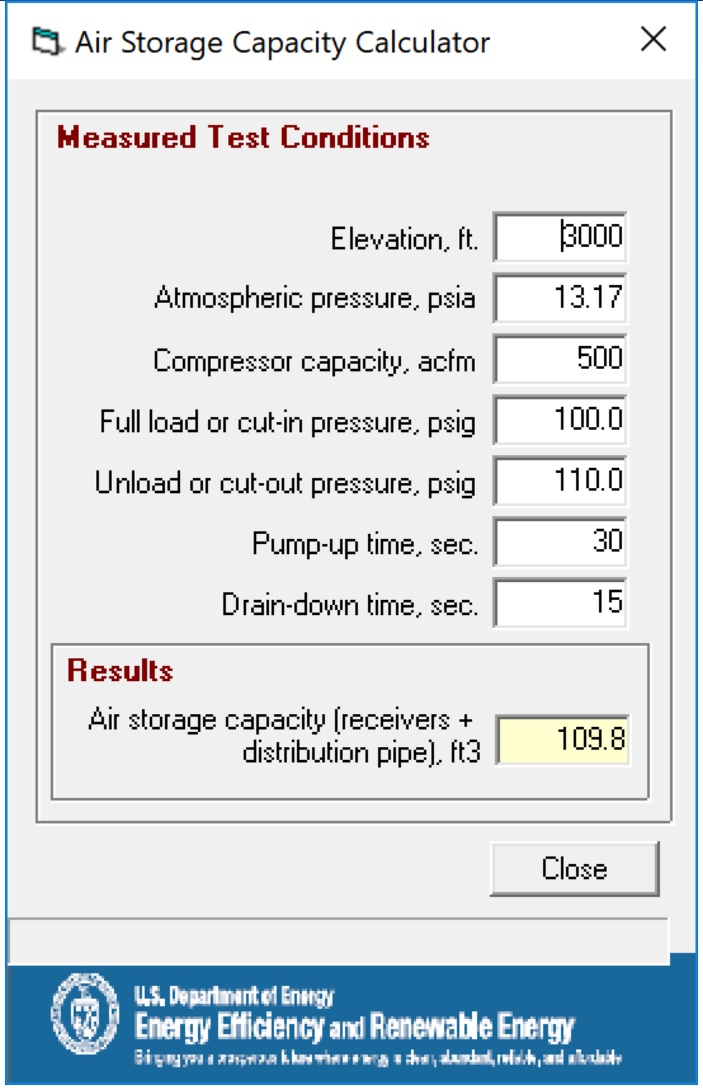
Bar Graphs

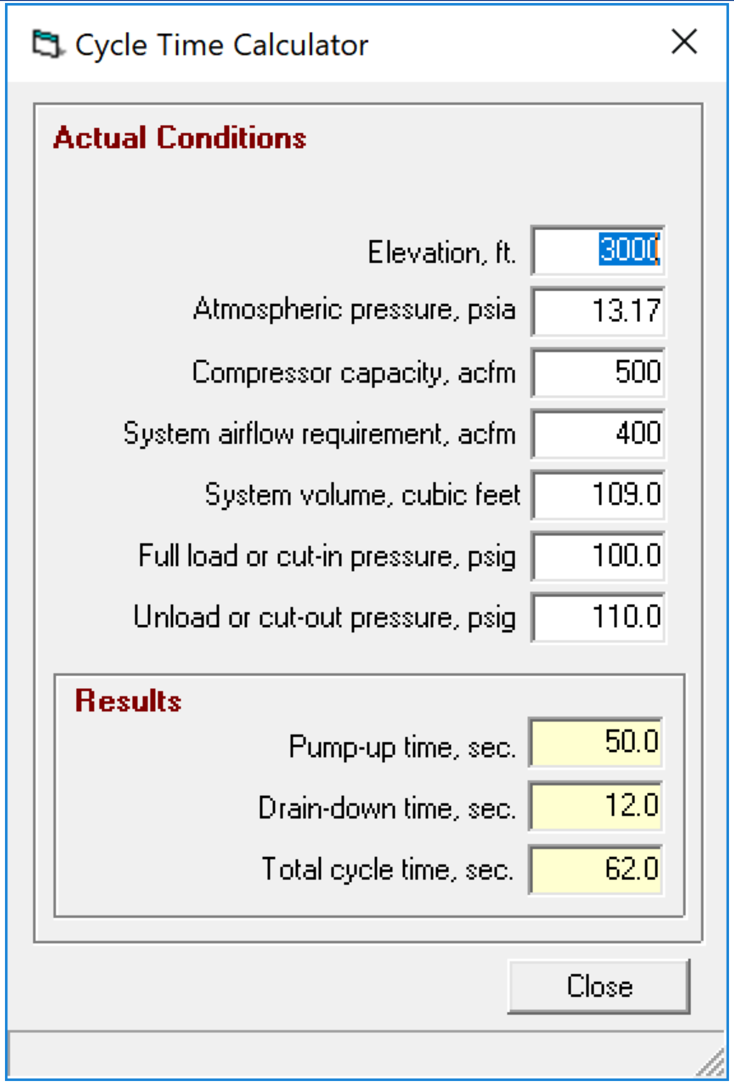

EEM Savings Scenario - leak reduction and add VSD
EEM Savings Scenario - leak reduction and add VSD
Week Day
500
450
400
350
300
250
200
150
100
50
0
Power, kW
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
System Baseline
After All Measures
Scale Adjust
Compressor
<System>
Air Flow (acfm)
Power (kW)
Capacity (%)
Print
Close

Calculators

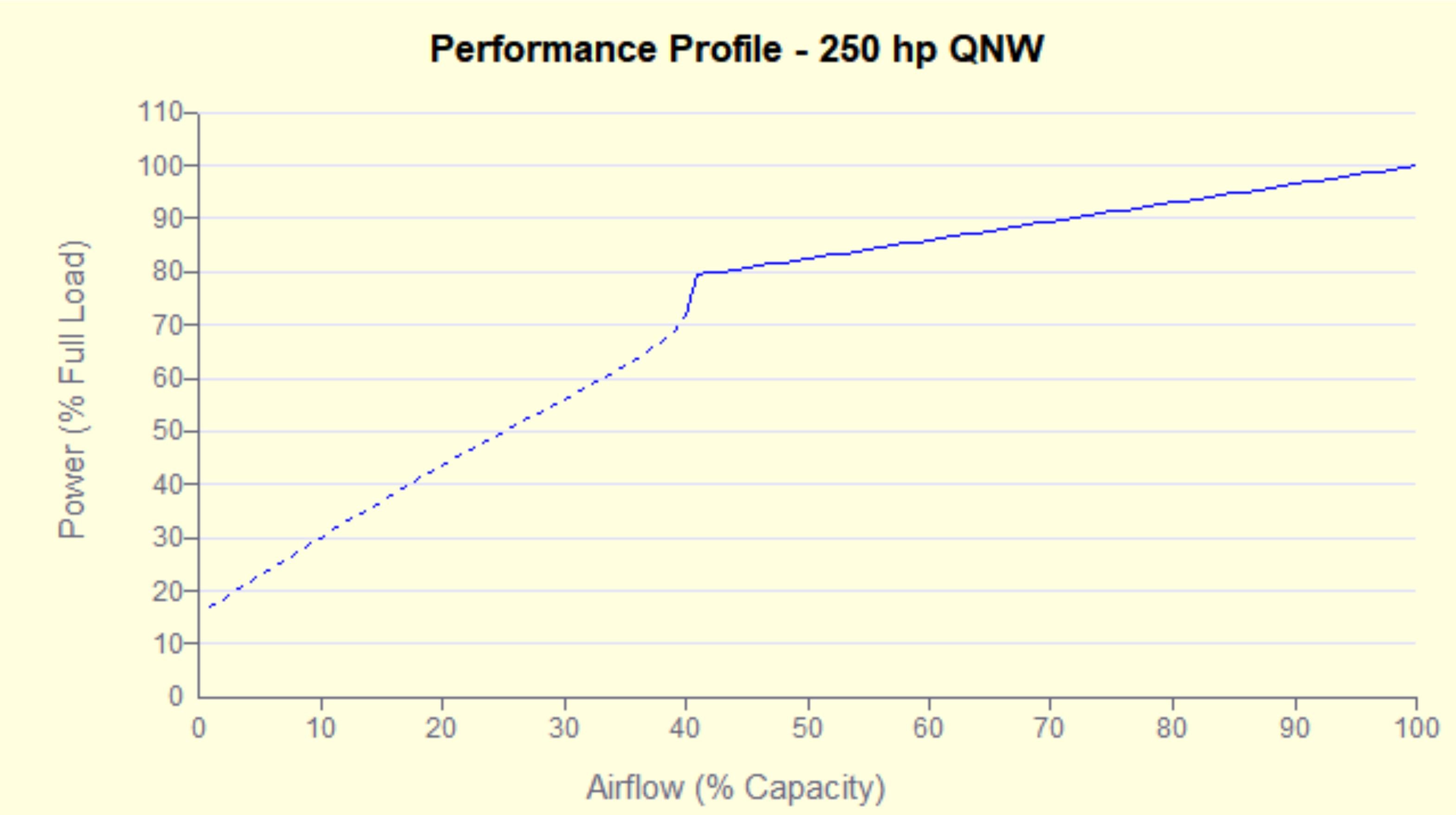


Calculators

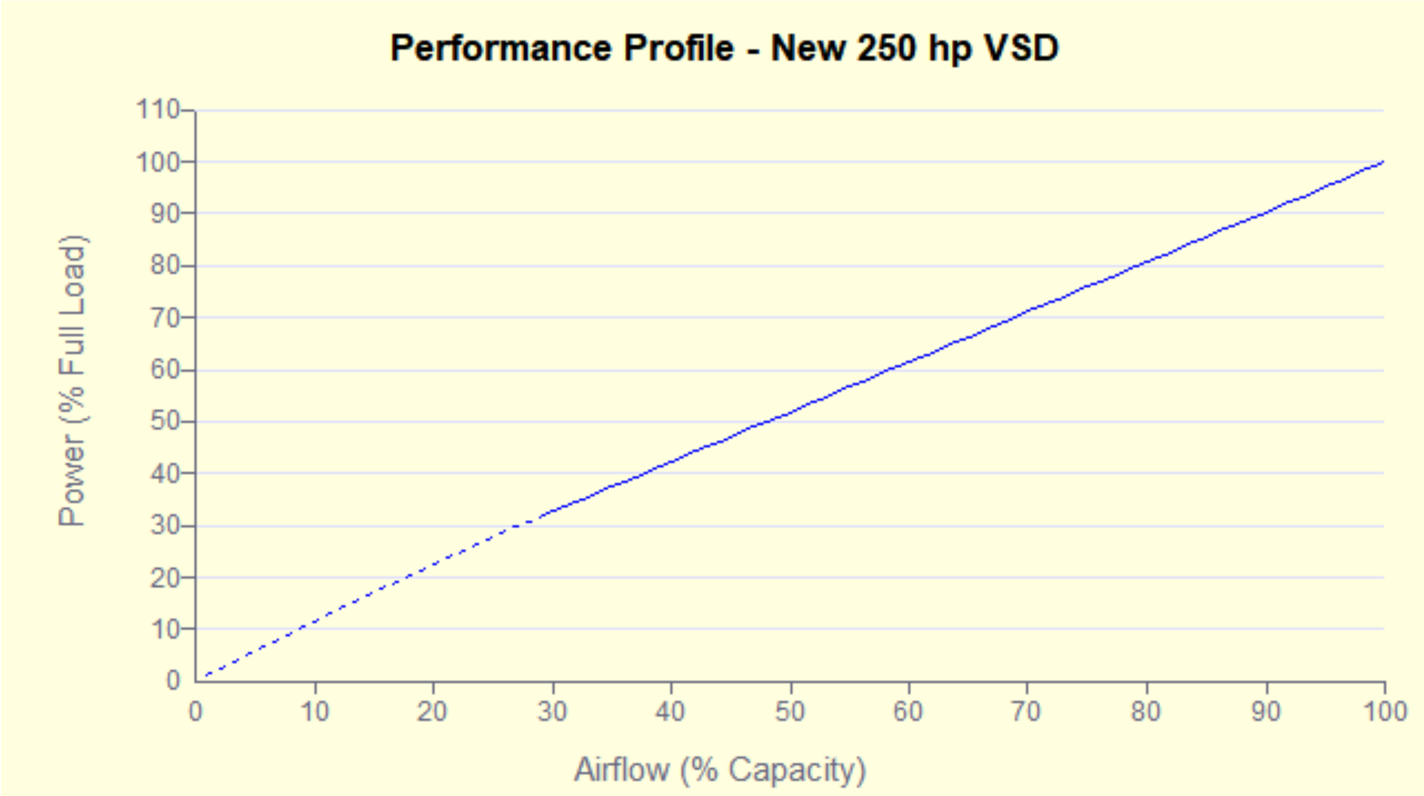




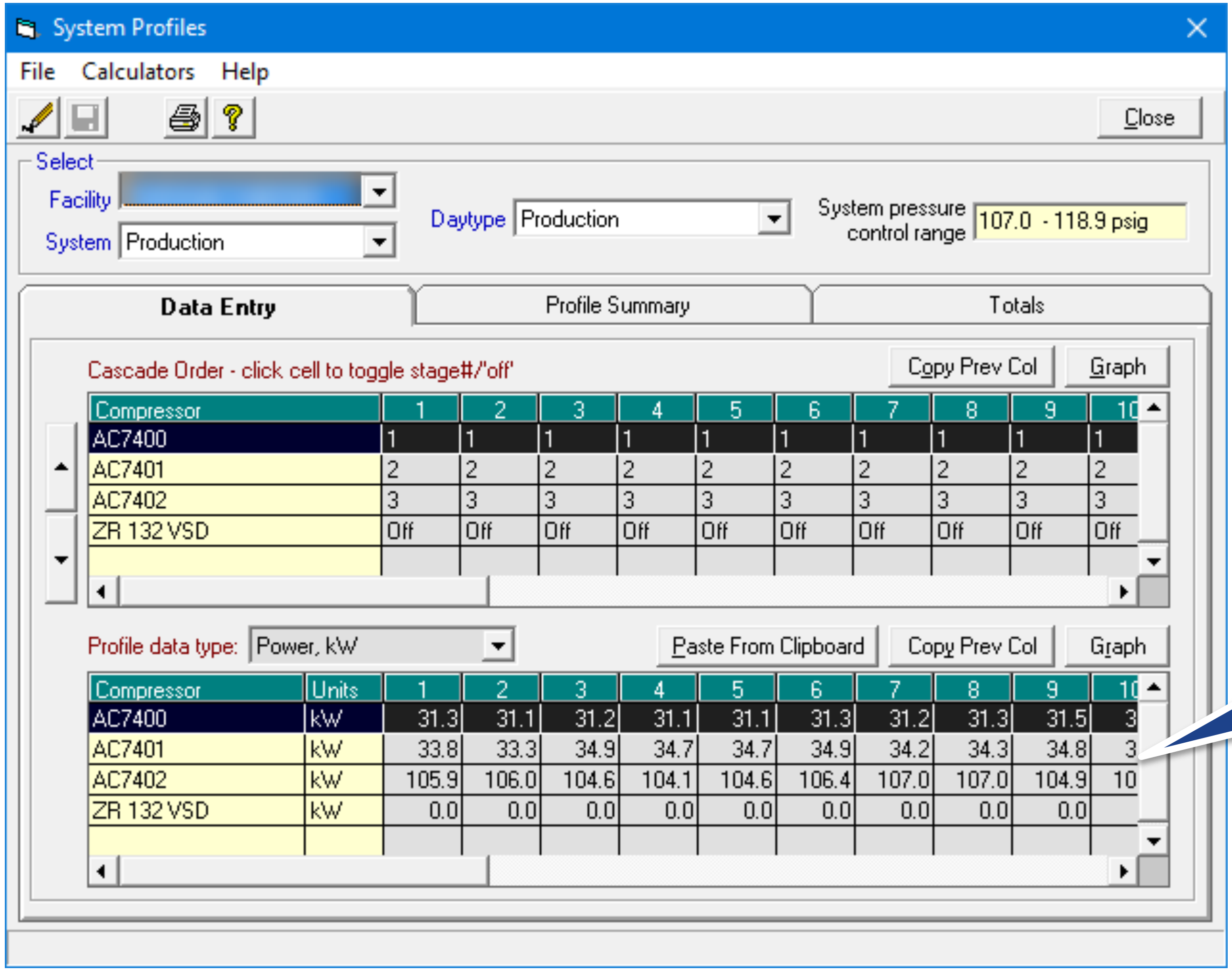
Performance Profile Graph



VSD Performance Graph

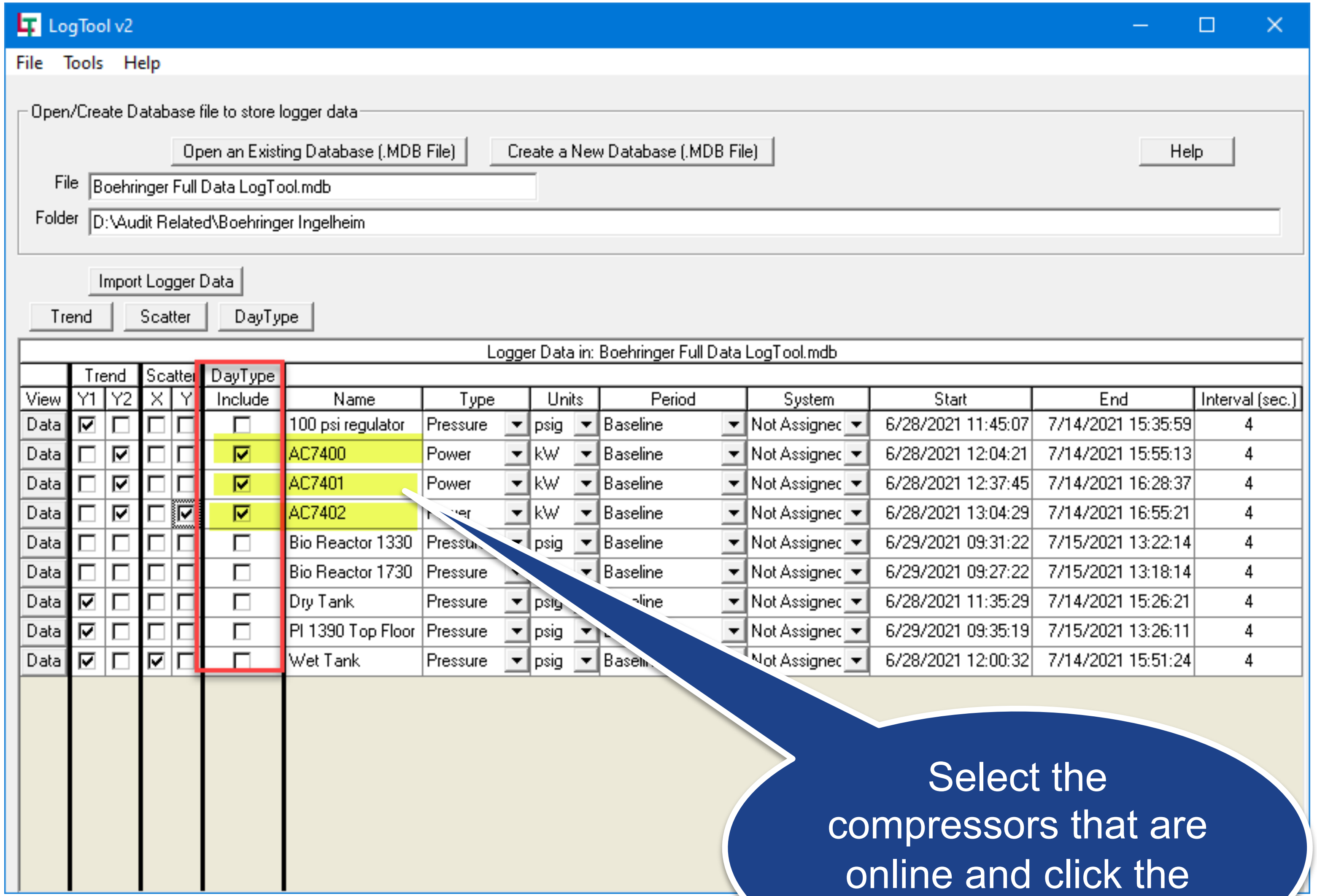


Another Airmaster+ Example Profile Data



Where did this data come from?

Another Airmaster+ Example Day Type From Log Tool



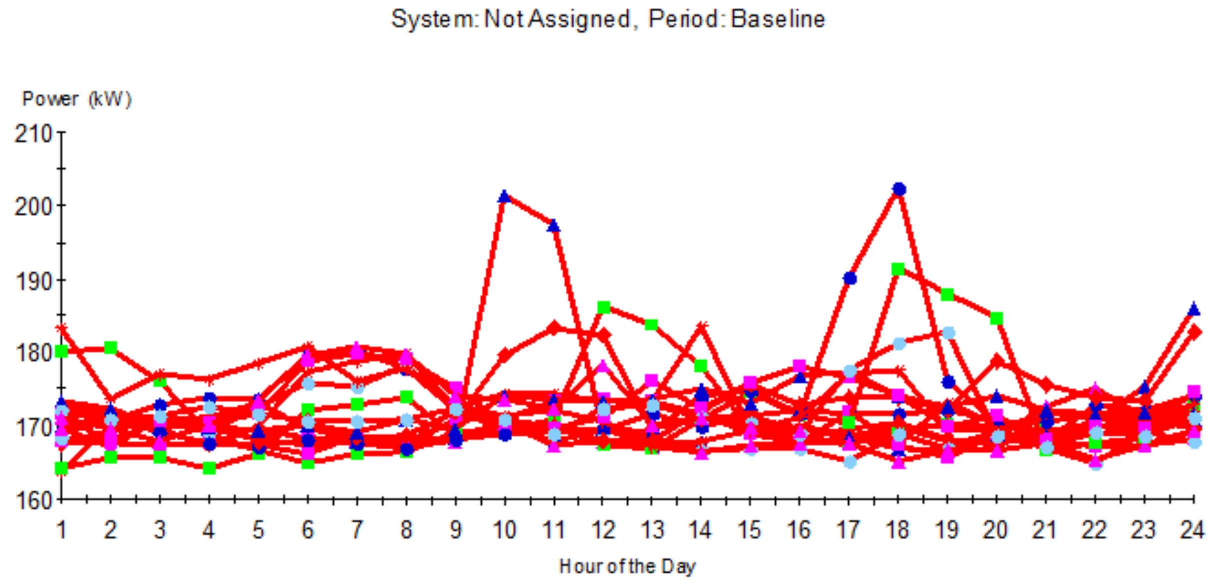
	Trend		Scatter		DayType								
View	Y1	Y2	X	Y	Include	Name	Type	Units	Period	System	Start	End	Interval (sec.)
Data	☑	☐	☐	☐	☐	100 psi regulator	Pressure	psig	Baseline	Not Assignec	6/28/2021 11:45:07	7/14/2021 15:35:59	4
Data	☐	☑	☐	☐	☑	AC7400	Power	kW	Baseline	Not Assignec	6/28/2021 12:04:21	7/14/2021 15:55:13	4
Data	☐	☑	☐	☐	☑	AC7401	Power	kW	Baseline	Not Assignec	6/28/2021 12:37:45	7/14/2021 16:28:37	4
Data	☐	☑	☐	☑	☑	AC7402	[illegible]	kW	Baseline	Not Assignec	6/28/2021 13:04:29	7/14/2021 16:55:21	4
Data	☐	☐	☐	☐	☐	Bio Reactor 1330	[illegible]	psig	Baseline	Not Assignec	6/29/2021 09:31:22	7/15/2021 13:22:14	4
Data	☐	☐	☐	☐	☐	Bio Reactor 1730	Pressure	[illegible]	Baseline	Not Assignec	6/29/2021 09:27:22	7/15/2021 13:18:14	4
Data	☑	☐	☐	☐	☐	Dry Tank	Pressure	psig	[illegible]	Not Assignec	6/28/2021 11:35:29	7/14/2021 15:26:21	4
Data	☑	☐	☐	☐	☐	PI 1390 Top Floor	Pressure	psig	[illegible]	Not Assignec	6/29/2021 09:35:19	7/15/2021 13:26:11	4
Data	☑	☐	☑	☐	☐	Wet Tank	Pressure	psig	[illegible]	Not Assignec	6/28/2021 12:00:32	7/14/2021 15:51:24	4

Select the compressors that are online and click the Day Type Button

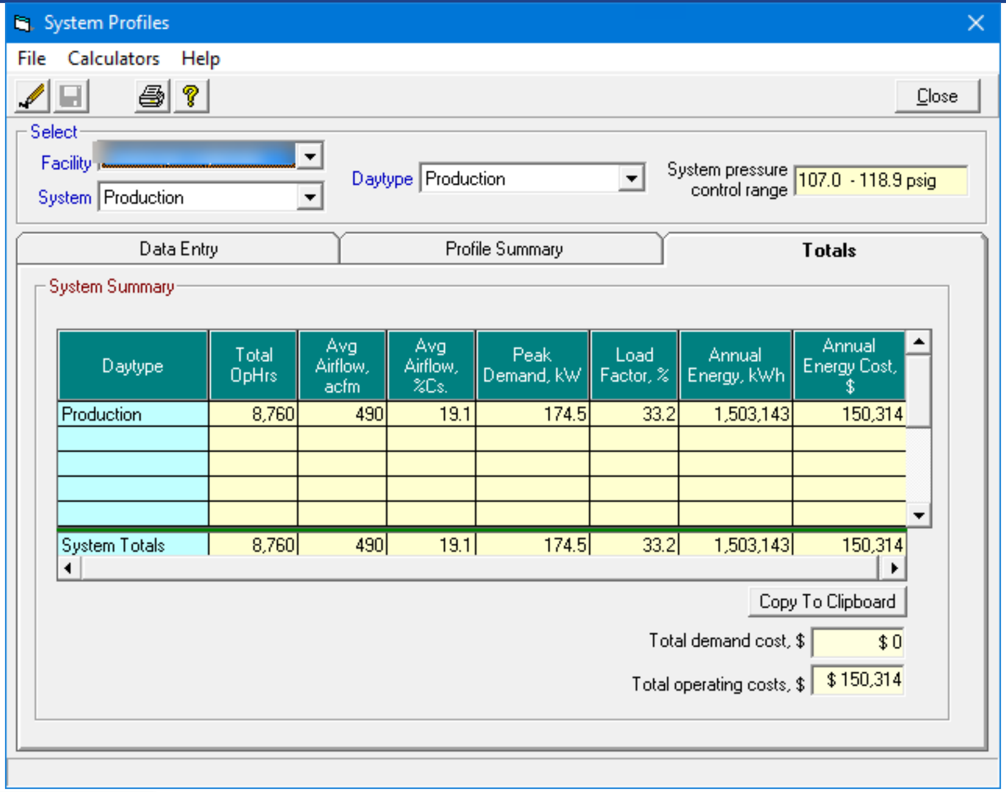
Another Airmaster+ Example

System	Type	Period	DayTypeName	ChannelName	Hr_01	Hr_02	Hr_03	Hr_04	Hr_05	Hr_06	Hr_07	Hr_08	Hr_09	Hr_10	Hr_11	Hr_12	Hr_13	Hr_14	Hr_15	Hr_16	Hr_17	Hr_18	Hr_19	Hr_20	Hr_21	Hr_22	Hr_23	Hr_24
Not Assig	Power	Baseline	Production	AC7400	31.3	31.1	31.2	31.1	31.1	31.3	31.2	31.3	31.5	31.7	31.4	31.1	30.6	31.3	30.9	30.8	31.6	32.4	31.6	31.2	30.9	31.1	31.3	31.7
Not Assig	Power	Baseline	Production	AC7401	33.8	33.3	34.9	34.7	34.7	34.9	34.2	34.3	34.8	34.1	33.9	34.5	33.4	34.0	34.0	34.5	34.0	33.5	32.7	34.1	33.7	34.0	35.0	34.6
Not Assig	Power	Baseline	Production	AC7402	105.9	106.0	104.6	104.1	104.6	106.4	107.0	107.0	104.9	107.7	107.7	107.1	107.1	106.4	106.2	105.1	107.1	108.6	107.5	105.9	105.0	104.9	104.3	106.8

Date	Day	Day Type
Jun-28-20	Mon	Production
Jun-29-20	Tue	Production
Jun-30-20	Wed	Production
Jul-01-202	Thu	Production
Jul-02-202	Fri	Production
Jul-03-202	Sat	Production
Jul-04-202	Sun	Production
Jul-05-202	Mon	Production
Jul-06-202	Tue	Production
Jul-07-202	Wed	Production
Jul-08-202	Thu	Production
Jul-09-202	Fri	Production
Jul-10-202	Sat	Production
Jul-11-202	Sun	Production
Jul-12-202	Mon	Production
Jul-13-202	Tue	Production
Jul-14-202	Wed	Production

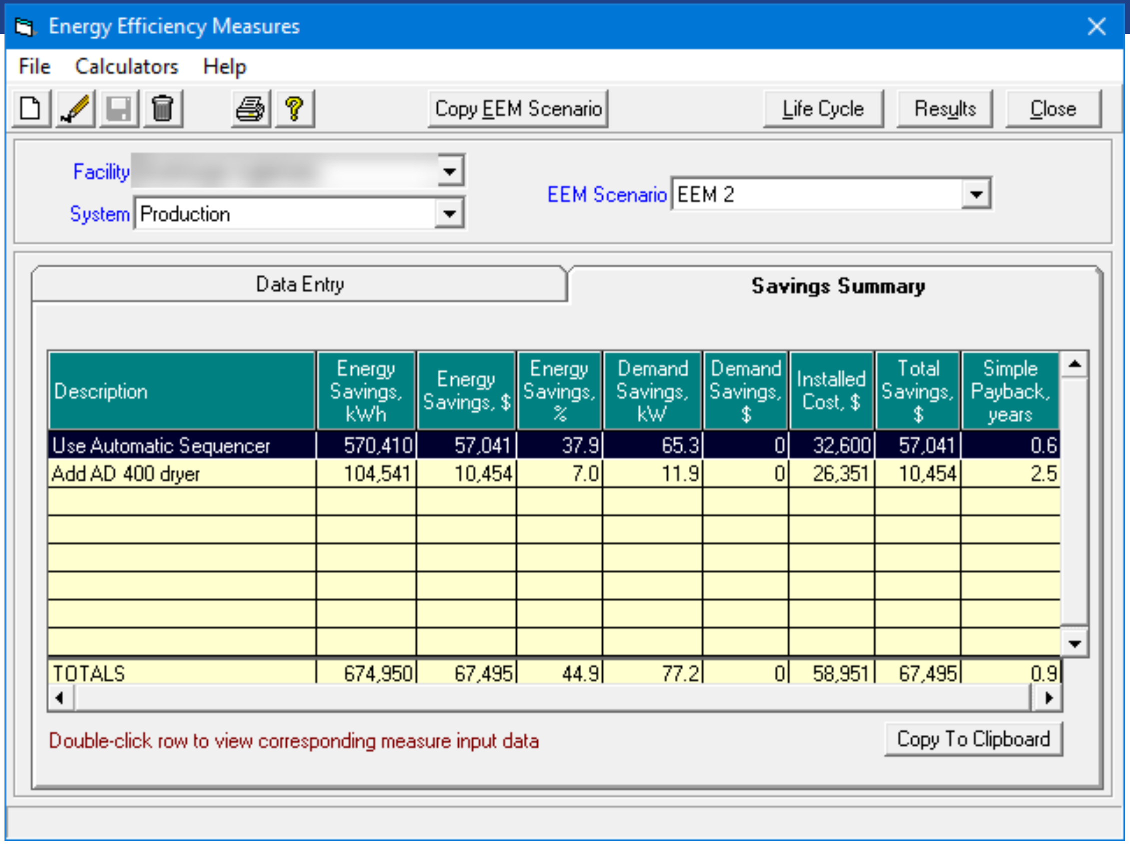


Another Airmaster+ Example



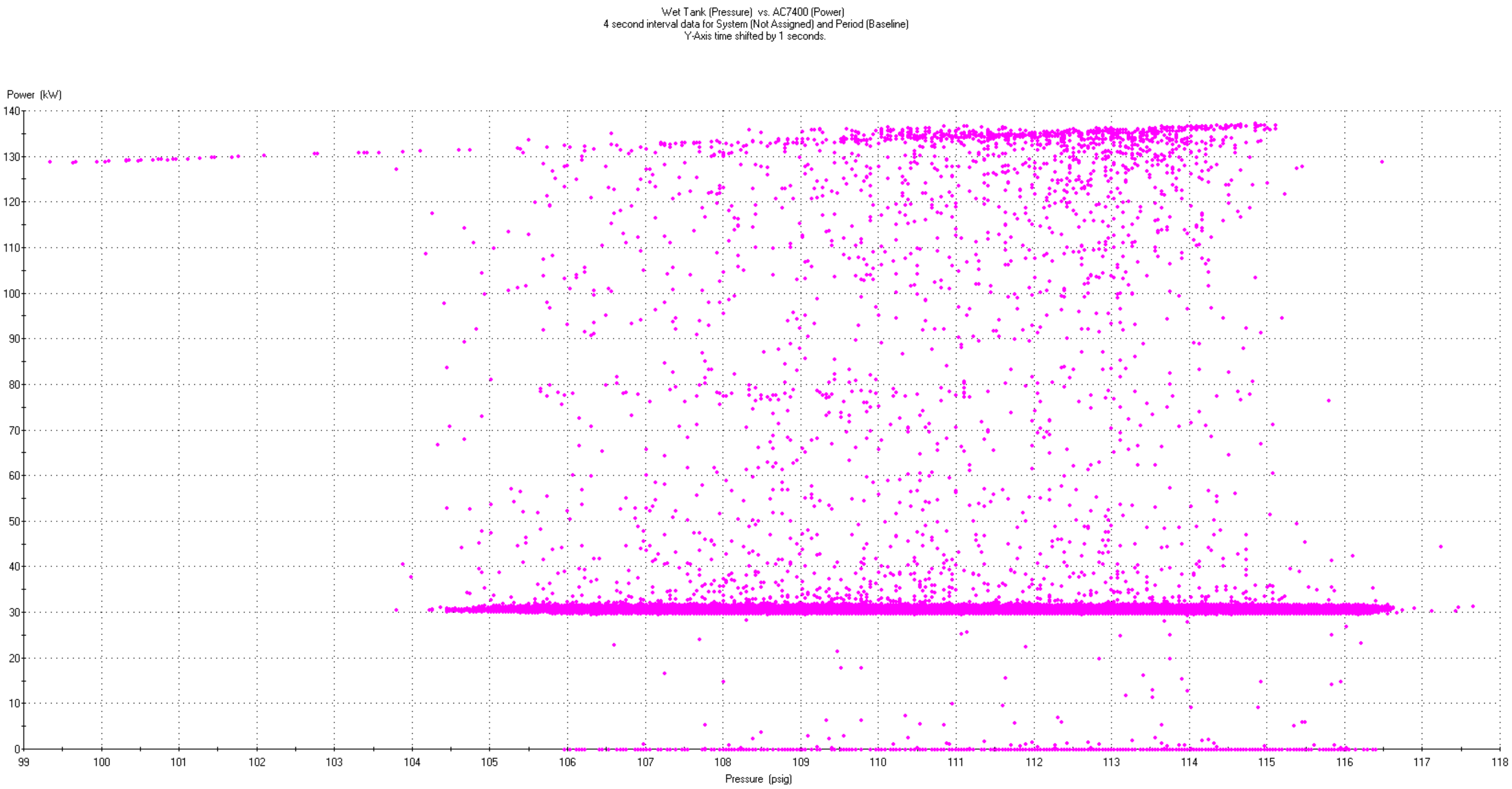
Compressed Air Baseline Energy using $0.10/kWh							
Daytype	Total OpHrs	Avg Airflow, acfm	Avg Airflow, %Cs.	Peak Demand, kW	Load Factor, %	Annual Energy, kWh	Annual Energy Cost, $
Production	8,760	490	19.1	174.5	33.2	1,503,143	$150,314
System Totals	**8,760**	**490**	**19.1**	**174.50**	**33.2**	**1,503,143**	**$150,314**

Another Airmaster+ Example

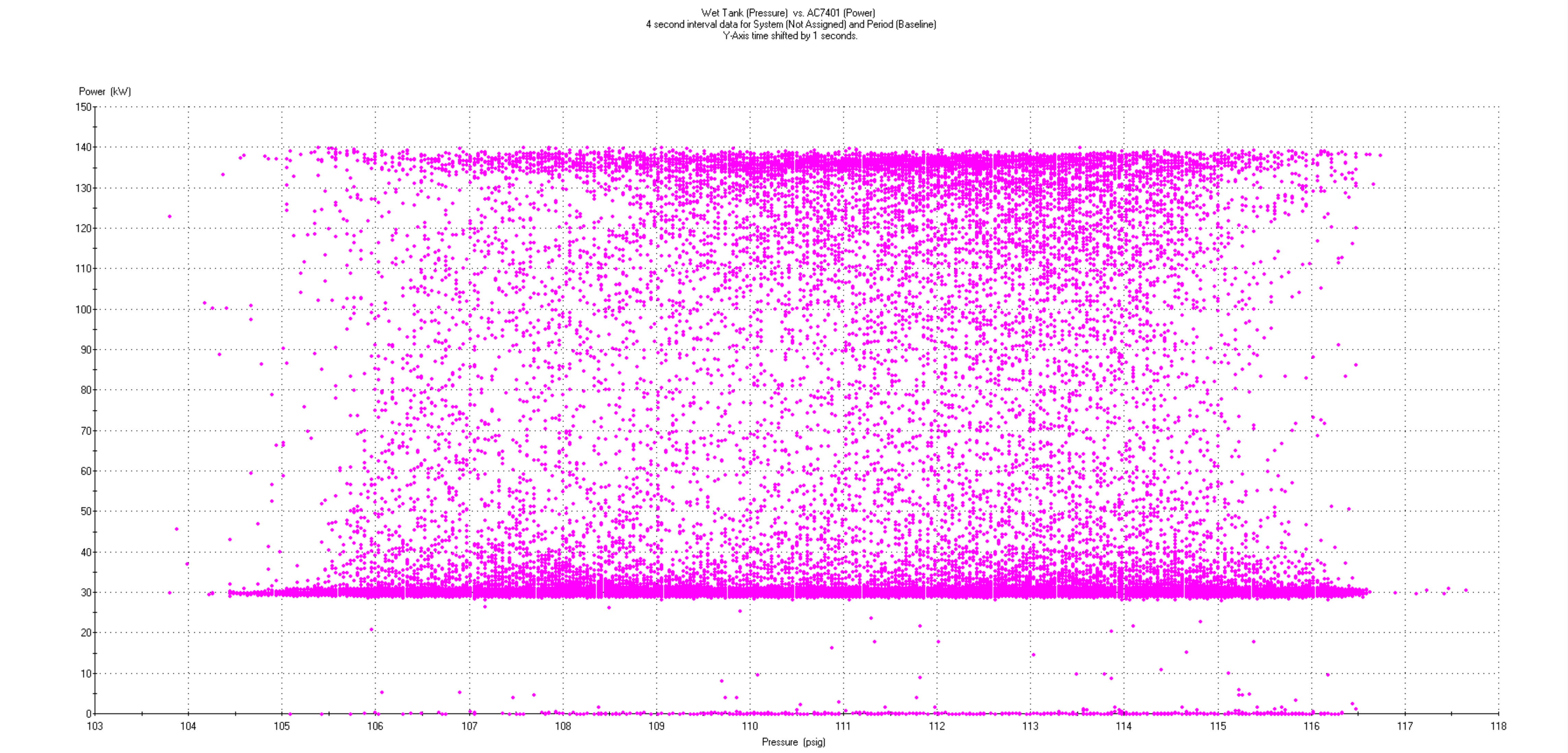


EEM -- Sequence Compressors purchase AD400 dryer							
Description	Energy Savings, kWh	Energy Savings, $	Energy Savings, %	Demand Savings, kW	Installed Cost, $	Total Savings, $	Simple Payback, years
Use Automatic Sequencer	570,410	$57,041.00	37.9	65.3	$32,600.00	$57,041.00	0.6
Add AD 400 dryer	104,541	$10,454.00	7	11.9	$26,351.00	$10,454.00	2.5
TOTALS	**674,950**	**$67,495.00**	**44.9**	**77.2**	**$58,951.00**	**$67,495.00**	**0.9**

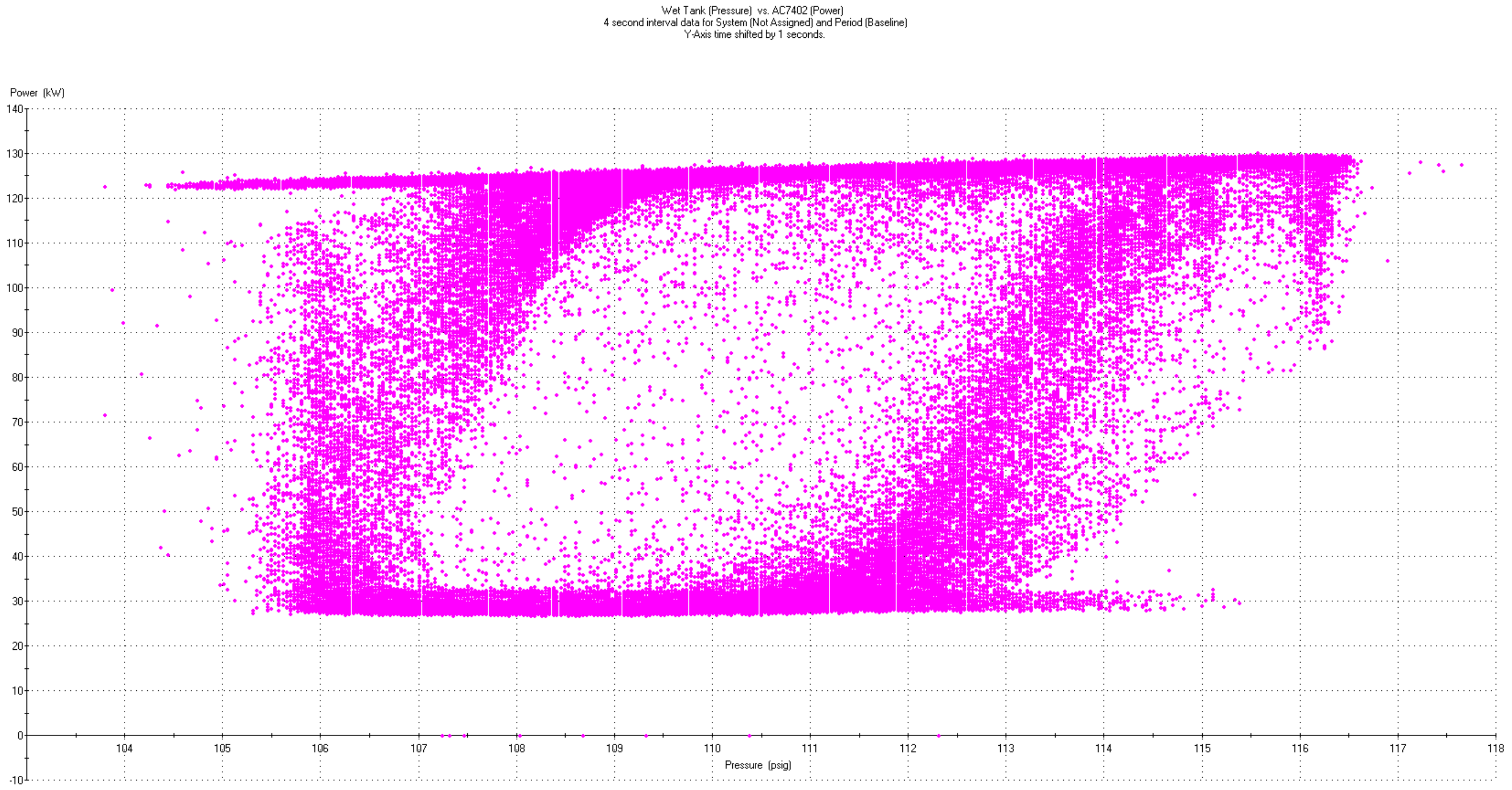
LogTool Scatter Plot



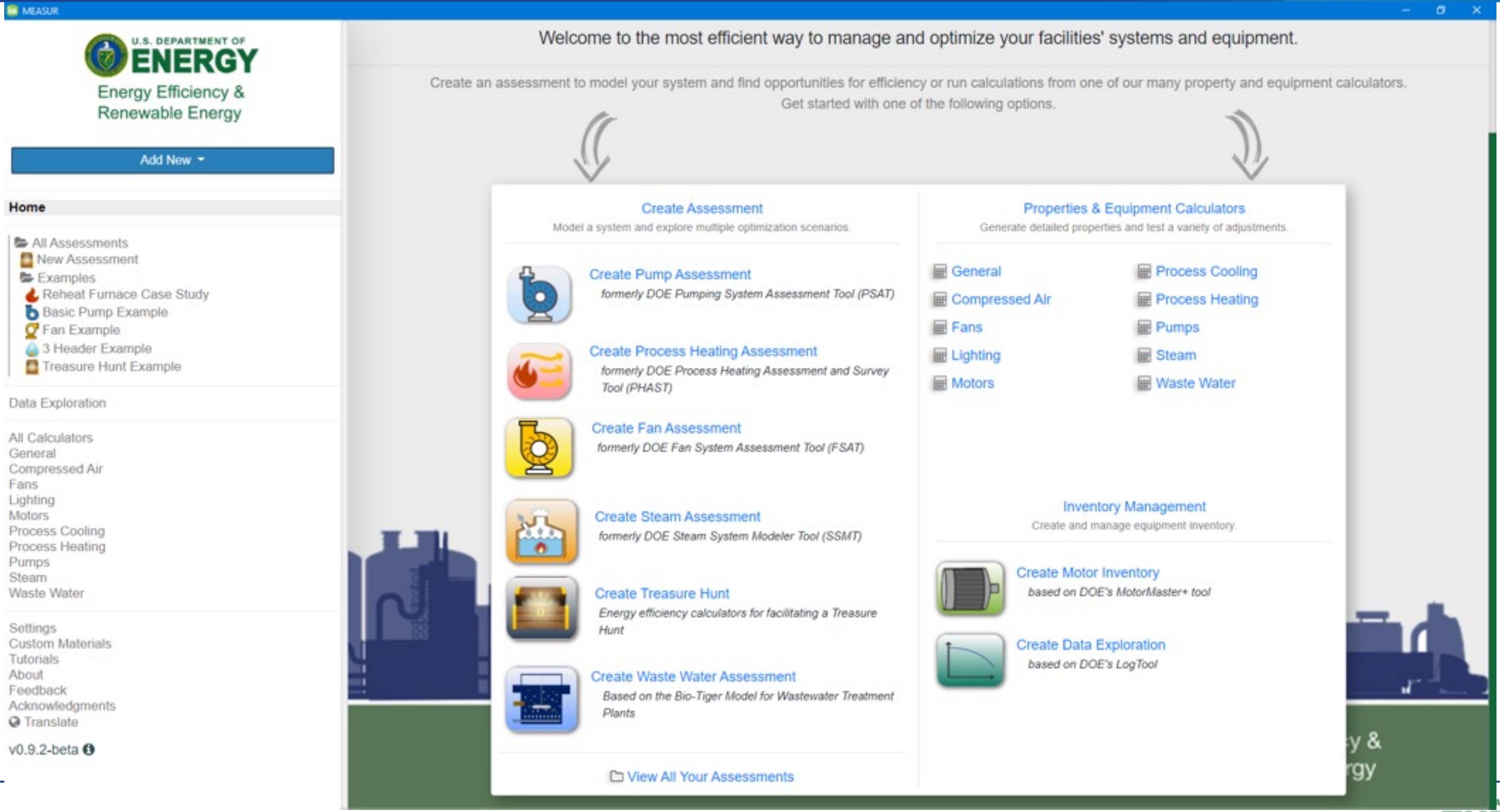
LogTool Scatter Plot



LogTool Scatter Plot



MEASUR Tool


MEASUR
U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy
Add New
Home
All Assessments
New Assessment
Examples
Reheat Furnace Case Study
Basic Pump Example
Fan Example
3 Header Example
Treasure Hunt Example
Data Exploration
All Calculators
General
Compressed Air
Fans
Lighting
Motors
Process Cooling
Process Heating
Pumps
Steam
Waste Water
Settings
Custom Materials
Tutorials
About
Feedback
Acknowledgments
Translate
v0.9.2-beta
Welcome to the most efficient way to manage and optimize your facilities' systems and equipment.
Create an assessment to model your system and find opportunities for efficiency or run calculations from one of our many property and equipment calculators.
Get started with one of the following options.
Create Assessment
Model a system and explore multiple optimization scenarios.
Create Pump Assessment
formerly DOE Pumping System Assessment Tool (PSAT)
Create Process Heating Assessment
formerly DOE Process Heating Assessment and Survey Tool (PHAST)
Create Fan Assessment
formerly DOE Fan System Assessment Tool (FSAT)
Create Steam Assessment
formerly DOE Steam System Modeler Tool (SSMT)
Create Treasure Hunt
Energy efficiency calculators for facilitating a Treasure Hunt
Create Waste Water Assessment
Based on the Bio-Tiger Model for Wastewater Treatment Plants
View All Your Assessments
Properties & Equipment Calculators
Generate detailed properties and test a variety of adjustments.
General
Compressed Air
Fans
Lighting
Motors
Process Cooling
Process Heating
Pumps
Steam
Waste Water
Inventory Management
Create and manage equipment inventory.
Create Motor Inventory
based on DOE's MotorMaster+ tool
Create Data Exploration
based on DOE's LogTool

MEASUR Tool

Compressed Air Calculators

Compressed Air Reduction
This calculator is used to quantify the energy savings associated with reducing compressed air usage.

Compressed Air Pressure Reduction
This calculator is used to quantify the energy savings associated with reducing compressed air system pressure.

Actual to Standard Airflow
The calculator converts ACFM (Actual cubic feet per minute) to SCFM (Standard cubic feet per minute) and vice versa for the given conditions using either ASME standard conditions or CAGI/ISO standard conditions.

Leak Loss Estimator - Bag Method
Estimates the leakage losses in a compressed air system using the bag method

Pneumatic Air Requirement
Estimate the quantity of air required by a specific single acting or a double acting piston cylinder compressor

Compressed Air - Leak Survey
Used to quantify the energy savings associated with reducing compressed air leaks.

MEASUR Tool

Receiver Tank Sizing
Calculate the required size of the receiver tank

Usable Air Capacity
Estimate the quantity of compressed air that is available for use

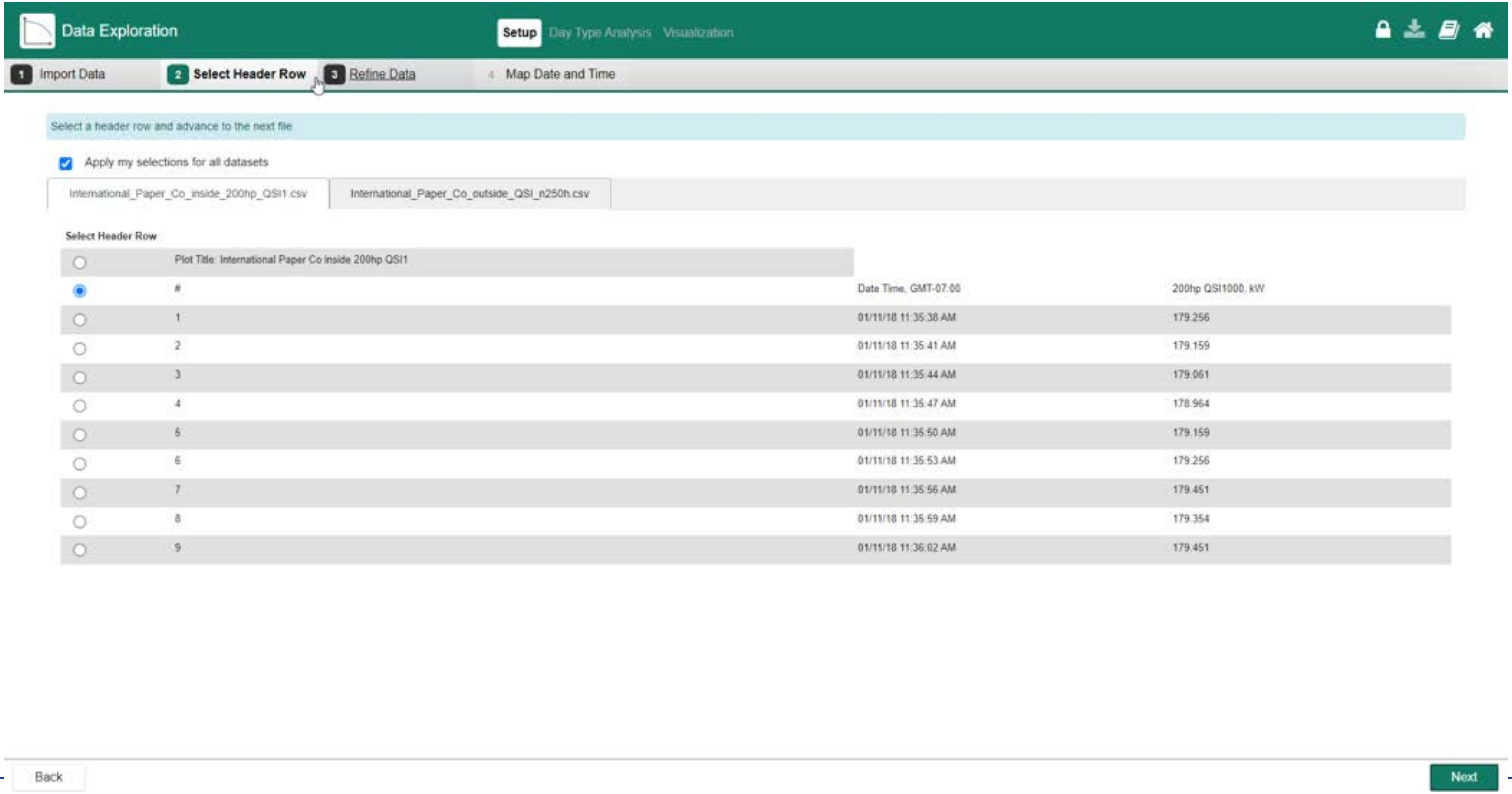
Pipe Sizing
Determine pipe diameter when the volumetric flow velocity, pressure, and design velocity are known

Velocity in the Piping
Estimate the velocity of compressed air throughout system piping

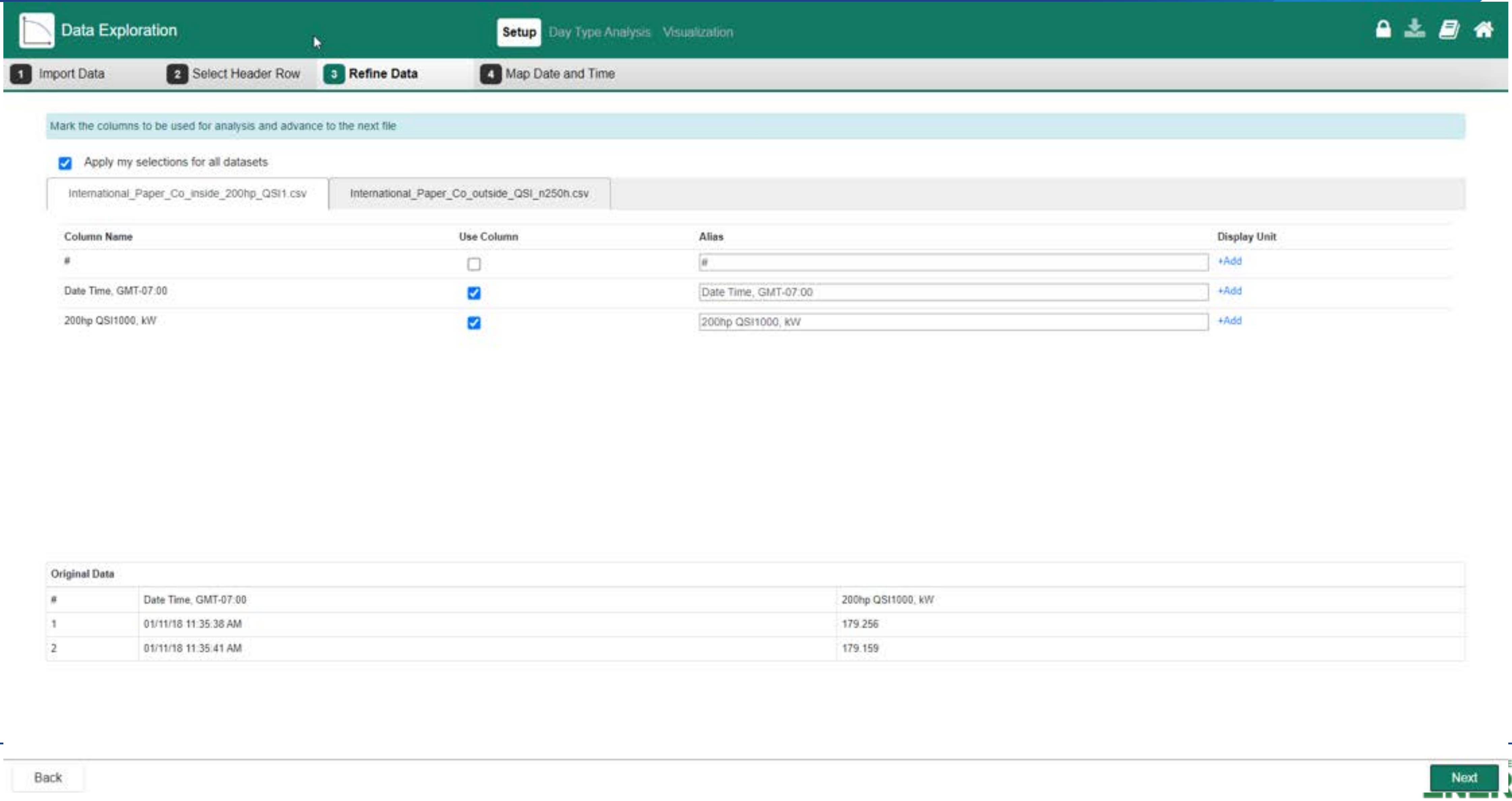
System Capacity
Determine total capacity of compressed air system or specific pipes and receiver tanks

Operation Costs
Estimate the cost of operation of the compressor in both fully and partially loaded instances

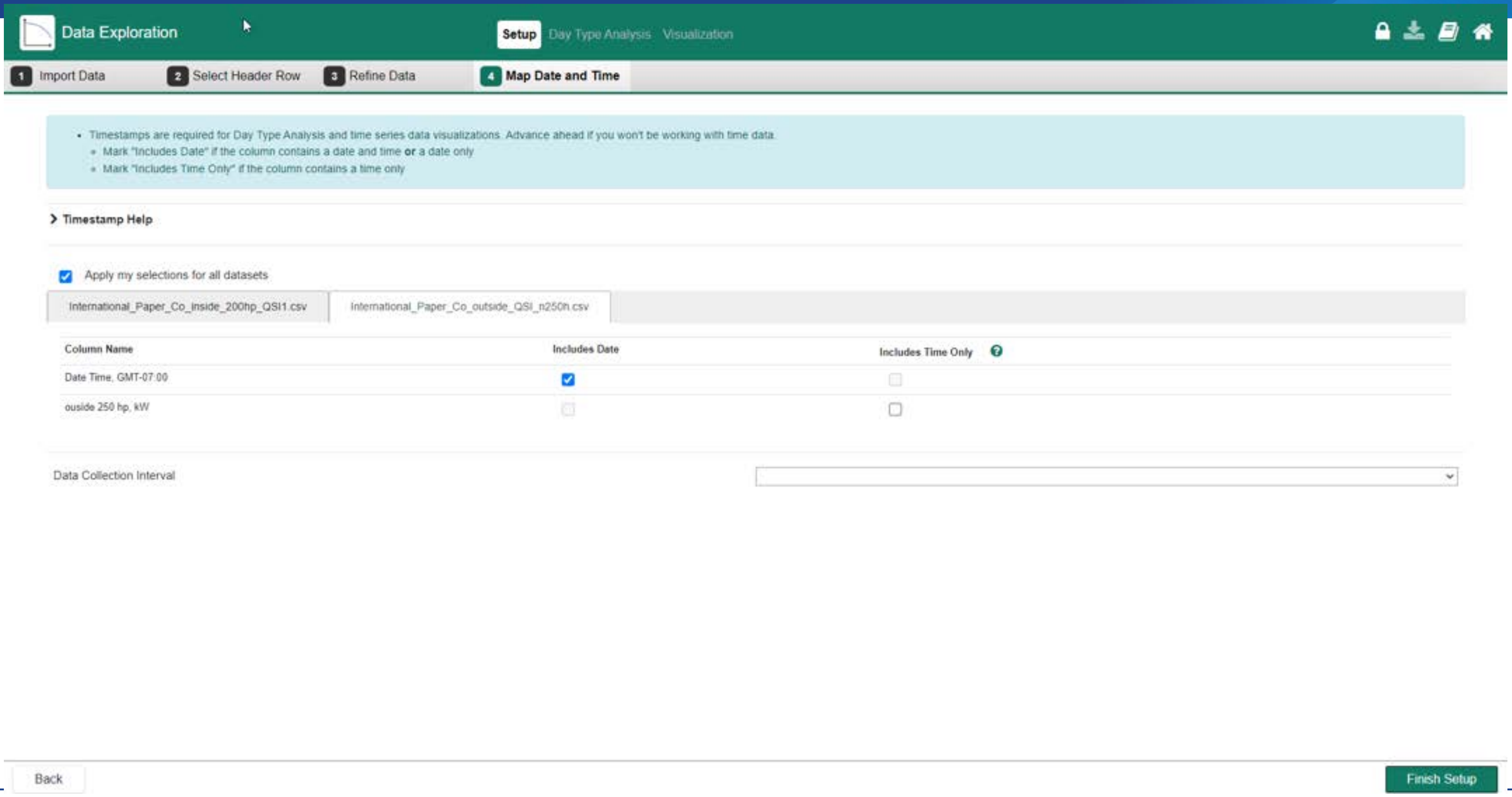
Let's compare to old Log Tool



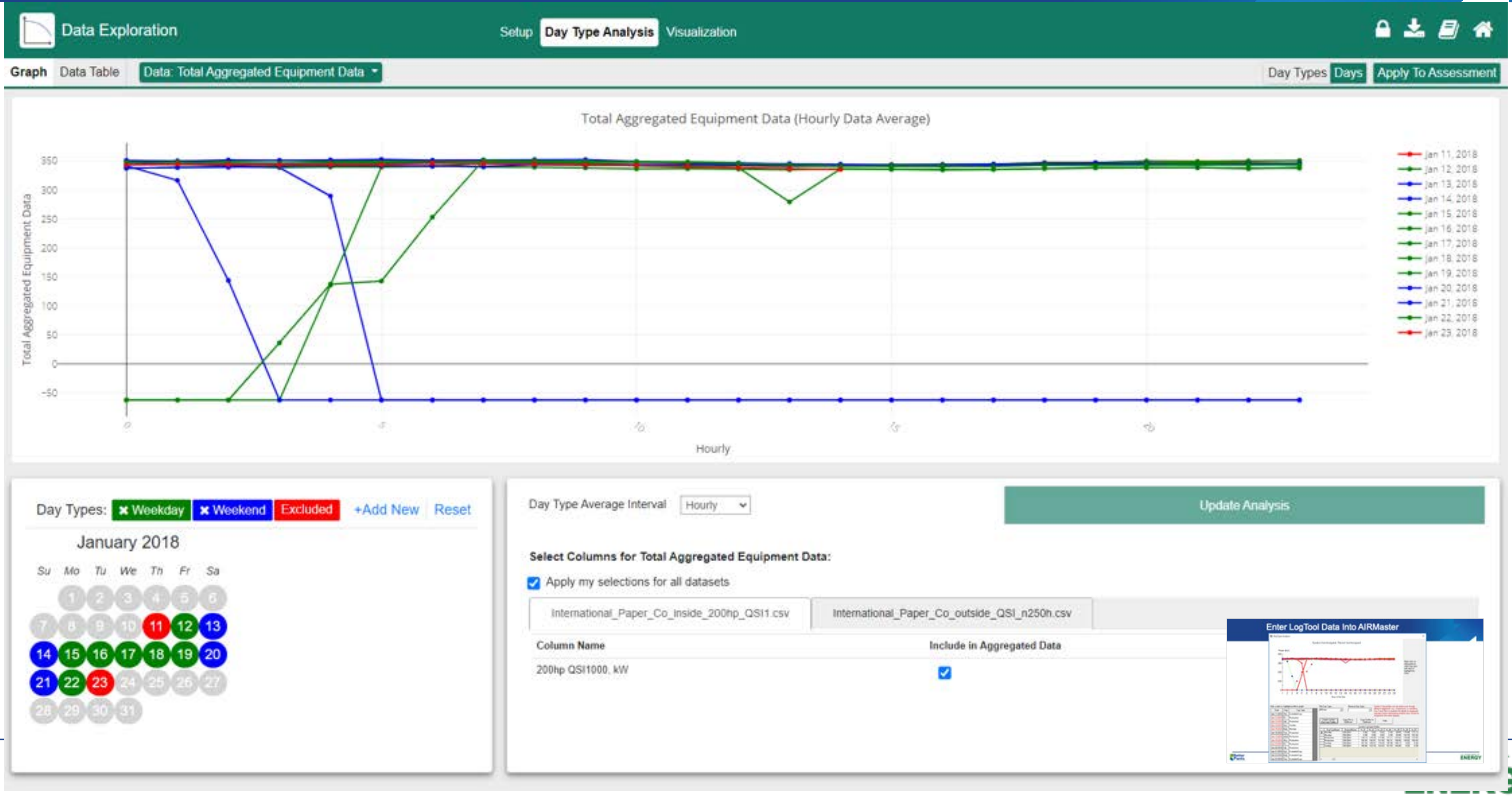
Let's compare to old Log Tool



Let's compare to old Log Tool



Let's compare to old Log Tool



Better Plants
U.S. DEPARTMENT OF ENERGY

Let's compare to old Log Tool

Data Exploration

Setup | **Day Type Analysis** | Visualization

Graph | **Data Table** | Data: Total Aggregated Equipment Data

Display Selected | Display All | Day Types | Days | Apply To Assessment

Day Type Summaries (Total Aggregated Equipment Data)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Weekday	228.377	228.905	228.787	242.79	286.037	316.346	332.26	346.52	346.149	345.545	344.301	343.832	342.328	332.301	340.319	340.034	339.788	340.325	342.196	342.645	343.561	343.737	343.301	343.897
Weekend	344.453	337.26	294.106	242.105	230.29	142.398	141.889	141.907	142.721	142.478	142.019	141.54	140.985	140.712	140.507	139.788	139.802	140.537	141.008	141.615	141.356	140.843	141.28	141.524
Excluded	343.151	344.6	343.84	343.205	343.652	343.678	345.983	345.427	344.92	343.188	342.499	343.677	341.853	340.265	338.766	343.887	344.11	343.776	347.291	347.341	349.506	349.346	349.406	350.719

Copy Table

Day Summaries (Total Aggregated Equipment Data)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Weekday																								
Jan 12, 2018	350.503	350.457	349.767	350.922	349.444	350.735	350.126	349.697	348.726	347.911	348.143	348.613	346.908	343.422	343.798	343.359	343.994	344.688	346.835	347.03	350.133	349.088	350.24	350.696
Jan 15, 2018	-62.48	-62.481	-62.479	-62.48	135.607	340.068	340.692	346.157	347.243	347.519	348.732	347.609	345.048	343.513	341.95	341.139	340.554	341.815	343.719	344.359	345.83	346.652	346.369	346.135
Jan 16, 2018	347.61	347.97	347.122	346.248	347.541	347.869	347.655	346.948	347.811	345.907	343.795	343.826	342.966	340.637	341.396	342.32	341.424	341.937	343.92	343.374	343.997	345.062	343.421	344.827
Jan 17, 2018	344.128	344.633	344.586	344.258	346.296	347.187	345.95	346.432	344.017	345.032	342.959	343.33	341.718	340.763	341.098	341.488	341.749	342.284	344.047	344.131	344.641	344.578	344.717	345.682
Jan 18, 2018	344.129	344.662	345.205	345.692	346.339	346.123	346.506	345.632	345.089	344.363	341.707	339.446	338.237	279.357	336.221	335.939	335.253	335.215	337.038	338.875	338.816	338.304	338.122	337.499
Jan 19, 2018	337.229	339.573	339.789	338.727	339.595	339.627	341.793	339.637	339.3	338.219	336.391	336.754	336.199	334.947	336.405	335.468	334.589	335.592	337.082	337.984	338.112	338.727	336.751	339.25
Jan 22, 2018	-62.479	-62.48	-62.48	36.16	137.439	142.81	253.096	351.139	350.856	349.867	348.384	347.243	345.219	343.466	341.363	340.524	340.952	340.747	342.73	342.761	343.397	343.746	343.488	343.188
Weekend																								
Jan 13, 2018	351.026	349.585	351.782	351.001	351.894	352.74	351.297	351.961	352.383	352.372	349.311	346.937	345.905	345.548	344.381	343.145	343.407	344.375	346.107	344.937	346.216	345.54	345.22	346.343
Jan 14, 2018	347.315	344.282	341.634	338.817	289.6	-62.48	-62.481	-62.479	-62.48	-62.48	-62.482	-62.481	-62.48	-62.48	-62.48	-62.488	-62.483	-62.48	-62.48	-62.479	-62.479	-62.48	-62.48	-62.48
Jan 20, 2018	337.969	338.586	339.17	341.079	342.147	341.811	341.216	340.627	343.462	342.497	343.729	344.185	342.992	342.259	342.607	340.974	340.766	342.729	342.885	346.484	344.162	342.792	344.86	344.712
Jan 21, 2018	341.5	316.585	143.837	-62.476	-62.479	-62.478	-62.478	-62.48	-62.48	-62.478	-62.48	-62.48	-62.477	-62.479	-62.481	-62.48	-62.481	-62.478	-62.479	-62.48	-62.476	-62.48	-62.479	-62.48
Excluded																								
Jan 11, 2018												346.218	345.07	343.465	342.276	343.887	344.11	343.776	347.291	347.341	349.506	349.346	349.406	350.719
Jan 23, 2018	343.151	344.6	343.84	343.205	343.652	343.678	345.983	345.427	344.92	343.188	342.499	341.135	338.636	337.064	335.257									

Copy Table

Day Types: ✖ Weekday | ✖ Weekend | Excluded | +Add New | Reset

January 2018

Day Type Average Interval: Hourly

Update Analysis

Select Columns for Total Aggregated Equipment Data:

Setup Profile | Profile Summary Table | Profile Summary Graphs

VSD
Selected Scenario

View / Add Scenarios

SELECT POTENTIAL ADJUSTMENT PROJECTS

Select potential adjustment projects to explore opportunities to increase efficiency and the effectiveness of your system.

Add New Scenario

Modification Name: VSD

Reduce Run Time | *Supply* — 1

Implementation Cost: 106700 $

Day Type: Weekday

	Capacity acfm	Shutdown Timer	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00
200 hp QNW	933 acfm	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
250 hp QNW	1261 acfm	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
New Compressor	1141 acfm	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Available Airflow			933	933	933	933	933	2,074	2,074	2,074	2,074	2,074	2,074	2,074	2,074
Required Airflow			705	708	709	775	907	1,085	1,347	1,526	1,527	1,524	1,524	1,521	1,513
Power, kW			159.5	159.7	159.8	164.1	172.7	244.1	300.9	357.7	357.8	357.6	357.6	357.4	344.2

Reduce Air Leaks | *Demand* — 2

Implementation Cost: 5000 $

Leak Flow: 600 acfm

Leak Reduction: 50 %

Improve End Use Efficiency | *Demand* — Off

Reduce System Air Pressure | *Supply* — Off

Add Primary Receiver Volume | *Supply* — Off

MODIFICATION RESULTS | PERFORMANCE PROFILE | HELP | NOTES

All Day Types

	Baseline	VSD
Percent Savings (%)	— —	39.6%

	Baseline	VSD
Flow Reallocation Energy Savings	— —	391,627 kWh
Reduce Air Leaks Energy Savings	— —	585,745 kWh
Reduce Run Time Energy Savings	— —	-233,967 kWh
Peak Demand	**346.6 kW**	**273.86 kW**
Annual Energy	**2,620,045 kWh**	**1,876,639 kWh**
Annual Emission Output Rate	**1,050,821 tonne CO_2**	**752,664 tonne CO_2**
Peak Demand Savings	— —	**72.74 kW**
Annual Energy Savings	— —	**743,405 kWh**
Annual Emission Savings	— —	**298,158 tonne CO_2**
Flow Reallocation Savings	— —	$25,847.38
Reduce Air Leaks Savings	— —	$55,352.94
Reduce Run Time Savings	— —	-$22,109.88
Peak Demand Cost	**$0.00**	**$0.00**
Annual Energy Cost	**$247,594.21**	**$177,342.40**
Annual Cost	**$247,594.21**	**$177,342.40**
Peak Demand Cost Savings	— —	**$0.00**
Annual Energy Cost Savings	— —	**$70,251.80**
Annual Cost Savings	— —	**$70,251.80**

Next Week Session 4 – Air Treatment

- Compressed air must be dried. This is an undeniable statement of fact.
  - Today's modern industry can no longer tolerate the problems of wet, dirty compressed air.
  - Wet air causes rust, pitting, blockages, and freeze-ups, with resultant component failure and product rejection.
  - Wet air is a major contributor of downtime, causing millions of dollars of lost production.

Homework for Week 3 – Compressor Controls

- Explain each of the following control methods:
  - Start/Stop
  - Load/Unload
  - Modulating
  - Variable Displacement
  - Variable Speed
  - Sequencer
  - Master Compressor Controller?
  - Pressure Flow Control?

Questions?

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