Better Plants
U.S. DEPARTMENT OF ENERGY

In-Plant Trainings

Virtual Platform
Session 3 – Controls

U.S. DEPARTMENT OF ENERGY

Homework Questions

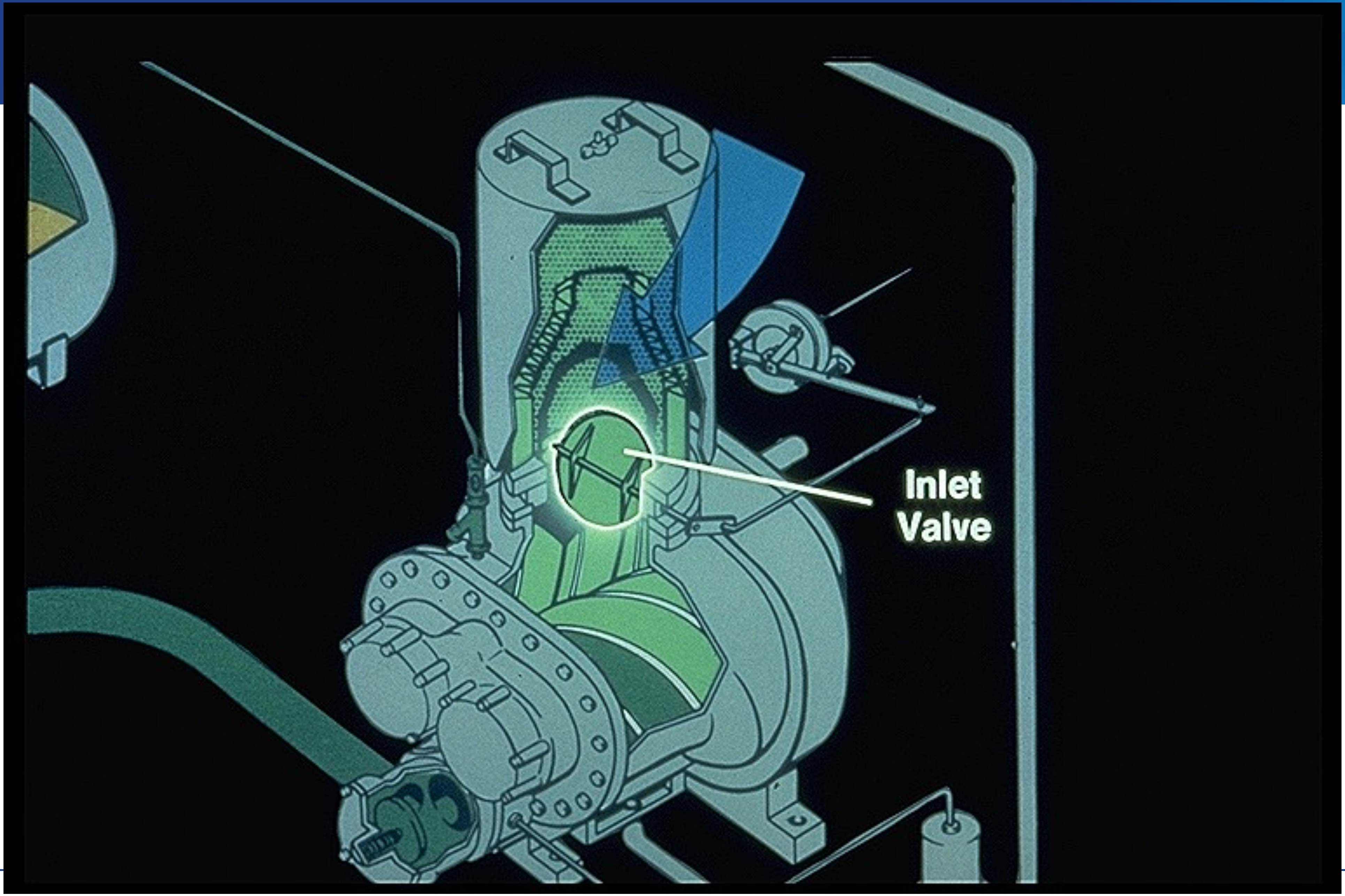
- How can we find the compressor discharge pressure?
- I'd like to get feedback regarding dry air storage system in my facility. I have some doubts, that it is efficient. As for me, majority of air is going to consumers via two bypasses. If my thoughts are correct, do we need to keep all 6 dry tanks?
- 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?

Session 3

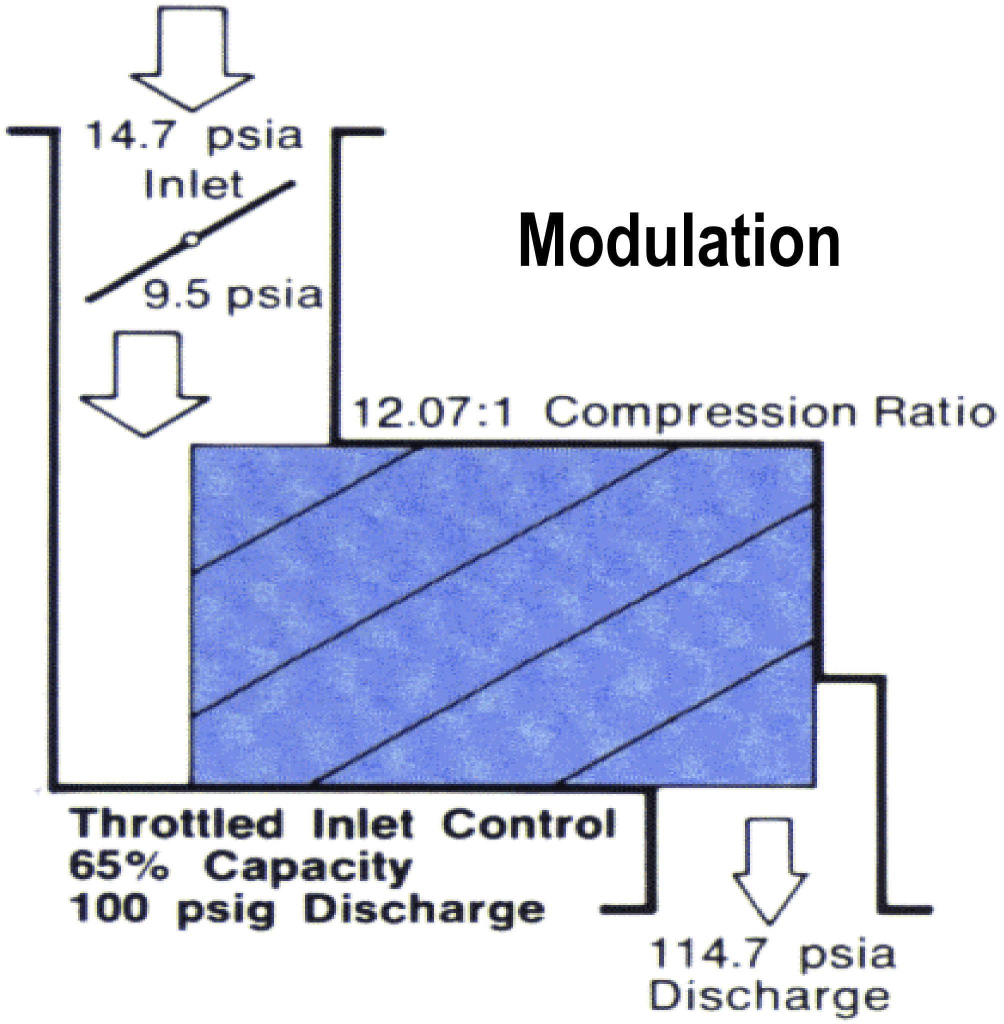
Compressor Controls

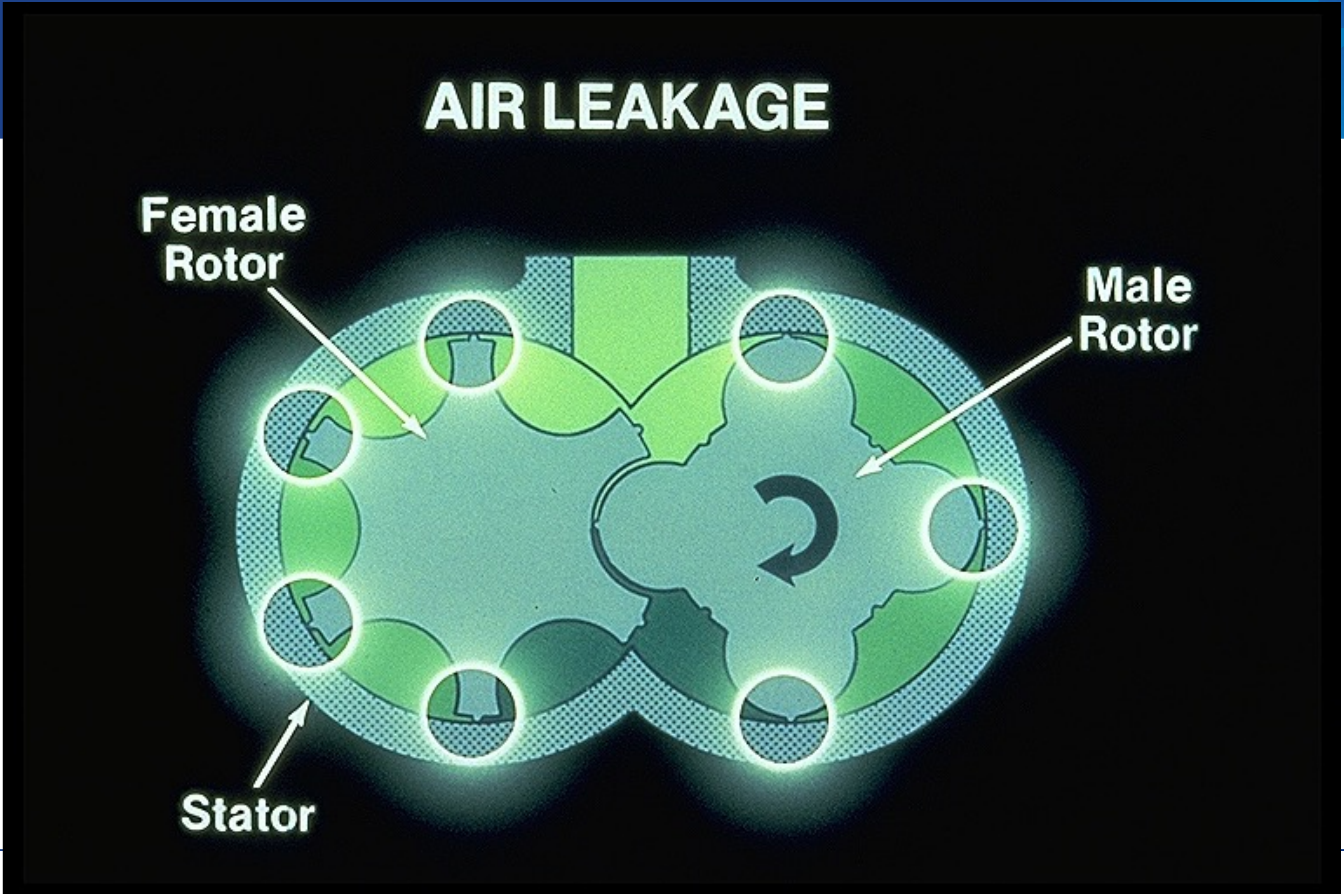
Compressor Control Types

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

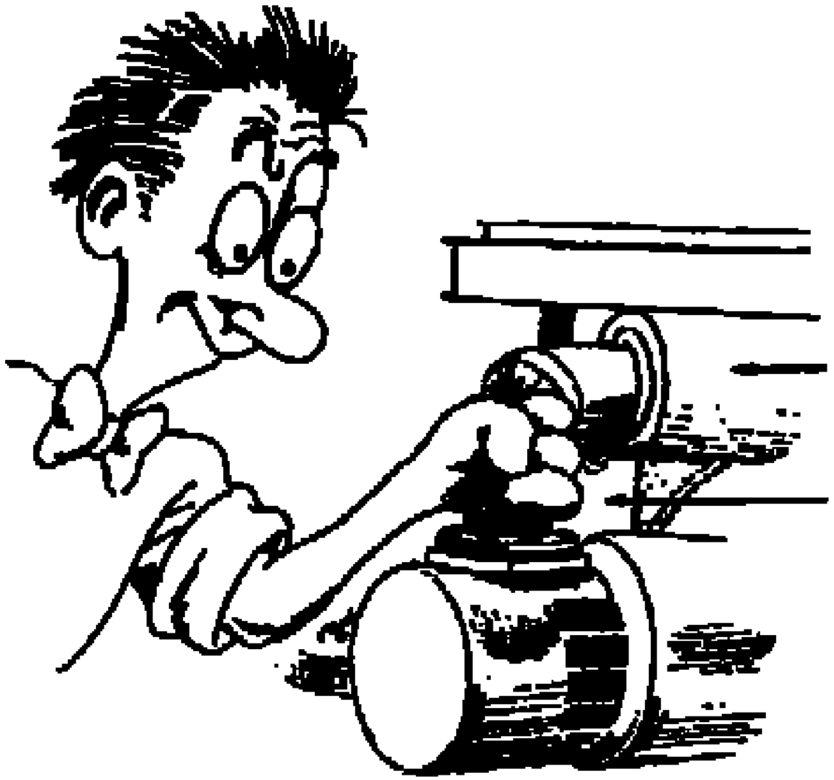

Inlet
Valve

Inlet Throttling



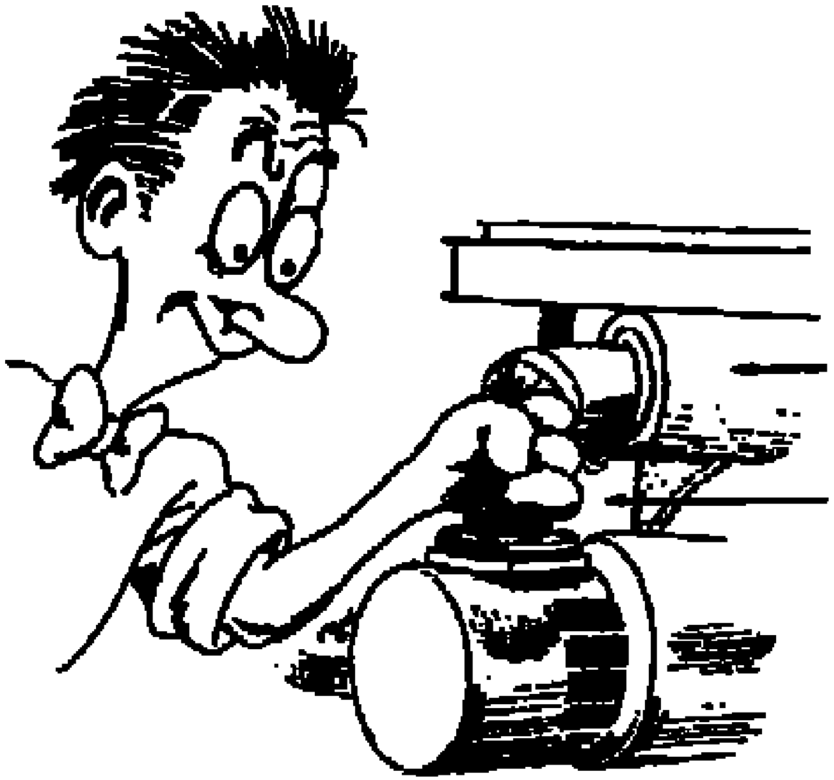

AIR LEAKAGE
Female Rotor
Male Rotor
Stator

Capacity Control by Inlet Throttling



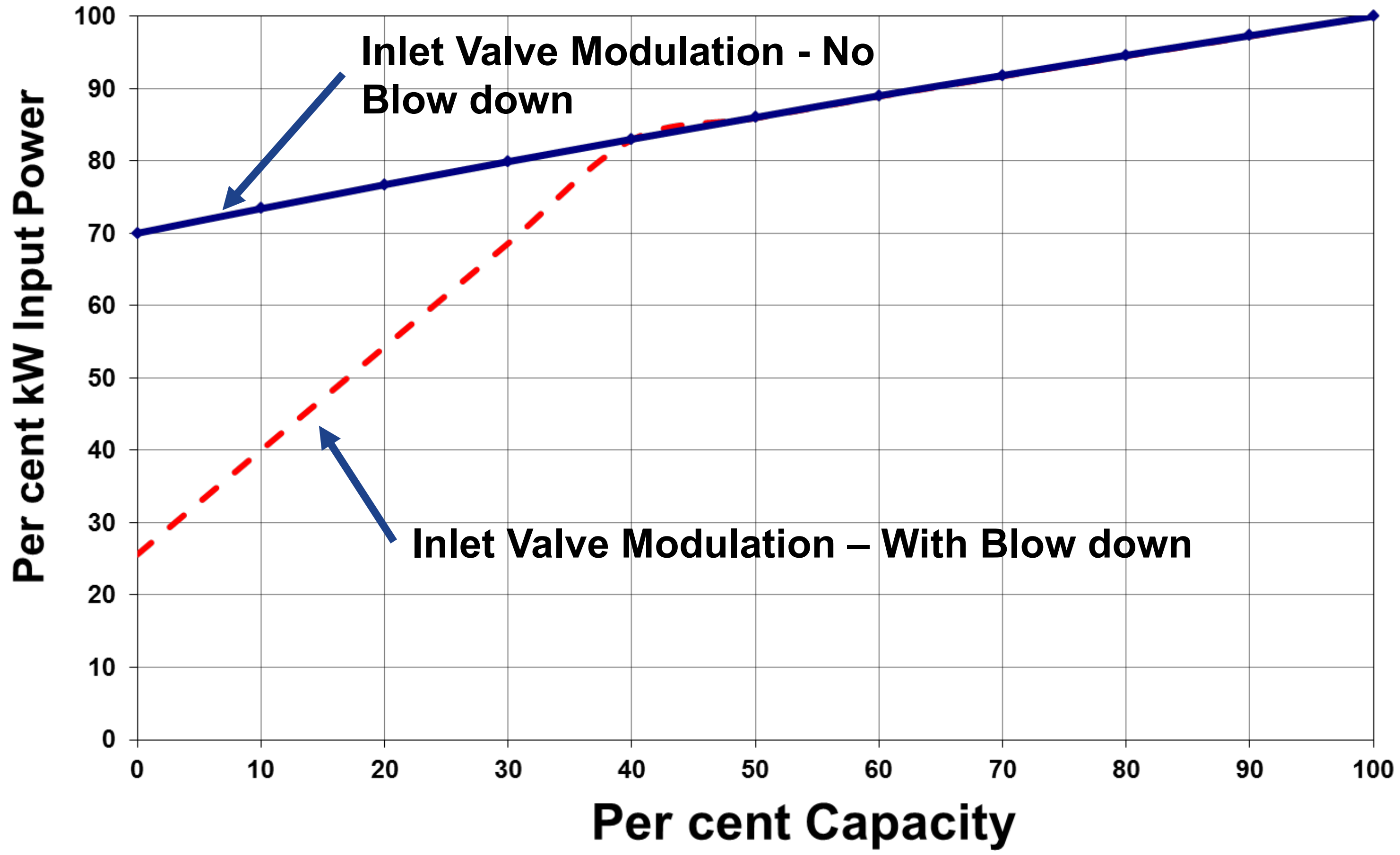
- Atmospheric pressure 14.7 psia
- Intake pressure 9.0 psia
- Discharge pressure 114.7
- Compression ratio: 114.7/9.0 = 12.7 to 1
- End Result?? Increased internal leakage due to a higher compression ratio

Capacity Control by Inlet Throttling



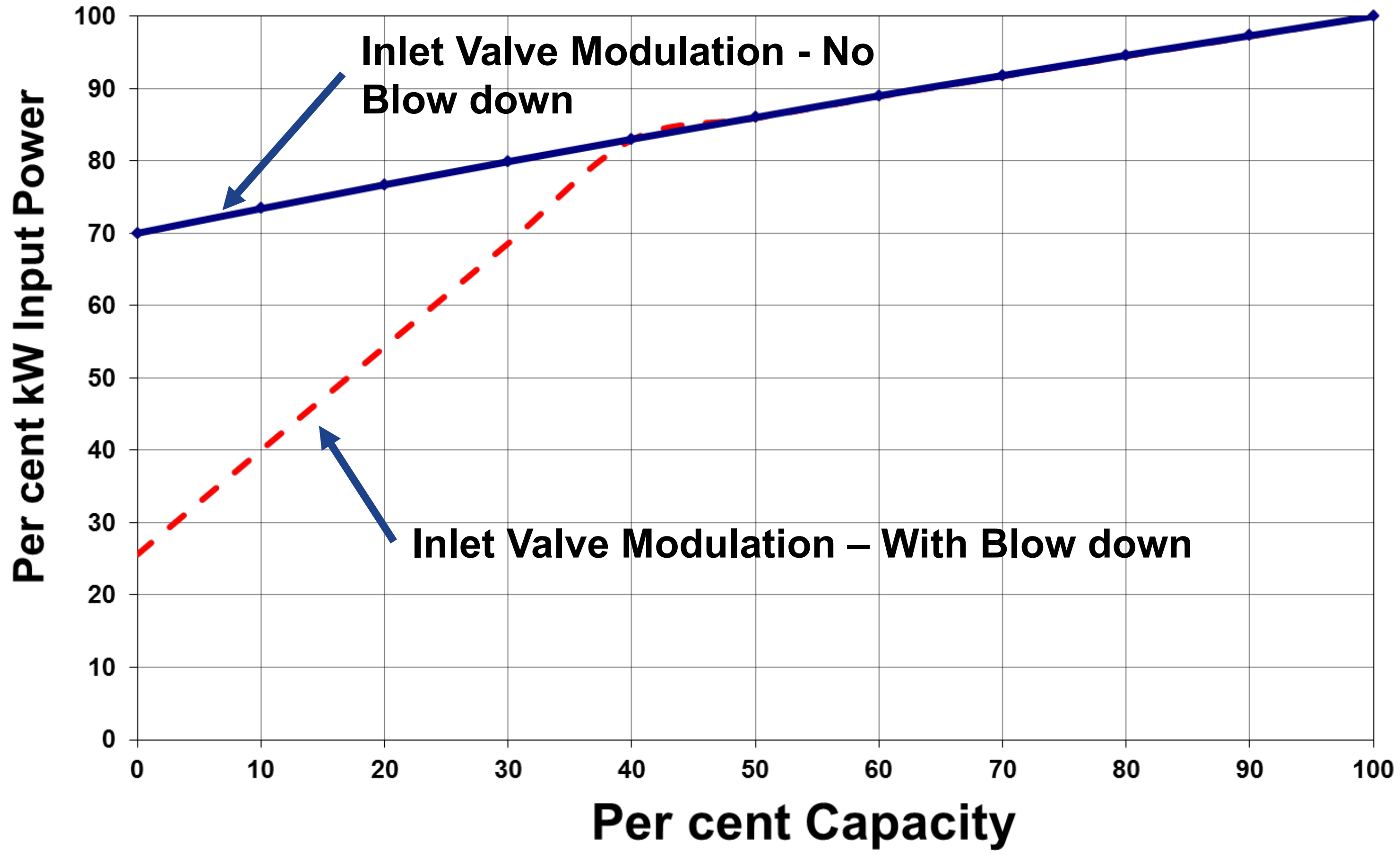
- Varies capacity by throttling (restricting) the inlet flow
- Provides a relatively stable output pressure
- Energy hog… least efficient
- Every 10% reduction in capacity yields only a 3% reduction in power(BHP)
- At zero capacity, power remains at 70% of full load power

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

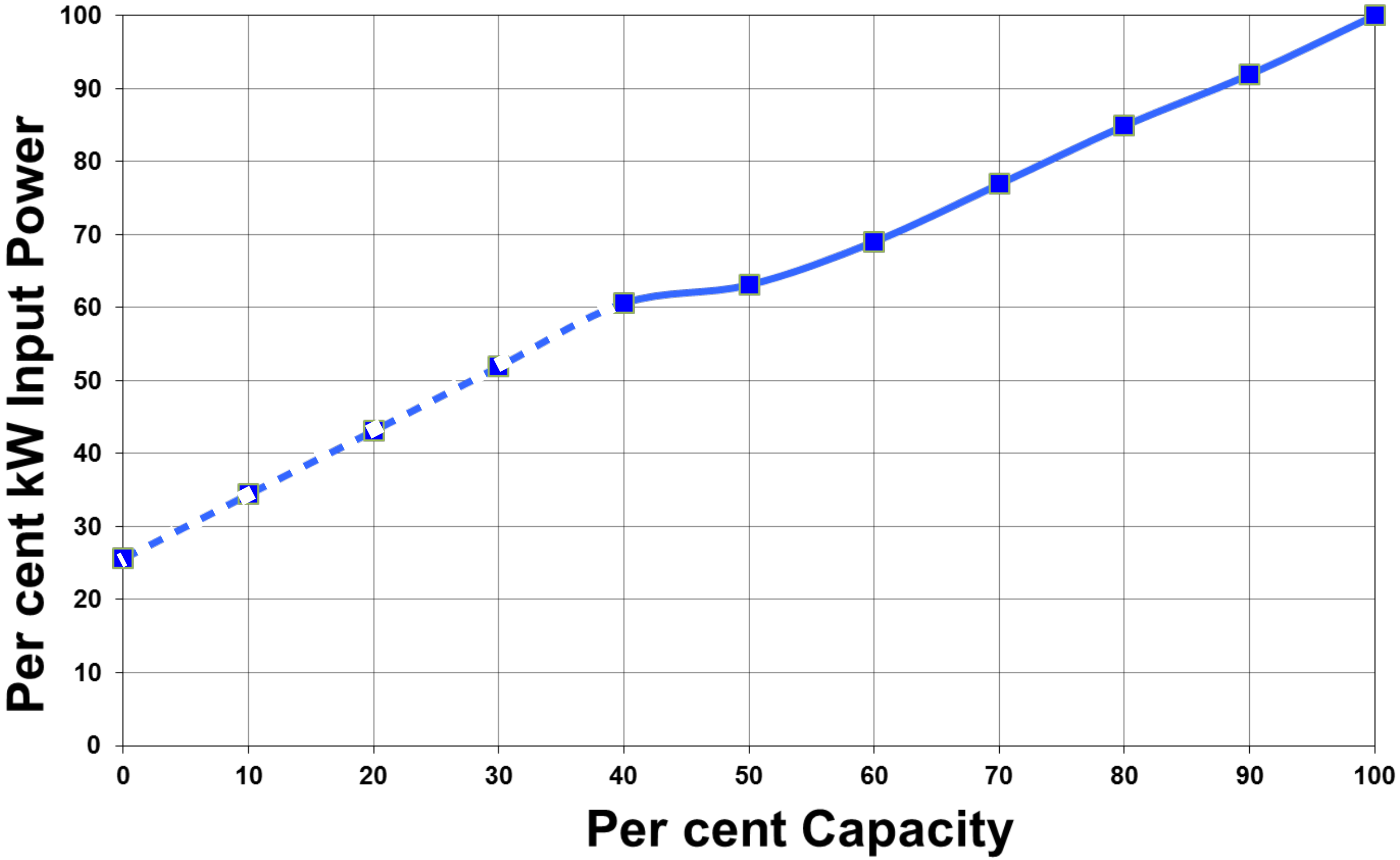


- This reduces the mass flow of air entering the air end in direct proportion to the absolute pressure.
- However, the reduced inlet pressure, with increasing discharge pressure, results in increasing pressure ratio.
- At 40% capacity the pressure ratio will be 124.7/5.88 = 21.21.
- This is why there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

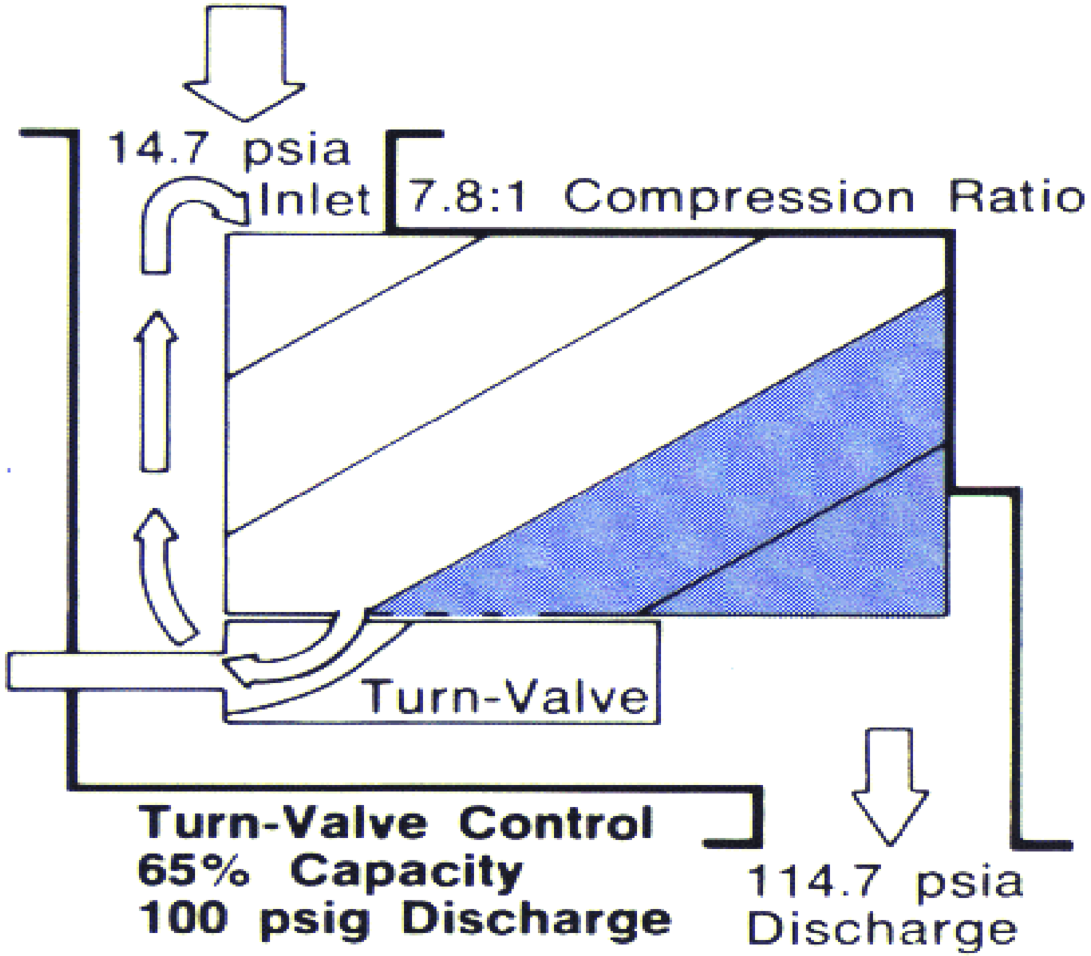
Variable Displacement

- 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

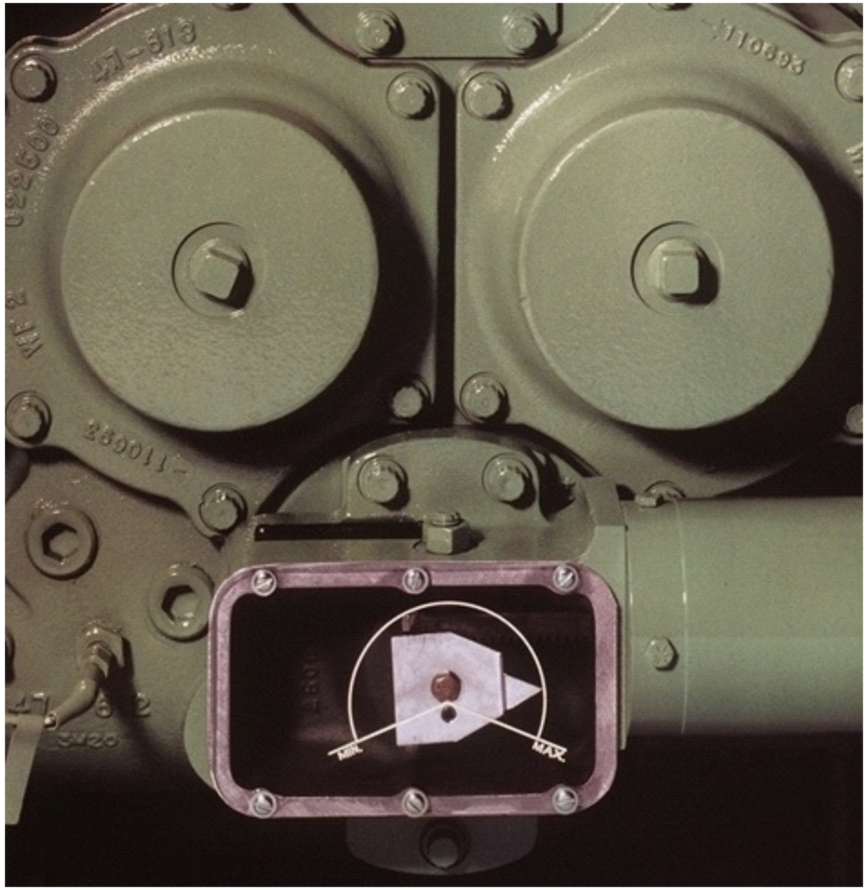


Variable Displacement



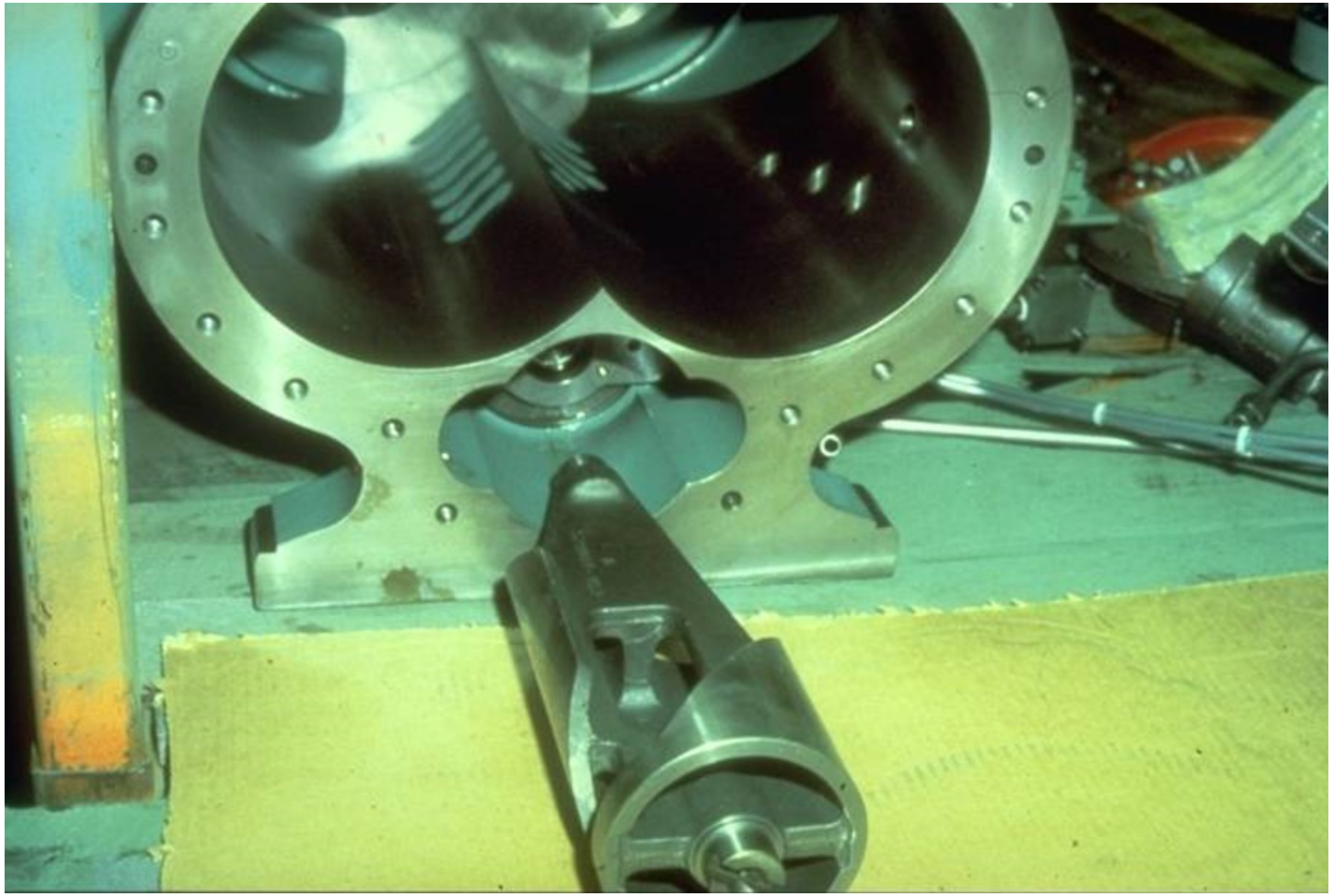
Variable Displacement

Original Version

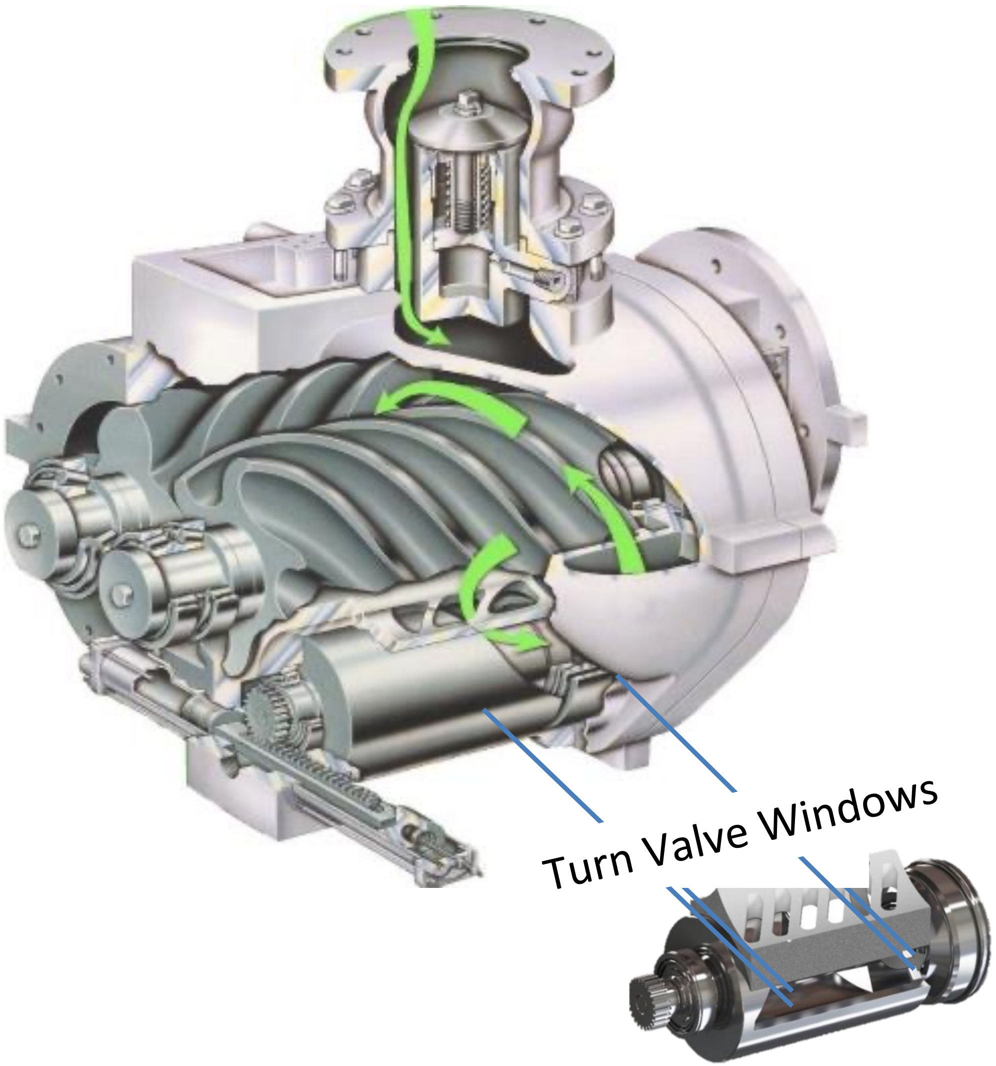


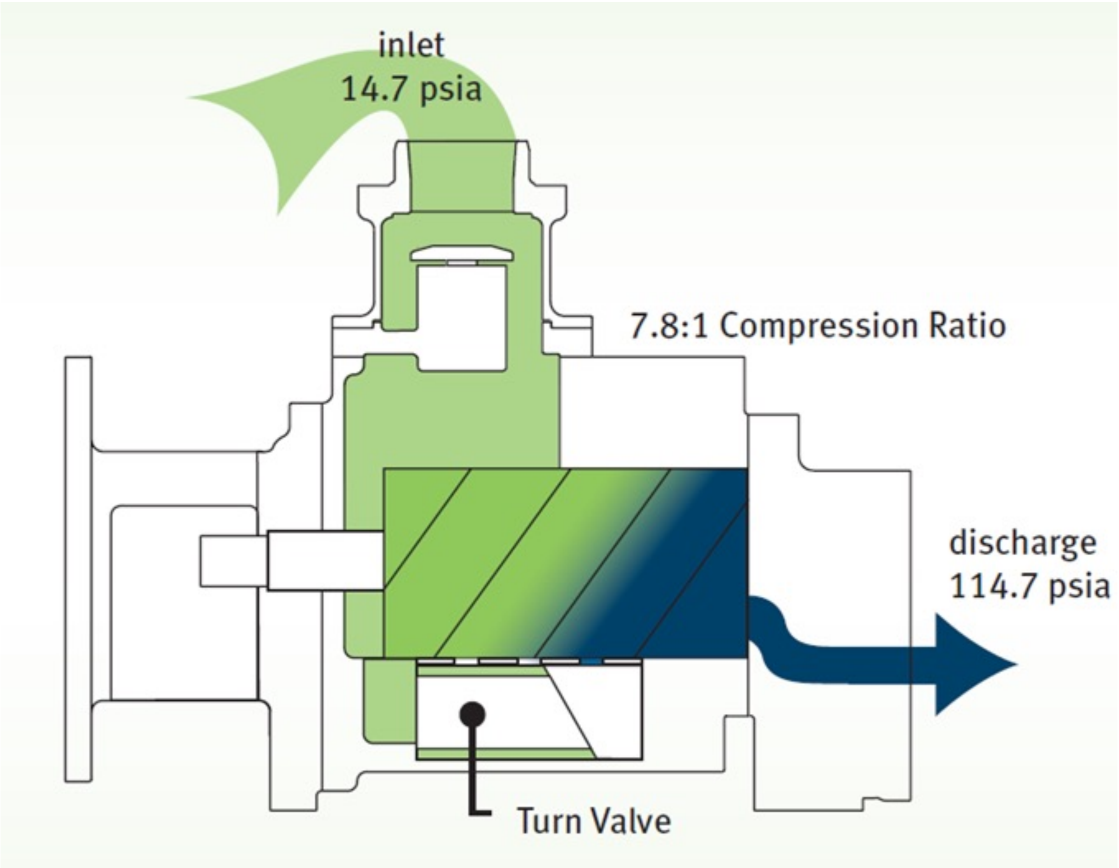
— UP TO 55% TURN DOWN

Variable Displacement

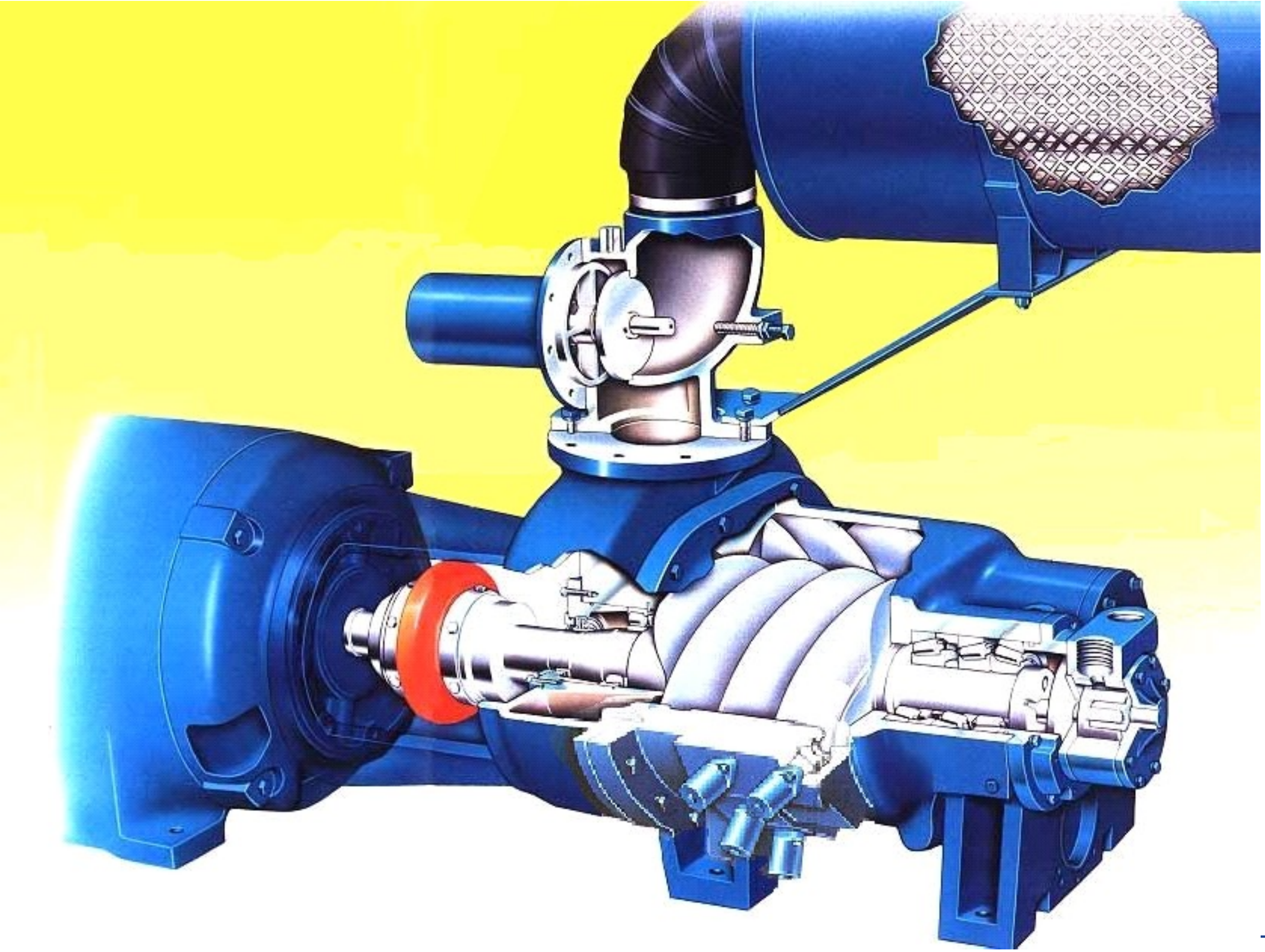


Variable Displacement

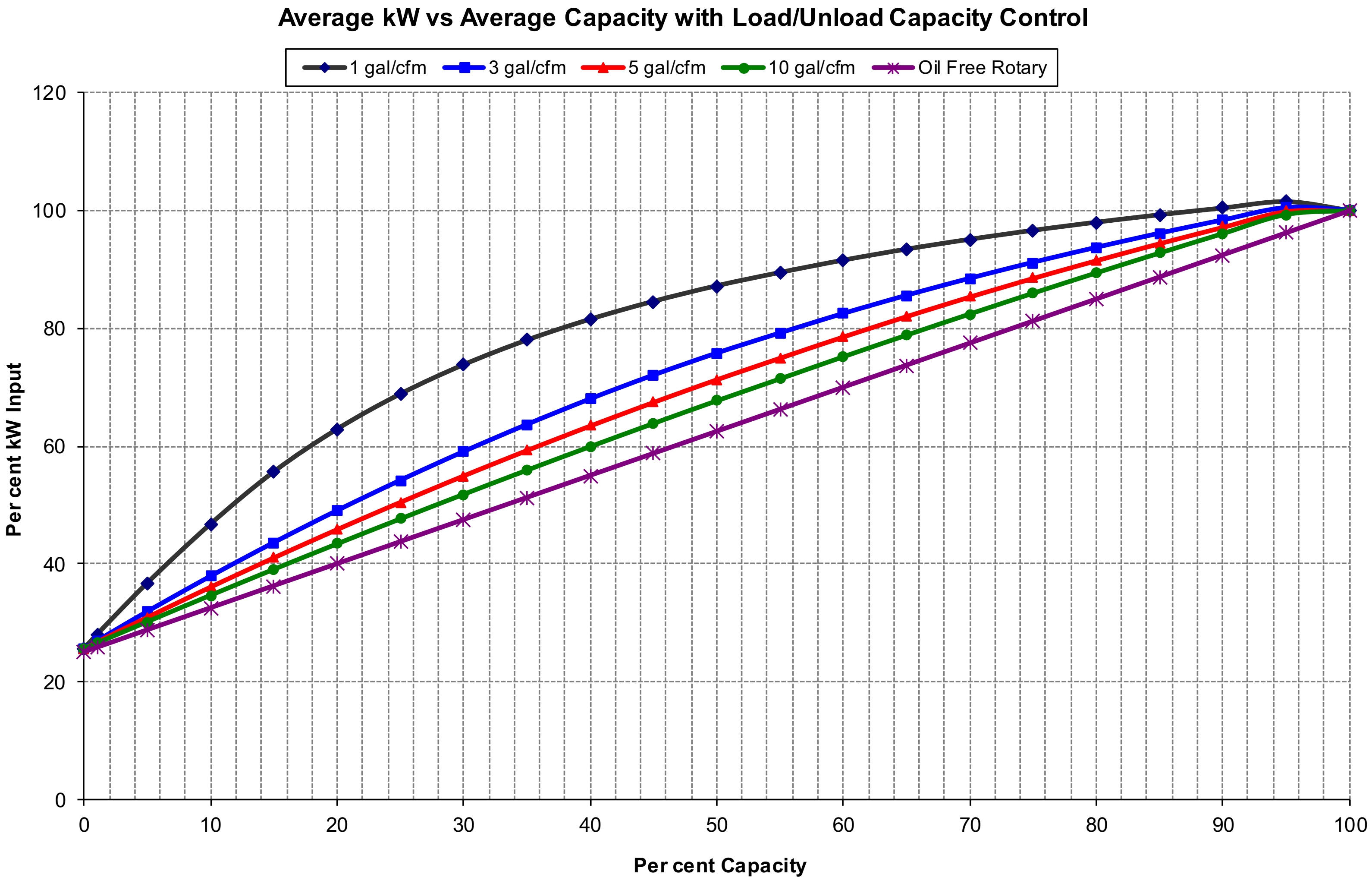




Variable Displacement



Load/No-load Control Curve

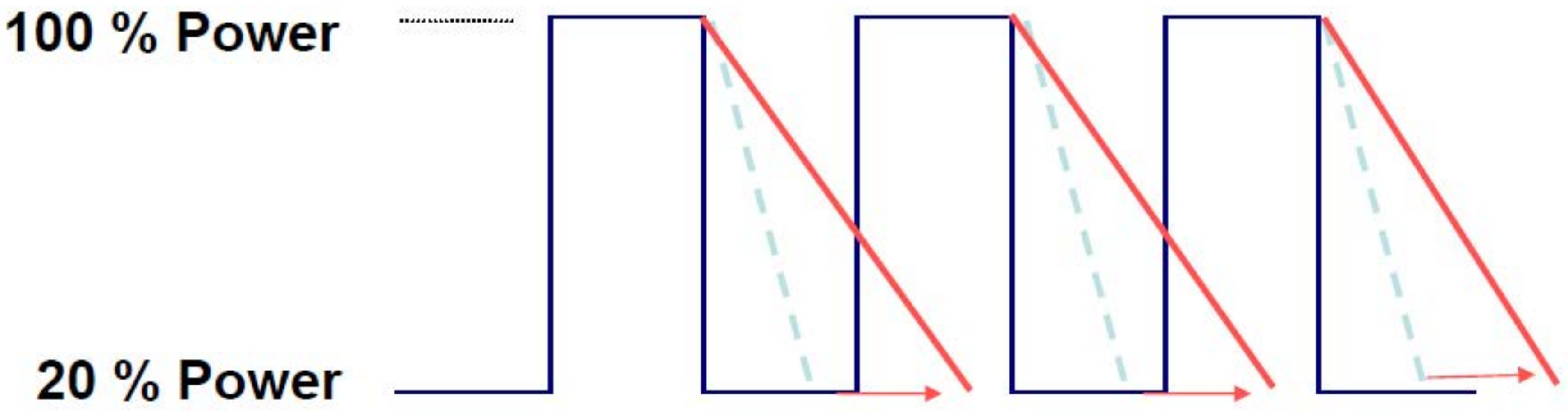


- This graph shows the effect of receiver size on the part load power of a lubricant injected rotary screw compressor with load/unload controls

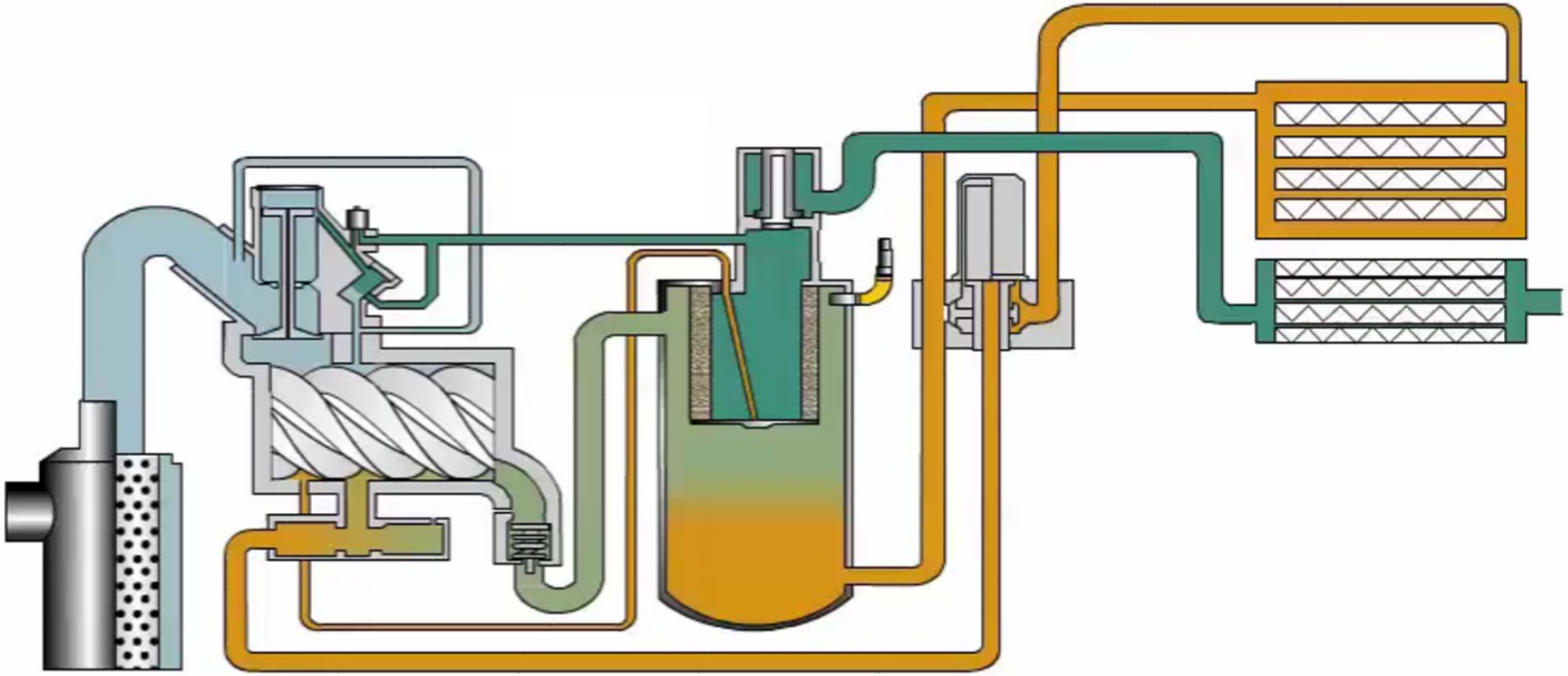
Load/Unload and Storage Size

- 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.

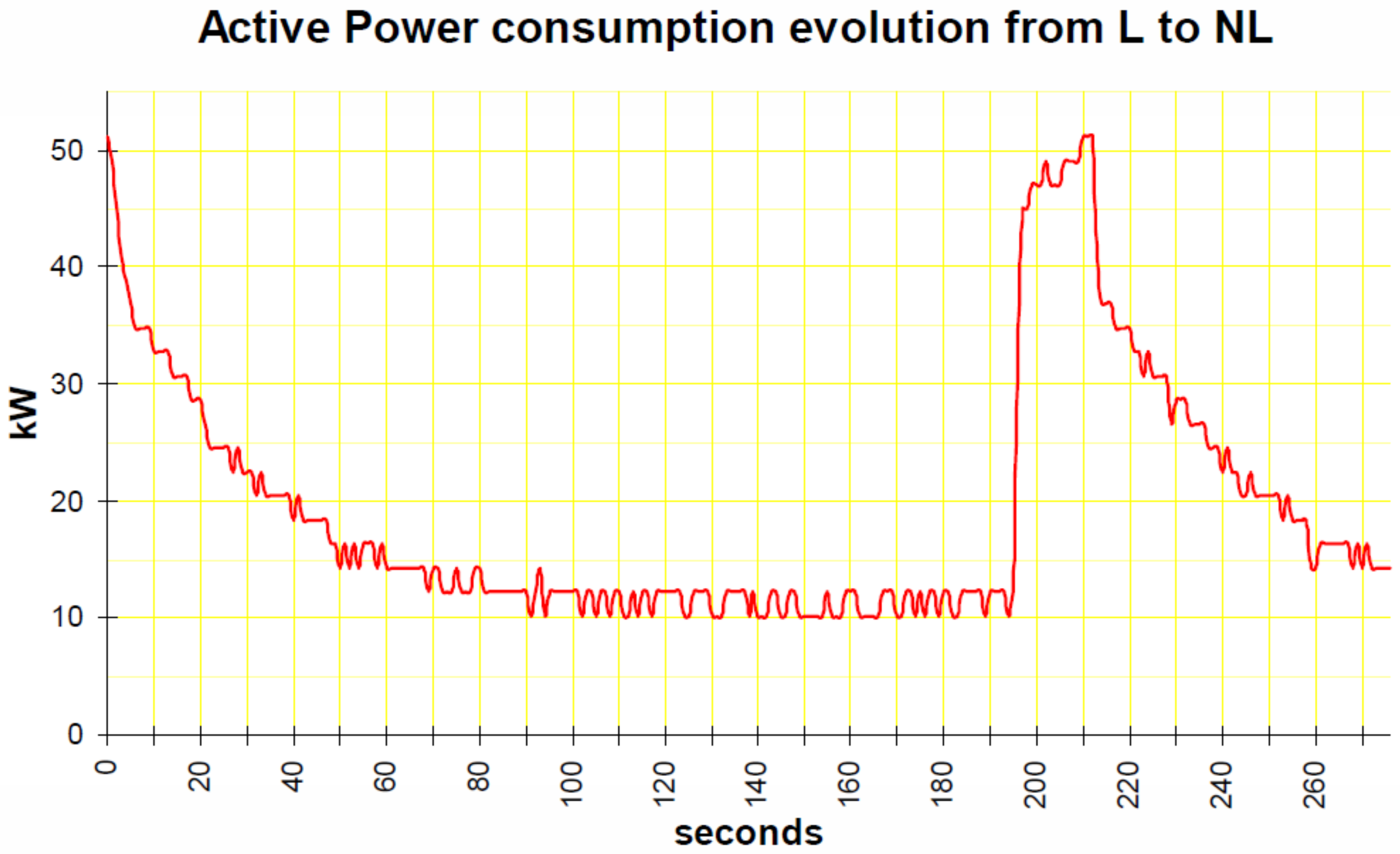
Capacity Control by Load/No-Load



- 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



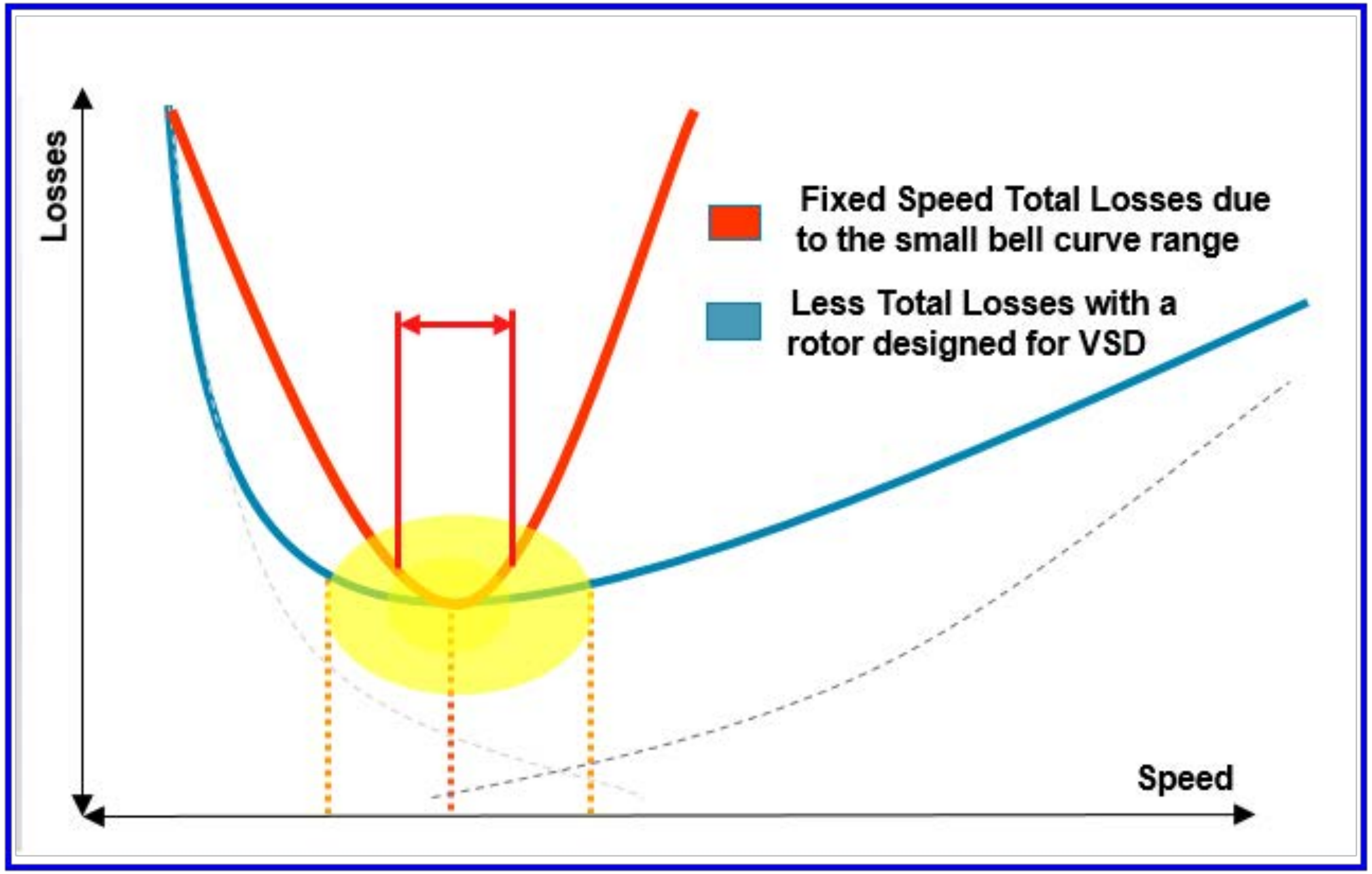
Capacity Control by Load/No-Load



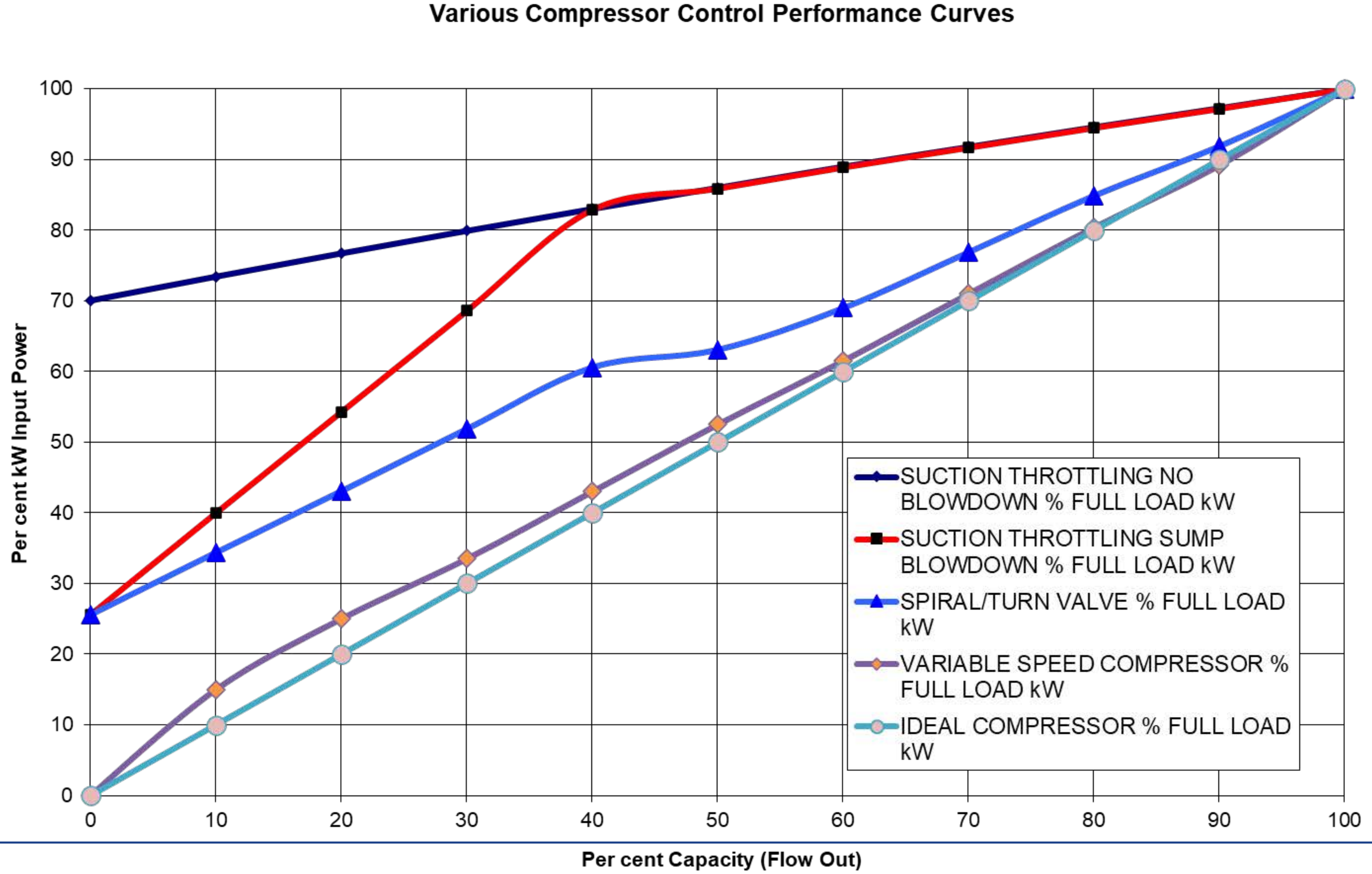
Variable Speed Compressors

- 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

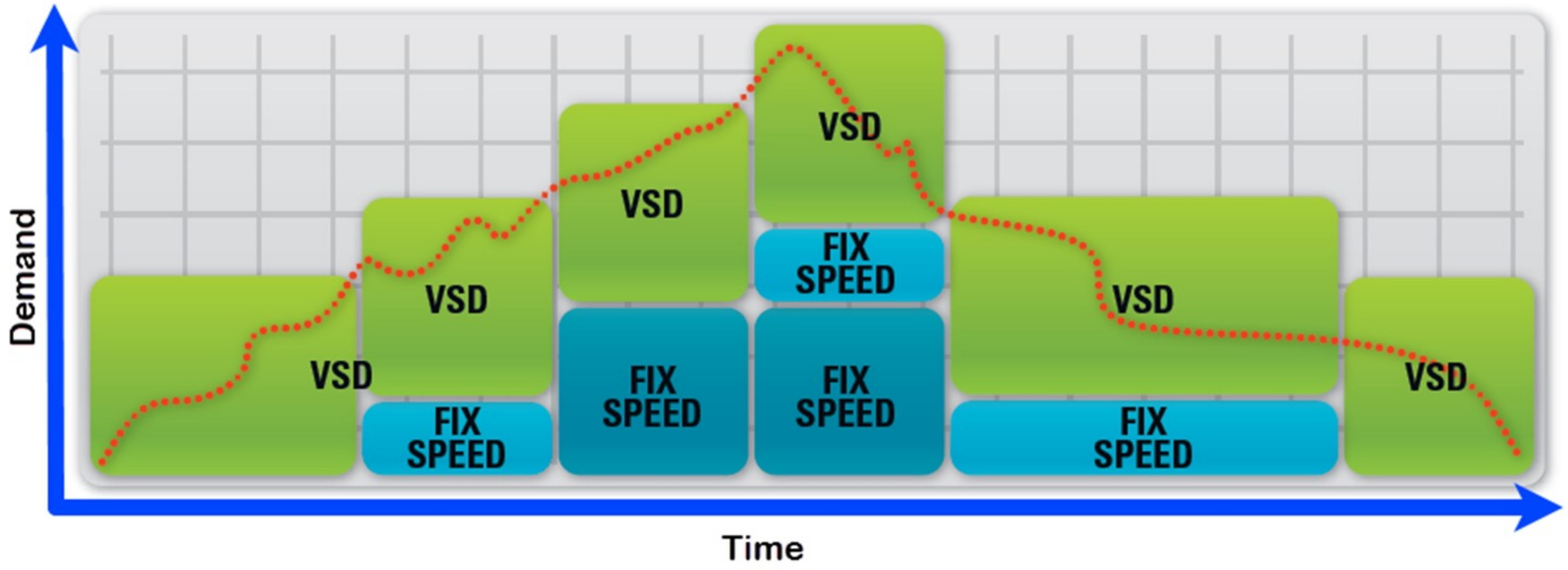
- The most common VSD is the variable frequency drive, which converts 60 Hz alternating current to direct current and then reconverts it to the proper frequency required to turn the drive motor at the desired speed.
- The variable frequency drive is less efficient at full load compared to modulation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

Variable Speed Compressors

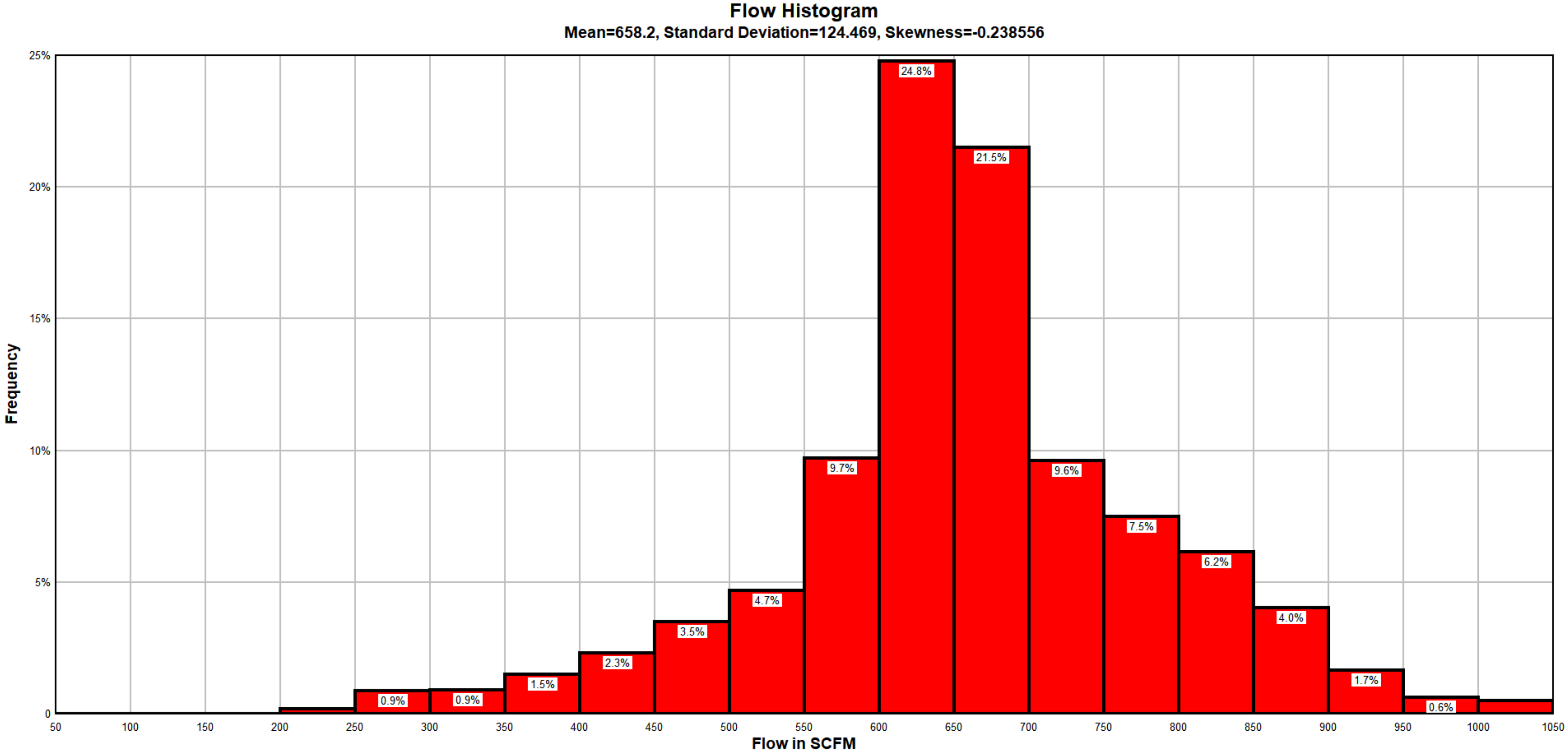
- VSD (variable speed drive) and VFD (variable frequency drive) are used interchangeably
- VFD is only one of the VSD technologies available.

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

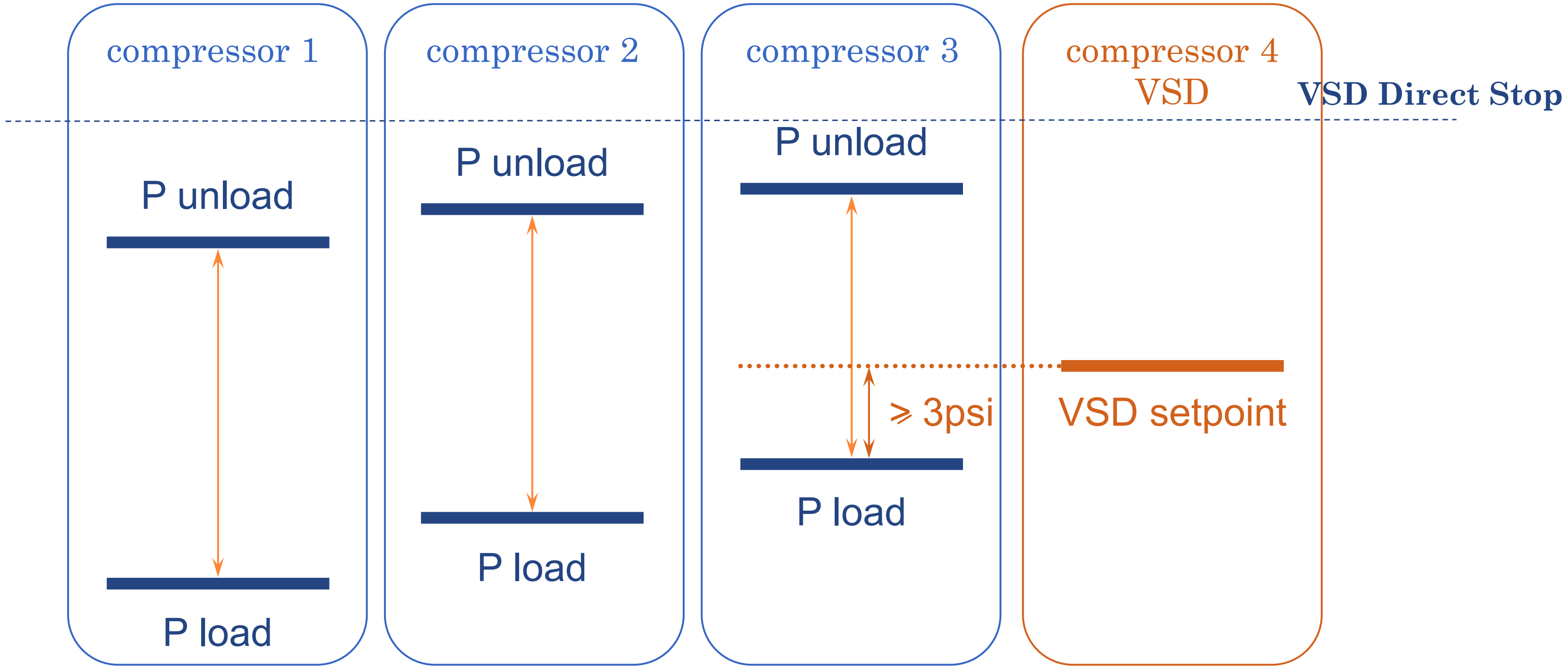


How do I know my flow patterns to size a VSD Correctly?



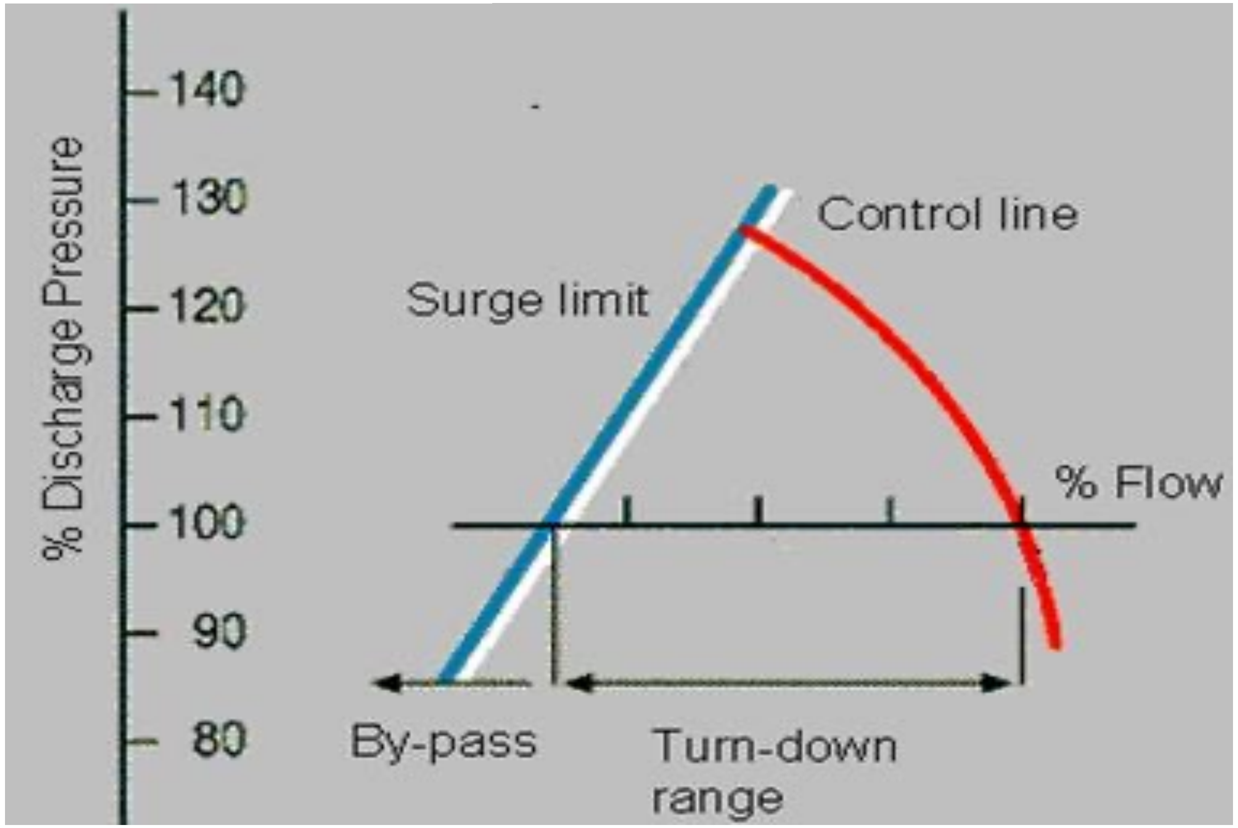
Control Gap and Position

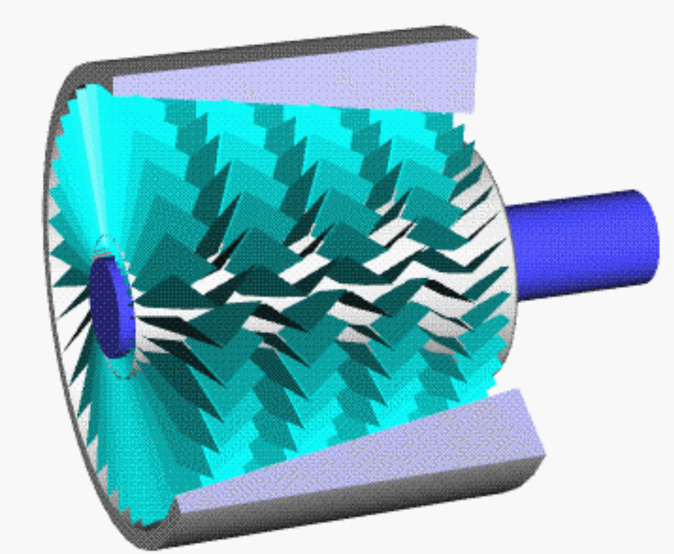
- In order to provide efficient VSD regulation over the complete range of the customer's air profile, the cfm of the VSD needs to be greater than the load/no load machine



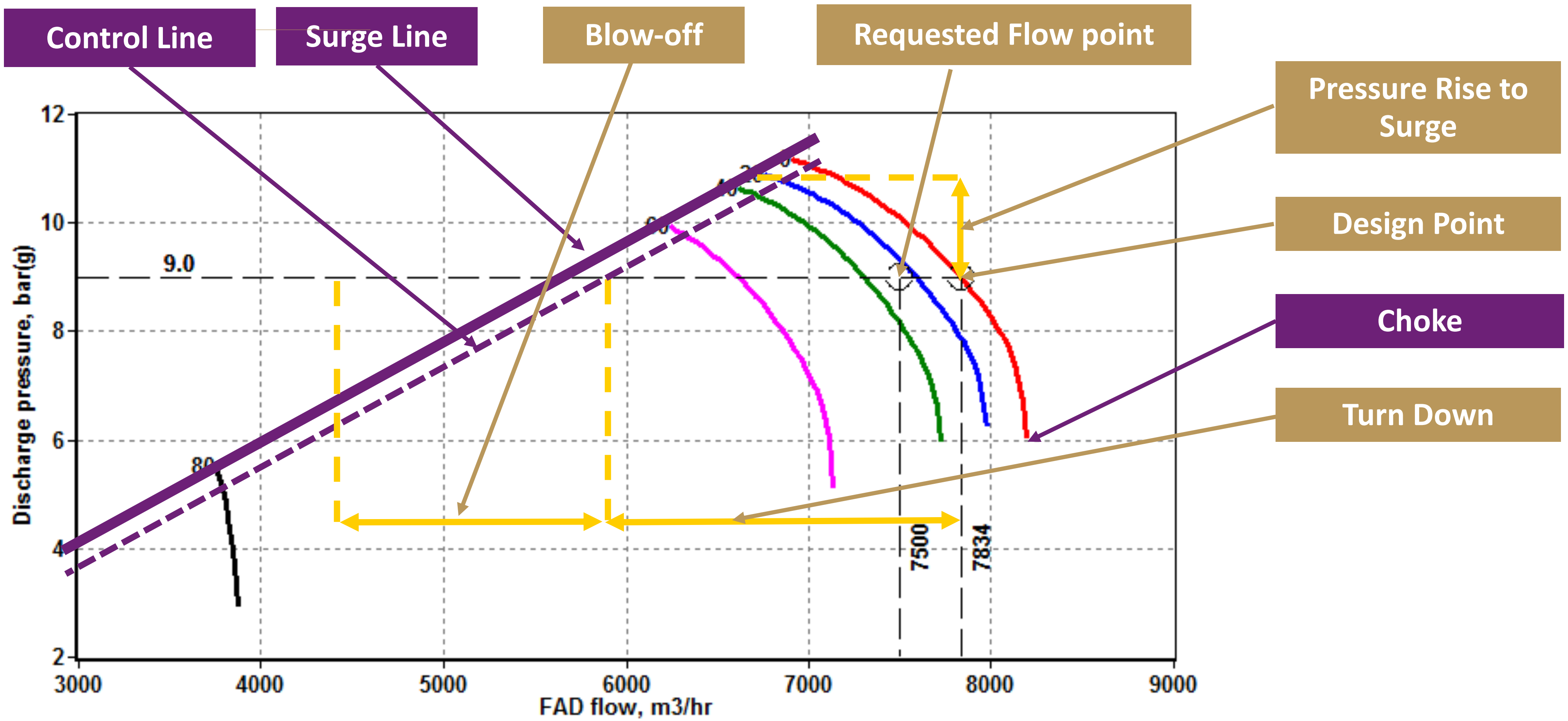
Centrifugal Compressor Control

- 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

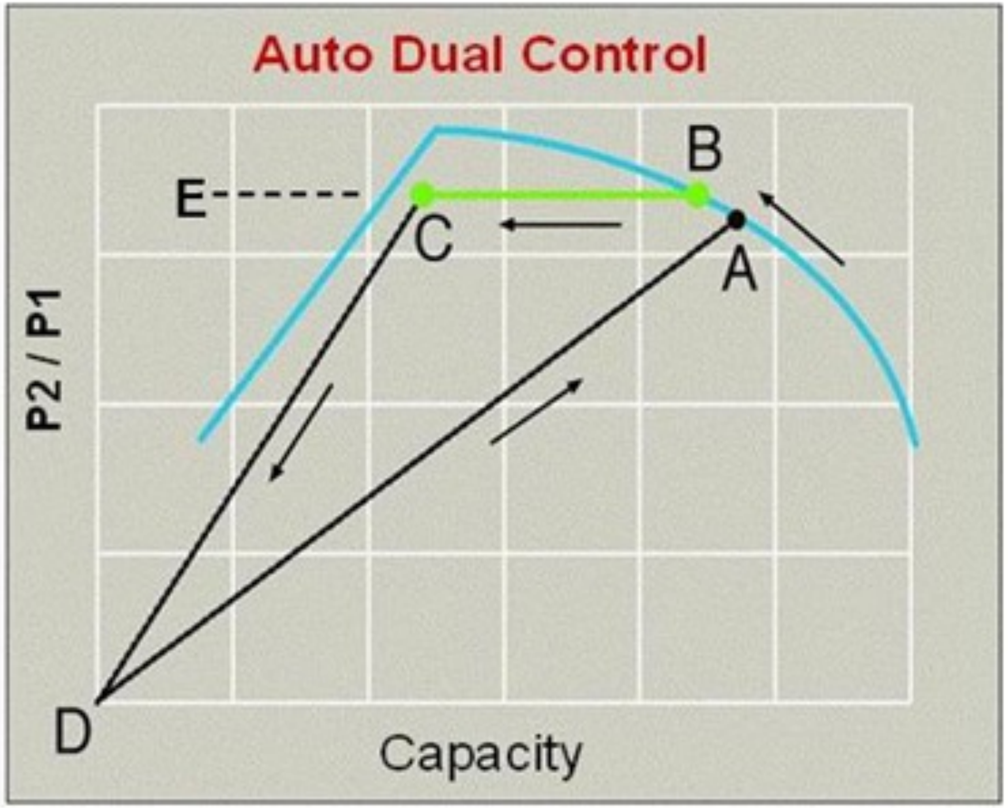


Centrifugal Compressor Control Common Terms



Auto-Dual Control or Load-Unload

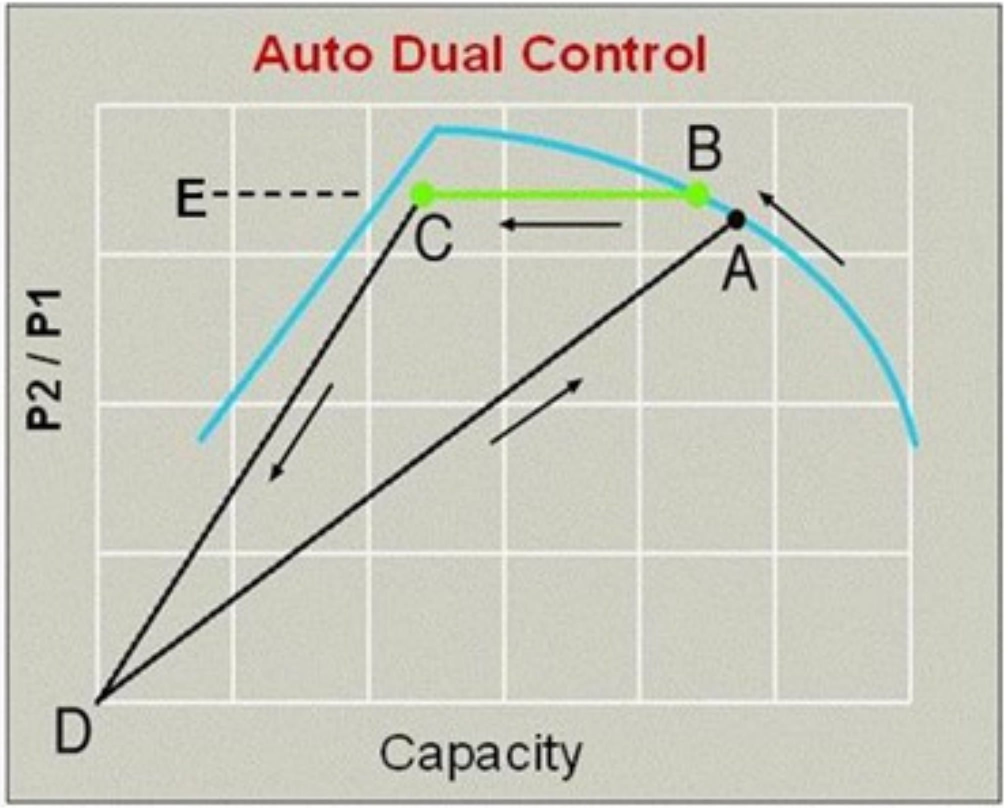
- The standard regulation is achieved by means of inlet guide vanes and controller. –
- The compressor discharge pressure set point (B) will be set at the desired level and IGVs will modulate the compressor inlet to maintain constant discharge pressure over the control (B→C) range.
- At the surge control point (C), the IGVs stop closing, allowing the discharge pressure to rise to the unload set point.
- At this moment, the compressor will unload (IGVs close and unloading valve fully opens).



From CAGI

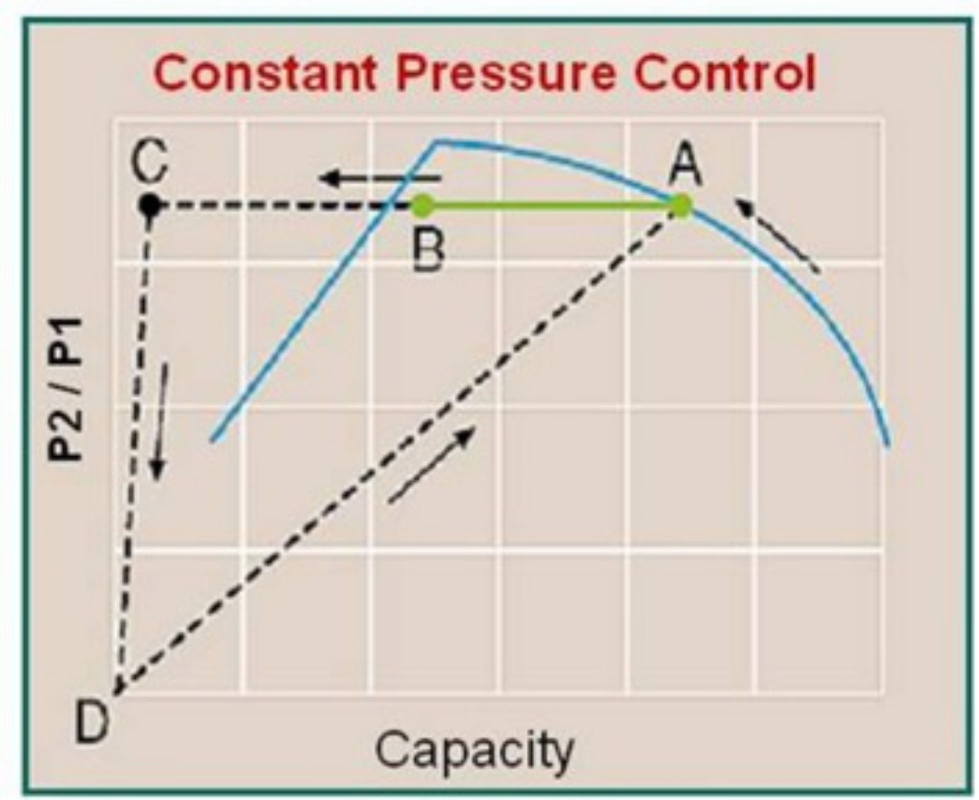
Auto-Dual Control or Load-Unload

- The compressor remains in the unloaded condition until the system pressure declines below the preset load set point (A), the compressor resumes load at full flow, and the cycle is repeated.
- Re-loading time may be variable depending on system capacitance.
- If the compressor does not need to reload within a fixed time period, the unit will stop automatically.
- The controller will automatically re-start and load in anticipation, when the system pressure falls to the load set point (A).



Constant Pressure Control with Modulation

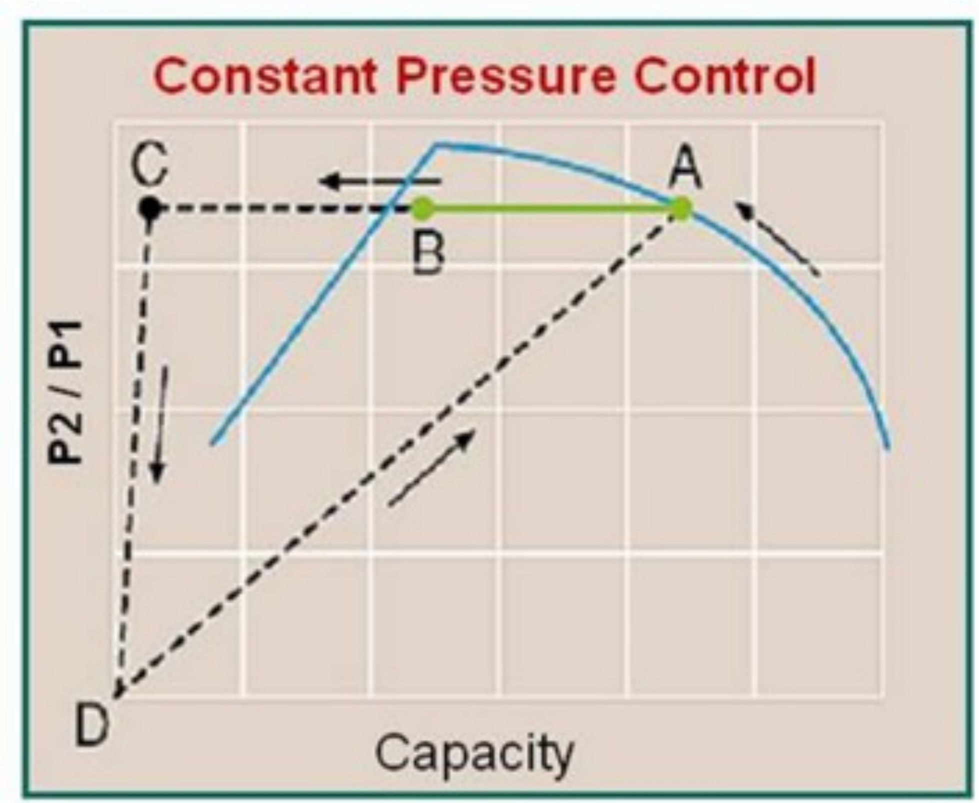
- This control method uses the inlet guide vanes (IGVs), unloading valve (ULV), and a controller.
- The compressor discharge pressure set point will be set at the desired level and the IGVs will modulate the compressor inlet to maintain constant discharge pressure over the control (A→B) range.
- At the surge control point (B), the position of the IGV is maintained fixed at min flow, the unloading valve starts to modulate open, and the excess compressed air is exhausted to atmosphere.



From CAGI

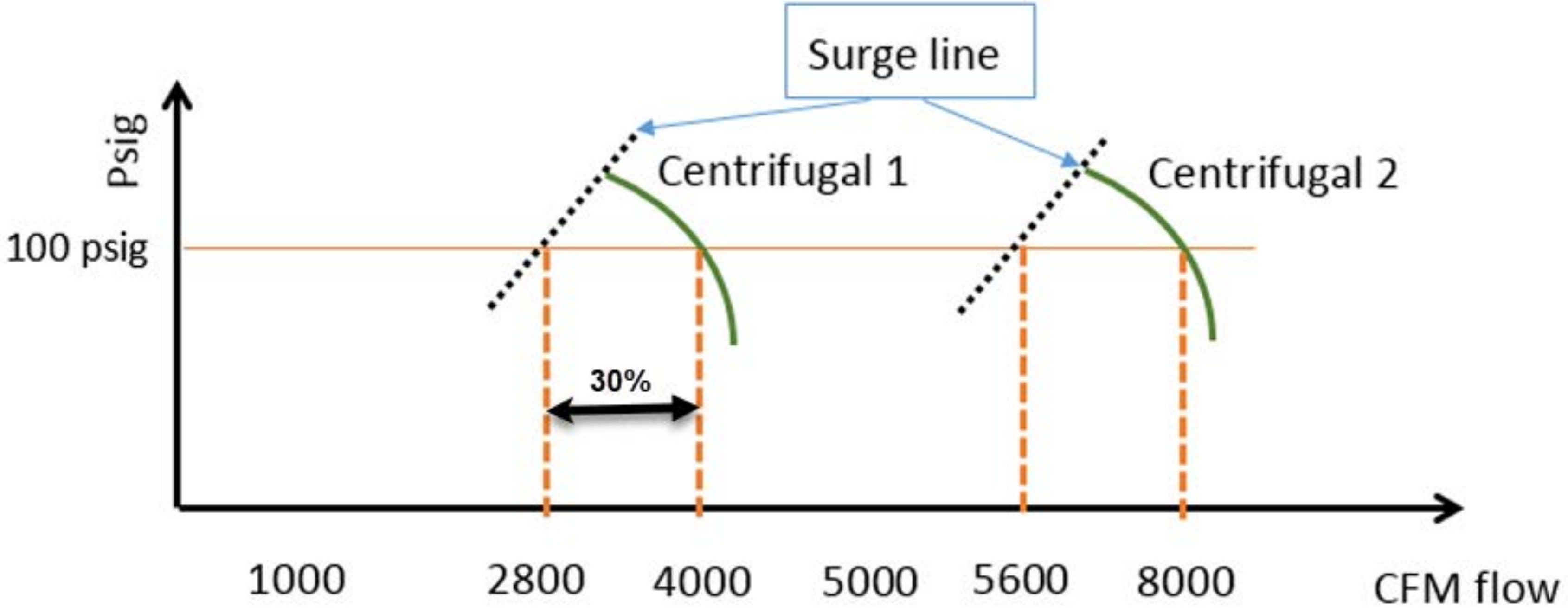
Constant Pressure Control with Modulation

- In this way, a constant discharge pressure is maintained over the full operating range of the compressor (A-C).
- Some controls can also provide for a maximum unloading valve (ULV) position to be programmed. This allows the plant to minimize inefficient operation during periods of low demand by limiting blow-off operation to a point between (B→C).
- The constant pressure control system is designed to continuously control the air output while keeping the net pressure fluctuations to a minimum.
- Constant pressure is critical in many applications.



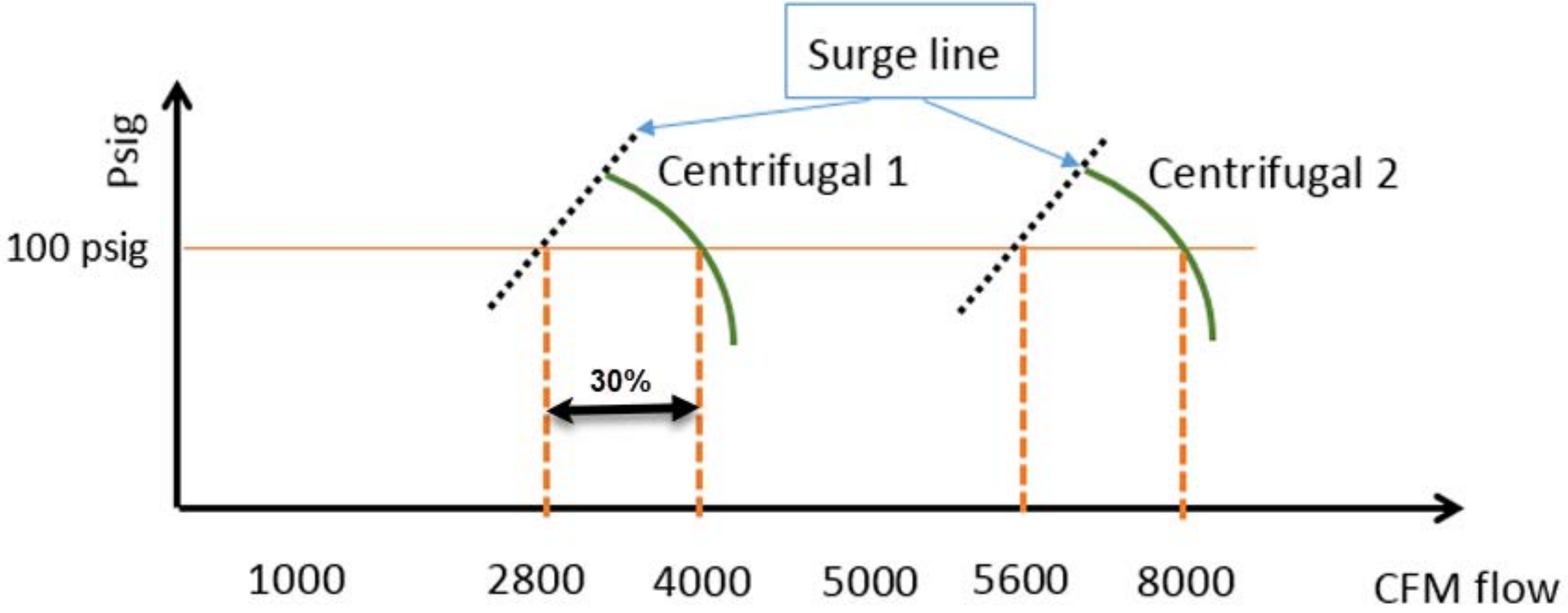
From CAGI

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



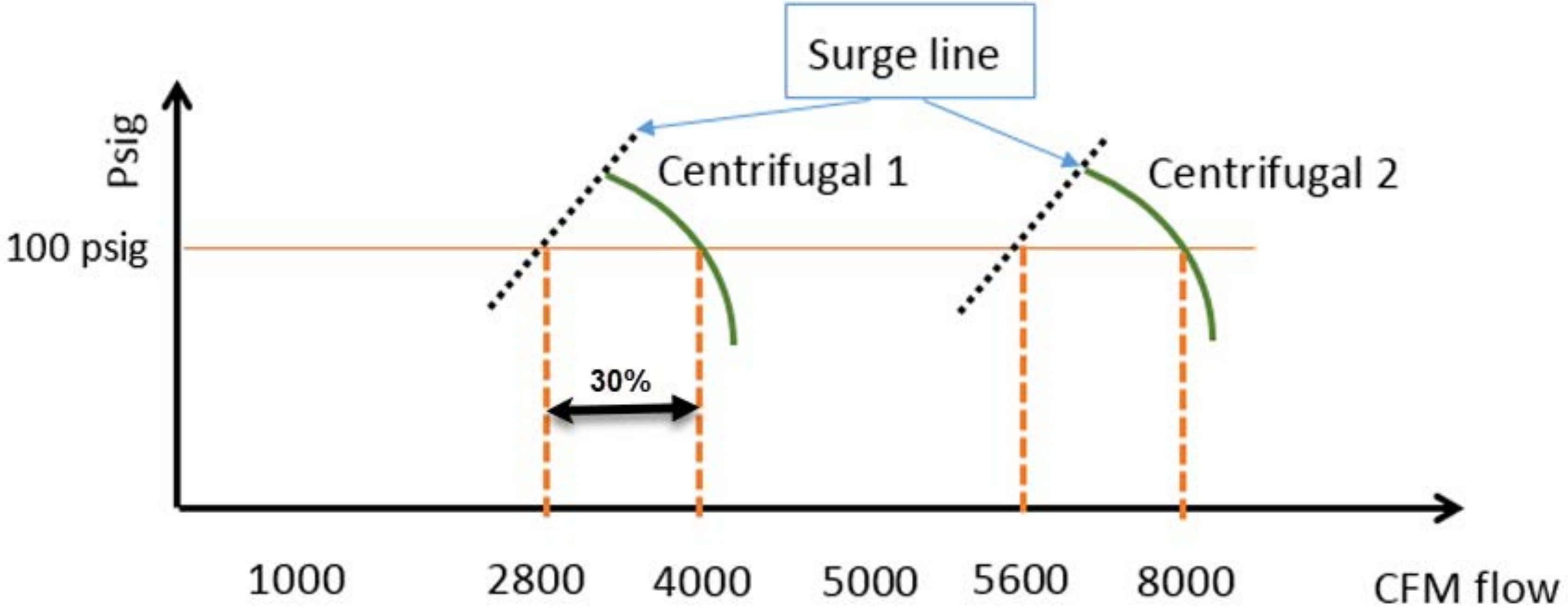
- Plant has 8000 cfm peak demand, 5800 cfm average demand, and 3000 cfm minimum demand during weekends at operating pressure of 100 psig.
- Two 4000 cfm centrifugals with a 30% turndown to 2800 cfm

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



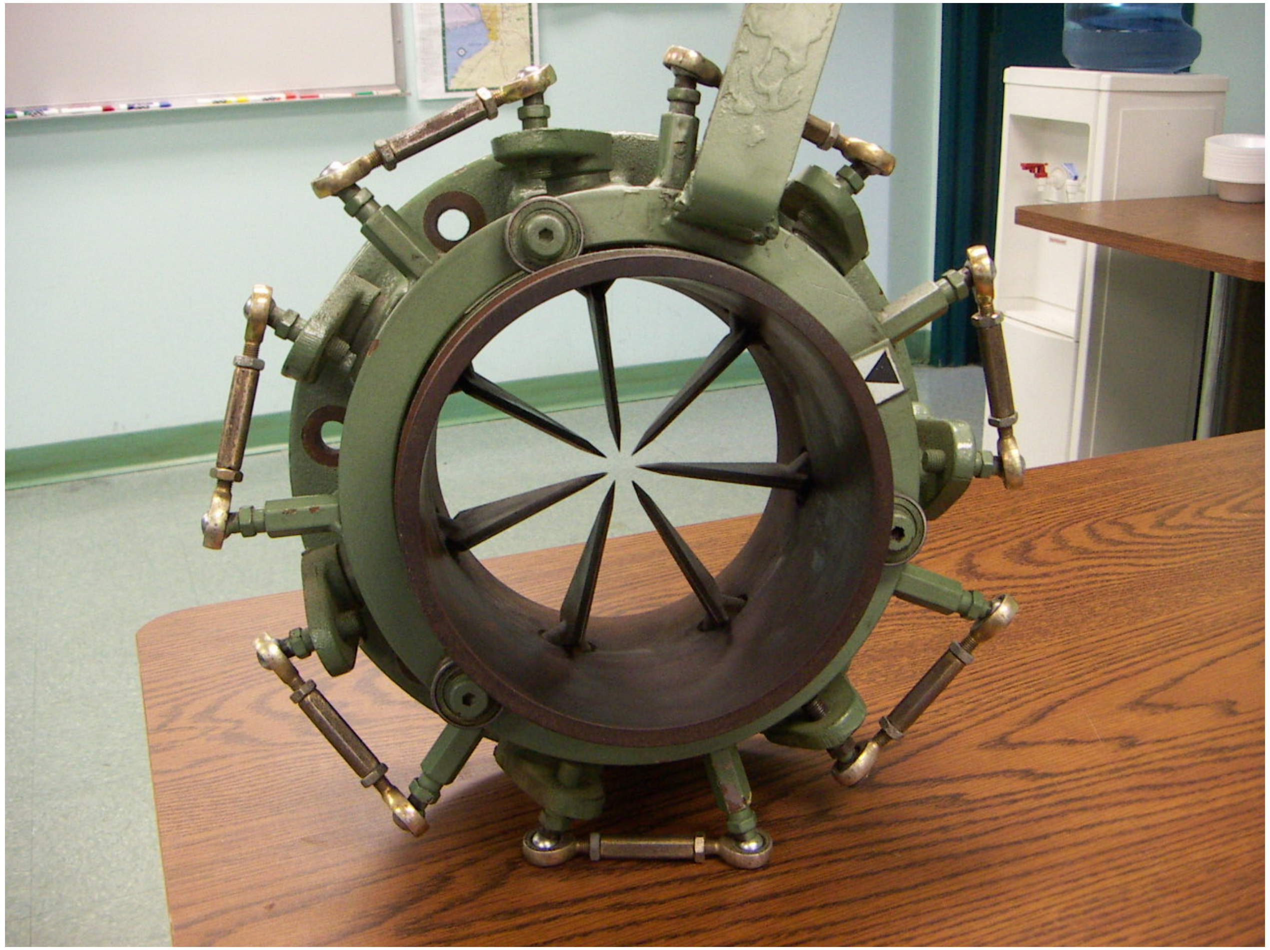
- During peak demand of 8000 cfm, both compressors will run at full load.
- When the flow demand is reduced to the average demand of 5800 cfm, the two centrifugal compressors will close the inlet guide valve and run in its turndown range without exhausting any compressed air to atmosphere.

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

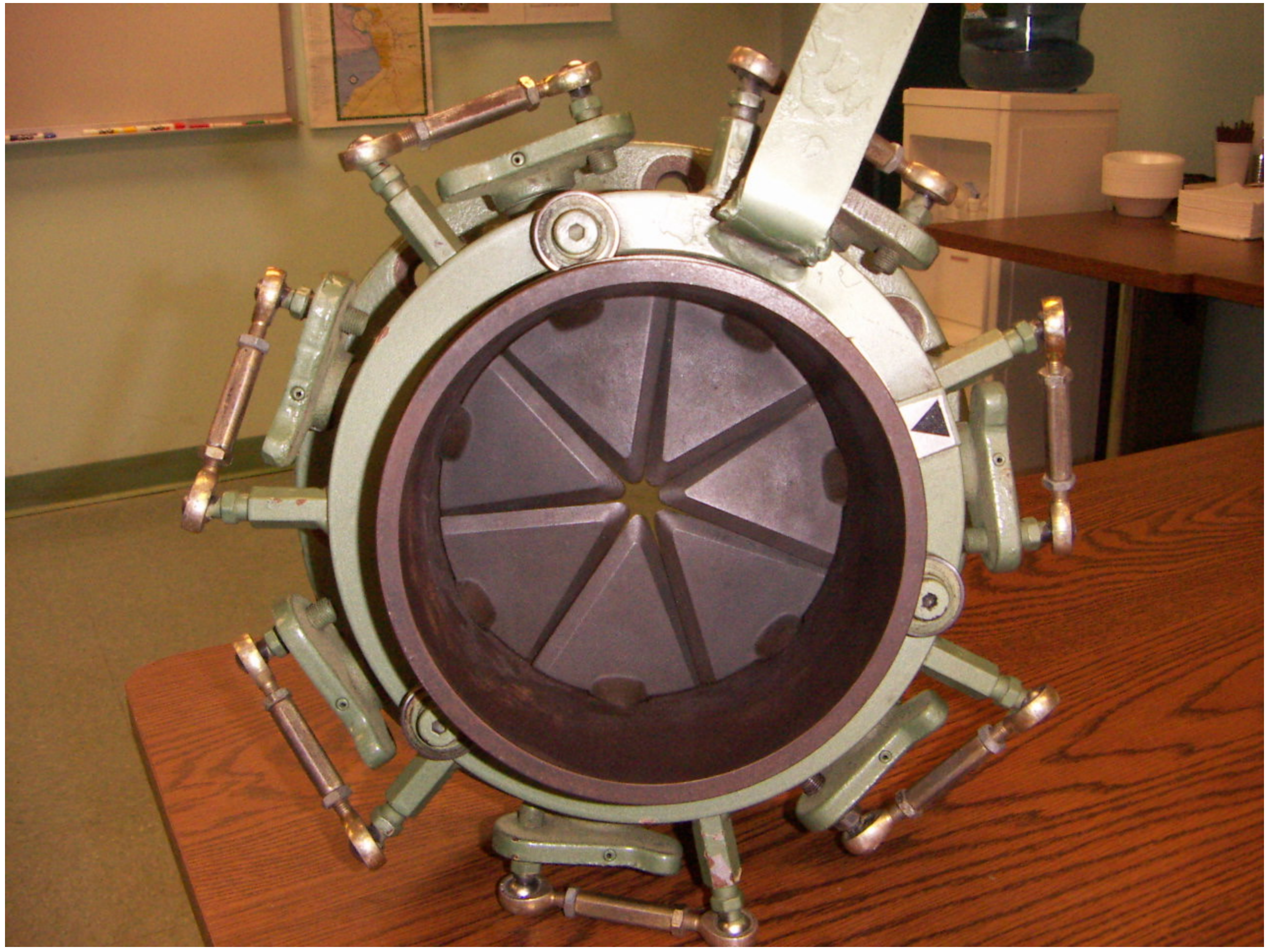


- During the weekend, when the demand reaches to minimum flow of 3000 cfm, one centrifugal compressor will stop and only one compressor will run in its turndown range.
- With this combination, the centrifugal compressors will work most efficiently and save a plant significant energy.

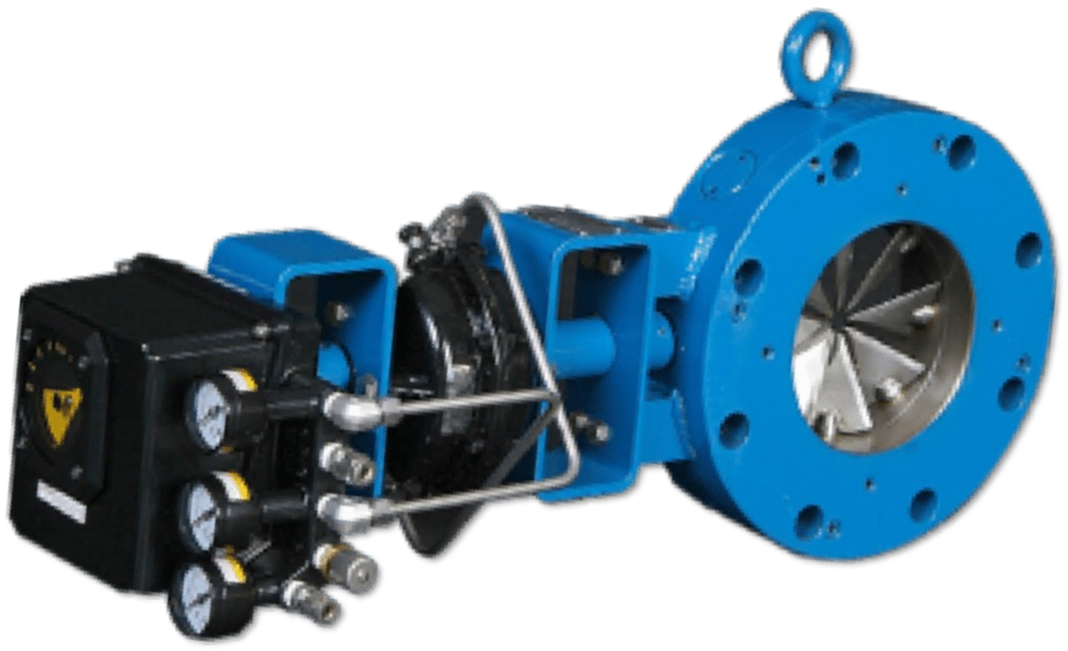
Inlet Guide Vanes - Open



Inlet Guide Vanes - Closed



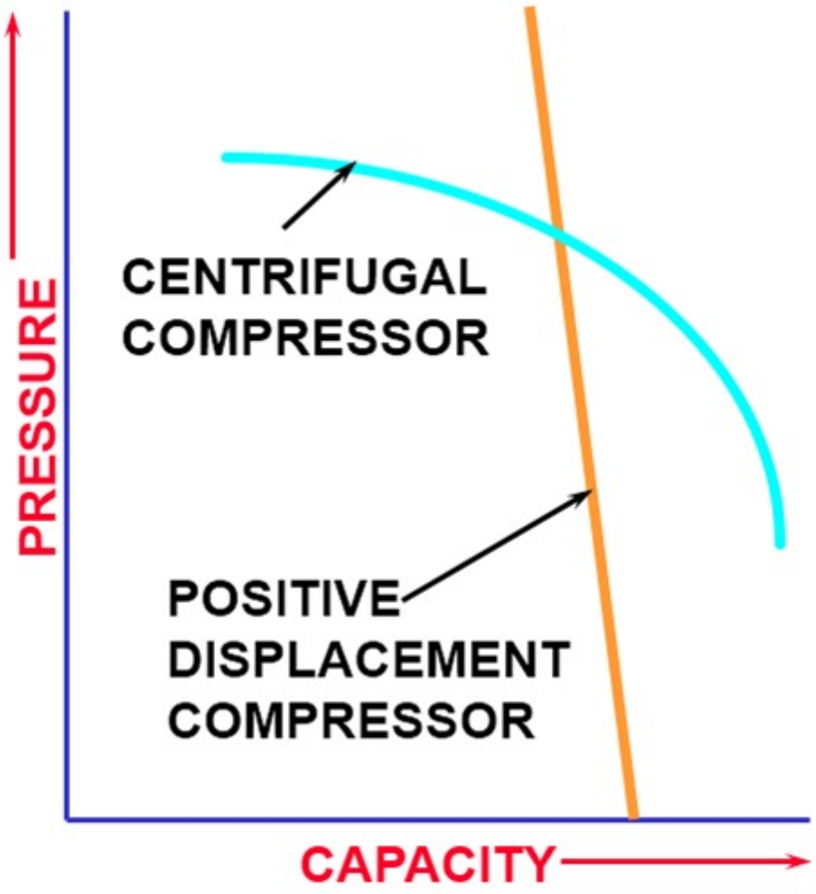
Inlet Guide Vanes



- 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.

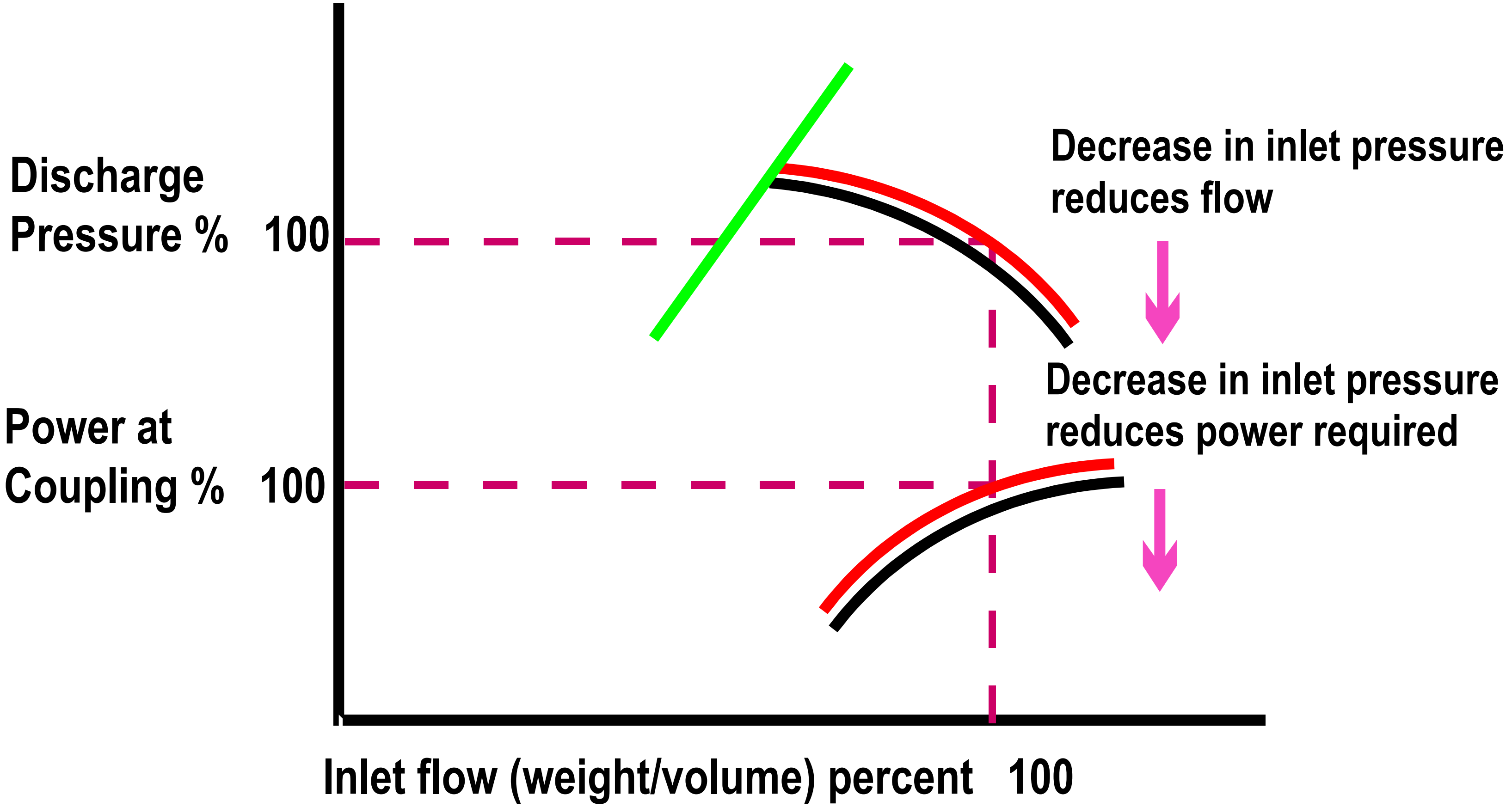


Effects on dynamic compressor performance

- Inlet pressure
- Inlet air temperature
- Cooling water temperature

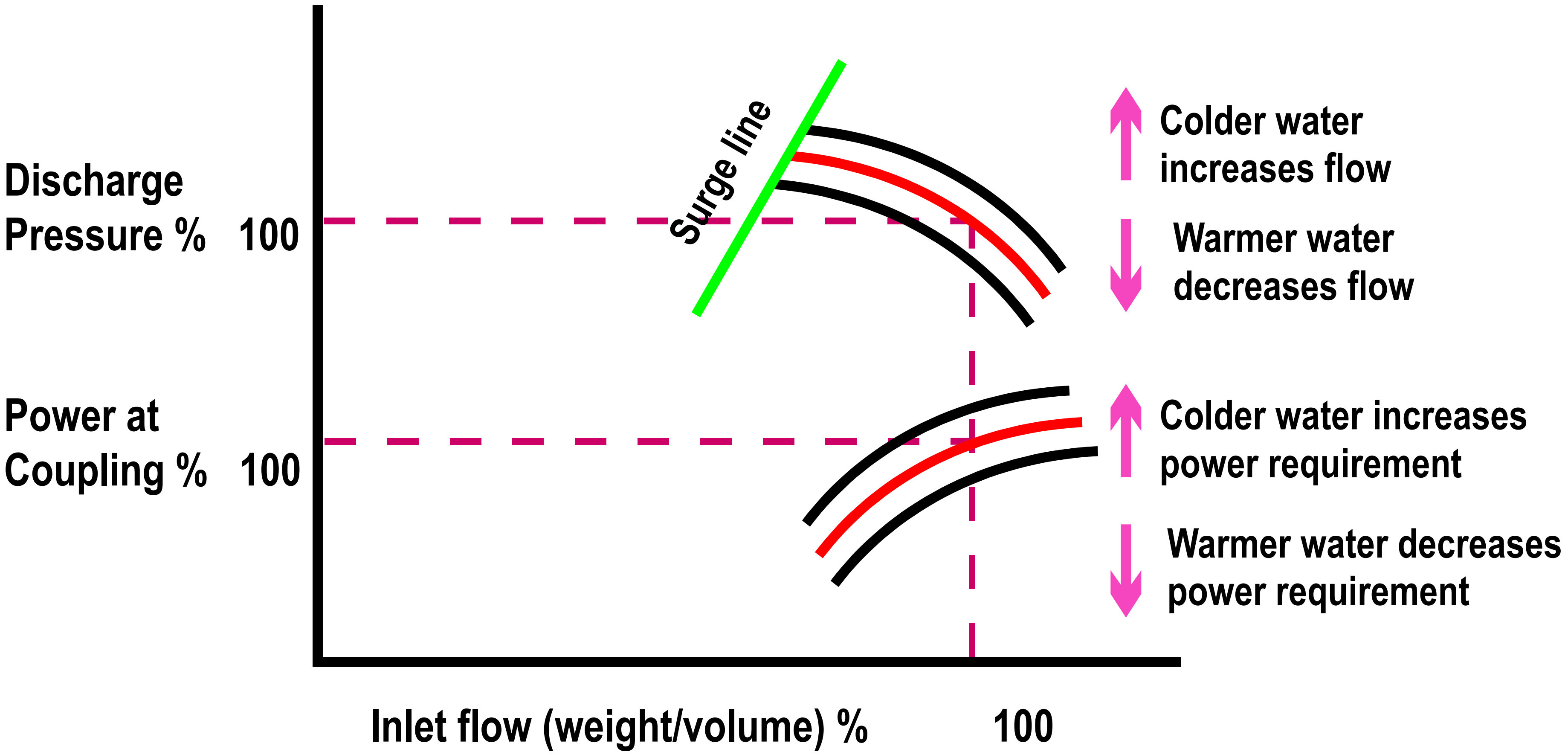
Inlet Pressure Effects On Dynamic Compressor Performance

Inlet pressure



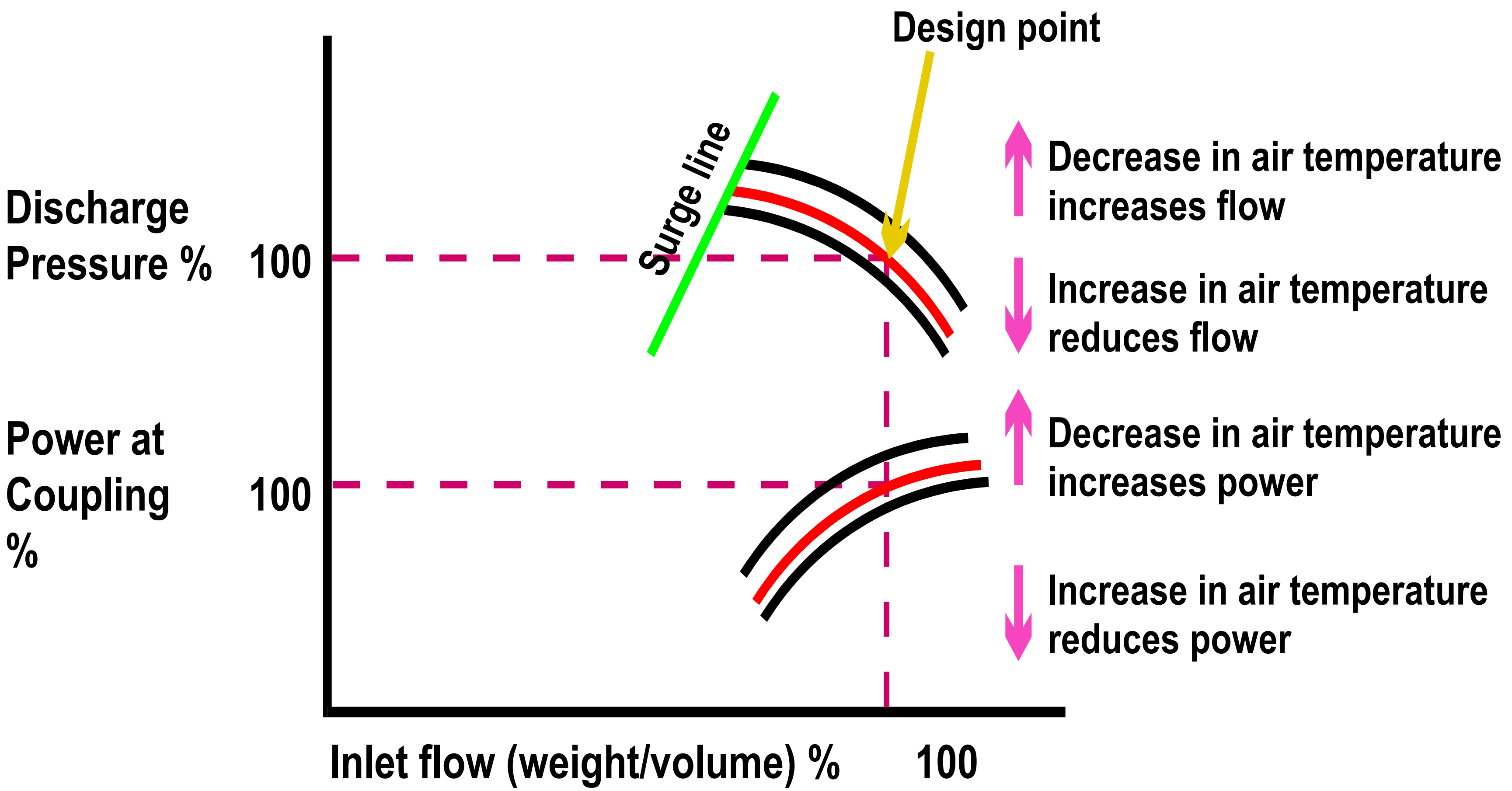
Cooling Water Effects On Dynamic Compressor Performance

Cooling water temperature



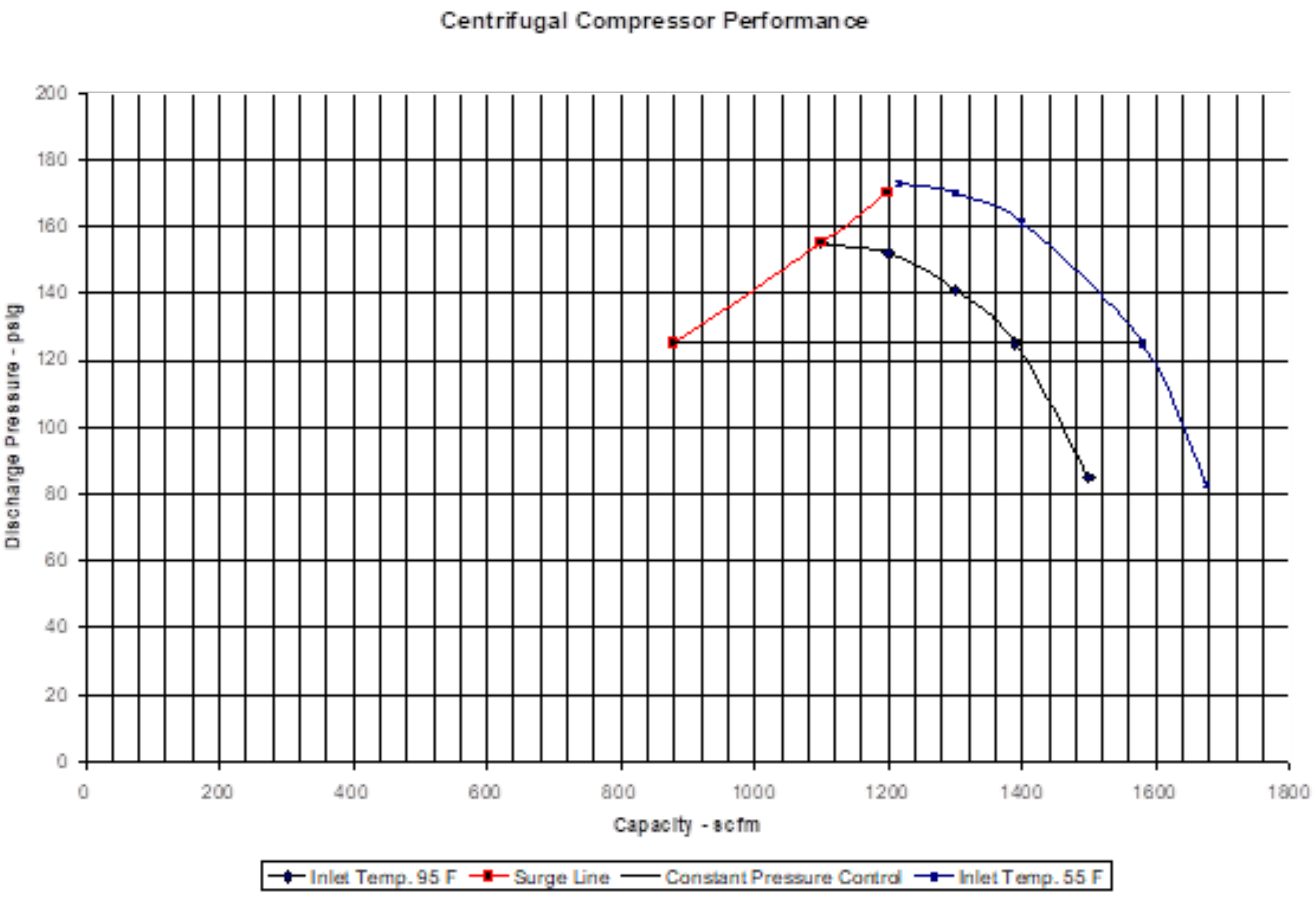
Inlet Air Temperature Effects On Dynamic Compressor Performance

Inlet air temperature influence

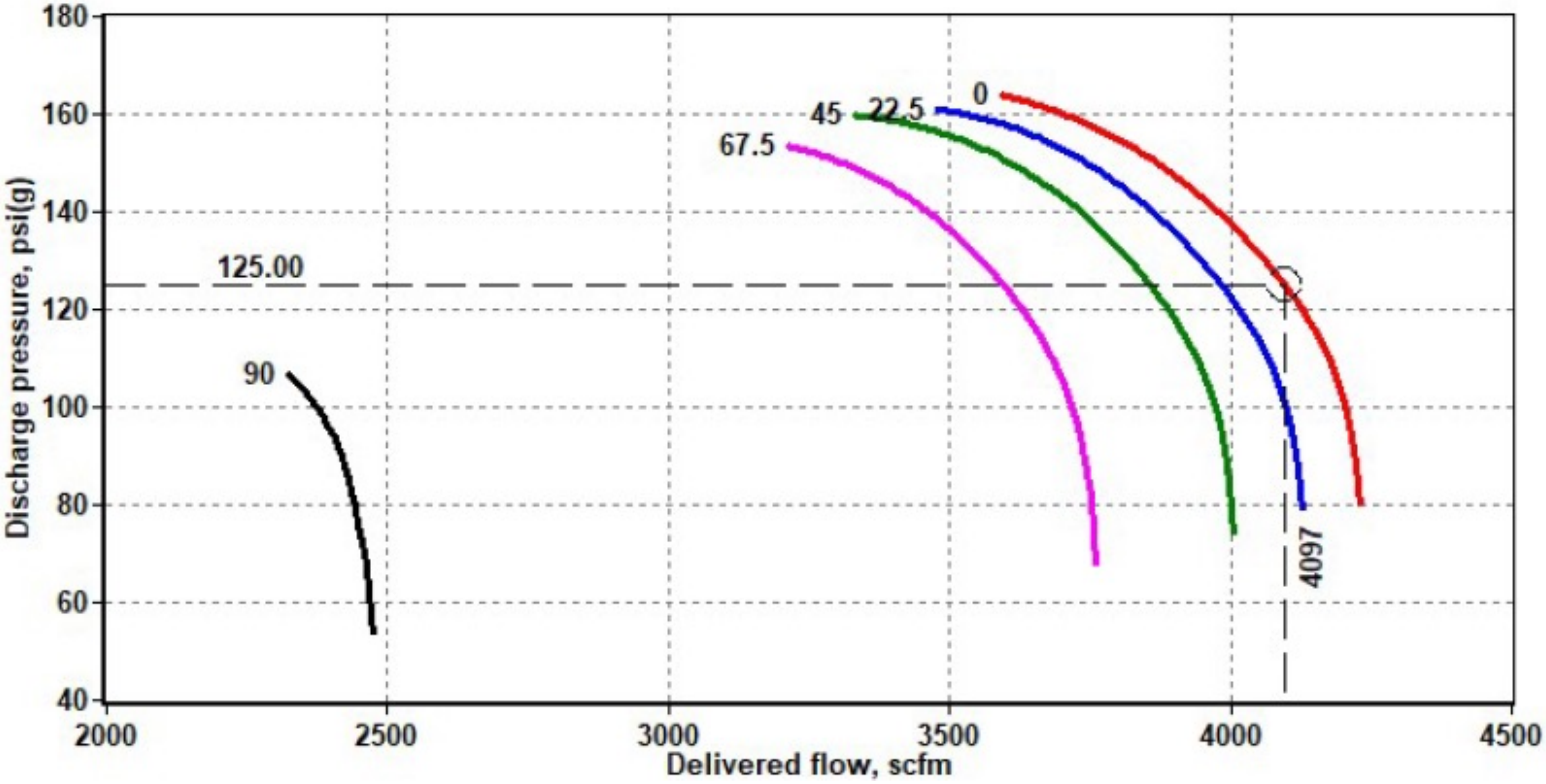


Effects on dynamic compressor performance

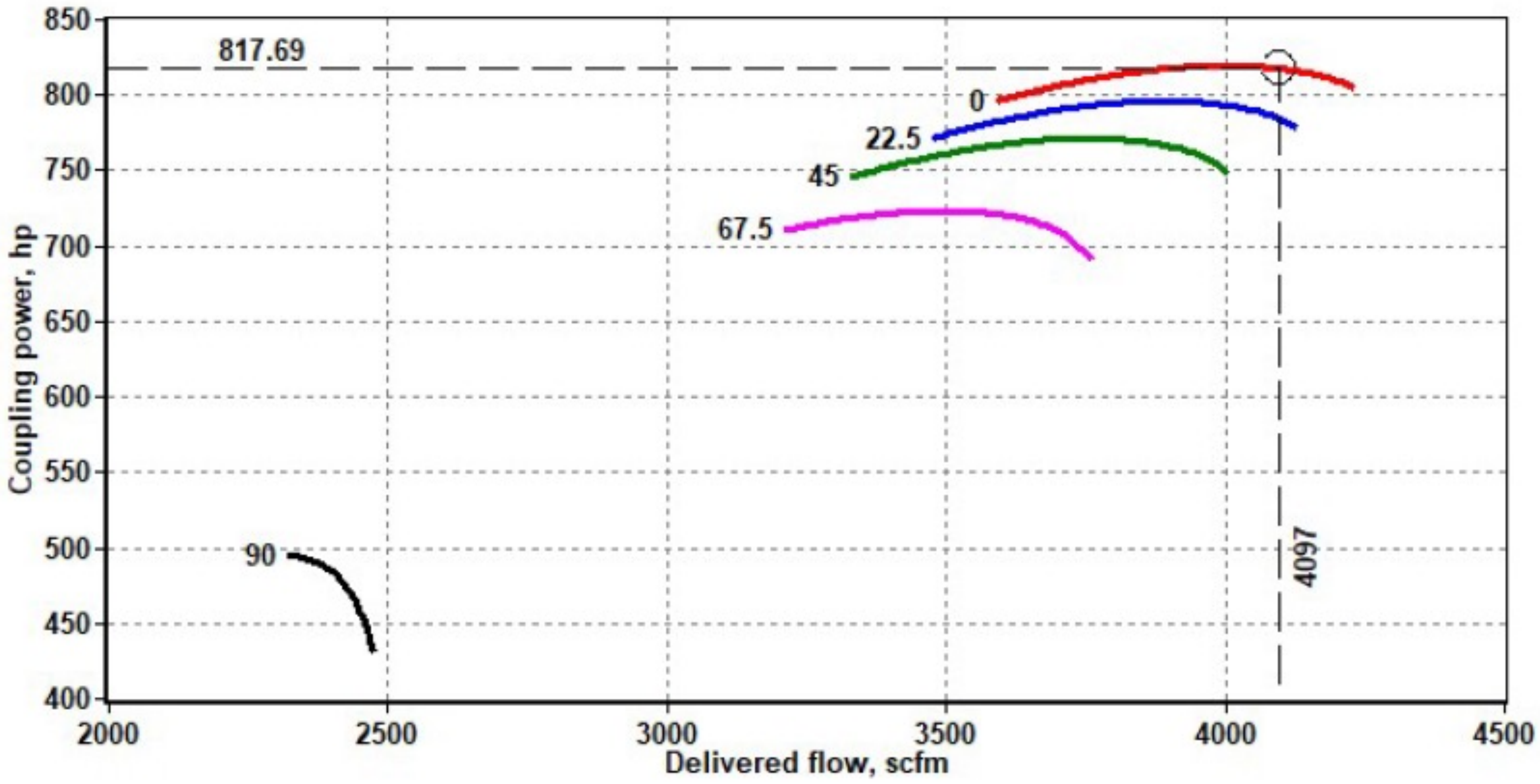
- As the inlet temperature is lowered the denser air gives the first stage impeller increased pressure head making capability, causing a further increase in mass flow at a given discharge pressure.
- The converse is true for an increase in inlet temperature.
- When the cooling water temperature is reduced, the air temperature to the second and successive stages also is reduced, increasing their ability to generate pressure head, and to handle increased mass flow.



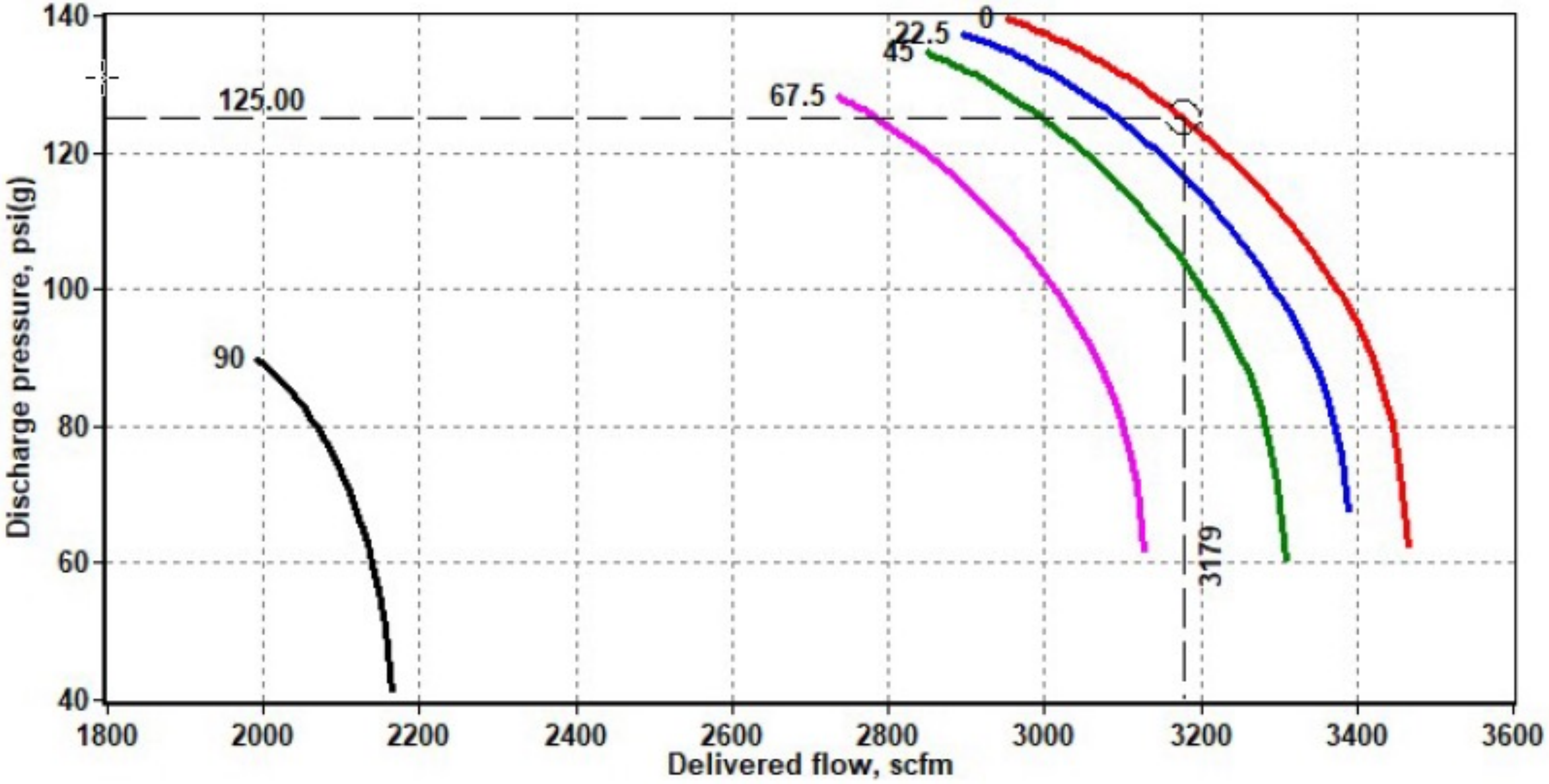
Curve showing air compressor performance at a 34°F inlet,60% RH, 77°F Coolant and 125 psig discharge pressure:



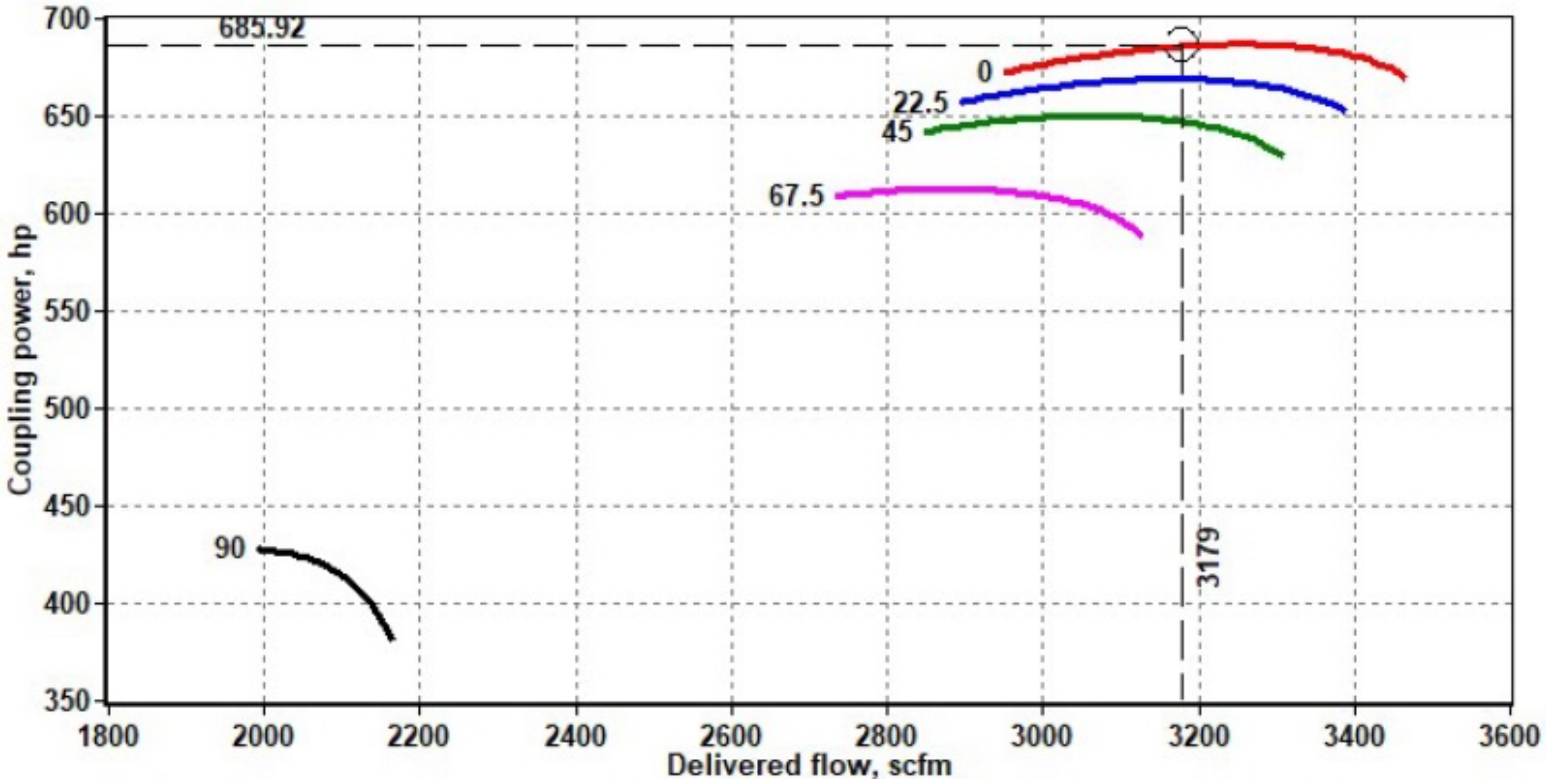
Curve showing air compressor horse power at a 34°F inlet,60% RH, 77°F Coolant and 125 psig discharge pressure:



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:



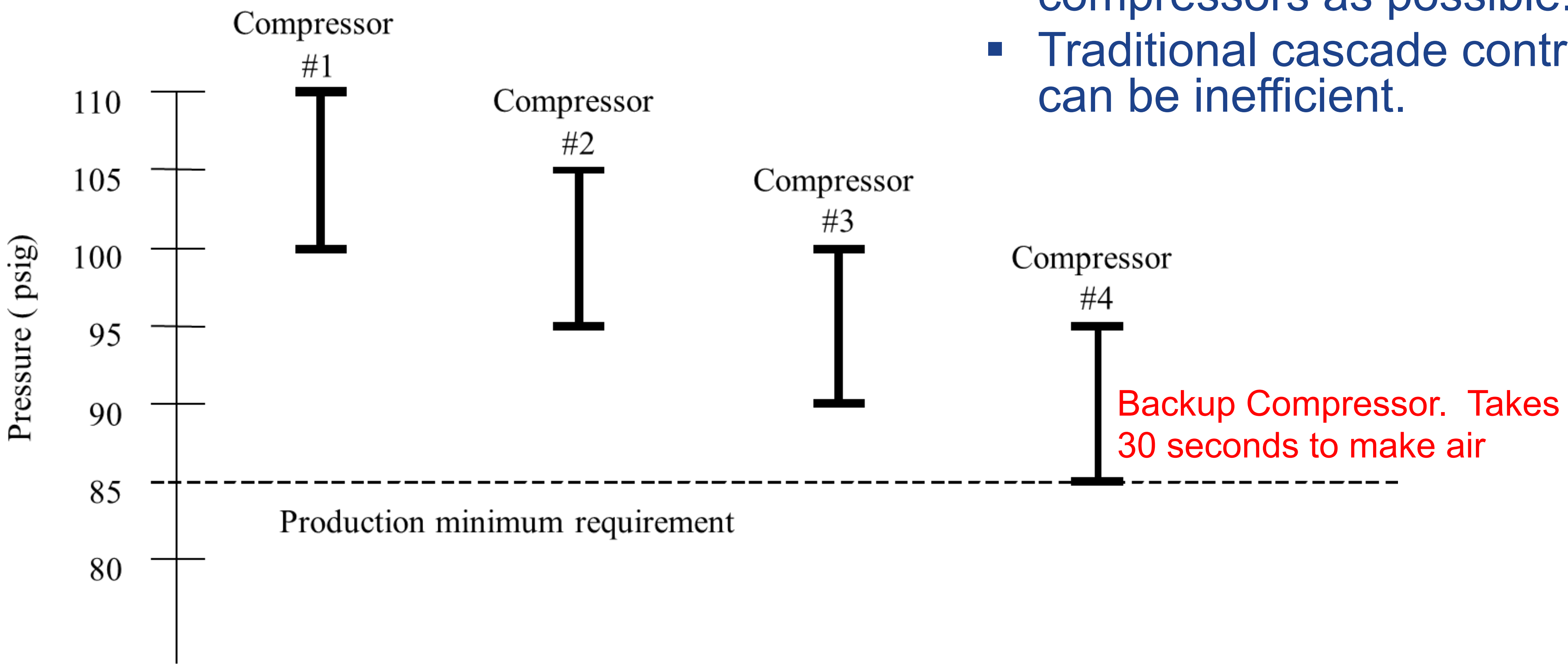
Multiple Compressor Control

- 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.

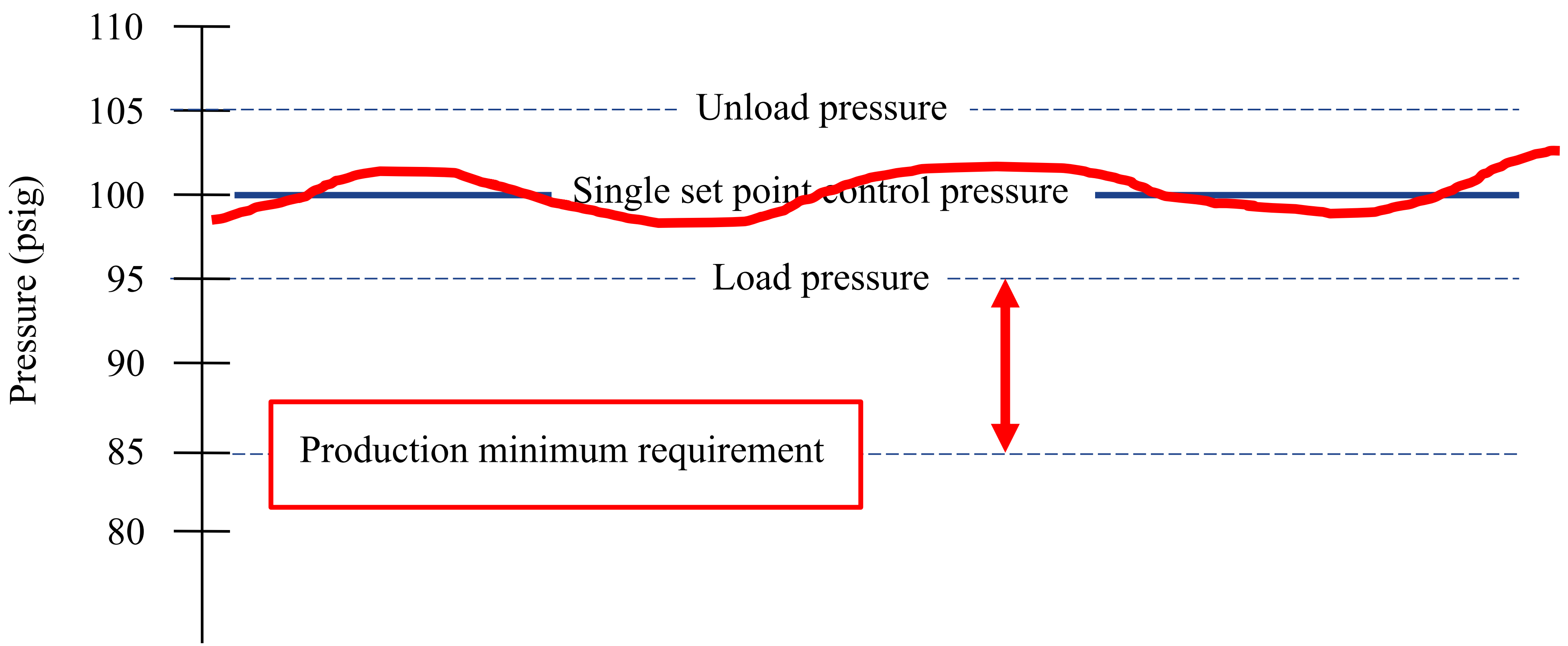
Cascade Compressor Control



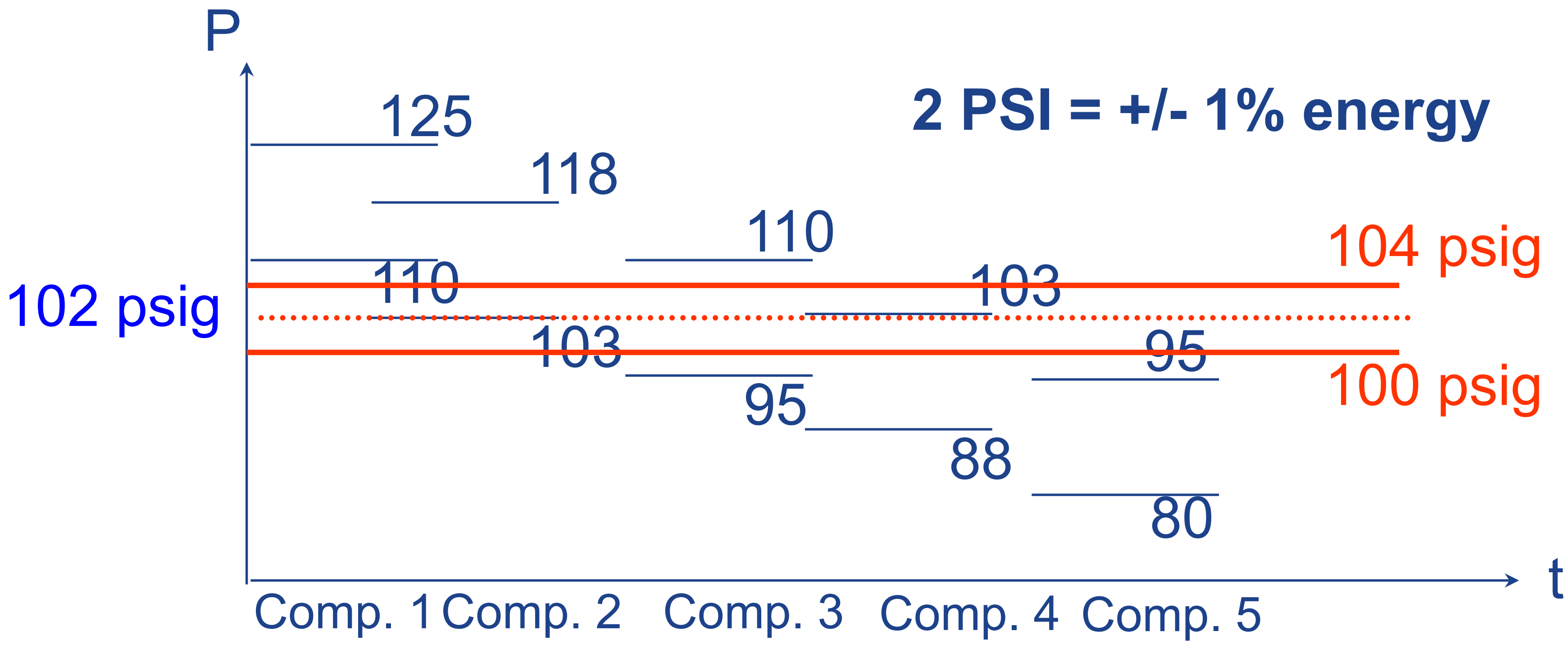
- Base load as many compressors as possible.
- Traditional cascade control can be inefficient.

Master Controls

- Basic single set point control scheme



Master Control Basics

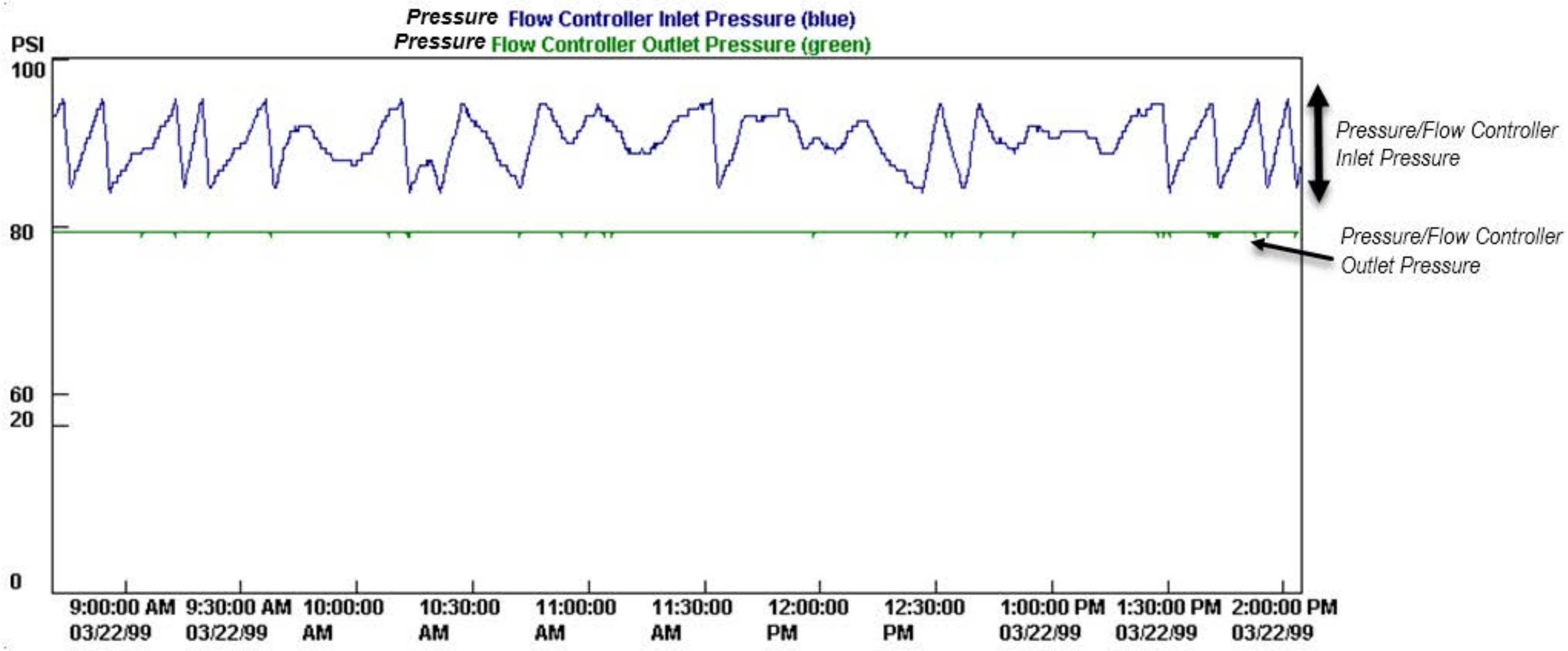


Cascaded Pressure Switches Vs Master

Pressure/Flow Controllers

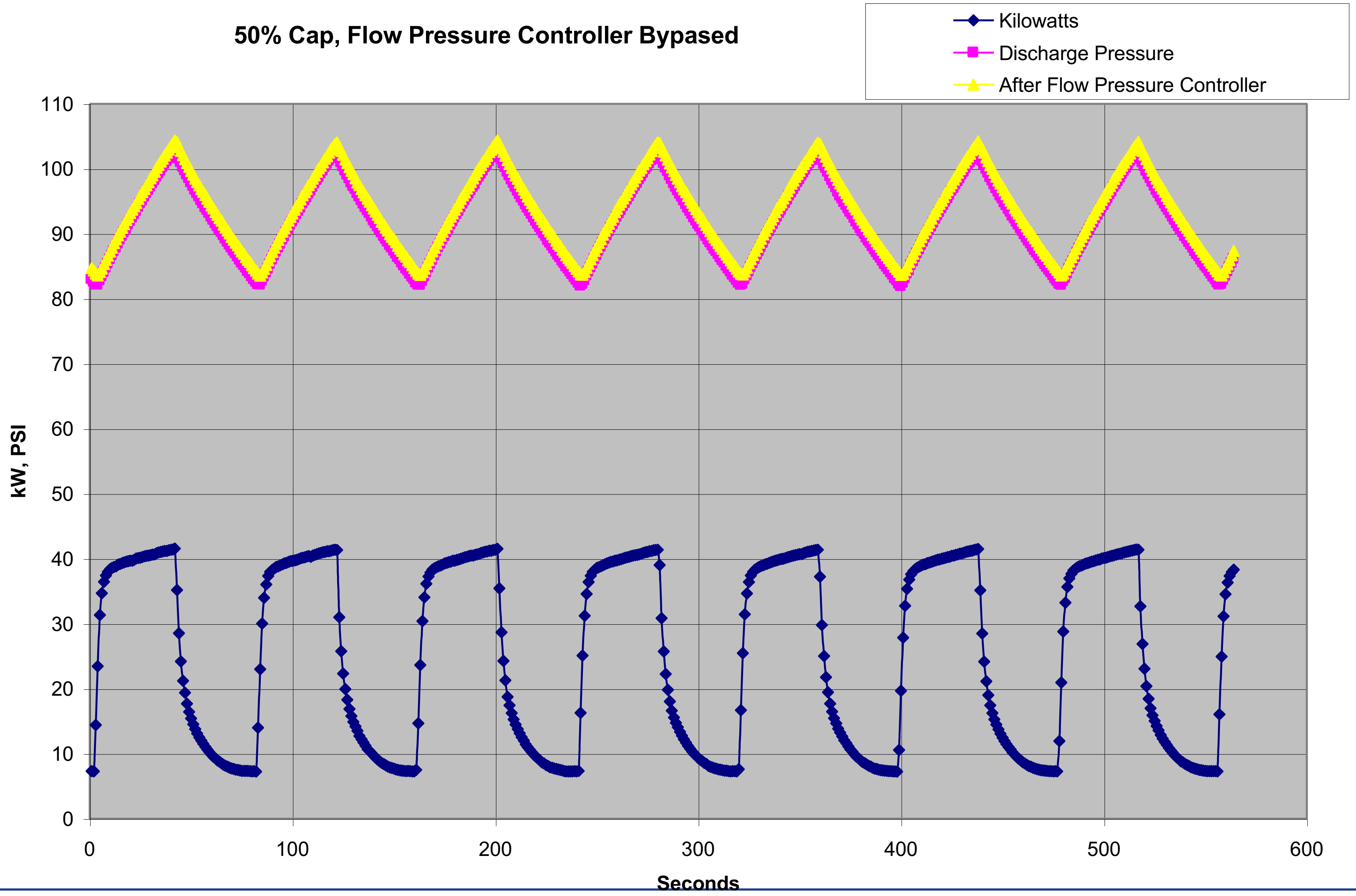
- Primary function: Stabilize pressure regardless of demand
- Most compressor controls cause 3-10 psi swings
- Multiple compressors can compound the system pressure swings
- Pressure/flow controllers typically hold pressure to production within ± 1% of set point
- The following graph is from a system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

Pressure/Flow Controllers

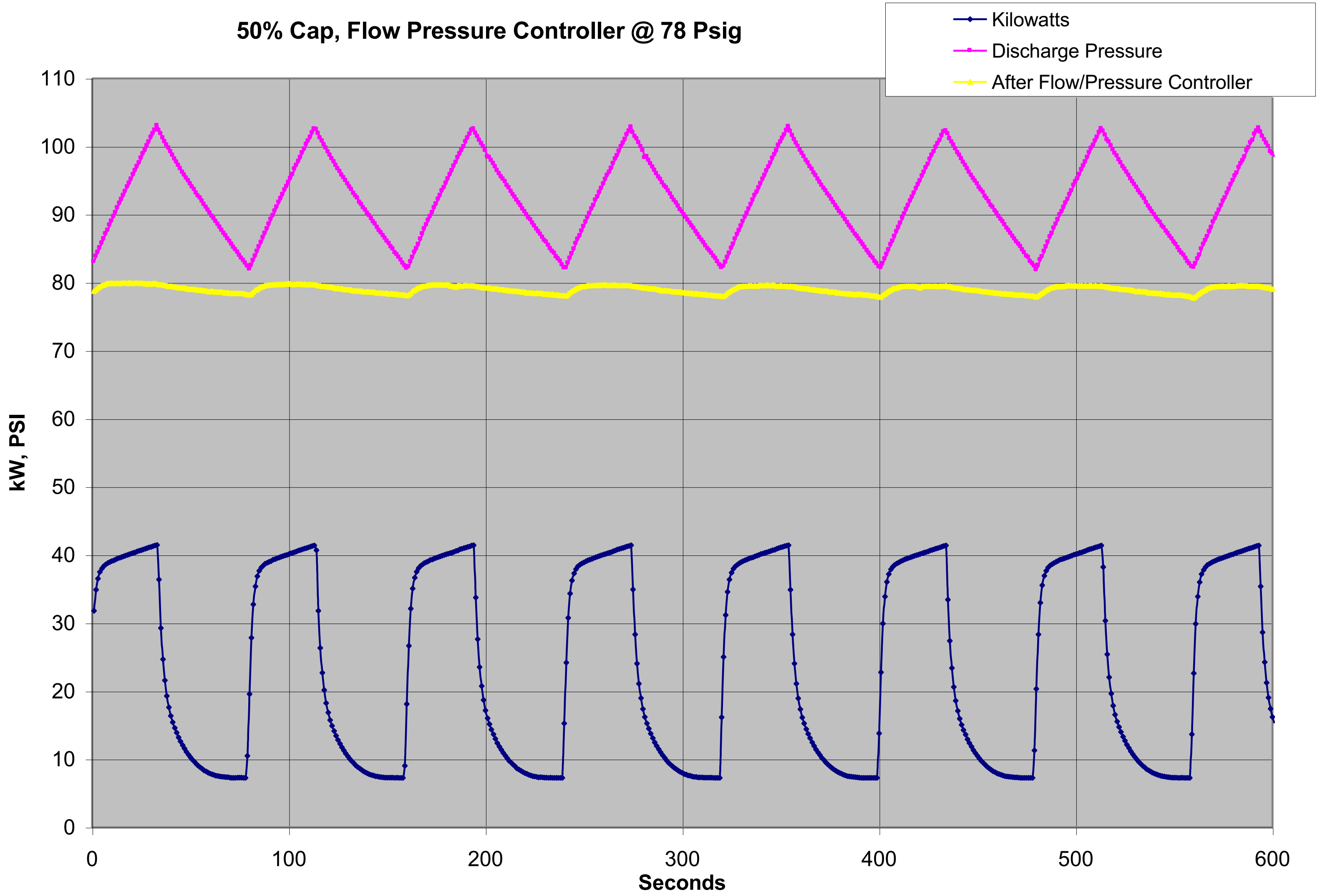


- The compressor discharge pressure varies about 10 psi as the trim compressor loads and unloads to meet plant demand.
- The pressure to the plant is kept at a constant 79 psig.

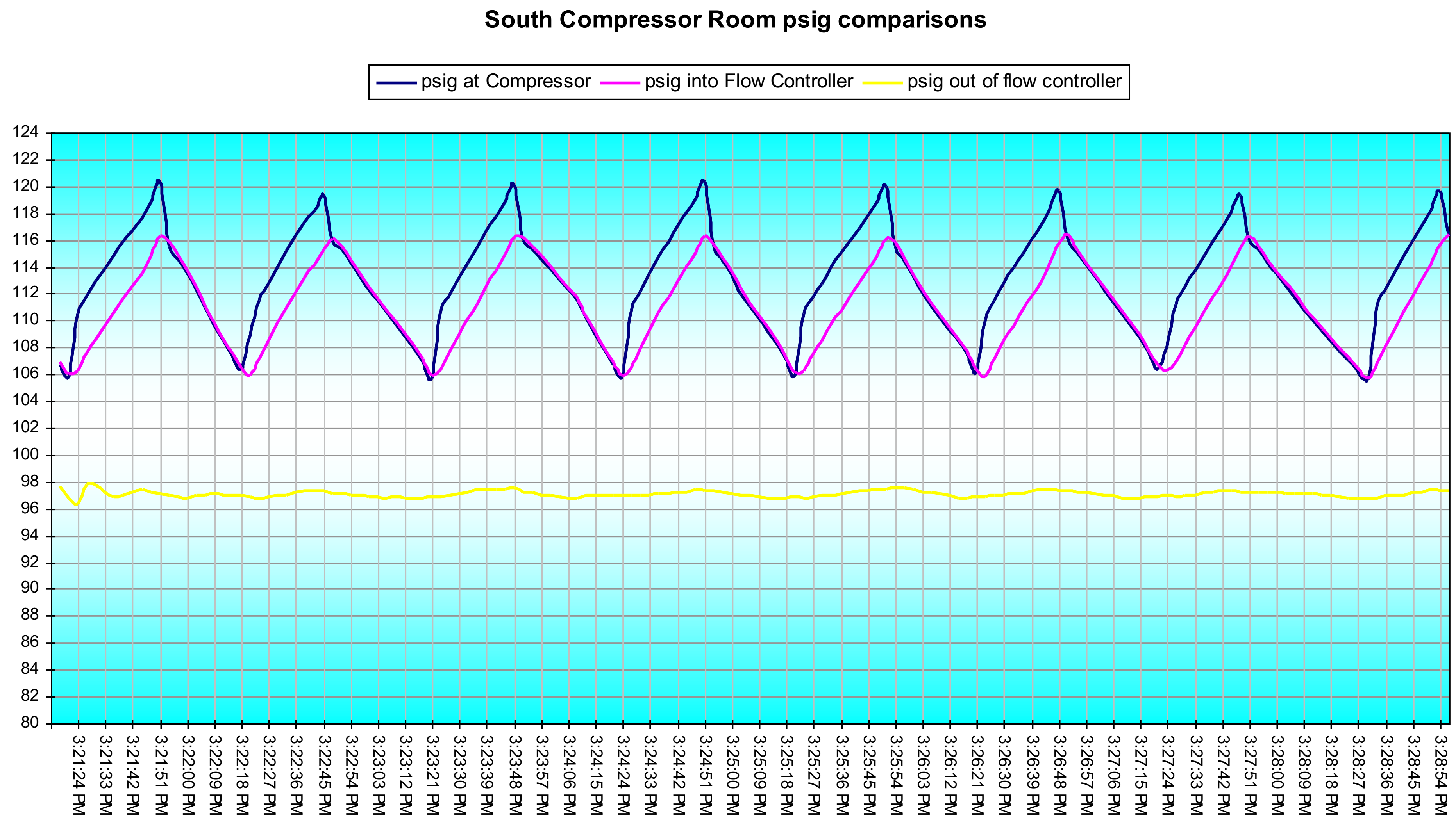
Pressure/Flow Controllers



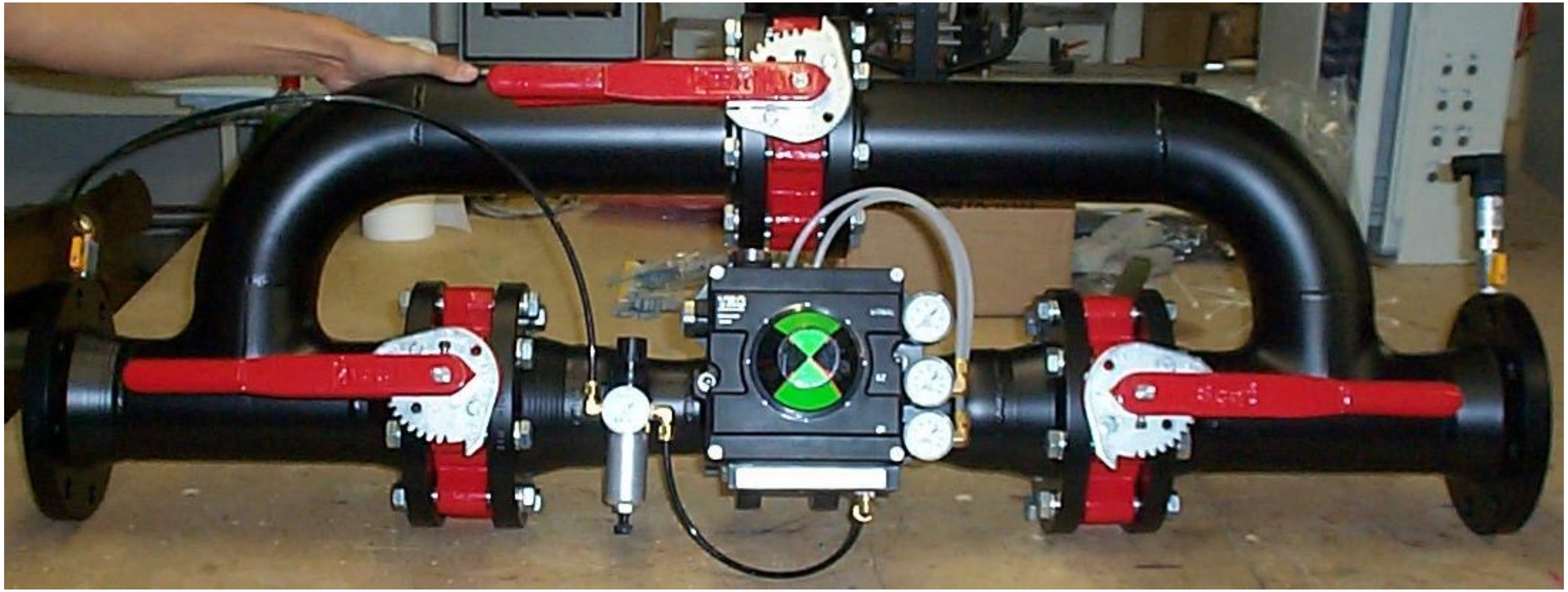
Pressure/Flow Controllers



Pressure/Flow Controllers



Pressure/Flow Controllers

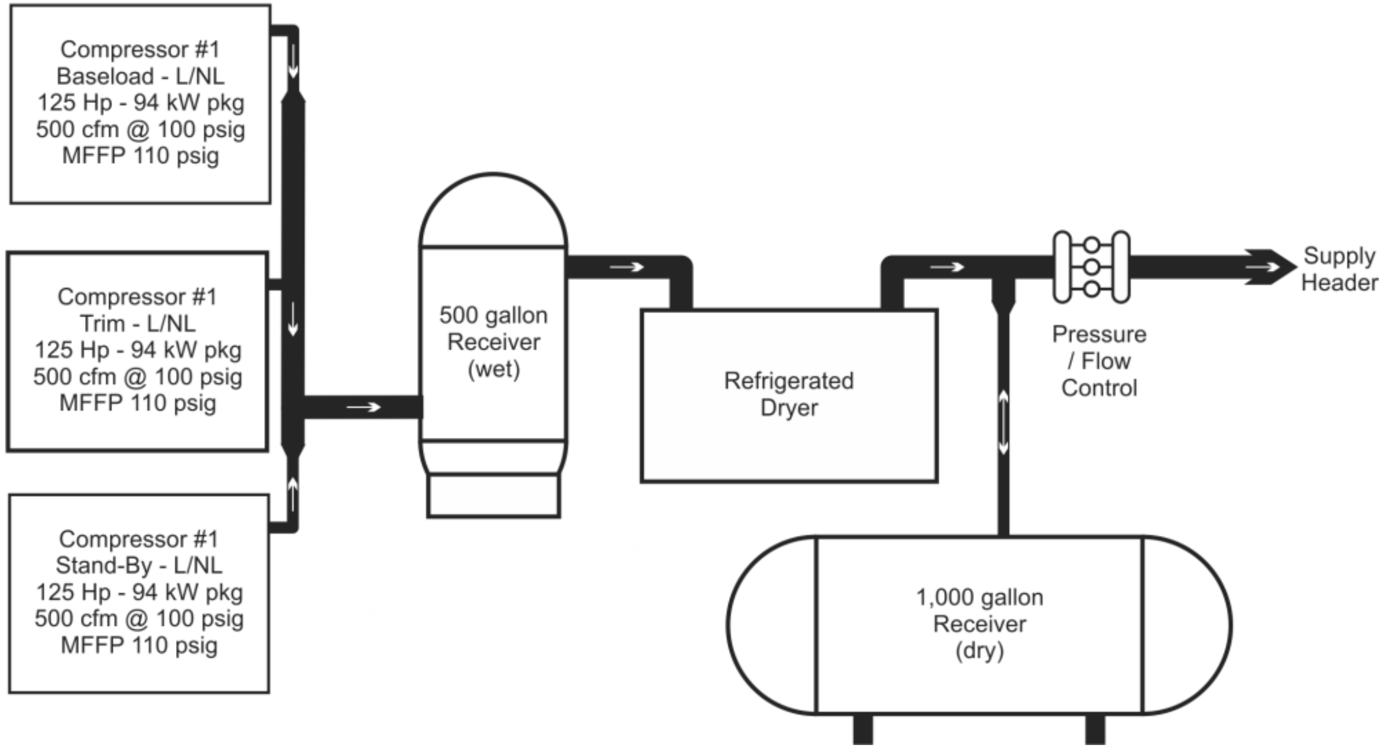


Better Plants U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY

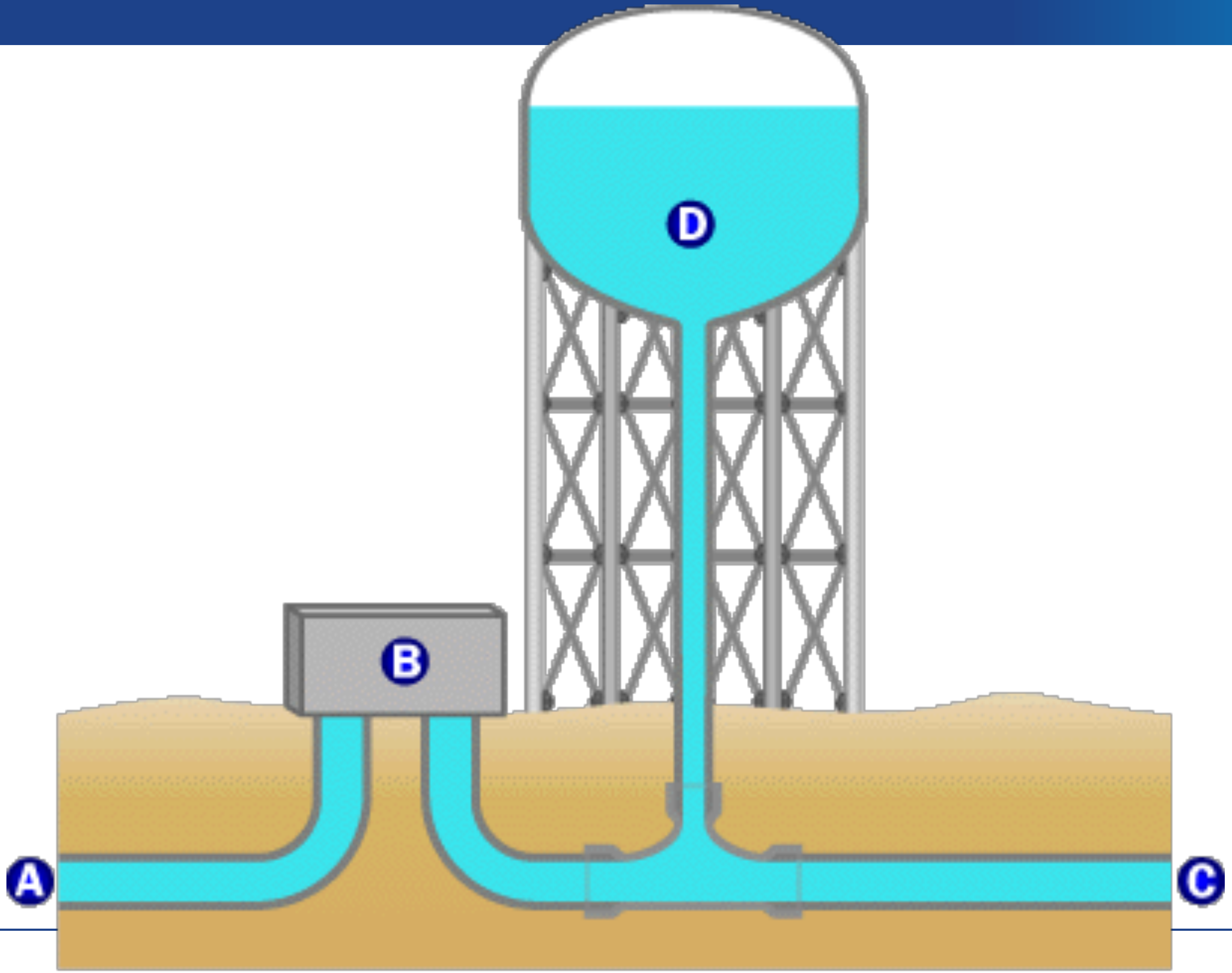
Pressure/Flow Controllers

Pressure/Flow Controllers

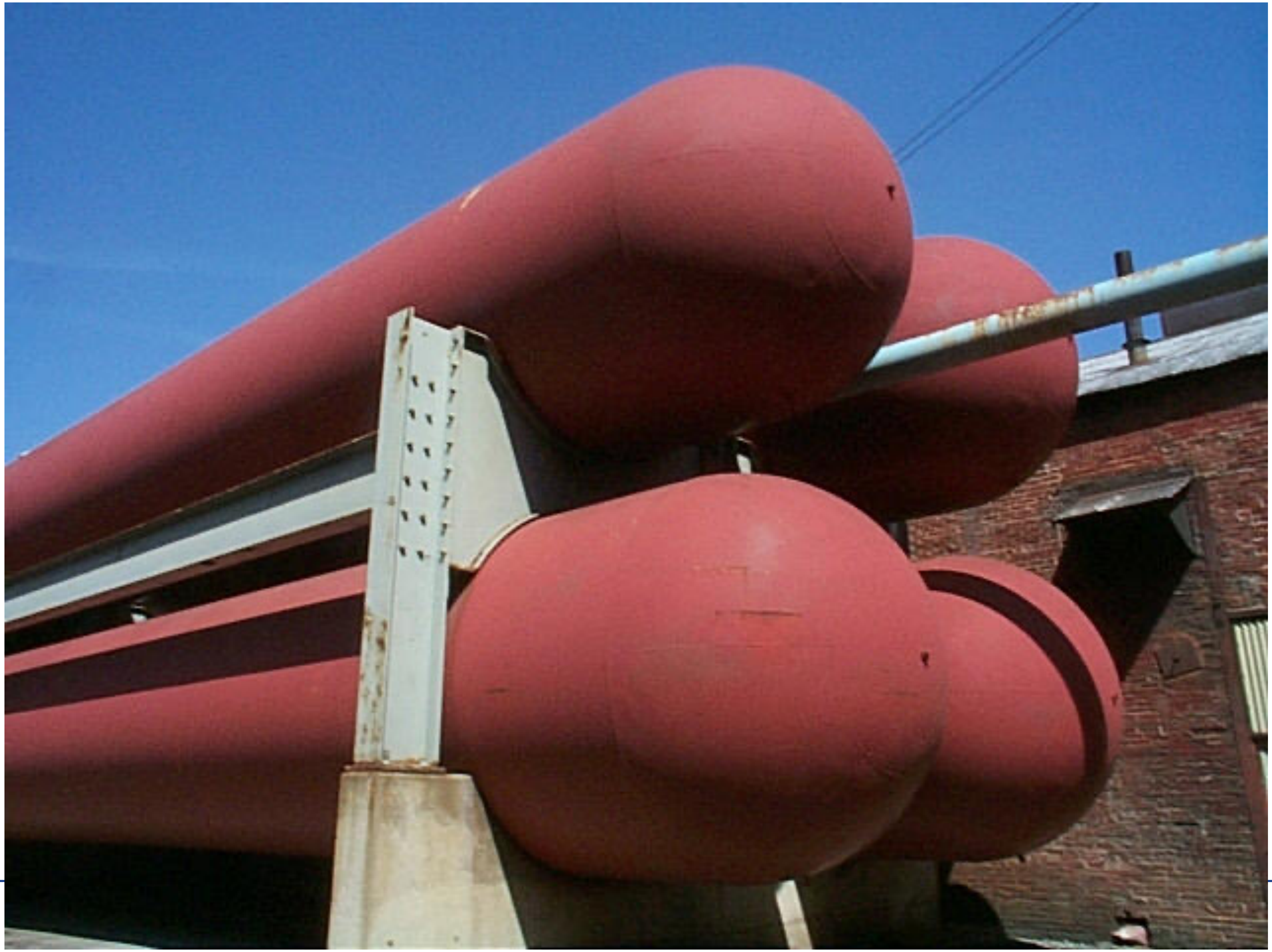


- A typical block diagram of a pressure/flow controller in a compressed air system with one point of entry (single compressor room)

Pressure/Flow Controllers

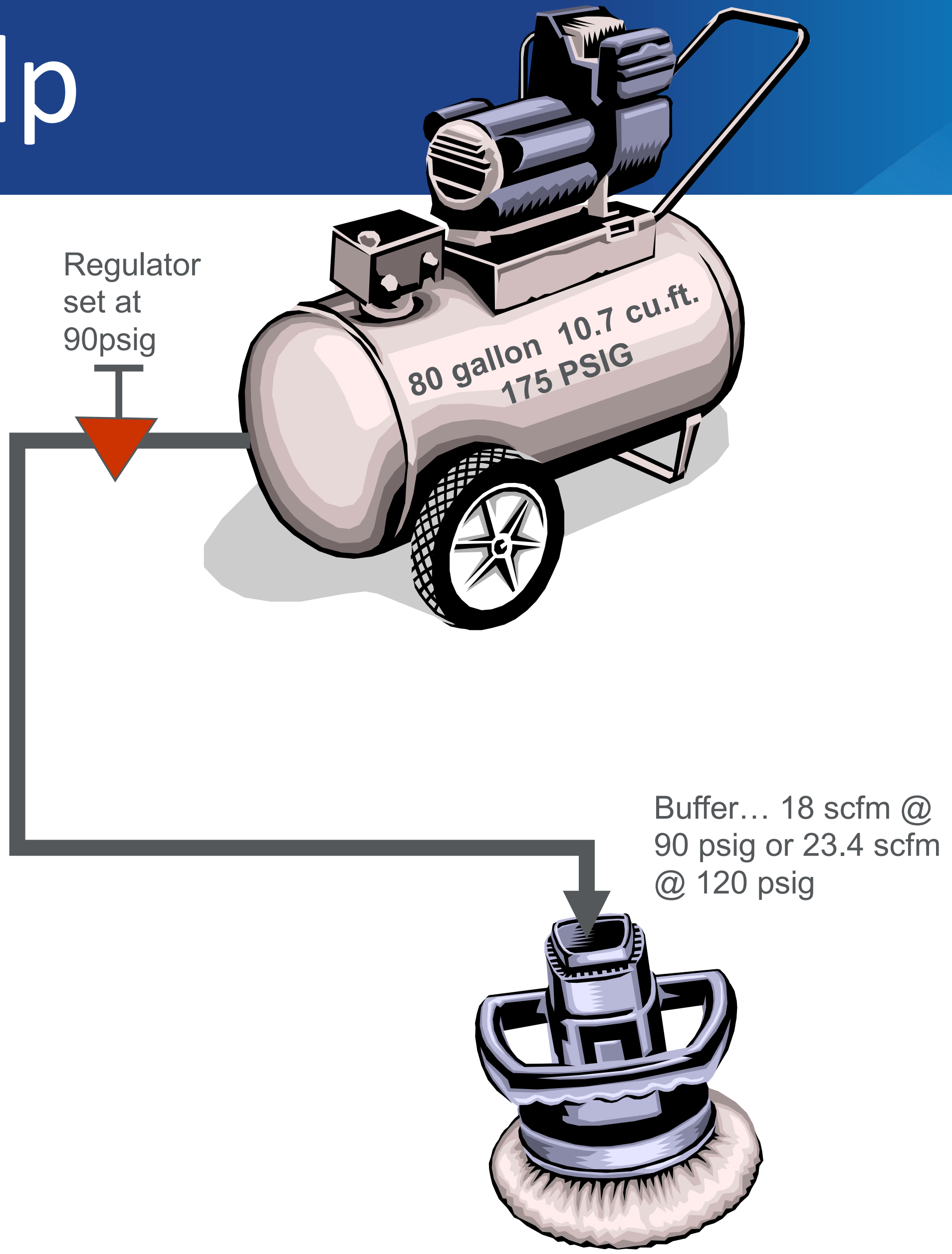


Primary Storage

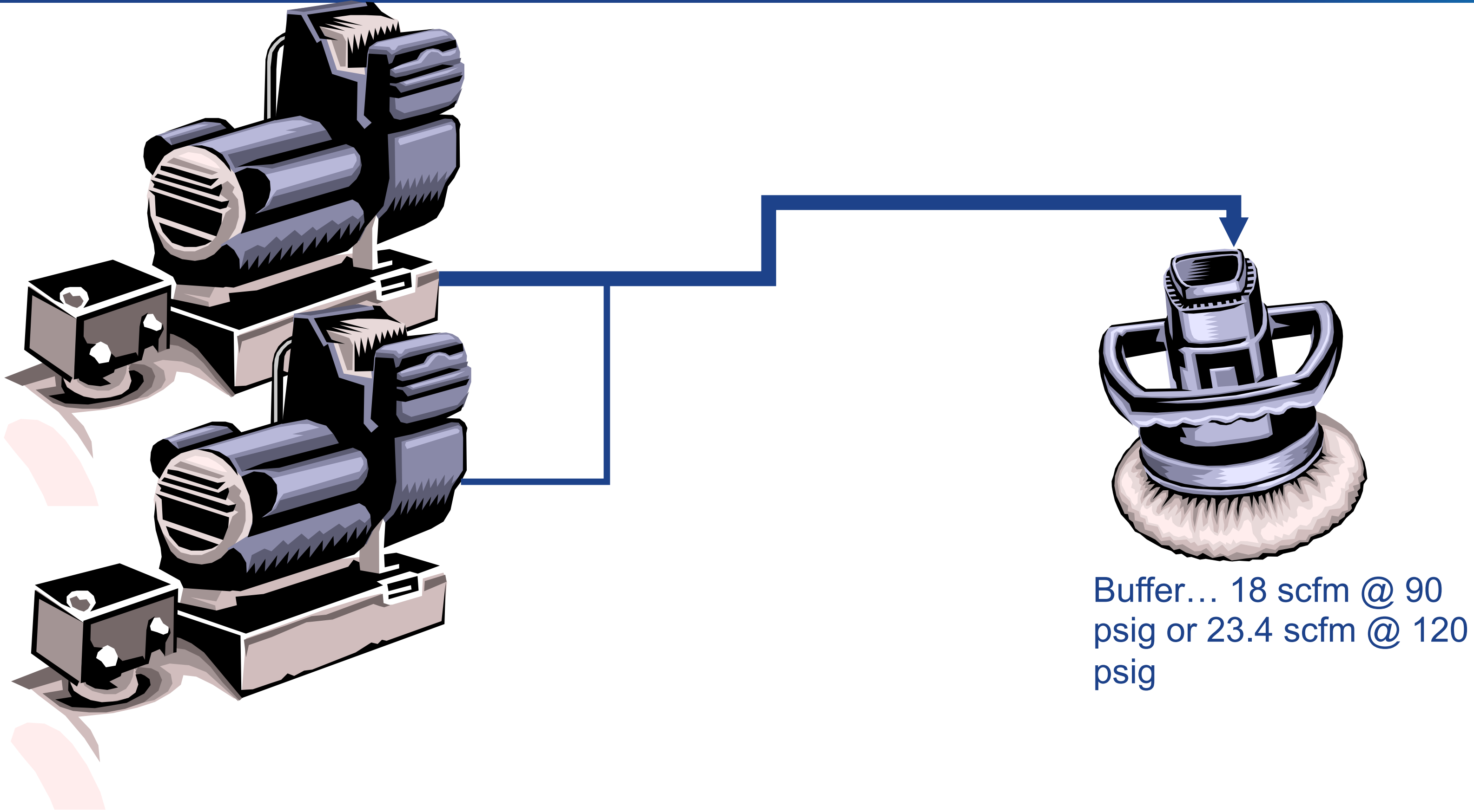


How does Volume Help

- 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



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

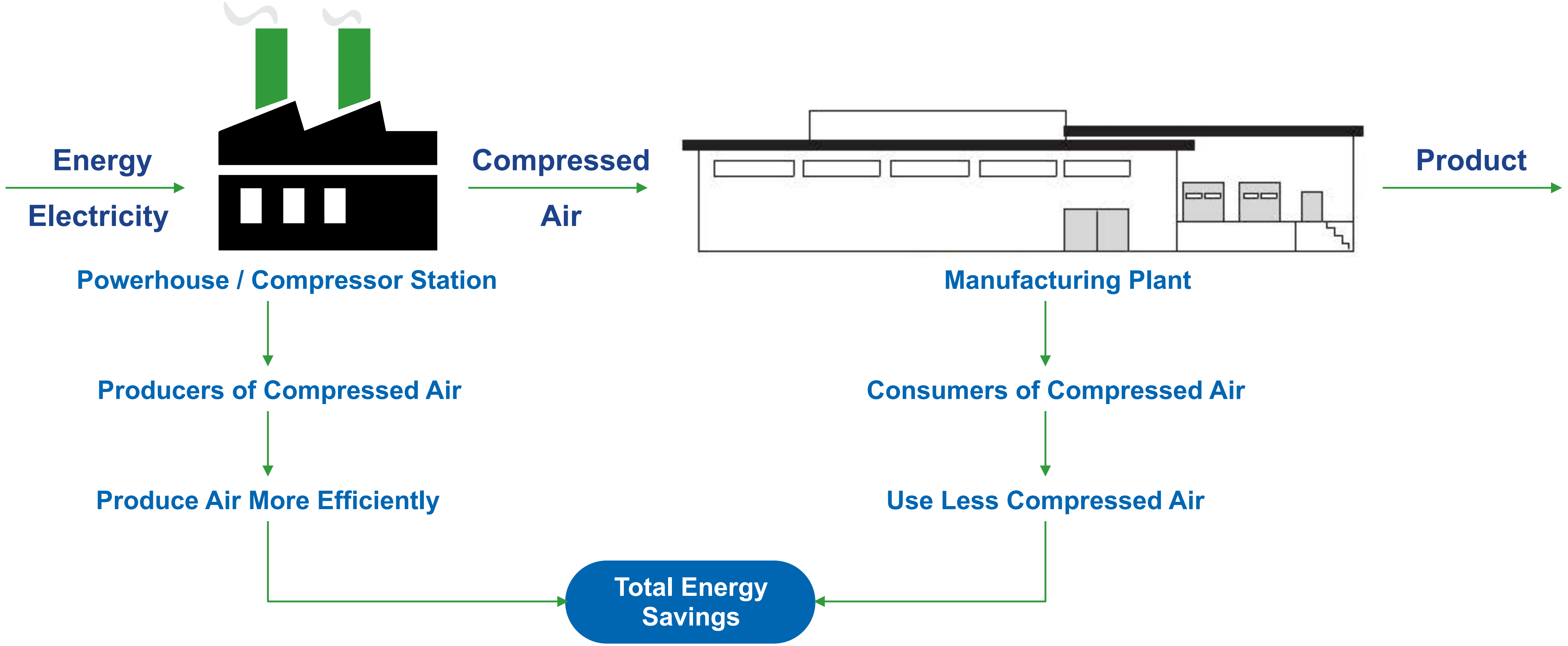
Logtool, AirMaster+ and the MEASUR Tool

Why AIRMaster+?

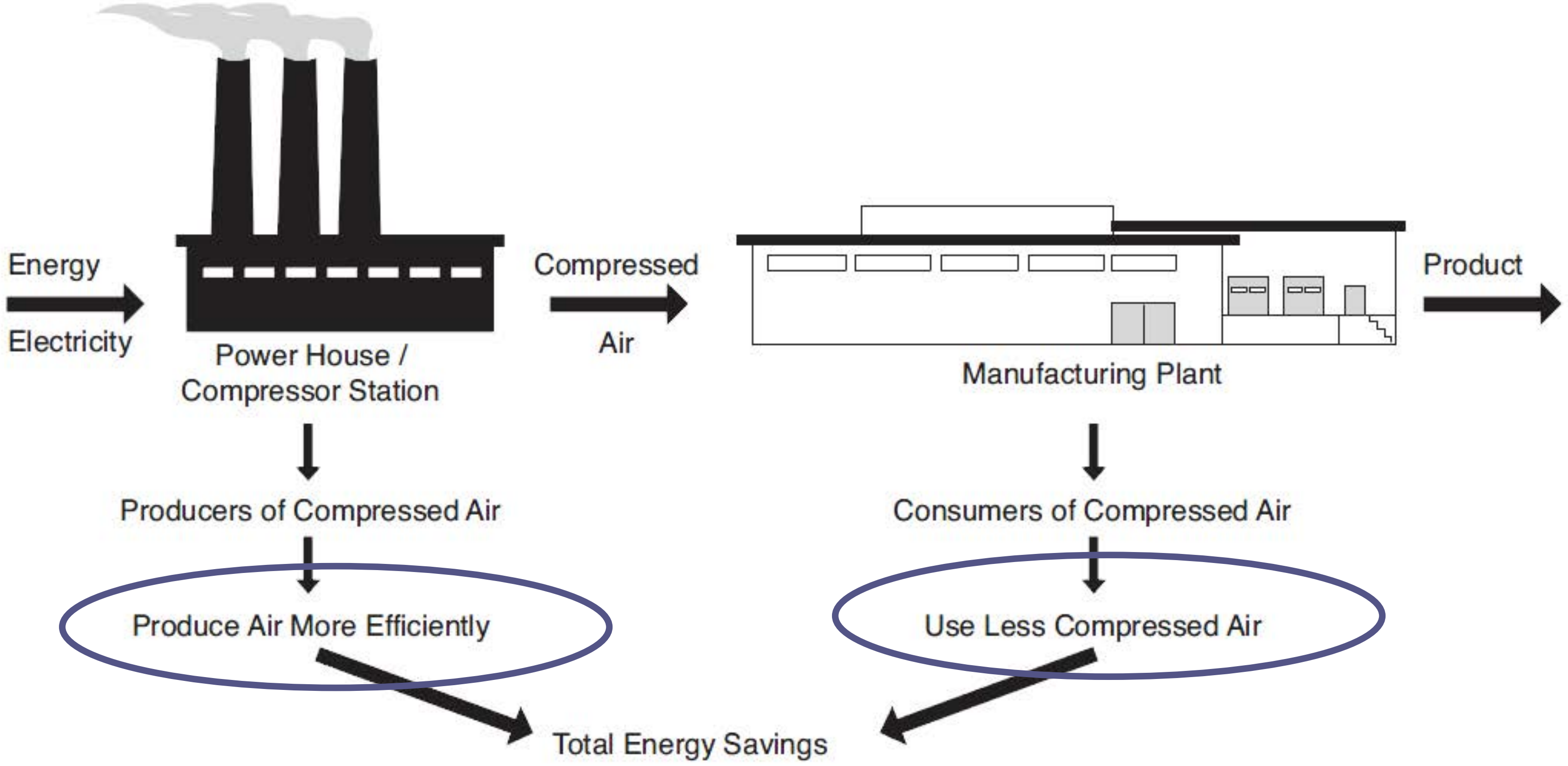
- ~90% of energy input to compressor never reaches tools (waste heat, drying, etc.)
- Leaks +pressure drops remove air energy before reaching tools--sometimes >50%
- Poor or improperly adjusted controls leave several compressors operating a part load
- System assessments can be an arduous task using 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?



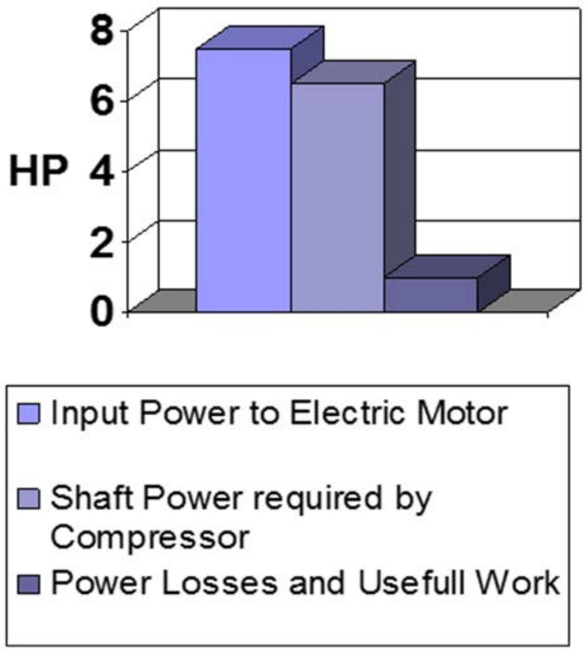
There are two basic ways to reduce the energy consumption of a compressed air system: produce compressed air more efficiently; and consume less compressed air.

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.

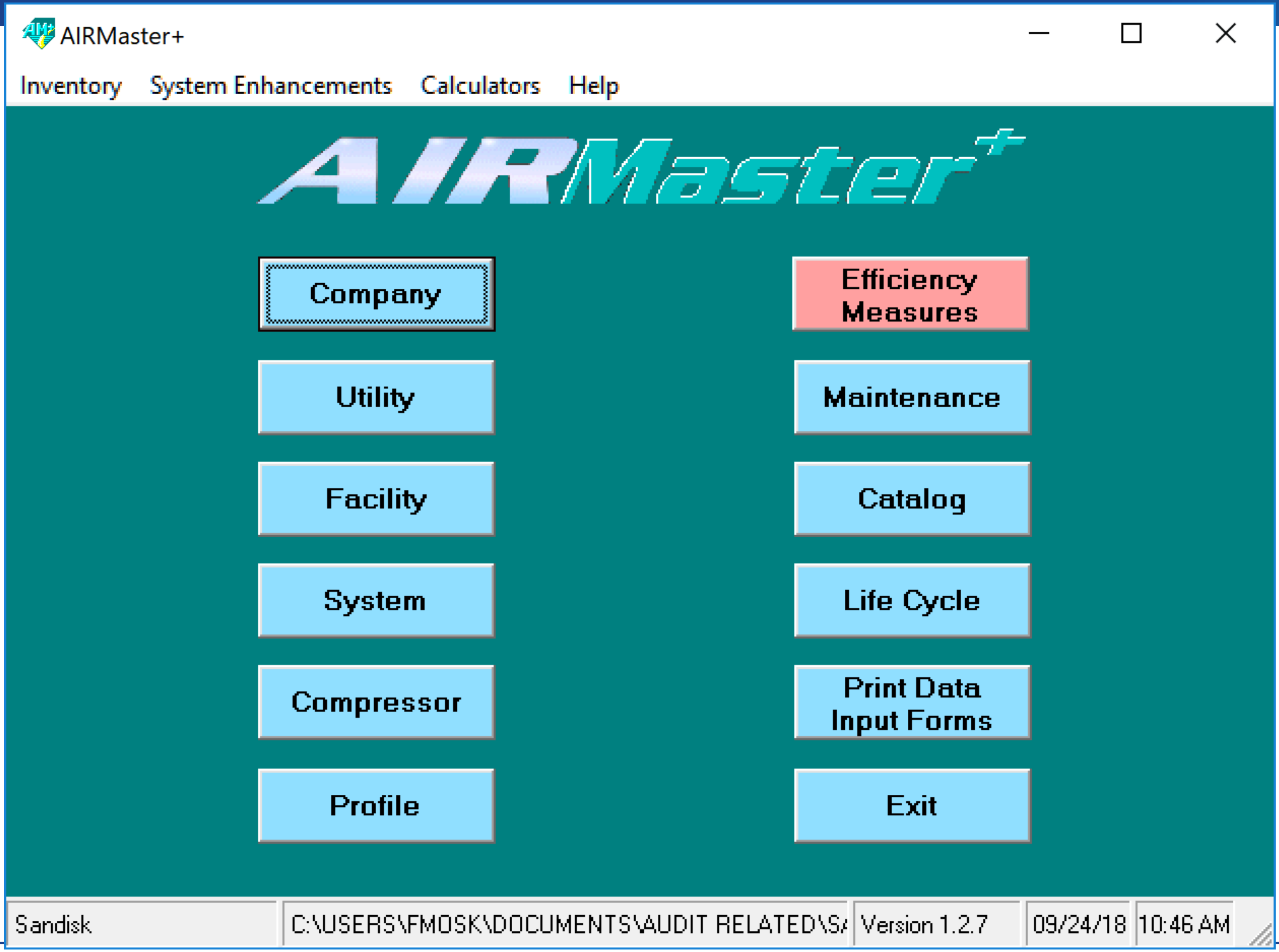
LogTool is Designed To:

- 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+

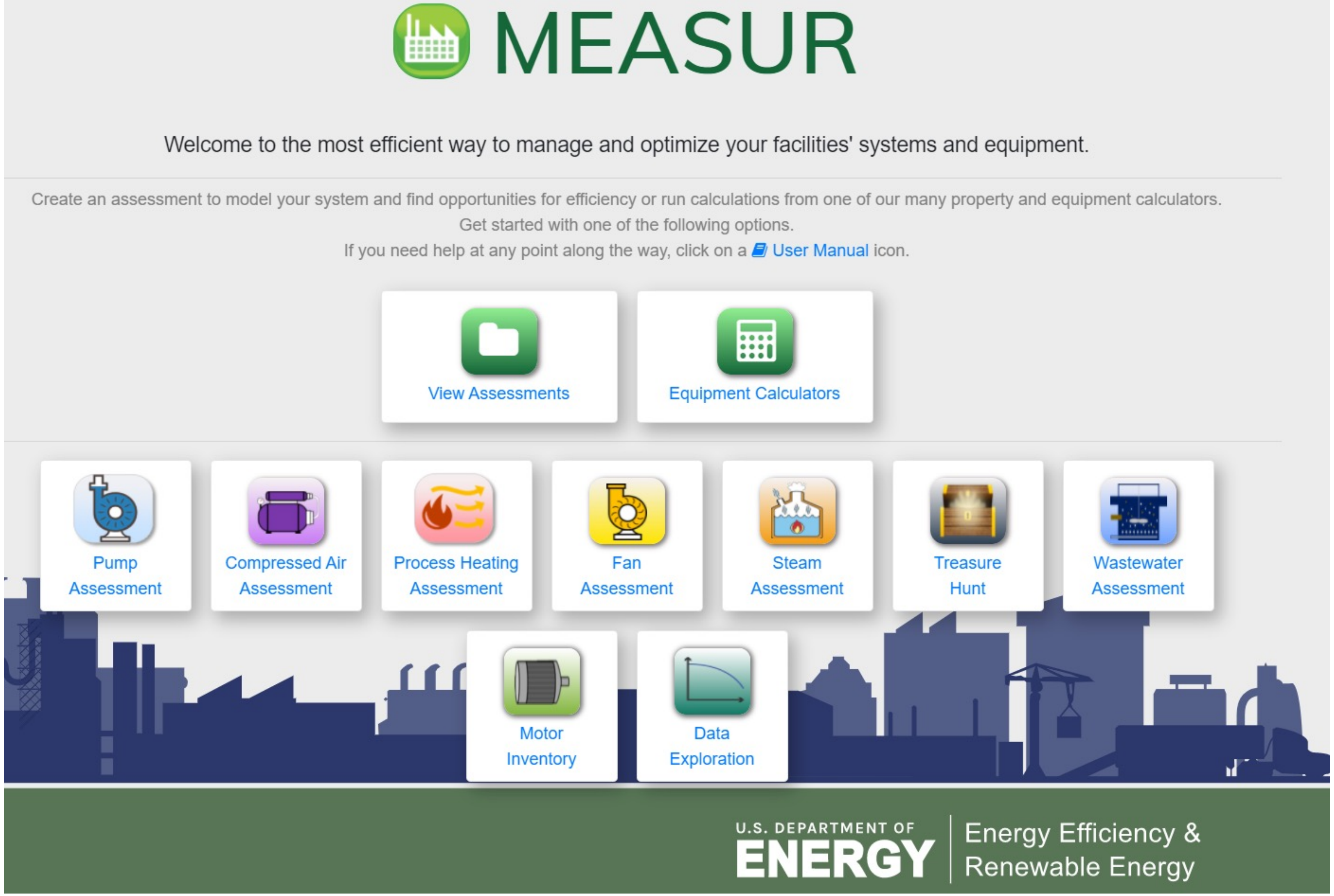
Enter LogTool Data Into AIRMaster

- 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

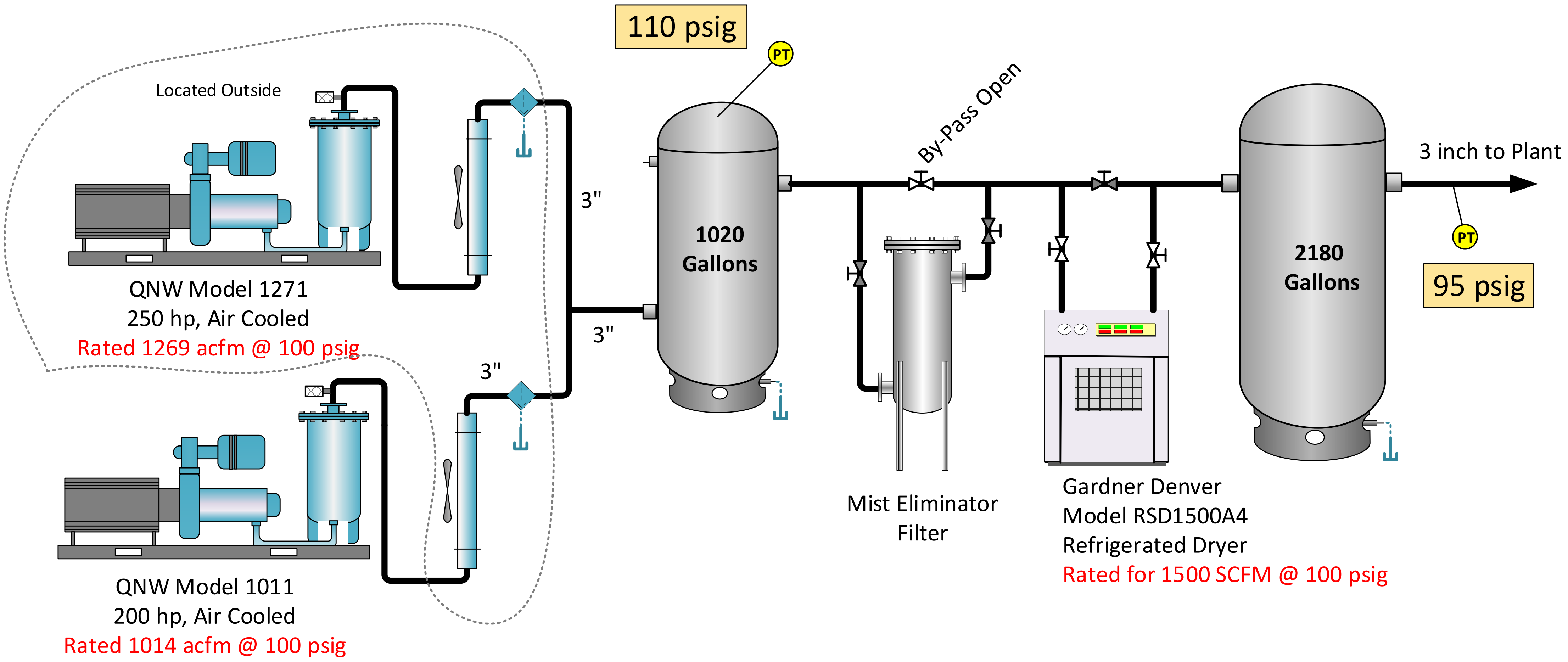
AIRMaster+ Main Menu



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

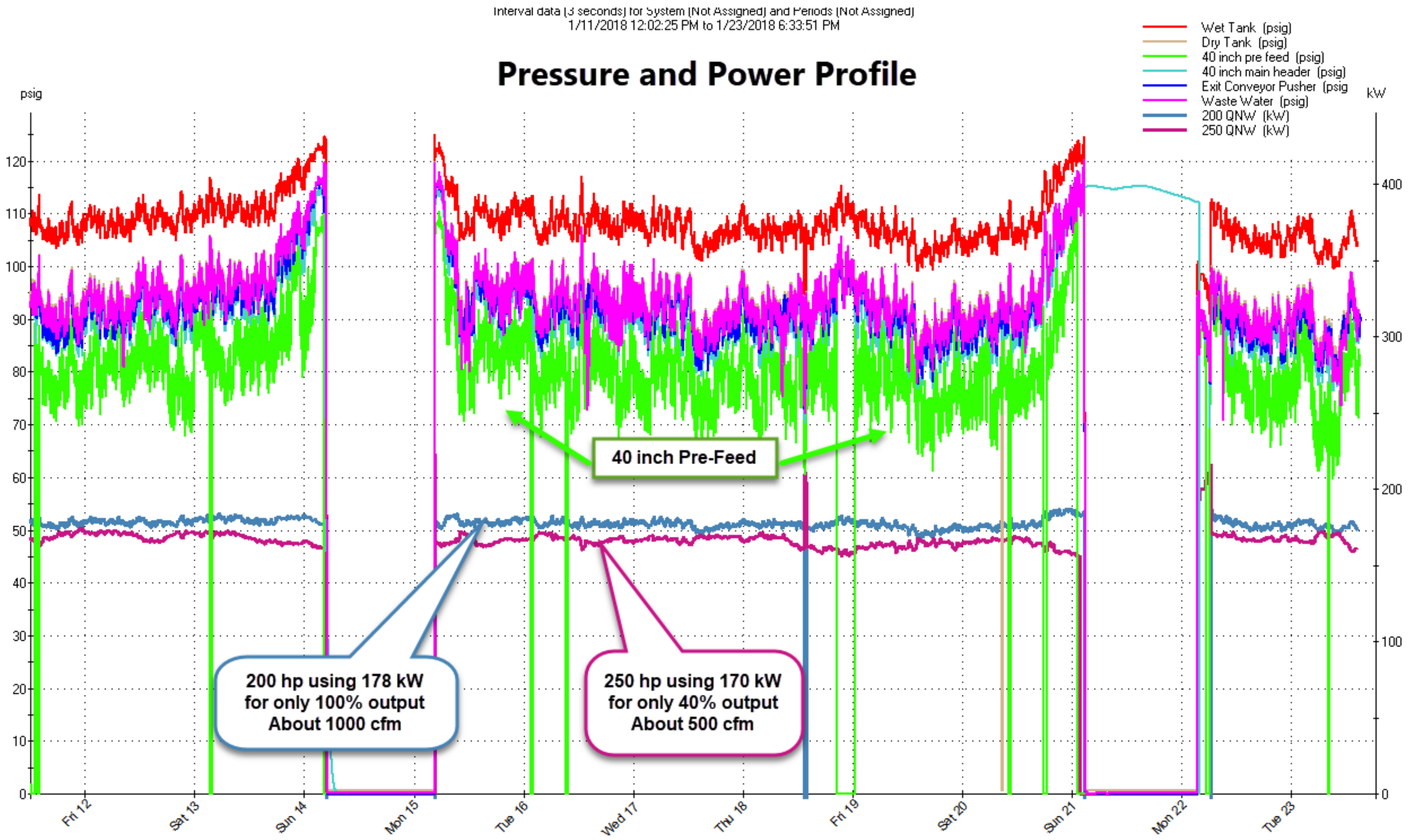
Baseline Info

- 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.

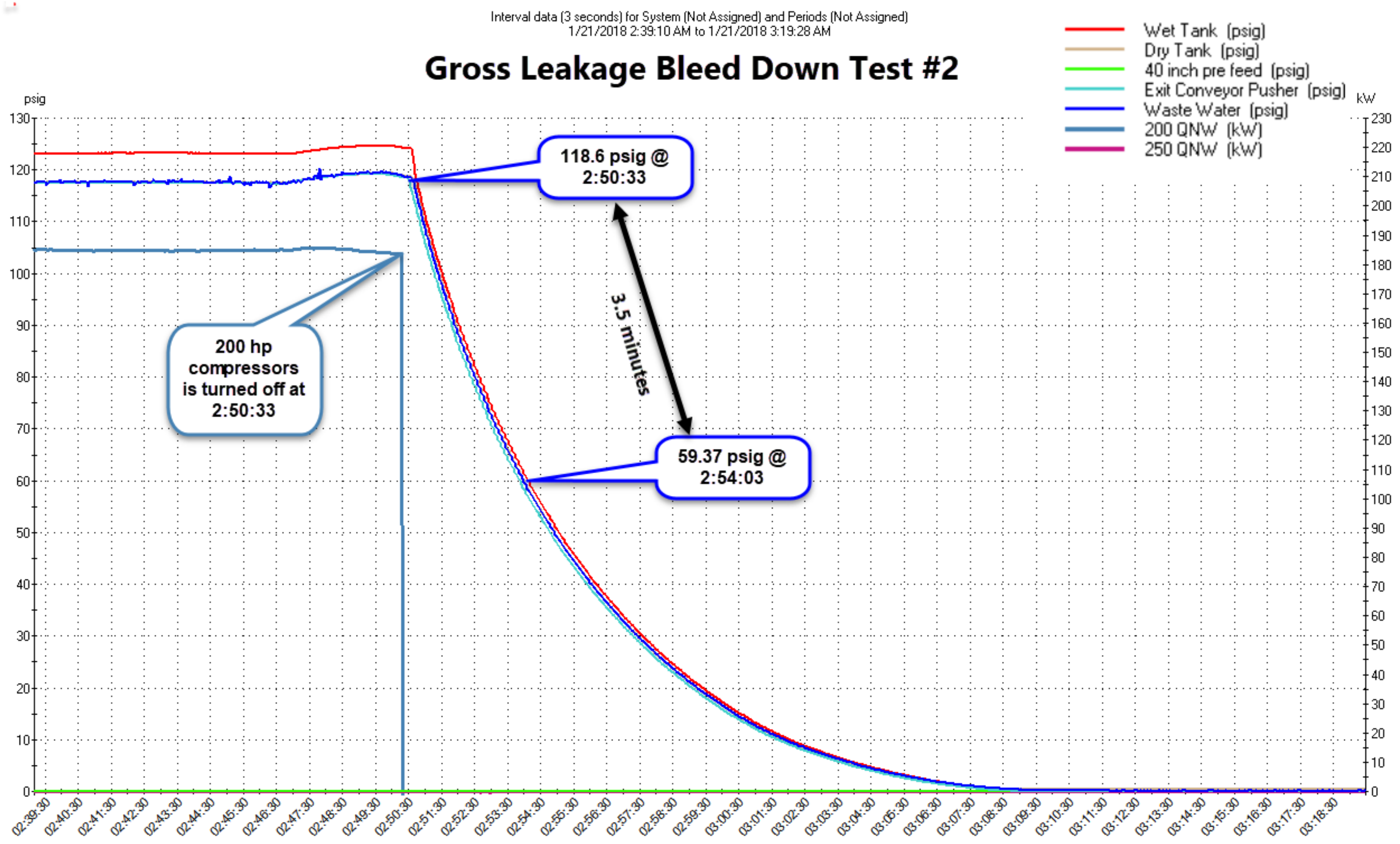
Table 4.7 Loss of Air Pressure Due to Friction

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



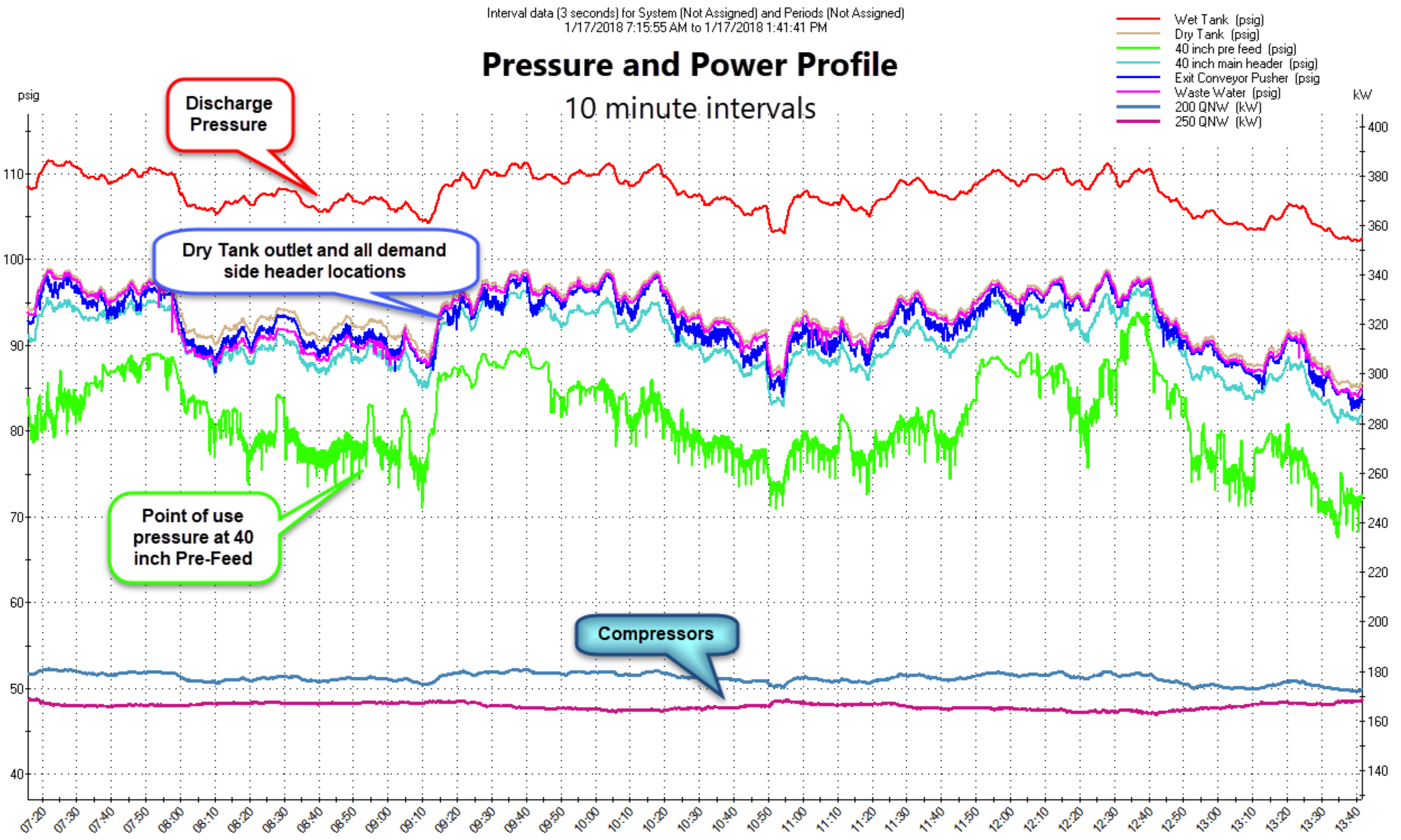
LogTool Trend Plot



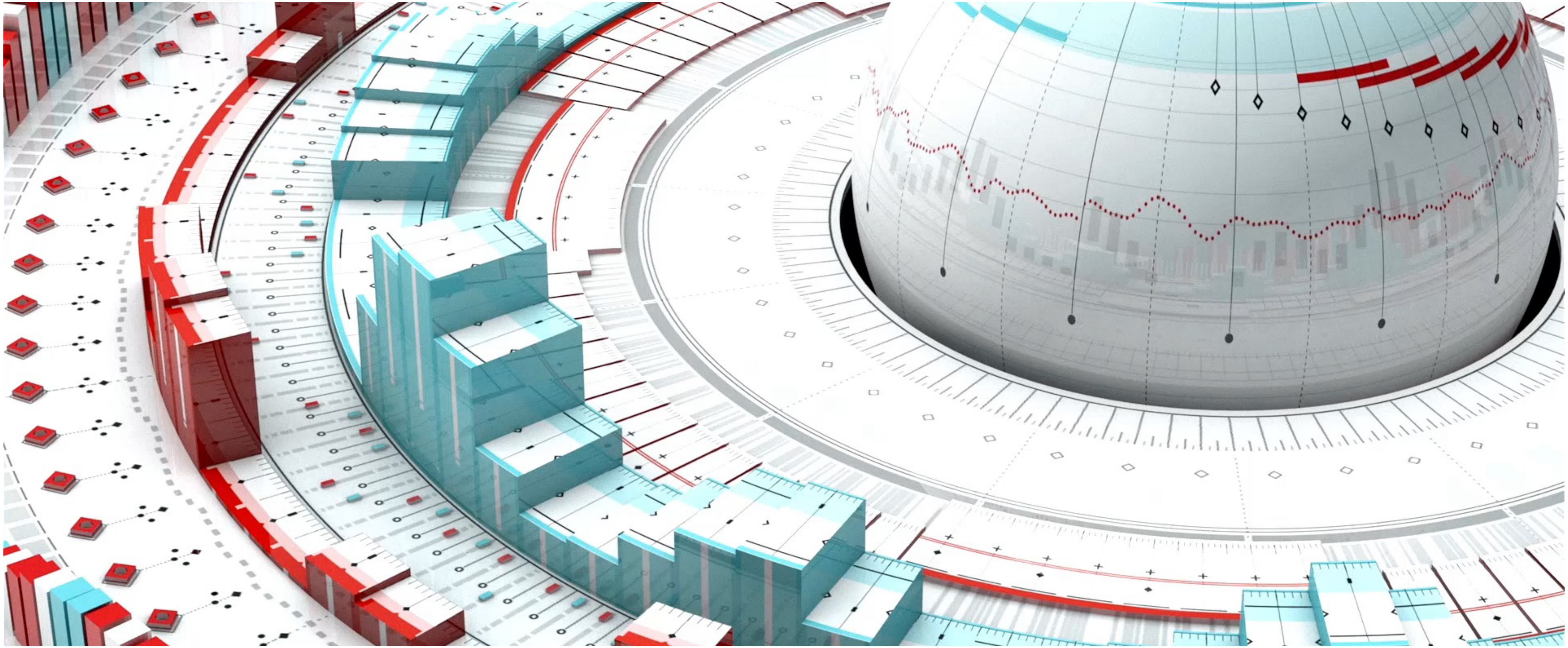
Bleed Down Test Calculation

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					

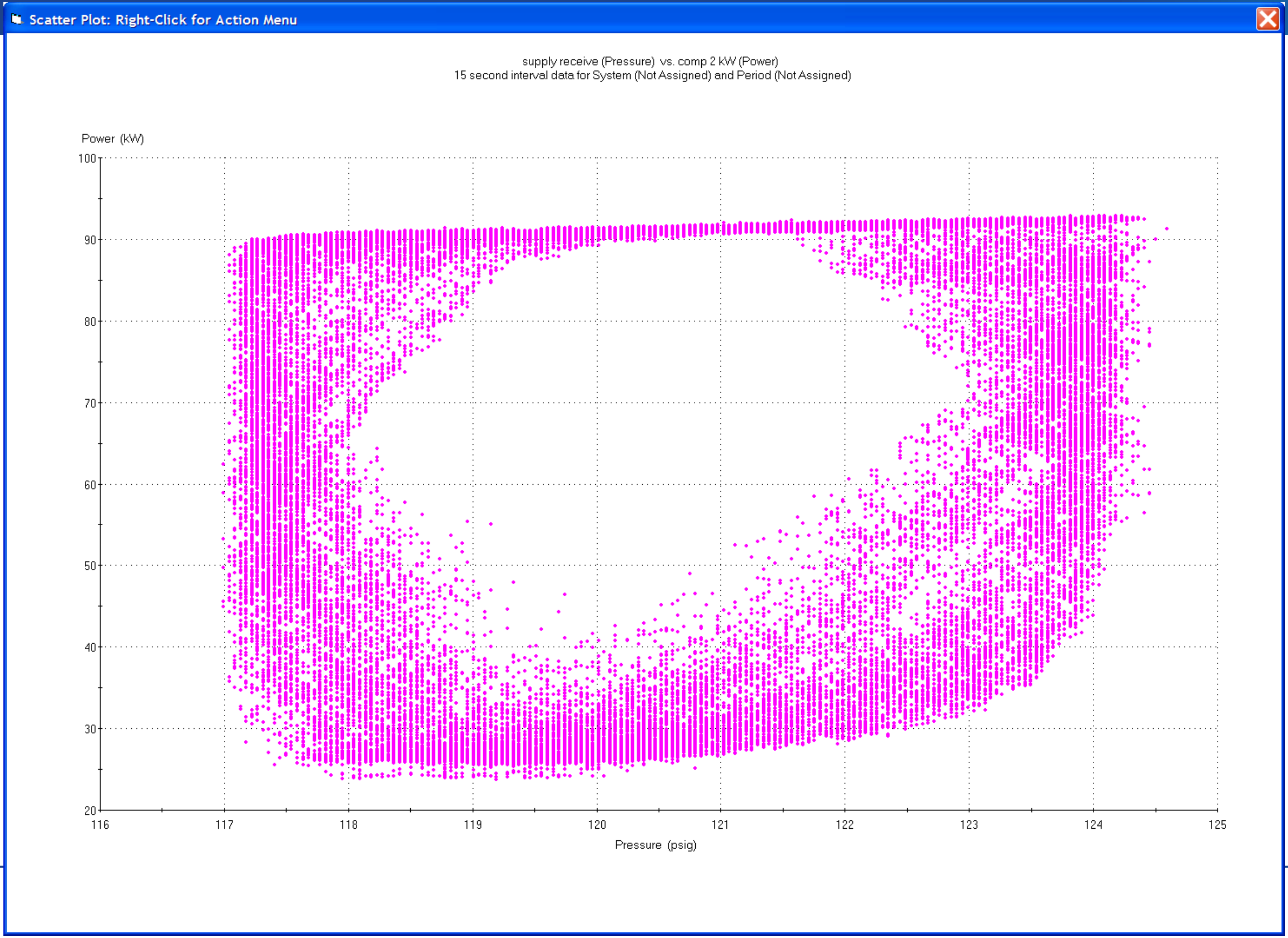
LogTool Trend Plot

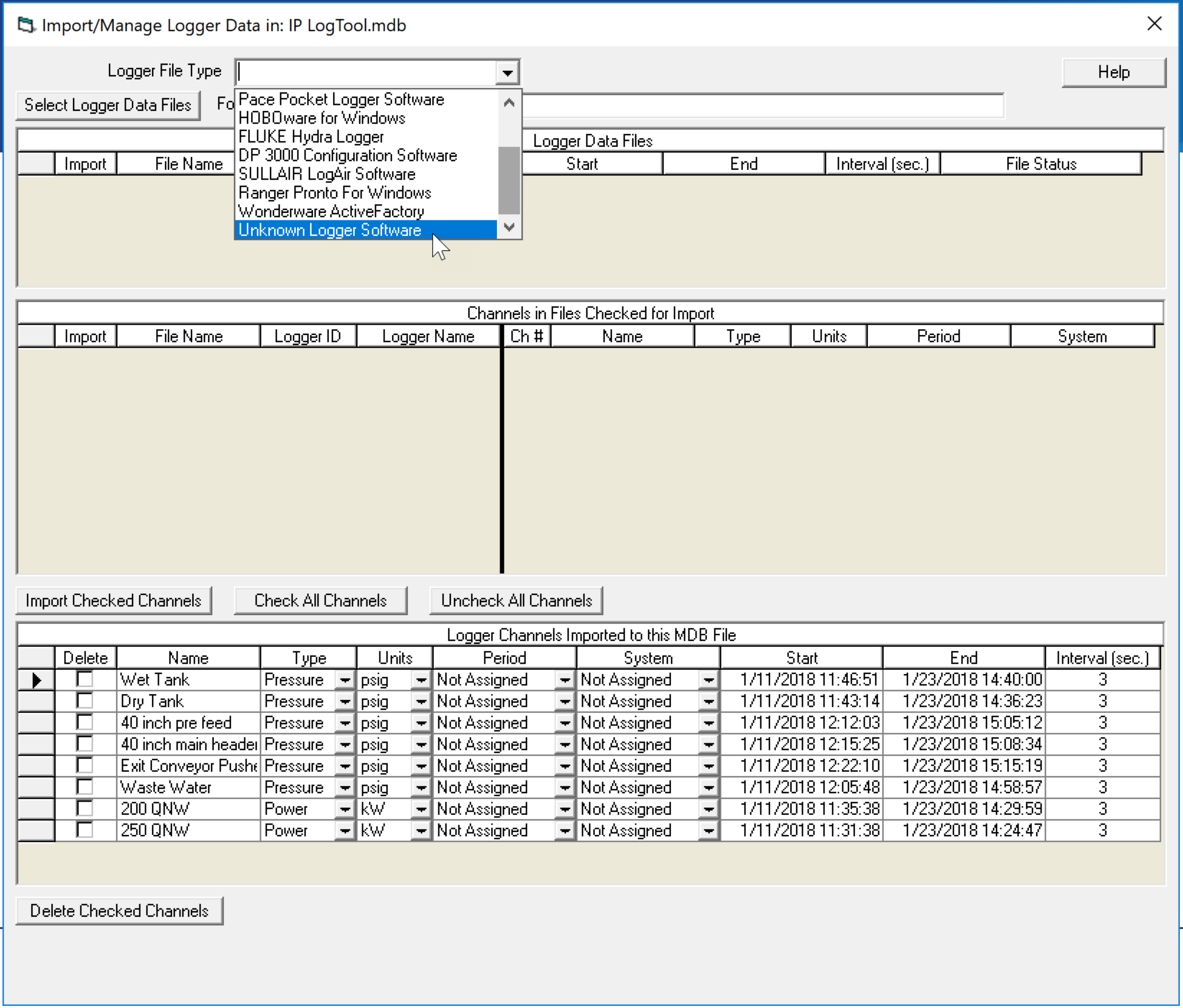


LogTool Scatter Plot

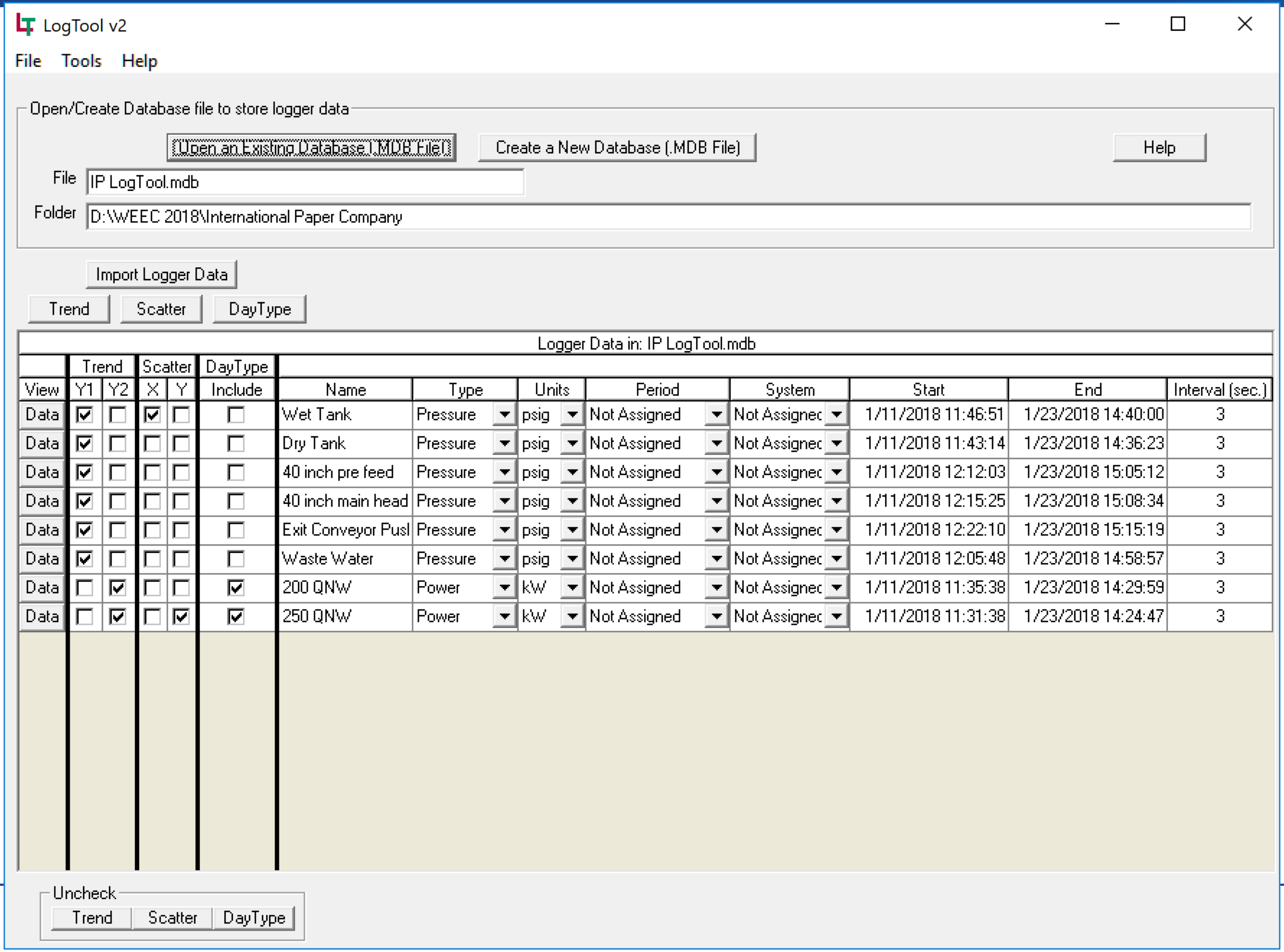


LogTool Scatter Plot




Import/Manage Logger Data in: IP LogTool.mdb
Logger File Type
Help
Select Logger Data Files
Fo
Pace Pocket Logger Software
HOBOware for Windows
FLUKE Hydra Logger
DP 3000 Configuration Software
SULLAIR LogAir Software
Ranger Pronto For Windows
Wonderware ActiveFactory
Unknown Logger Software
Logger Data Files
Import
File Name
Start
End
Interval (sec.)
File Status
Channels in Files Checked for Import
Import
File Name
Logger ID
Logger Name
Ch #
Name
Type
Units
Period
System
Import Checked Channels
Check All Channels
Uncheck All Channels
Logger Channels Imported to this MDB File
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 header 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
Delete Checked Channels

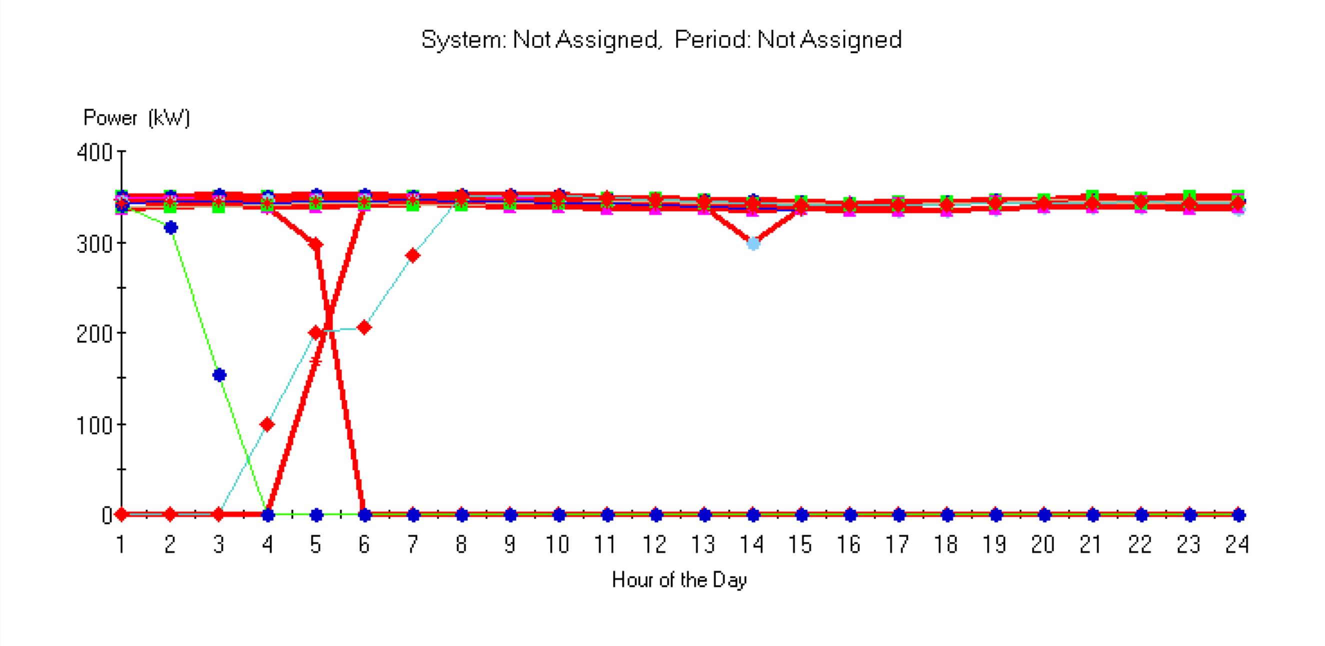
LogTool Main Menu



	Trend		Scatter		DayType								
View	Y1	Y2	X	Y	Include	Name	Type	Units	Period	System	Start	End	Interval (sec.)
Data	☑	☐	☑	☐	☐	Wet Tank	Pressure	psig	Not Assigned	Not Assignec	1/11/2018 11:46:51	1/23/2018 14:40:00	3
Data	☑	☐	☐	☐	☐	Dry Tank	Pressure	psig	Not Assigned	Not Assignec	1/11/2018 11:43:14	1/23/2018 14:36:23	3
Data	☑	☐	☐	☐	☐	40 inch pre feed	Pressure	psig	Not Assigned	Not Assignec	1/11/2018 12:12:03	1/23/2018 15:05:12	3
Data	☑	☐	☐	☐	☐	40 inch main head	Pressure	psig	Not Assigned	Not Assignec	1/11/2018 12:15:25	1/23/2018 15:08:34	3
Data	☑	☐	☐	☐	☐	Exit Conveyor Pusl	Pressure	psig	Not Assigned	Not Assignec	1/11/2018 12:22:10	1/23/2018 15:15:19	3
Data	☑	☐	☐	☐	☐	Waste Water	Pressure	psig	Not Assigned	Not Assignec	1/11/2018 12:05:48	1/23/2018 14:58:57	3
Data	☐	☑	☐	☐	☑	200 QNW	Power	kW	Not Assigned	Not Assignec	1/11/2018 11:35:38	1/23/2018 14:29:59	3
Data	☐	☑	☐	☑	☑	250 QNW	Power	kW	Not Assigned	Not Assignec	1/11/2018 11:31:38	1/23/2018 14:24:47	3

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...

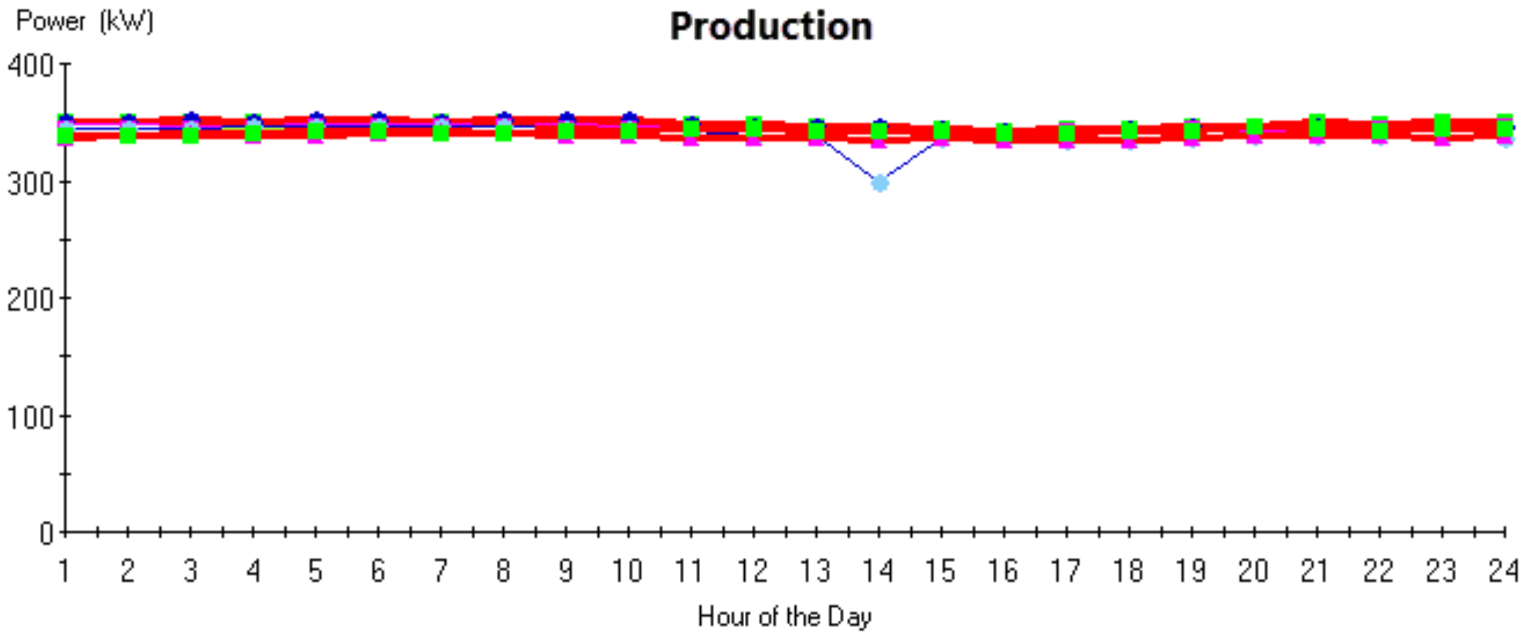
Caution: Day profiles can be similar even though different equipment, e.g., compressors, is operating. Use Trend Plots to examine the details of equipment operation before determining whether days should be assigned to the same daytype.

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

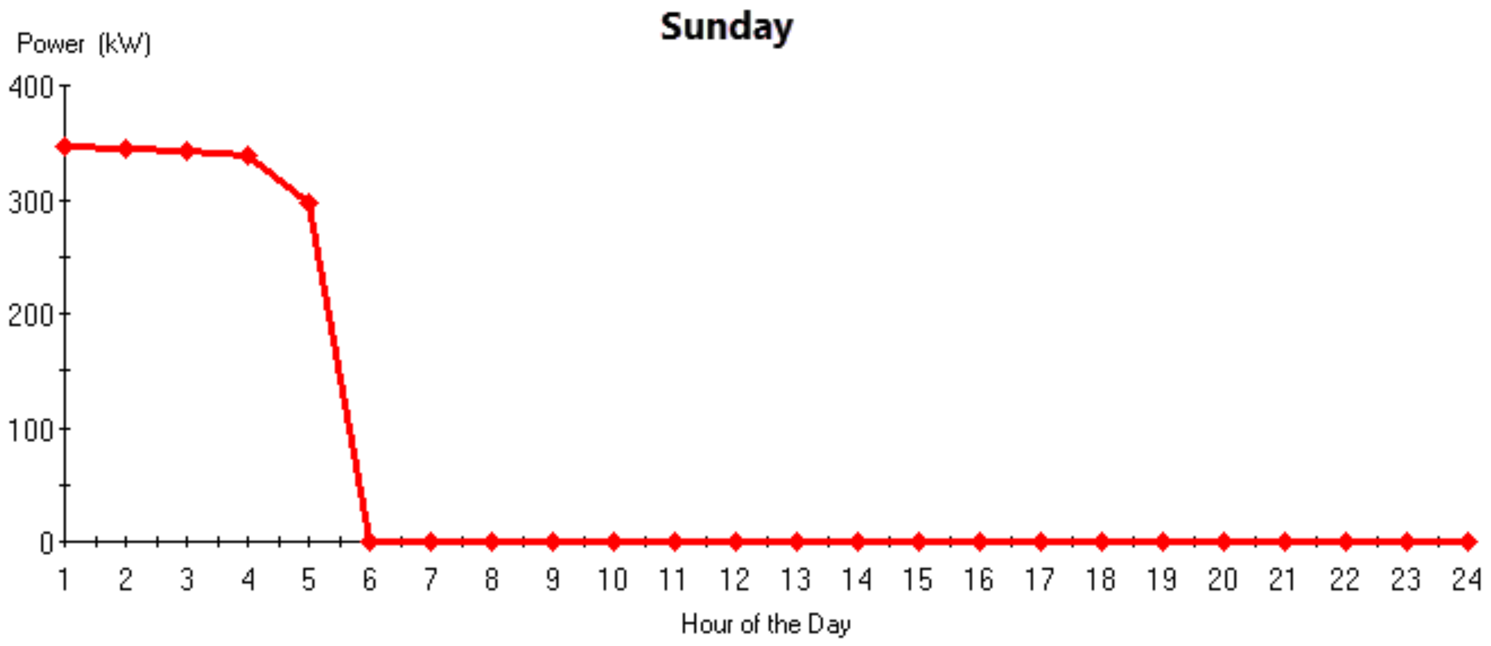
System DayType Profiles

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

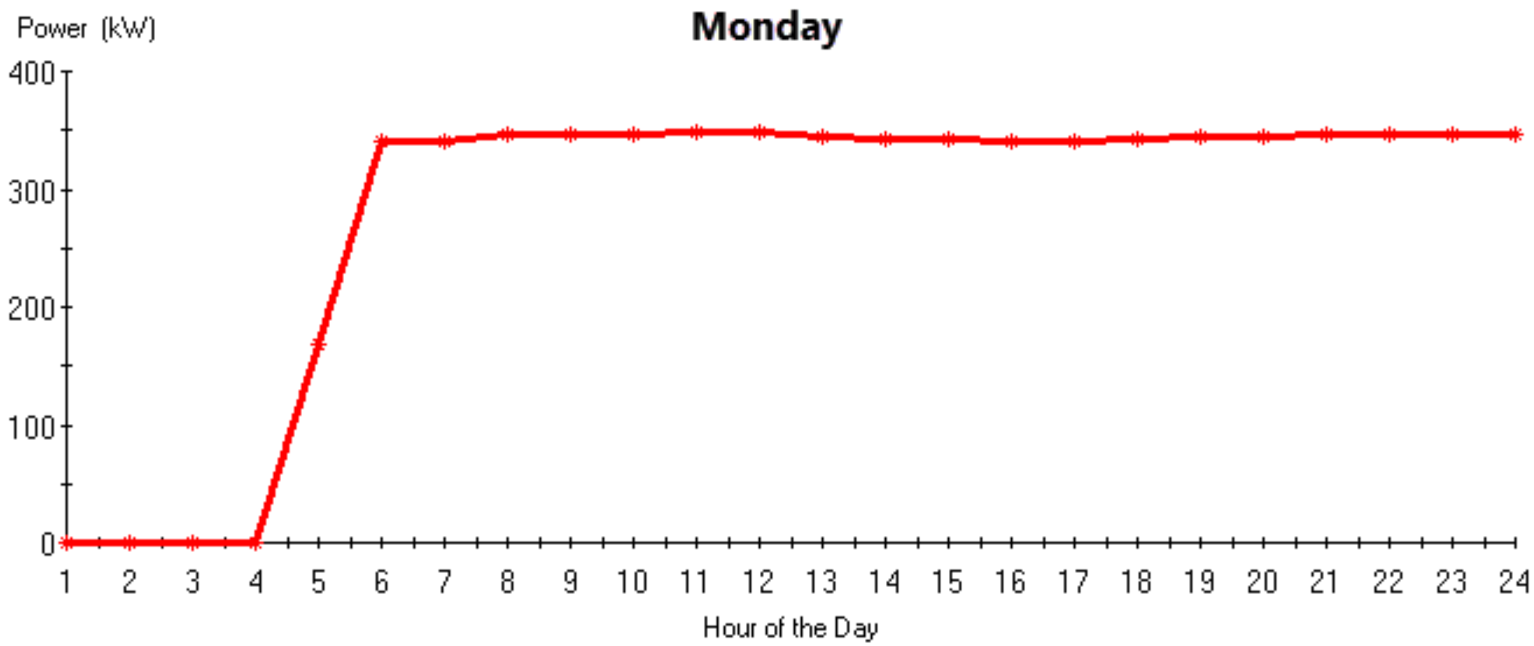
DayType Profiles



DayType Profiles



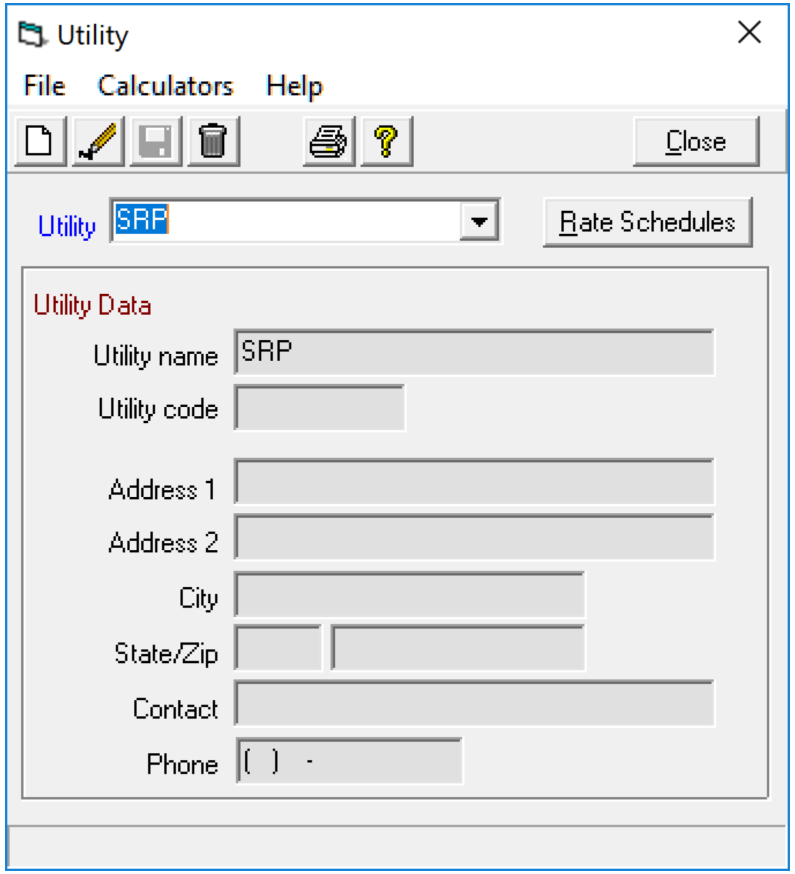
DayType Profiles

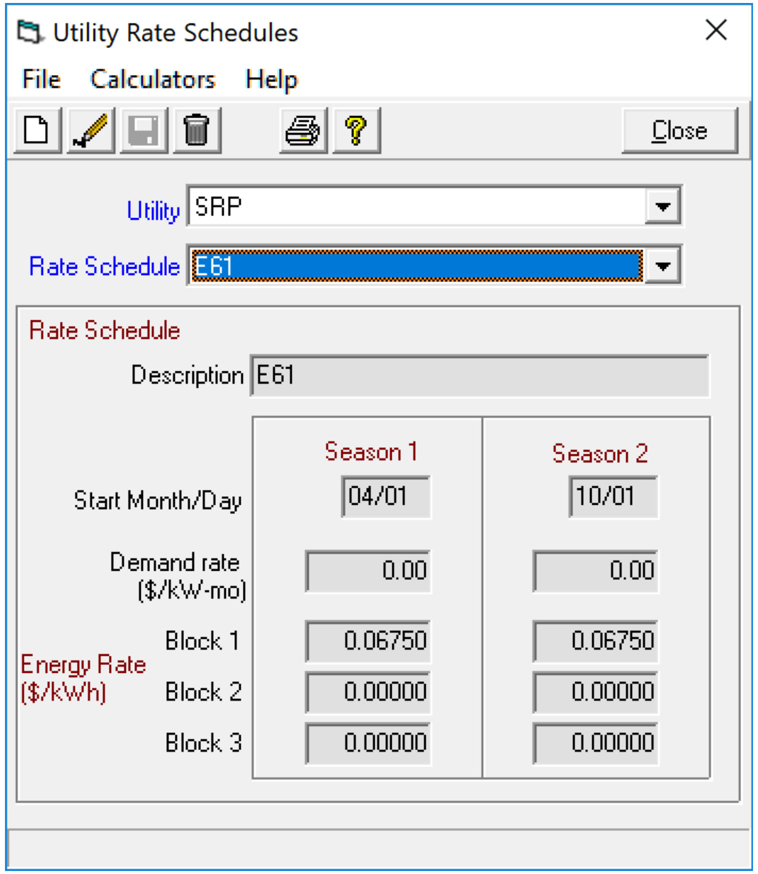


Enter LogTool Data Into AIRMaster

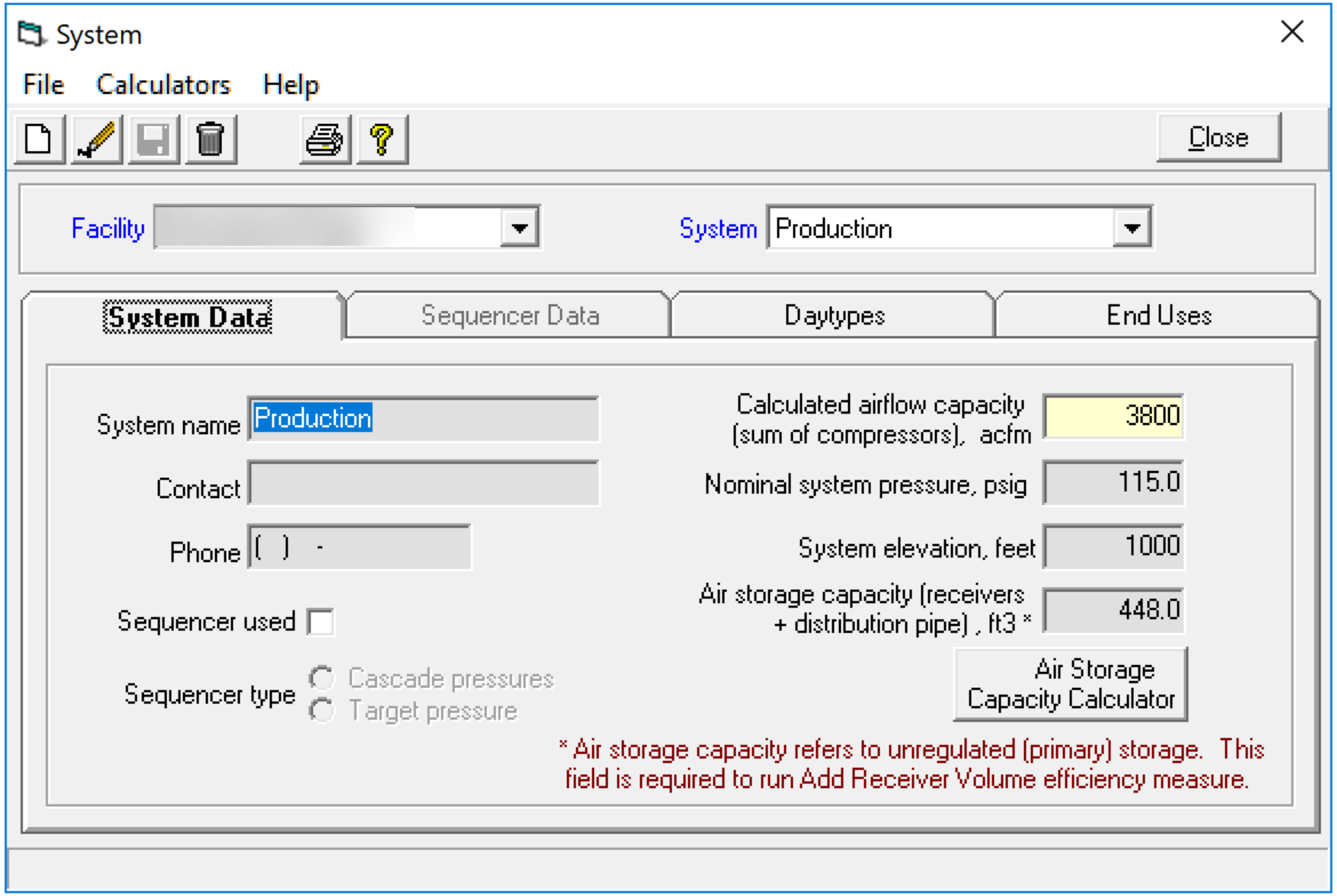
- Enter Utility and rate information
- Enter System information including Day Types
- Enter compressor Information
- Enter recorded data to establish the baseline
  - This data comes from LogTool
- Experiment with different EEM's

Utility and Rate Information

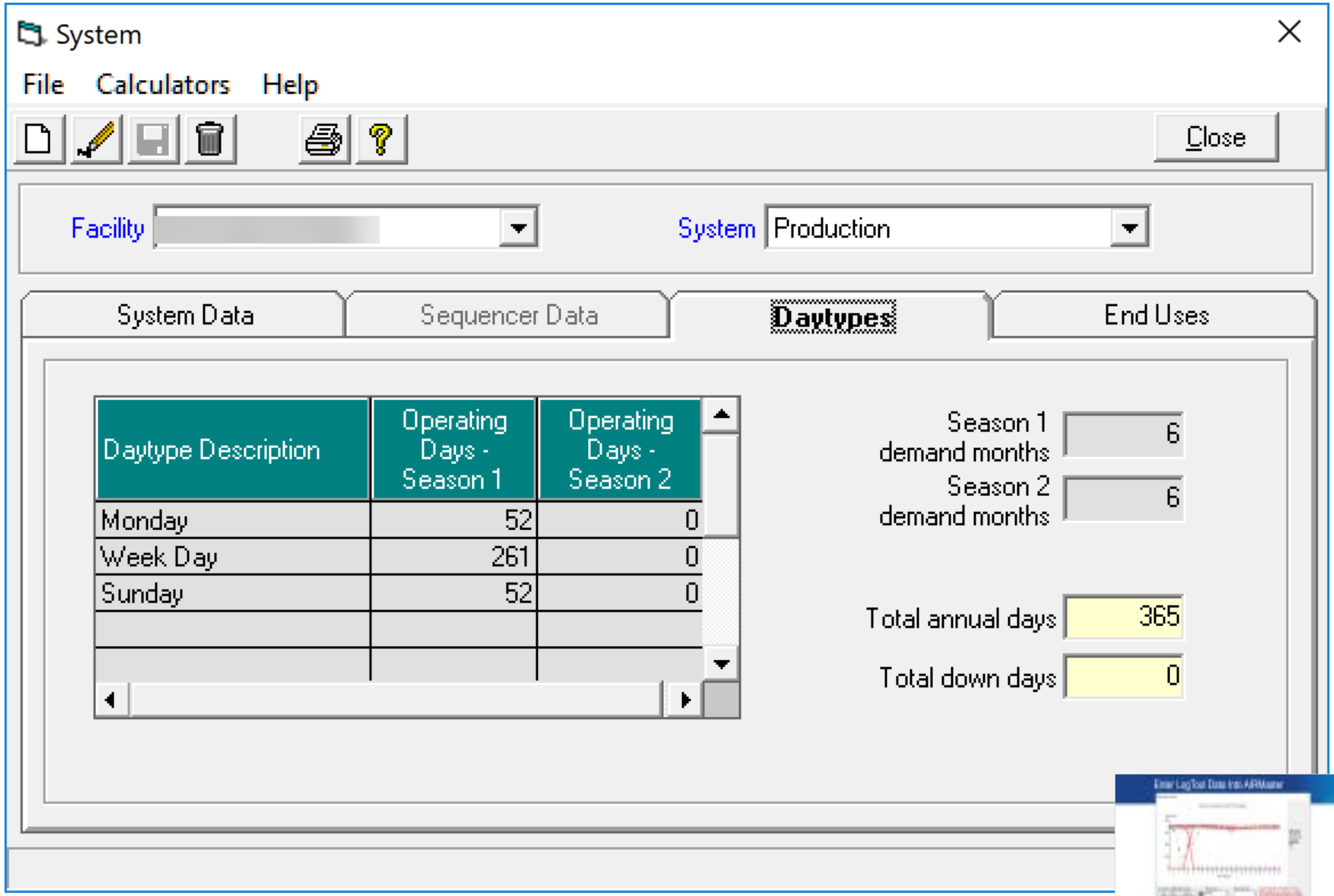




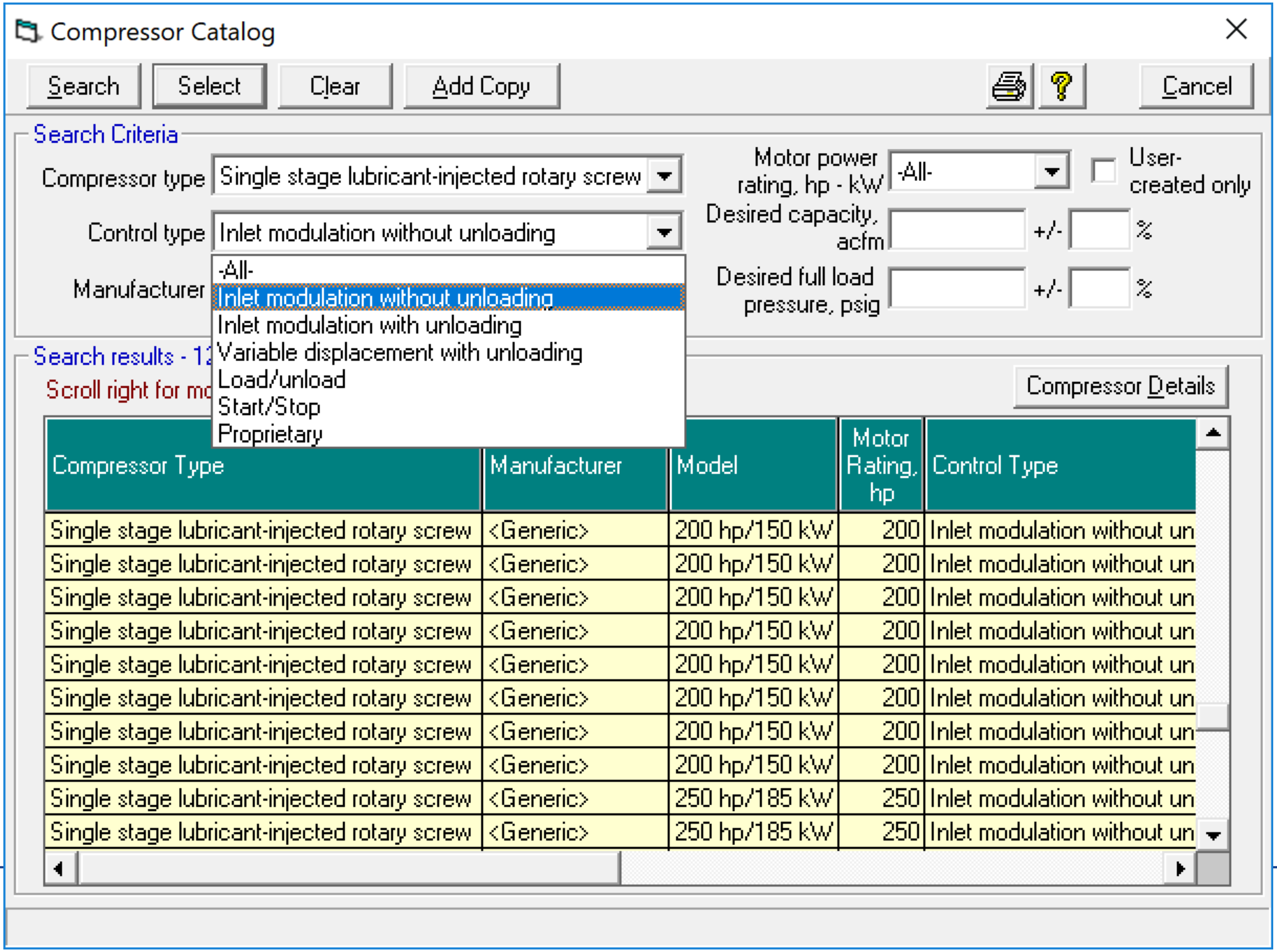
System Information



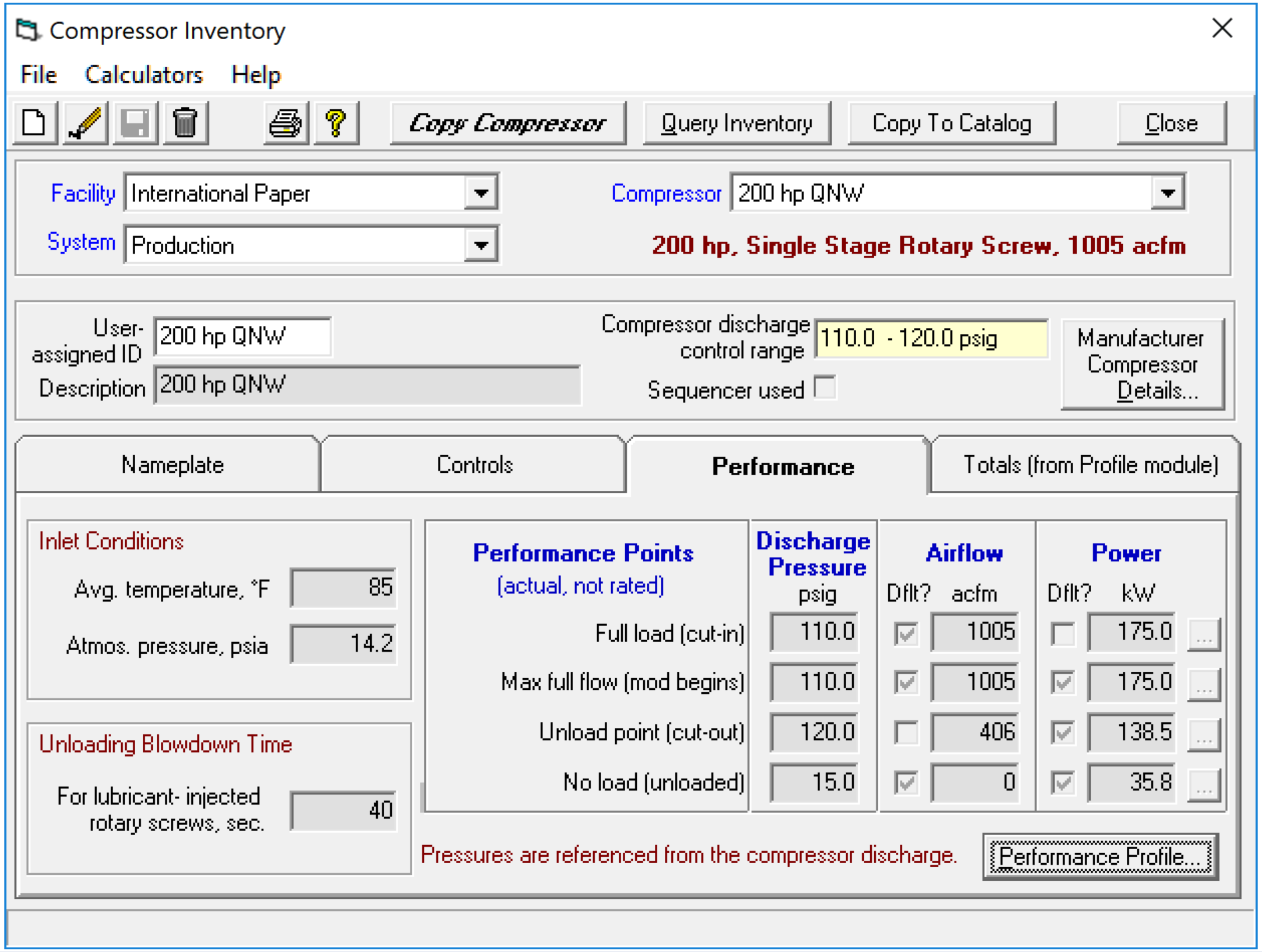
System Information Day Types



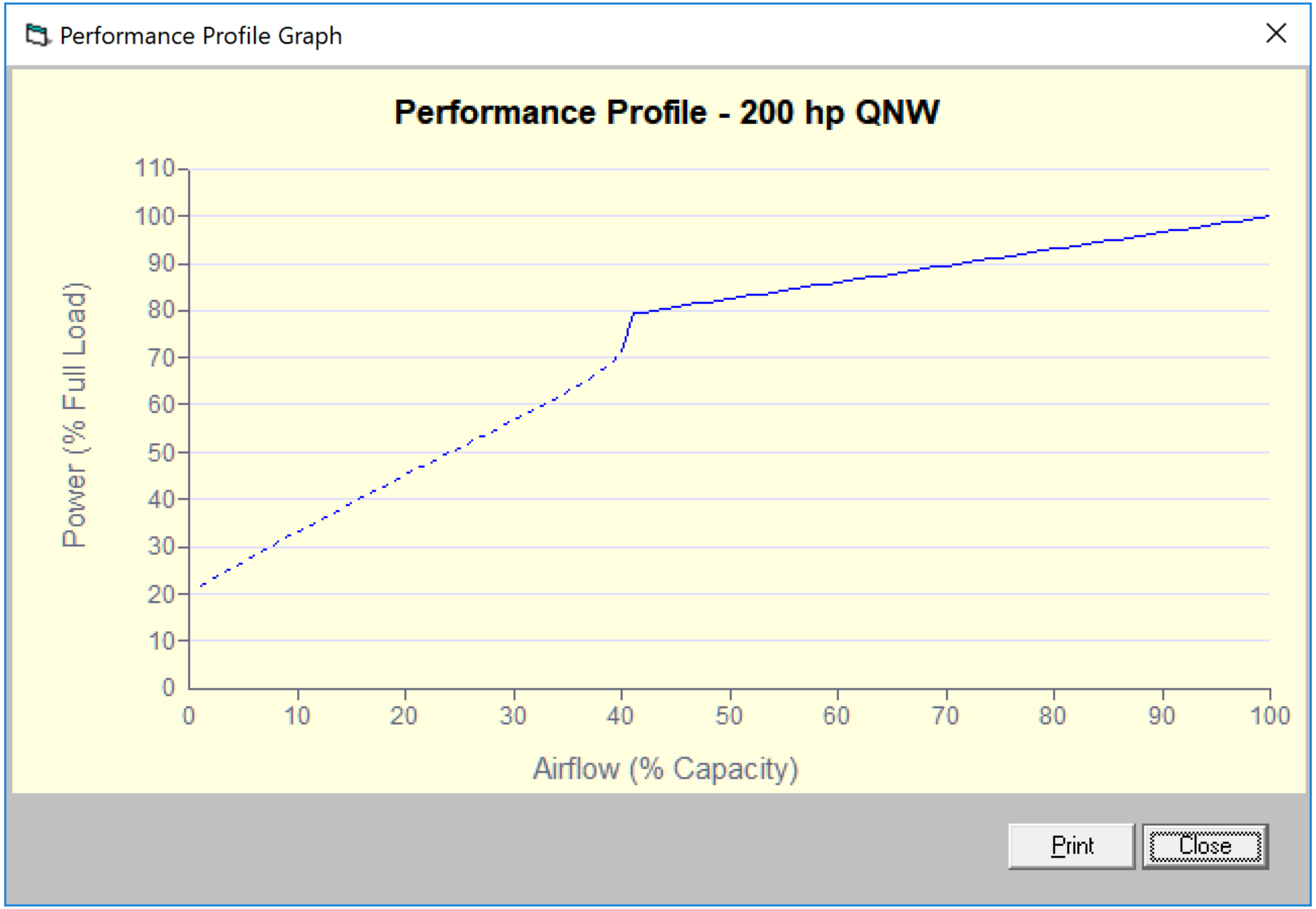
Compressor Information



Compressor Information

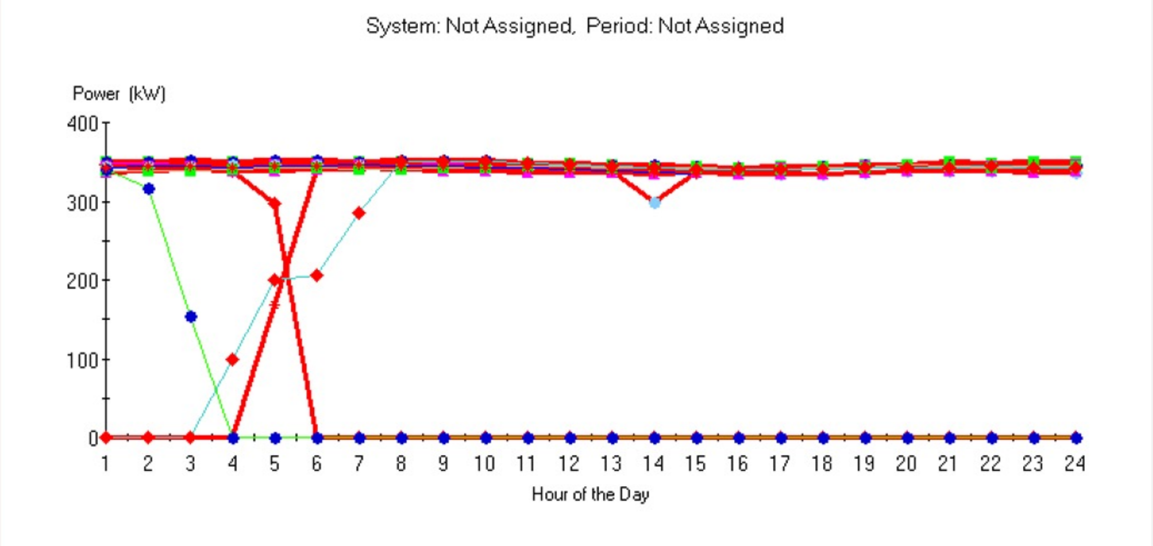


Compressor Information



Create the baseline from the Data

DayType Analysis



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

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Date	Day	Day Type
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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...

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

System DayType Profiles

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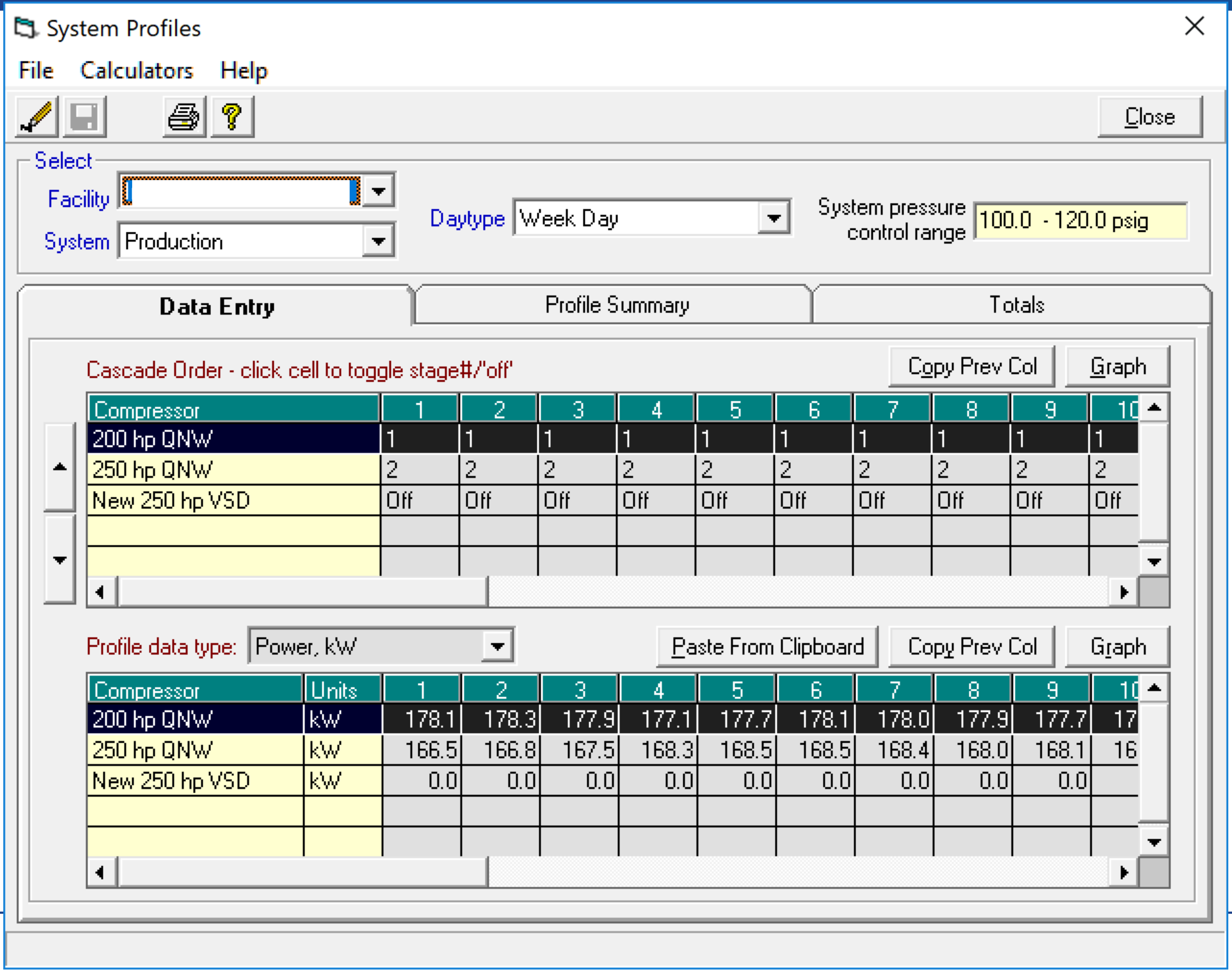
Monday	200 QNW	0.00	0.00	0.00	0.00	84.55	175.88	177.13
Monday	250 QNW	0.00	0.00	0.00	0.00	83.80	164.18	163.56
Production	200 QNW	178.12	178.25	177.86	177.11	177.67	178.09	177.97
Production	250 QNW	166.54	166.81	167.49	168.31	168.50	168.50	168.40
Sunday	200 QNW	181.76	180.51	179.20	176.98	154.17	0.00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

Enter LogTool Data Into AIRMaster

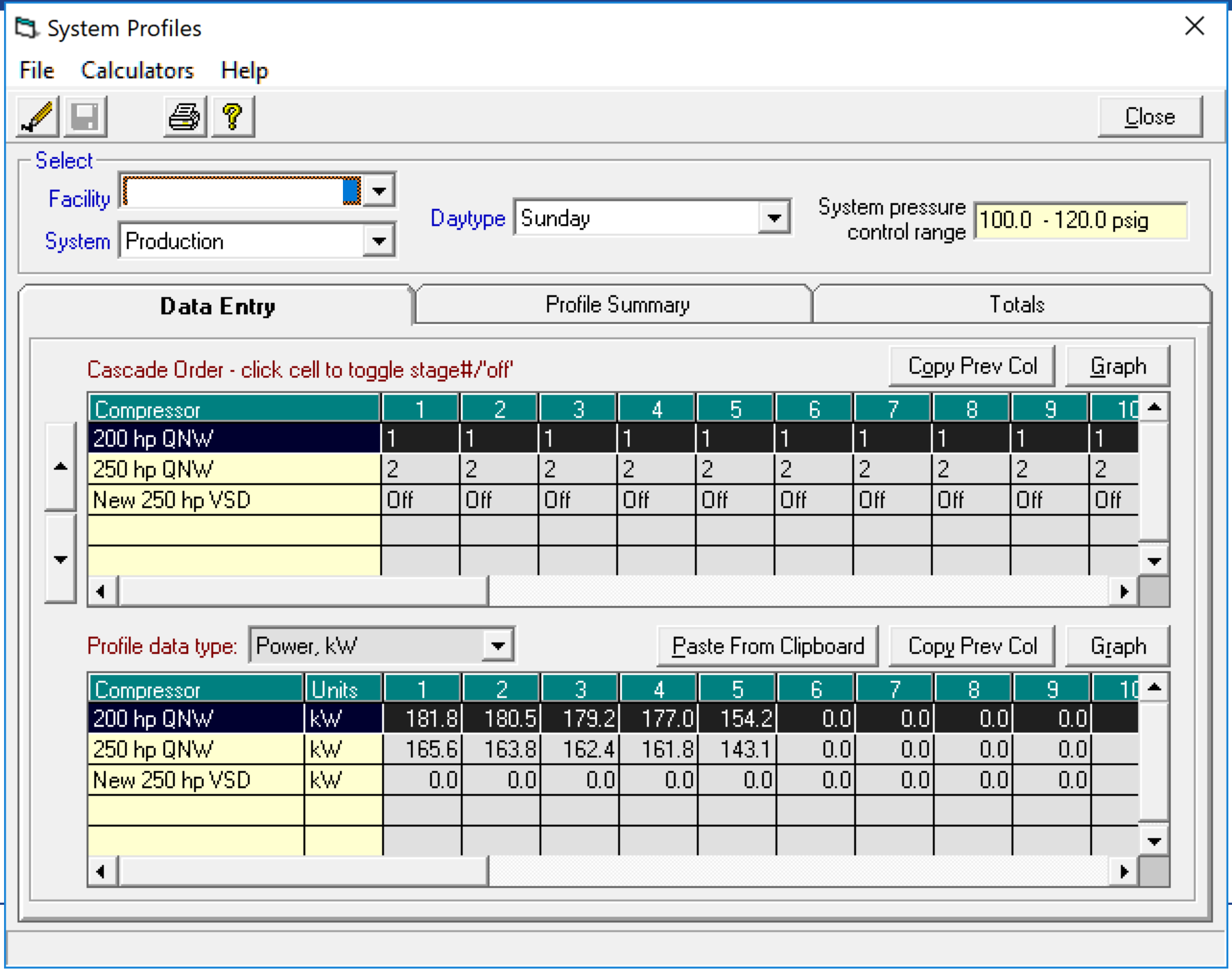
System	Type	Period	DayTypeNa	ChannelName	Hr_01	Hr_02	Hr_03	Hr_04	Hr_05	Hr_06	Hr_07	Hr_08	Hr_09	Hr_10	Hr_11	Hr_12	Hr_13	Hr_14	Hr_15	Hr_16	Hr_17	Hr_18	Hr_19	Hr_20	Hr_21	Hr_22	Hr_23	Hr_24
Not Assign	Power	Not Assign	Monday	200 QNW	0.0	0.0	0.0	0.0	84.6	175.9	177.1	181.6	182.2	180.8	177.2	177.7	177.0	178.6	178.7	178.7	176.9	177.0	178.2	177.2	178.7	179.6	180.1	179.3
Not Assign	Power	Not Assign	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 Assign	Power	Not Assign	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 Assign	Power	Not Assign	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 Assign	Power	Not Assign	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 Assign	Power	Not Assign	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

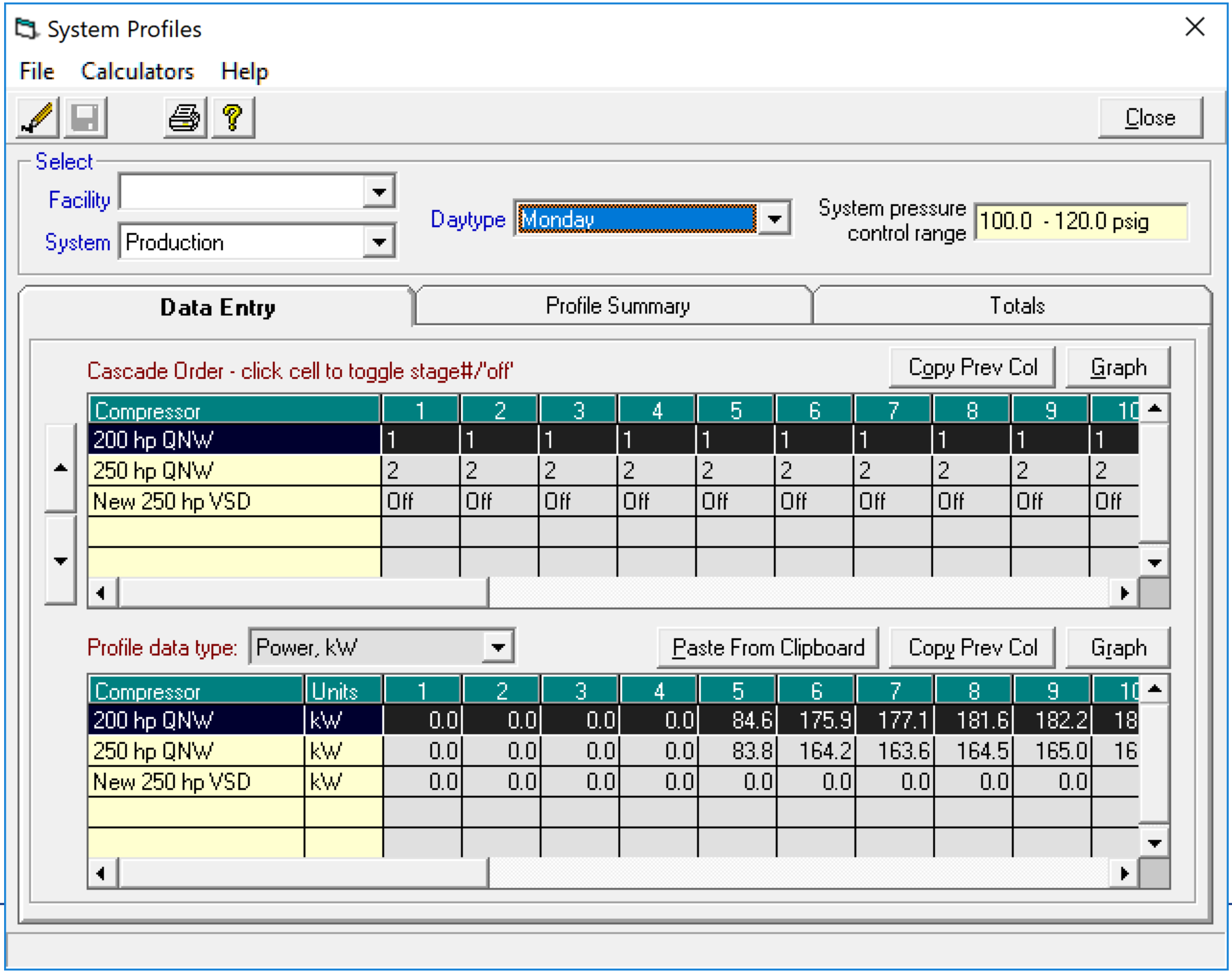
Enter LogTool Data Into AIRMaster



Enter LogTool Data Into AIRMaster



Enter LogTool Data Into AIRMaster



The Baseline

System Profiles

File Calculators Help

Close

Select

Facility

System Production

Daytype

System pressure control range 100.0 - 120.0 psig

Data Entry | Profile Summary | **Totals**

System Summary

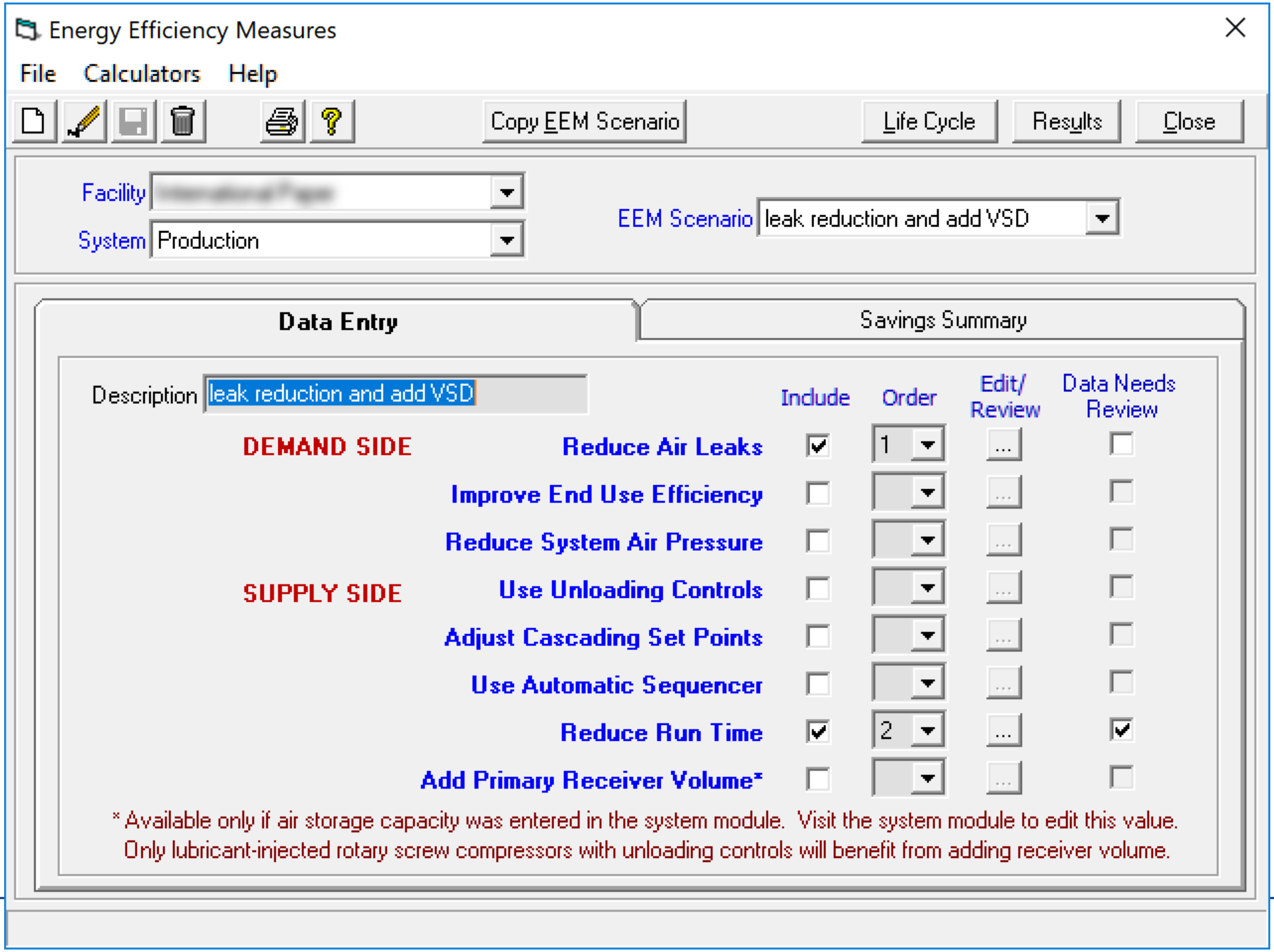
Daytype	Total OpHrs	Avg Airflow, acfm	Avg Airflow, %Cs.	Peak Demand, kW	Load Factor, %	Annual Energy, kWh	Annual Energy Cost, $
Monday	1,040	1,459	38.4	348.8	51.3	349,102	23,564
Week Day	6,264	1,509	39.7	346.6	52.5	2,151,606	145,233
Sunday	260	1,434	37.7	347.4	51.0	86,809	5,860
System Totals	7,564	1,500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

Copy To Clipboard

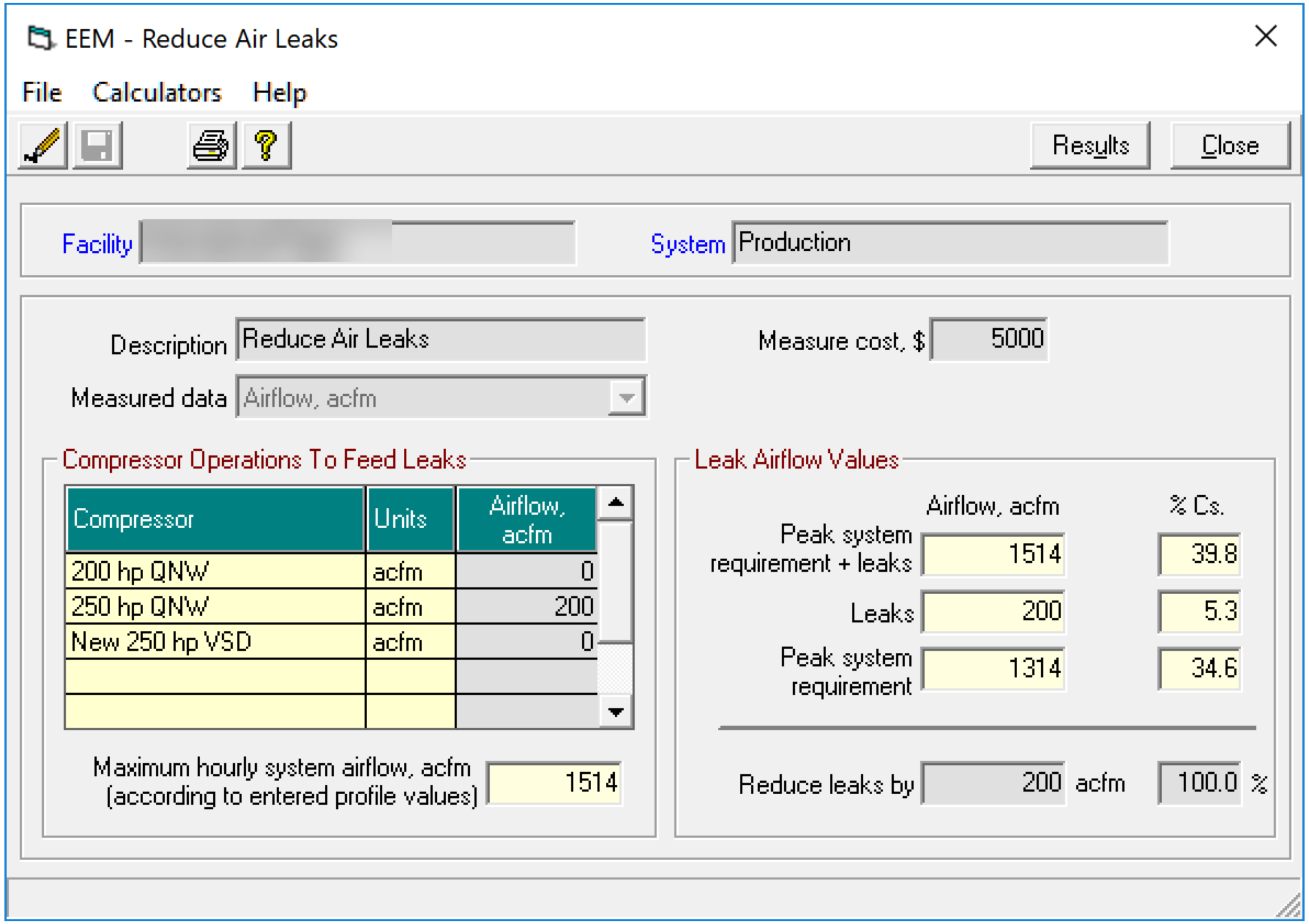
Total demand cost, $ $ 0

Total operating costs, $ $ 174,657

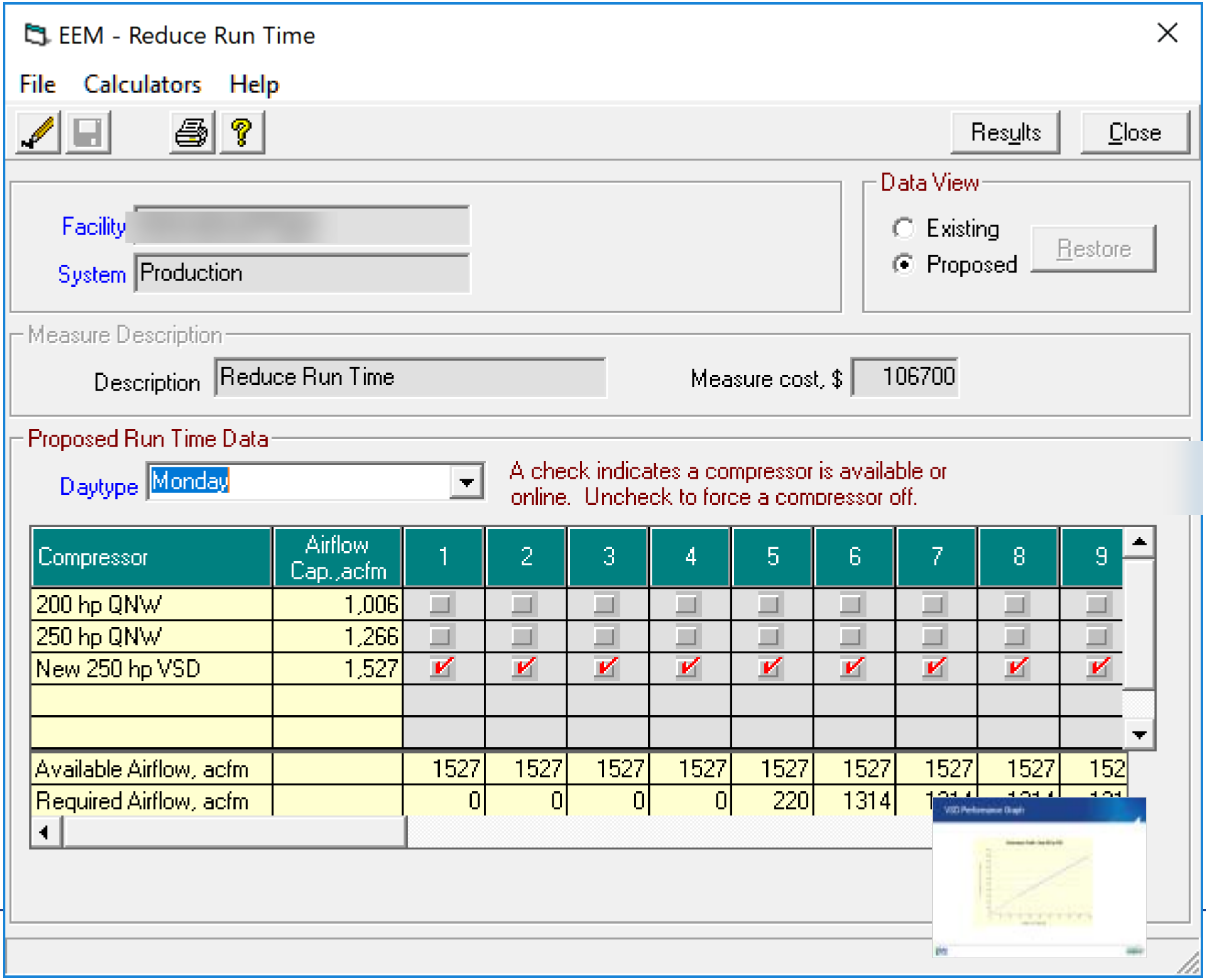
EEM’s


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.

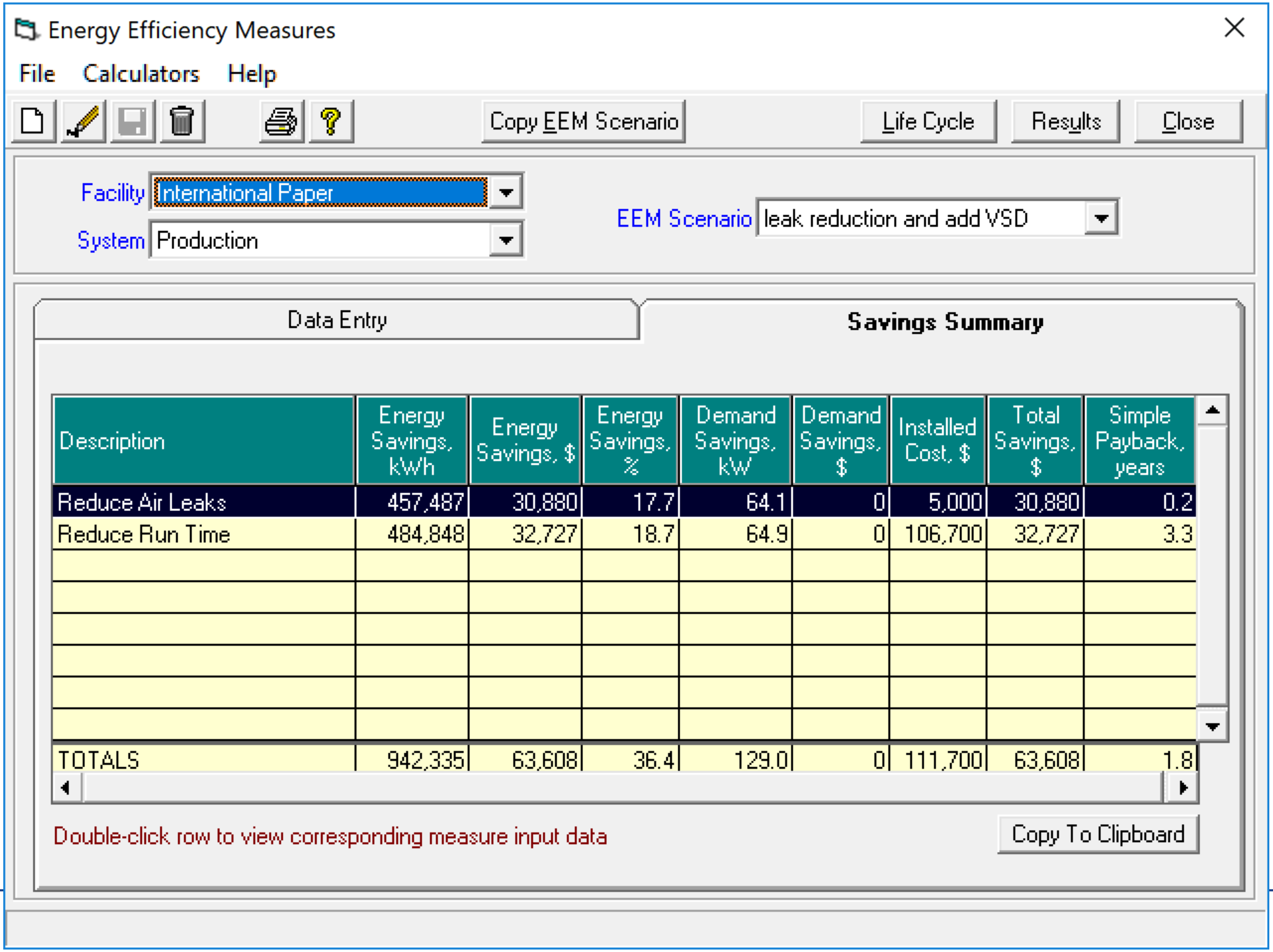
EEM’s


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

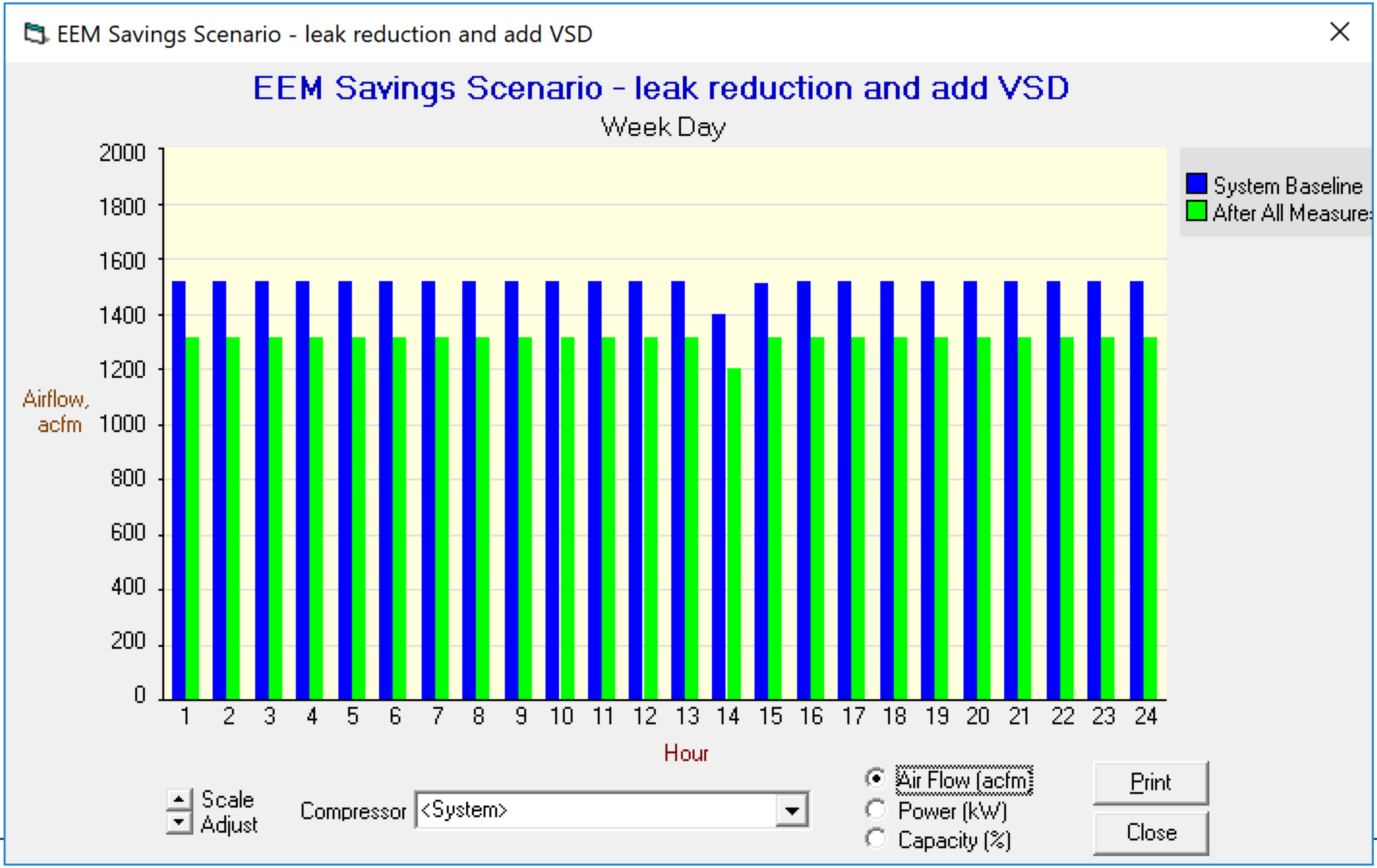

EEM - Reduce Run Time
File
Calculators
Help
Results
Close
Facility
System
Production
Data View
Existing
Proposed
Restore
Measure Description
Description
Reduce Run Time
Measure cost, $
106700
Proposed Run Time Data
Daytype
Monday
A check indicates a compressor is available or online. Uncheck to force 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
152
Required Airflow, acfm
0
0
0
0
220
1314
VSD Performance Graph

EEM’s

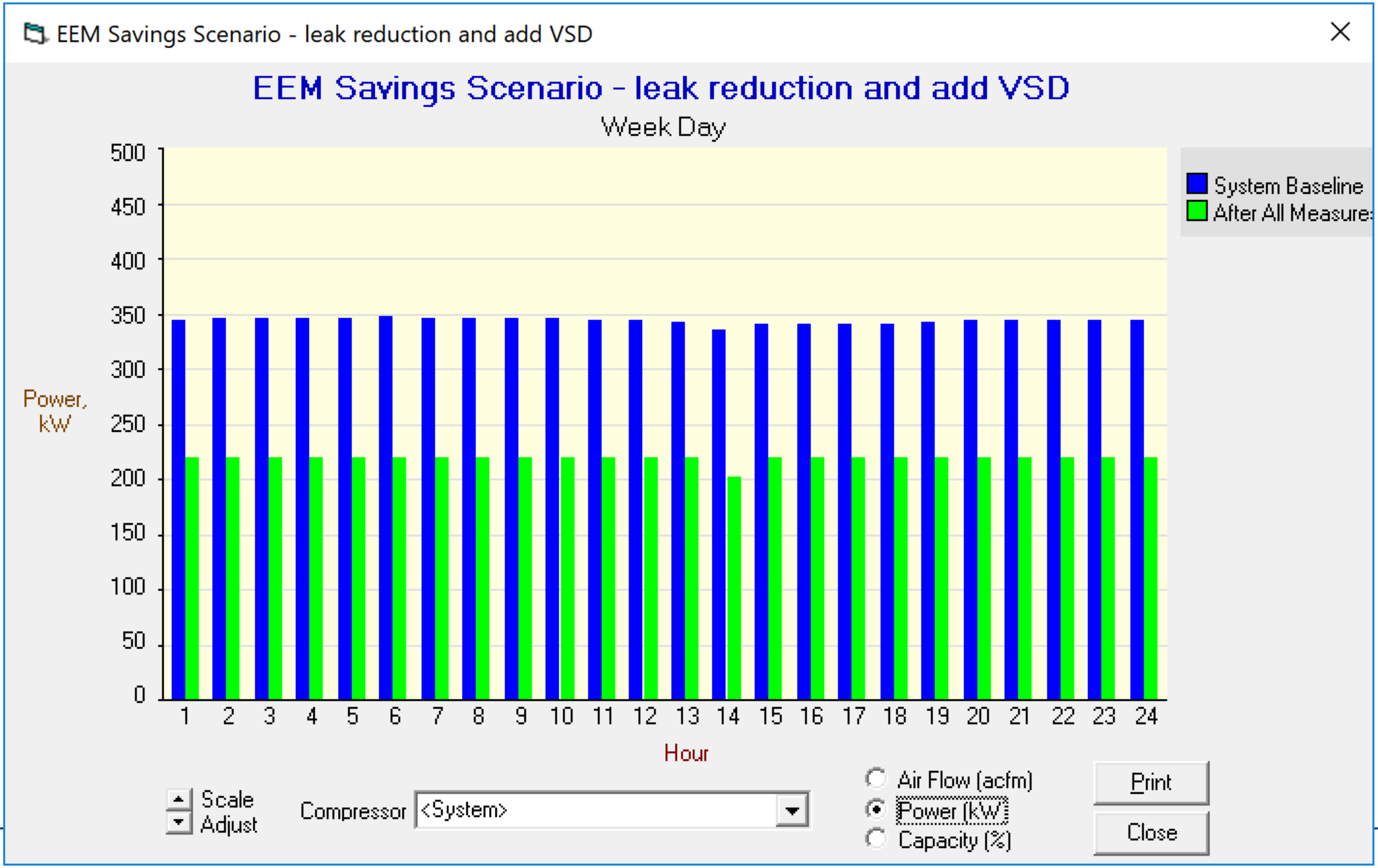


Description	Energy Savings, kWh	Energy Savings, $	Energy Savings, %	Demand Savings, kW	Demand Savings, $	Installed Cost, $	Total Savings, $	Simple Payback, years
Reduce Air Leaks	457,487	30,880	17.7	64.1	0	5,000	30,880	0.2
Reduce Run Time	484,848	32,727	18.7	64.9	0	106,700	32,727	3.3
TOTALS	942,335	63,608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

Bar Graphs

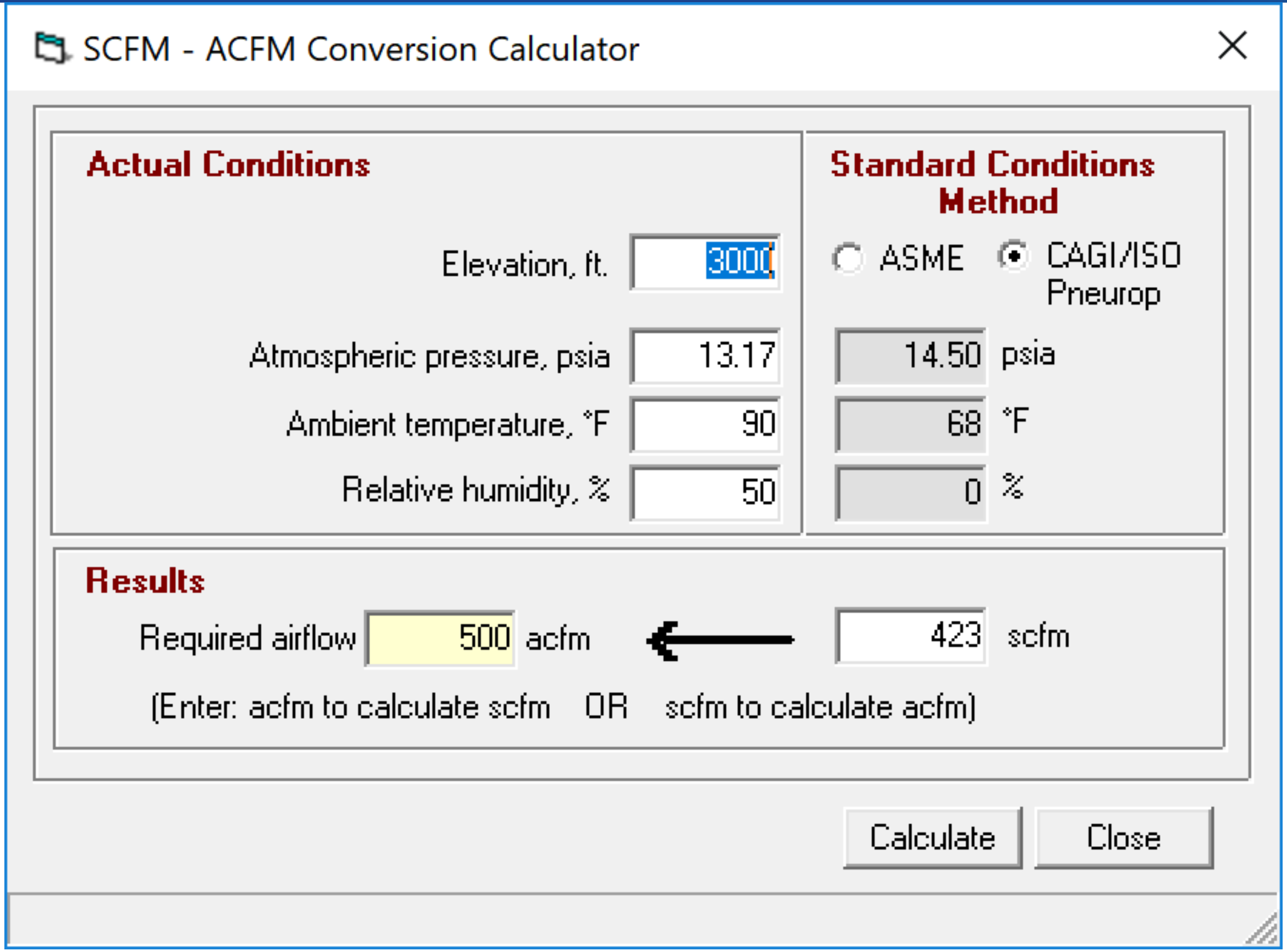

EEM Savings Scenario - leak reduction and add VSD
EEM Savings Scenario - leak reduction and add VSD
Week Day
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Airflow, acfm
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
System Baseline
After All Measures
Scale Adjust
Compressor
<System>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

Air Storage Capacity Calculator

Measured Test Conditions

Elevation, ft.	3000
Atmospheric pressure, psia	13.17
Compressor capacity, acfm	500
Full load or cut-in pressure, psig	100.0
Unload or cut-out pressure, psig	110.0
Pump-up time, sec.	30
Drain-down time, sec.	15

Results

Air storage capacity (receivers + distribution pipe), ft3	109.8

Close

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Cycle Time Calculator

Actual Conditions

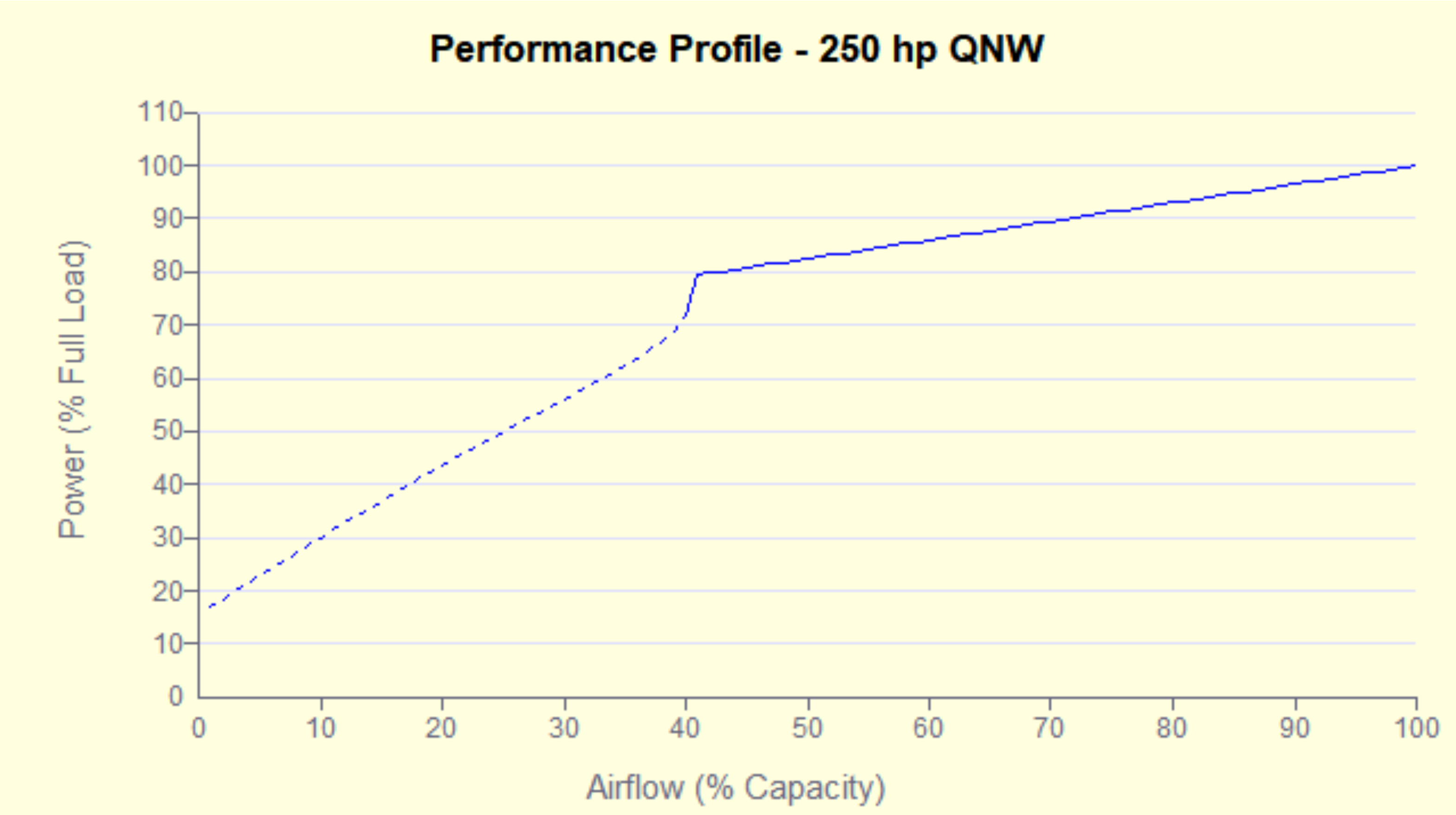
Elevation, ft.	3000
Atmospheric pressure, psia	13.17
Compressor capacity, acfm	500
System airflow requirement, acfm	400
System volume, cubic feet	109.0
Full load or cut-in pressure, psig	100.0
Unload or cut-out pressure, psig	110.0

Results

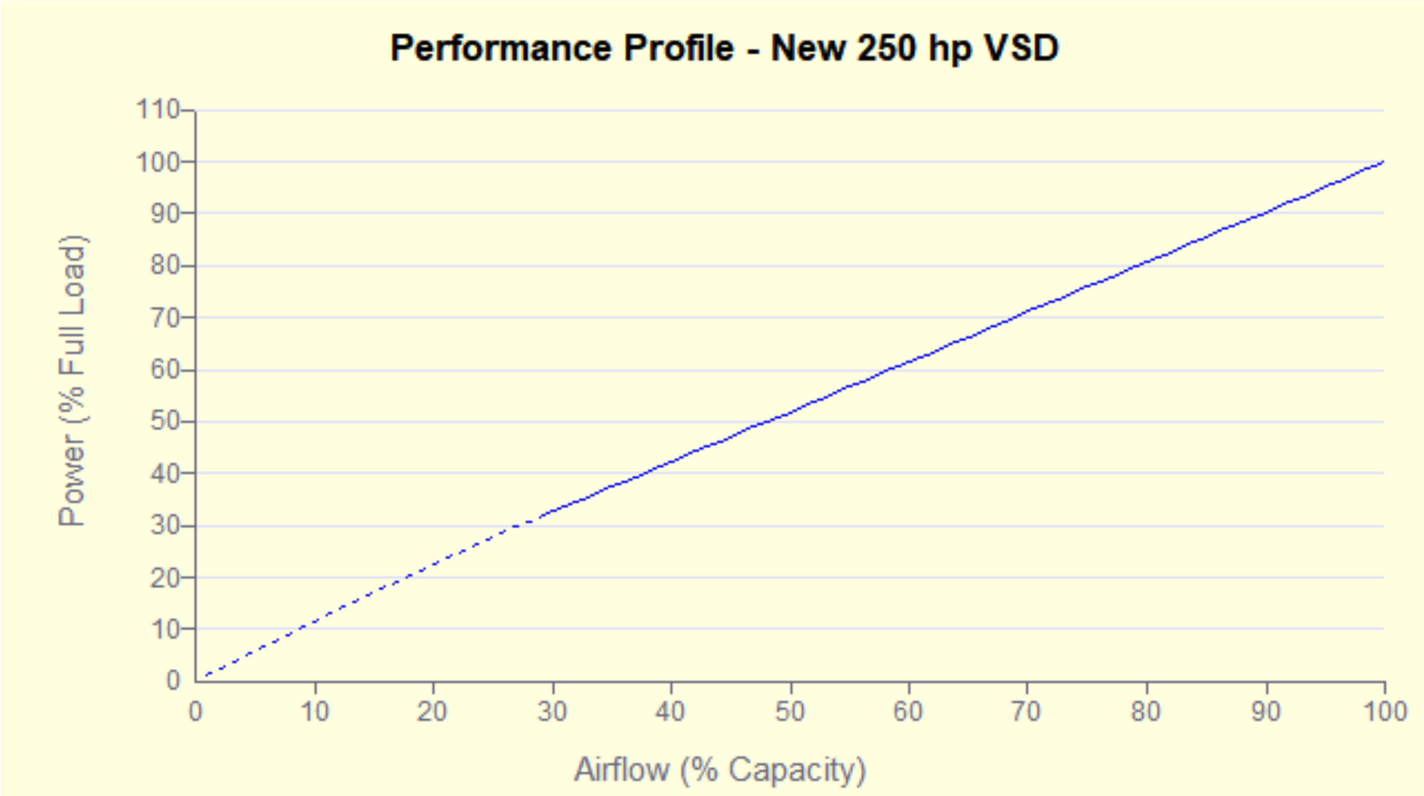
Pump-up time, sec.	50.0
Drain-down time, sec.	12.0
Total cycle time, sec.	62.0

Close

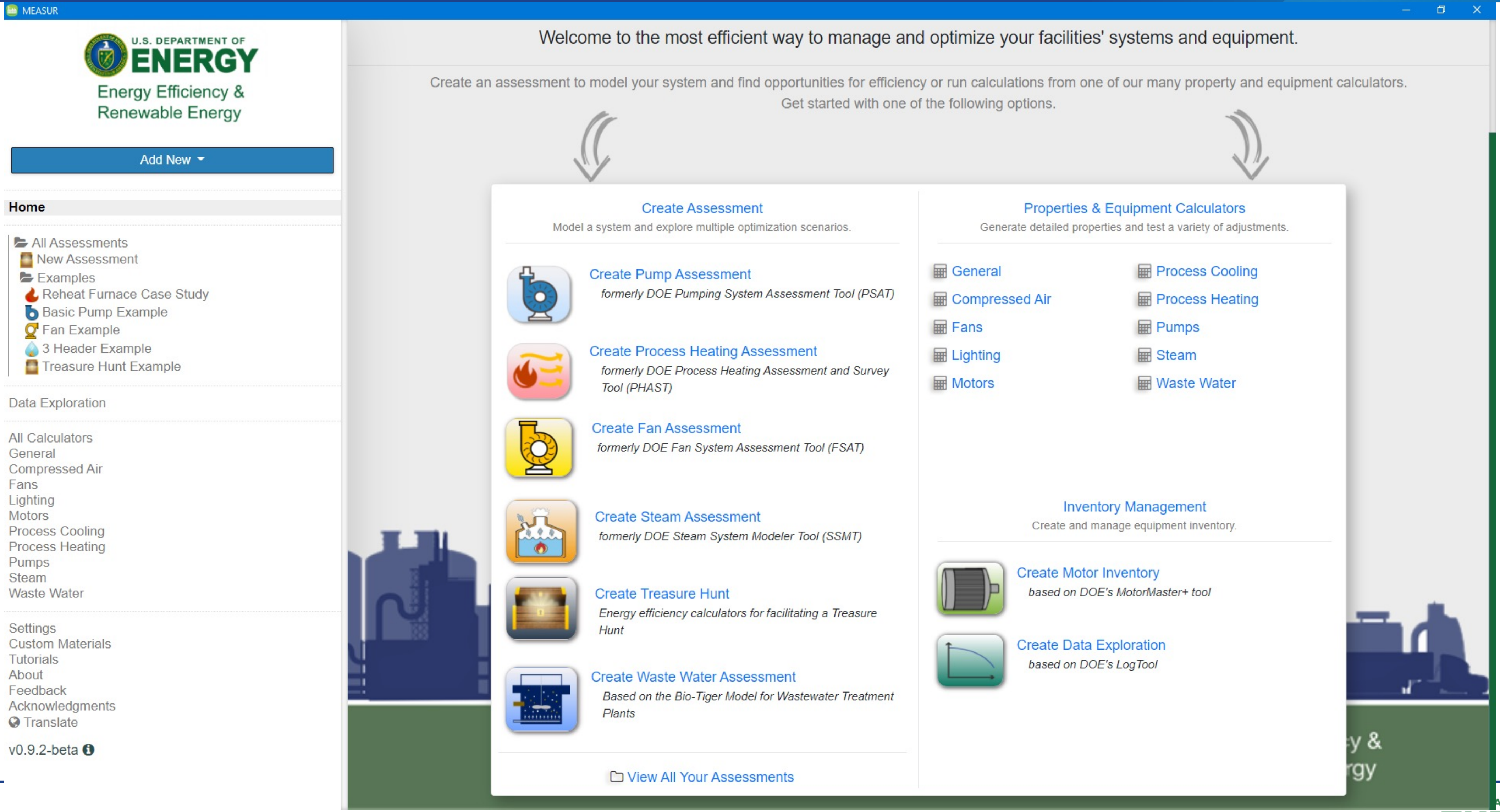
Performance Profile Graph



VSD Performance Graph



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

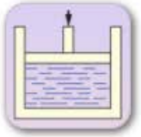
Compressed Air Calculators

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

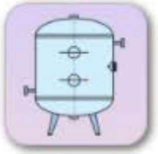


Pneumatic Air Requirement
Estimate the quantity of air required by a specific single acting or a double acting piston cylinder compressor

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

MEASUR Tool

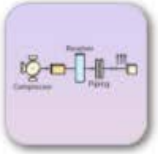
Receiver Tank Sizing
Calculate the required size of the receiver tank



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

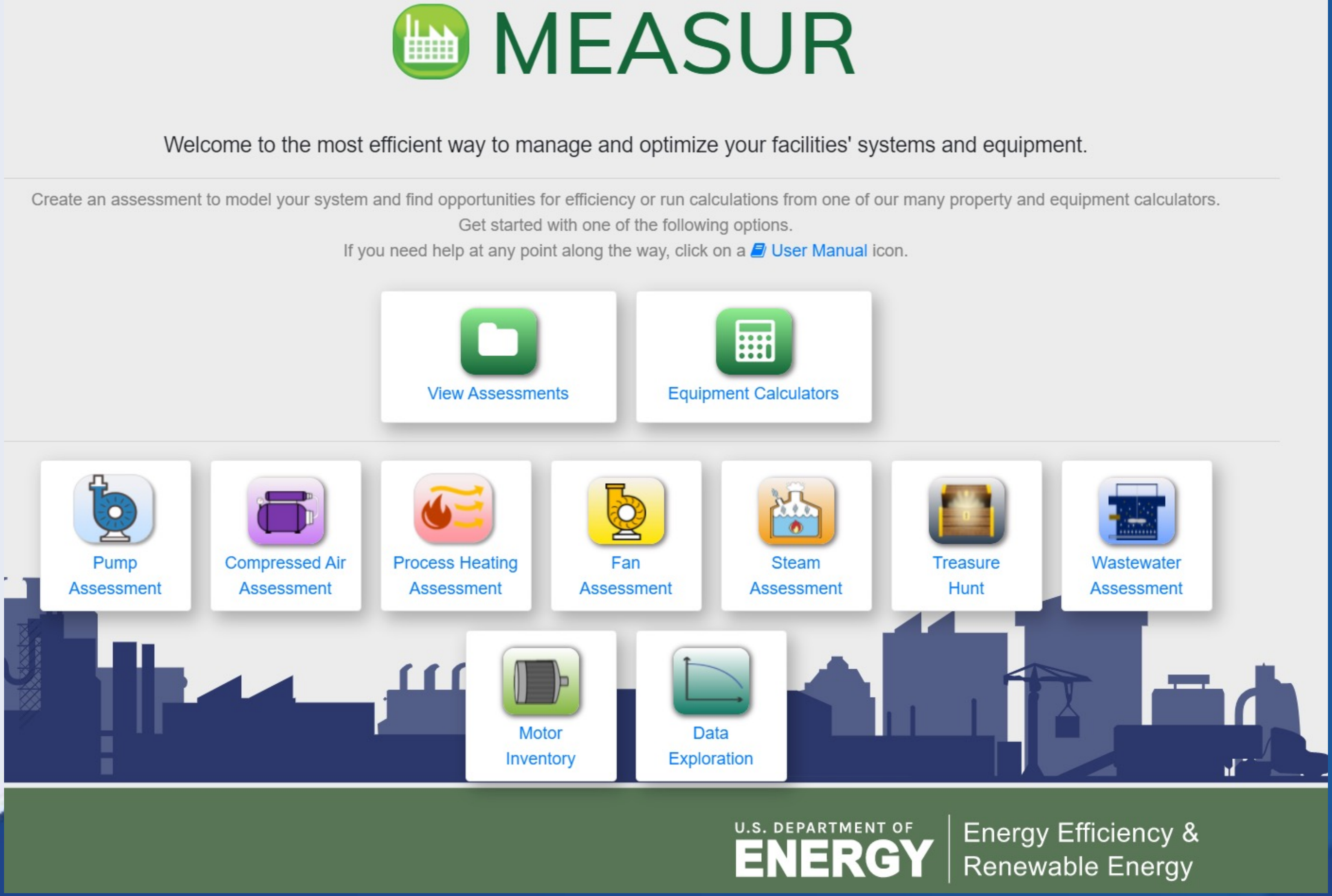
Velocity in the Piping
Estimate the velocity of compressed air throughout system piping



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

MEASUR Tool



- Let's go live to see how the MEASUR Tool works

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.

Questions?

U.S. DEPARTMENT OF ENERGY