Free Air Delivered

Jim Timmersman, D.O.E. AirMaster+ Certified
Power Supply Industries

What to expect today

- Compressed Air Systems
- Block Diagramming
- Maximizing Energy Savings
- Compressor Efficiency
- Temperature & Water Control
- The Right Compressor

Where is all of my compressed air going?

How to…

…determine leakage without measurement or detection
…use existing power company incentives to fix & repair leakage turn key
…measure leakage
…measure waste & inappropriate uses
…prevent leaks

Where is all of my compressed air going?

How to determine leakage without measurement or detection

Photo Credit: https://spotlight.lehigh.edu/content/full-steam-ahead-using-new-performance-draft-book

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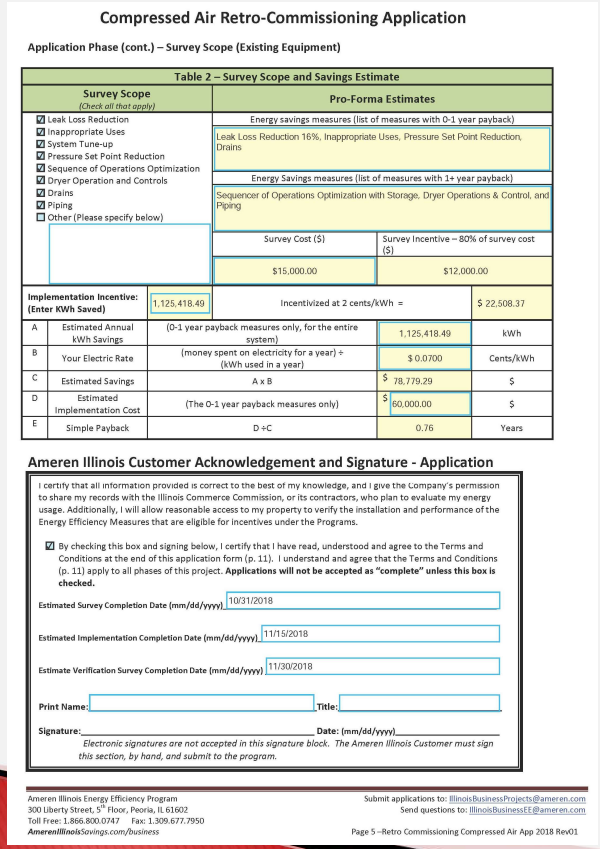

Compressed Air Retro-Commissioning Application

Application Phase (cont.) – Survey Scope (Existing Equipment)

Table 2 – Survey Scope and Savings Estimate				
Survey Scope *(Check all that apply)*		**Pro-Forma Estimates**		
☑ Leak Loss Reduction ☑ Inappropriate Uses ☑ System Tune-up ☑ Pressure Set Point Reduction ☑ Sequence of Operations Optimization ☑ Dryer Operation and Controls ☑ Drains ☑ Piping ☐ Other (Please specify below)		Energy savings measures (list of measures with 0-1 year payback) Leak Loss Reduction 16%, Inappropriate Uses, Pressure Set Point Reduction, Drains Energy Savings measures (list of measures with 1+ year payback) Sequencer of Operations Optimization with Storage, Dryer Operations & Control, and Piping		
		Survey Cost ($)	Survey Incentive – 80% of survey cost ($)	
		$15,000.00	$12,000.00	
Implementation Incentive: (Enter KWh Saved)	1,125,418.49	Incentivized at 2 cents/kWh =		$ 22,508.37
A	Estimated Annual kWh Savings	(0-1 year payback measures only, for the entire system)	1,125,418.49	kWh
B	Your Electric Rate	(money spent on electricity for a year) ÷ (kWh used in a year)	$ 0.0700	Cents/kWh
C	Estimated Savings	A x B	$ 78,779.29	$
D	Estimated Implementation Cost	(The 0-1 year payback measures only)	$ 60,000.00	$
E	Simple Payback	D ÷C	0.76	Years

Ameren Illinois Customer Acknowledgement and Signature - Application

I certify that all information provided is correct to the best of my knowledge, and I give the Company's permission to share my records with the Illinois Commerce Commission, or its contractors, who plan to evaluate my energy usage. Additionally, I will allow reasonable access to my property to verify the installation and performance of the Energy Efficiency Measures that are eligible for incentives under the Programs.

☑ By checking this box and signing below, I certify that I have read, understood and agree to the Terms and Conditions at the end of this application form (p. 11). I understand and agree that the Terms and Conditions (p. 11) apply to all phases of this project. **Applications will not be accepted as "complete" unless this box is checked.**

Estimated Survey Completion Date (mm/dd/yyyy) 10/31/2018

Estimated Implementation Completion Date (mm/dd/yyyy) 11/15/2018

Estimate Verification Survey Completion Date (mm/dd/yyyy) 11/30/2018

Print Name: _____ **Title:** _____

Signature: _____ **Date: (mm/dd/yyyy)** _____

Electronic signatures are not accepted in this signature block. The Ameren Illinois Customer must sign this section, by hand, and submit to the program.

Compressed Air Retro-Commissioning Application

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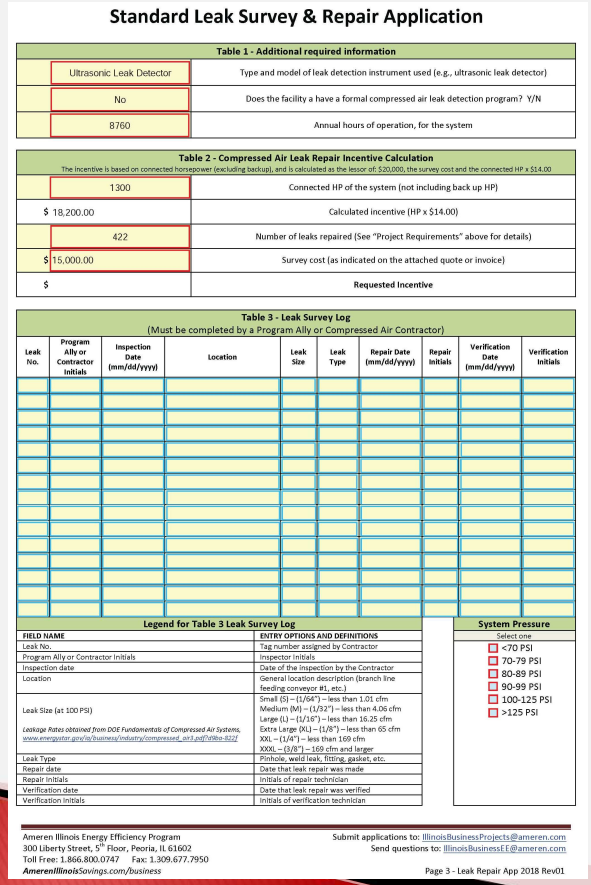
How to use existing power company incentives to fix & repair leakage turn key



Standard Leak Survey & Repair Application

Table 1 - Additional required information	
Ultrasonic Leak Detector	Type and model of leak detection instrument used (e.g., ultrasonic leak detector)
No	Does the facility a have a formal compressed air leak detection program? Y/N
8760	Annual hours of operation, for the system

Table 2 - Compressed Air Leak Repair Incentive Calculation The incentive is based on connected horsepower (excluding backup), and is calculated as the lessor of: $20,000, the survey cost and the connected HP x $14.00	
1300	Connected HP of the system (not including back up HP)
$ 18,200.00	Calculated incentive (HP x $14.00)
422	Number of leaks repaired (See "Project Requirements" above for details)
$ 15,000.00	Survey cost (as indicated on the attached quote or invoice)
$	**Requested Incentive**

Table 3 - Leak Survey Log
(Must be completed by a Program Ally or Compressed Air Contractor)

Leak No.	Program Ally or Contractor Initials	Inspection Date (mm/dd/yyyy)	Location	Leak Size	Leak Type	Repair Date (mm/dd/yyyy)	Repair Initials	Verification Date (mm/dd/yyyy)	Verification Initials

Legend for Table 3 Leak Survey Log	
FIELD NAME	**ENTRY OPTIONS AND DEFINITIONS**
Leak No.	Tag number assigned by Contractor
Program Ally or Contractor Initials	Inspector Initials
Inspection date	Date of the inspection by the Contractor
Location	General location description (branch line feeding conveyor #1, etc.)
Leak Size (at 100 PSI) *Leakage Rates obtained from DOE Fundamentals of Compressed Air Systems, www.energystar.gov/ia/business/industry/compressed_air3.pdf?d8bc-822f*	Small (S) – (1/64") – less than 1.01 cfm Medium (M) – (1/32") – less than 4.06 cfm Large (L) – (1/16") – less than 16.25 cfm Extra Large (XL) – (1/8") – less than 65 cfm XXL – (1/4") – less than 169 cfm XXXL – (3/8") – 169 cfm and larger
Leak Type	Pinhole, weld leak, fitting, gasket, etc.
Repair date	Date that leak repair was made
Repair Initials	Initials of repair technician
Verification date	Date that leak repair was verified
Verification Initials	Initials of verification technician

System Pressure
Select one
- ☐ <70 PSI
- ☐ 70-79 PSI
- ☐ 80-89 PSI
- ☐ 90-99 PSI
- ☐ 100-125 PSI
- ☐ >125 PSI

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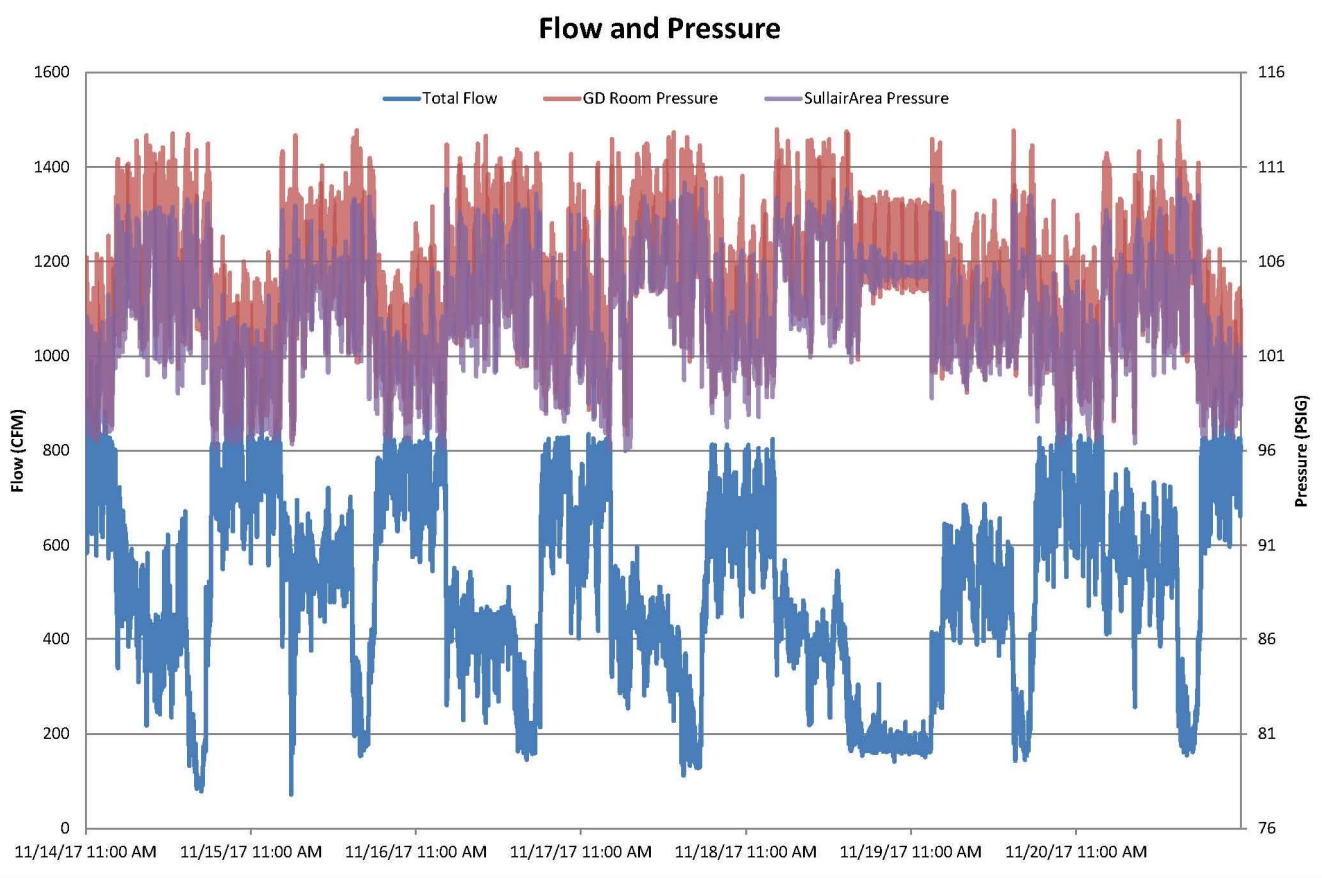
How to use existing power company incentives to fix & repair leakage turn key

Where is all of my compressed air going?

How to measure leakage

Where is all of my compressed air going?

How to measure waste and inappropriate uses



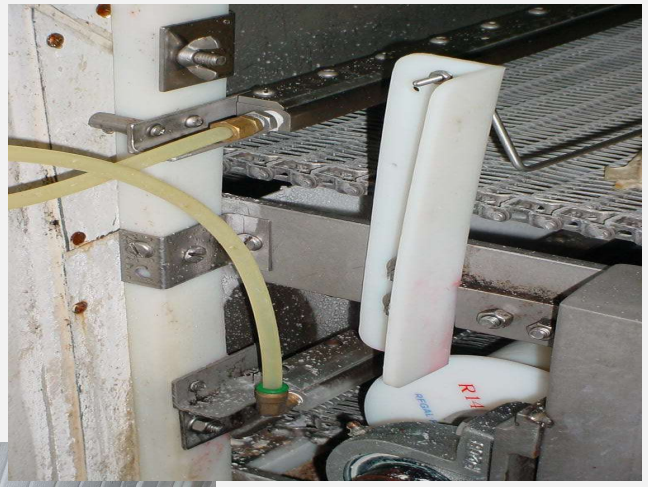
Where is all of my compressed air going?

How to measure waste and inappropriate uses

Air Nozzles

Where is all of my compressed air going?

How to measure waste and inappropriate uses



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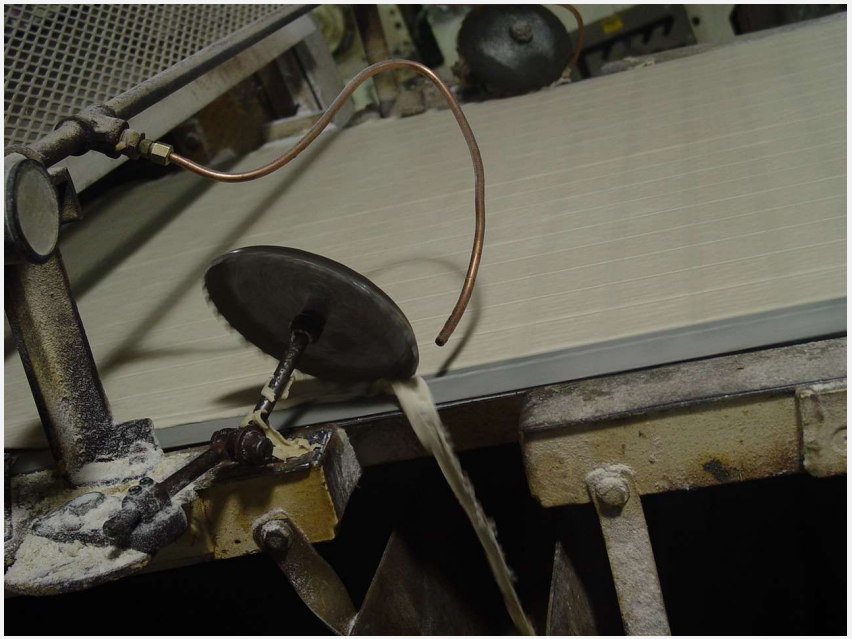

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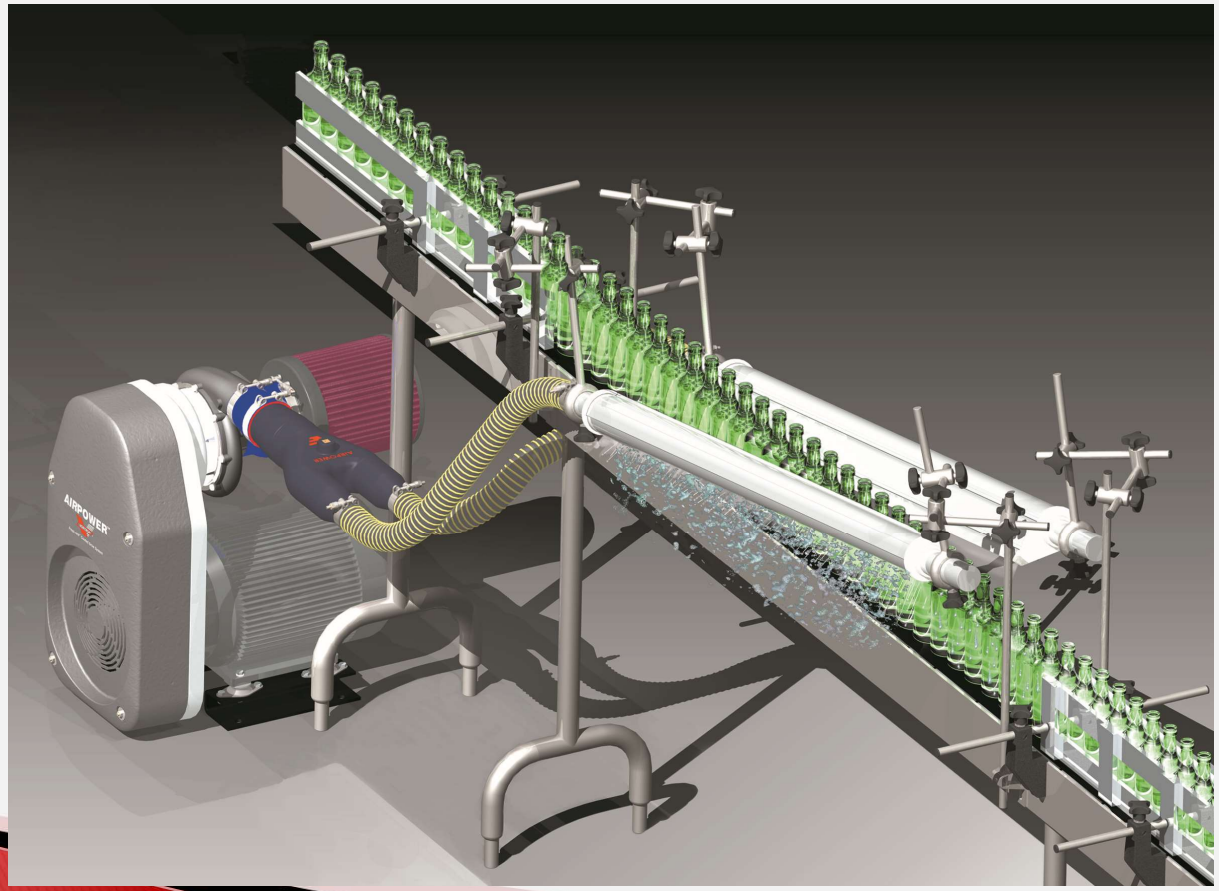


Where is all of my compressed air going?

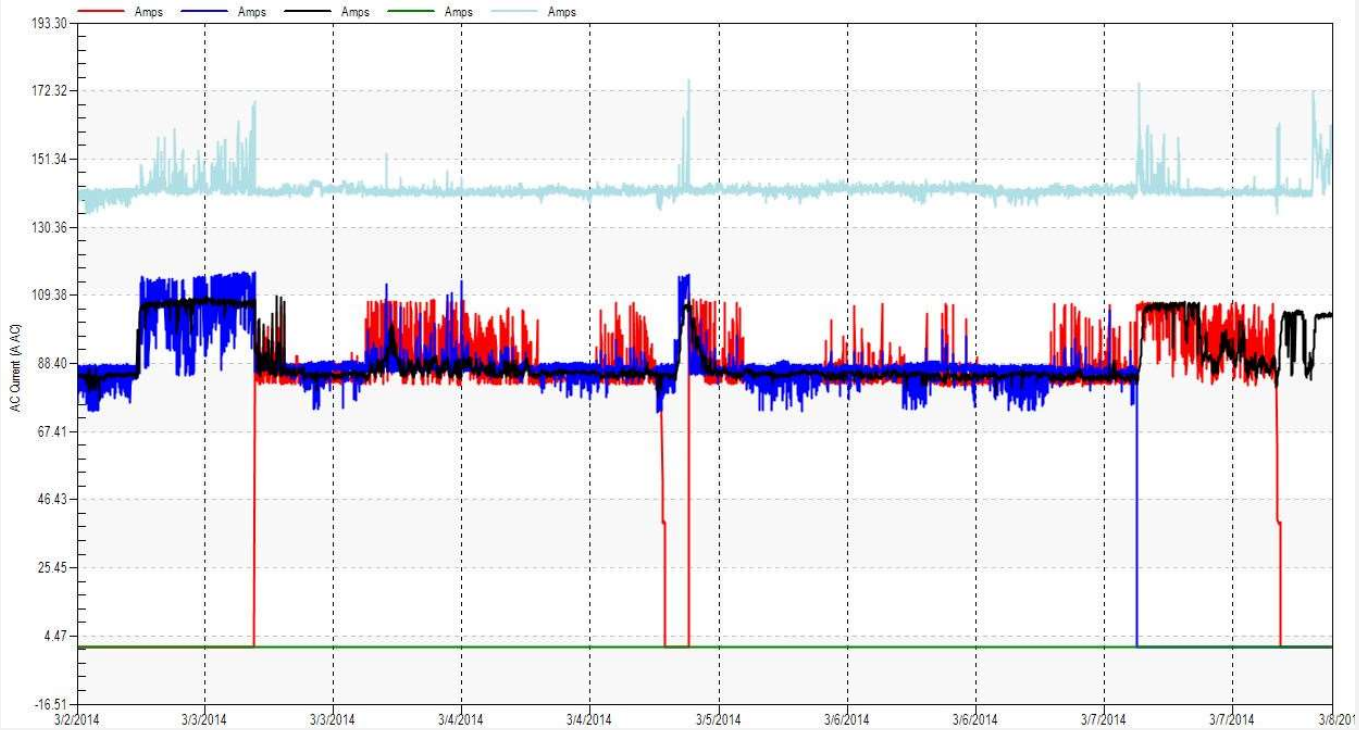
How to prevent leaks

Auditing your own compressed Air system

- Turn it off using compressor sequencing
- Compressor controls including VSD
- Compressor measurement
- Storage calculations

Auditing your own compressed air system

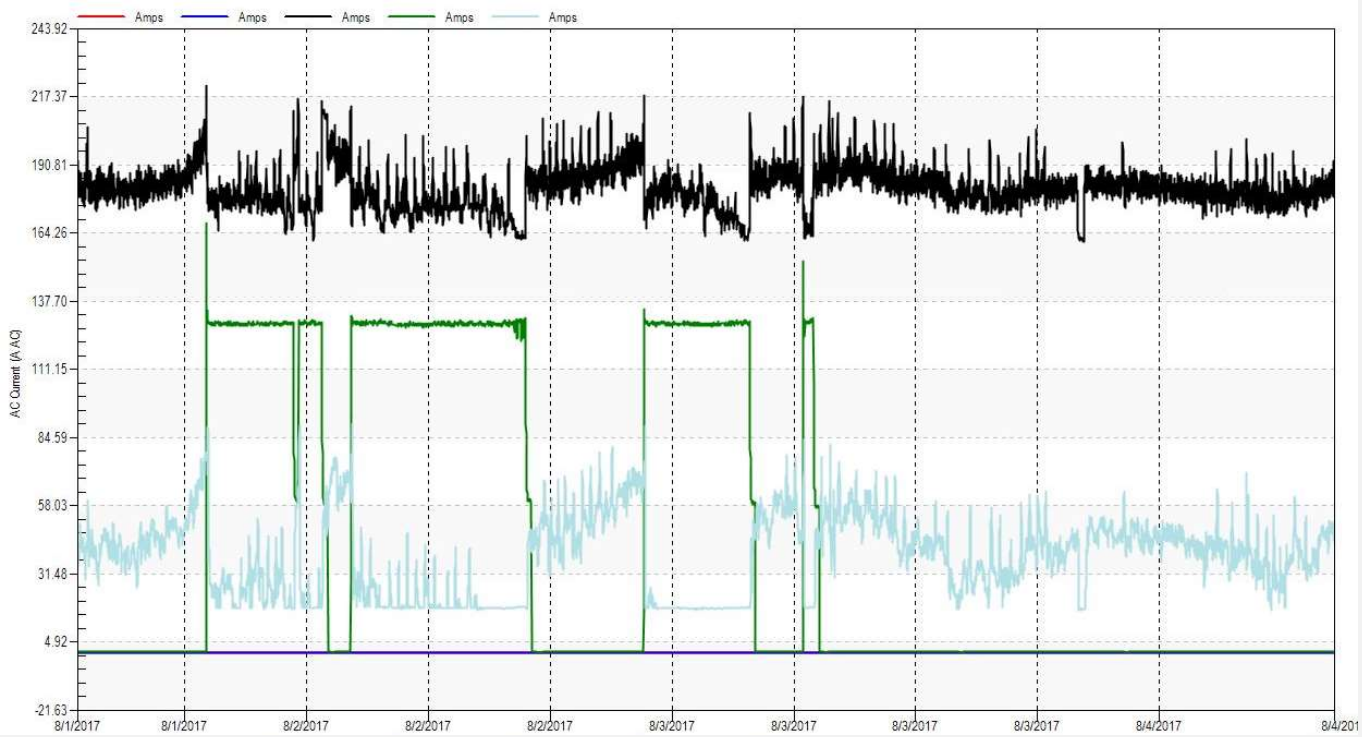
Turn it off using compressor sequencing



BEFORE

Auditing your own compressed air system

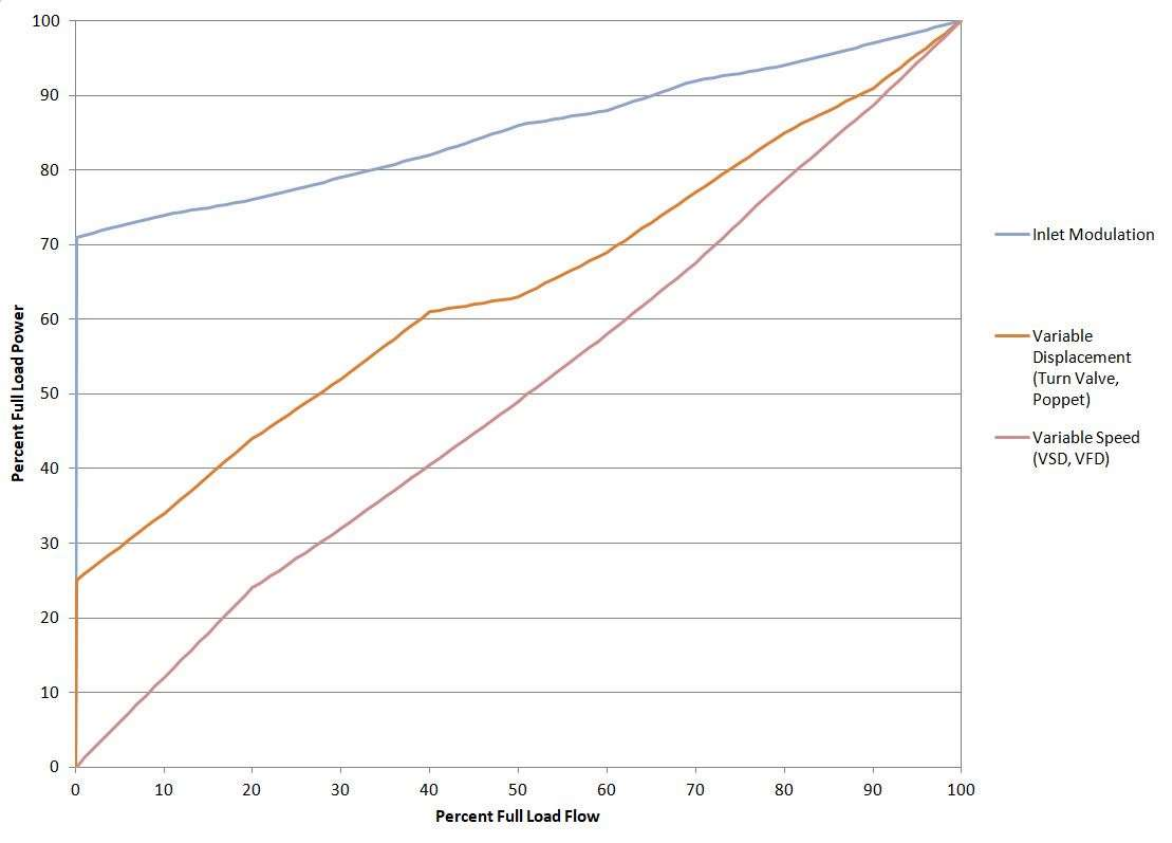
Turn it off using compressor sequencing



AFTER

Auditing your own compressed air system

Compressor controls including VSD



Auditing your own compressed air system

Compressor Measurement

VPFlowScope dP

> Extreme resistance to pollution and water drops
> Mass Flow, Pressure & Temperature
> Display/data logger module for easy recording of data

VPFlowScope dP

The VPFlowScope dP is designed for wet air[1]. When properly applied, it can be used in the discharge of the compressor. The VPFlowScope dP is fully compatible with the standard VPFlowScope, which means that it is easy to install and operate without additional training.

Typical applications

- Wet air, untreated compressed air[1]
- High temperature up to 150 °C (302 °F)
- High velocity applications (undersized pipes)

Auditing your own compressed air system

Storage Calculations

System Capacitence Analysis

Date	Jul 22 2002
Customer	**Sample**
Project	Compressor Addition

Pipe Size	CF / ft run	Length	cf / bar	cf/psig
1	0.0055		0.0	0.0
2	0.0218		0.0	0.0
3	0.0491		0.0	0.0
4	0.0872	500	43.6	3.0
5	0.1363		0.0	0.0
6	0.1963	600	117.8	8.1
8	0.3489		0.0	0.0
10	0.5451		0.0	0.0
12	0.7850		0.0	0.0
Total Piping Capcitence			161.4	11.1

Rec Gals	Rec CF	Qty	cf / bar	cf / psig
200	26.7		0.0	0.0
400	53.5		0.0	0.0
600	80.2		0.0	0.0
1000	133.7		0.0	0.0
1500	200.5		0.0	0.0
2000	267.4	2	534.8	36.9
3000	401.1		0.0	0.0
4000	534.8		0.0	0.0
5000	668.4		0.0	0.0
Total Receiver Capacitence			534.8	36.9
Total System Capacitence			**696.1**	**48.0**

Block diagram what should you look for?

- Air line header sizing
- Power & Flow metering total flow
- Nameplate Horsepower & actual BHP
- Denote trim & base units
- Denote VSD & load unload
- Show storage capacitance as a measurement of time

Block Diagram what should you look for?

Air Line Header Sizing

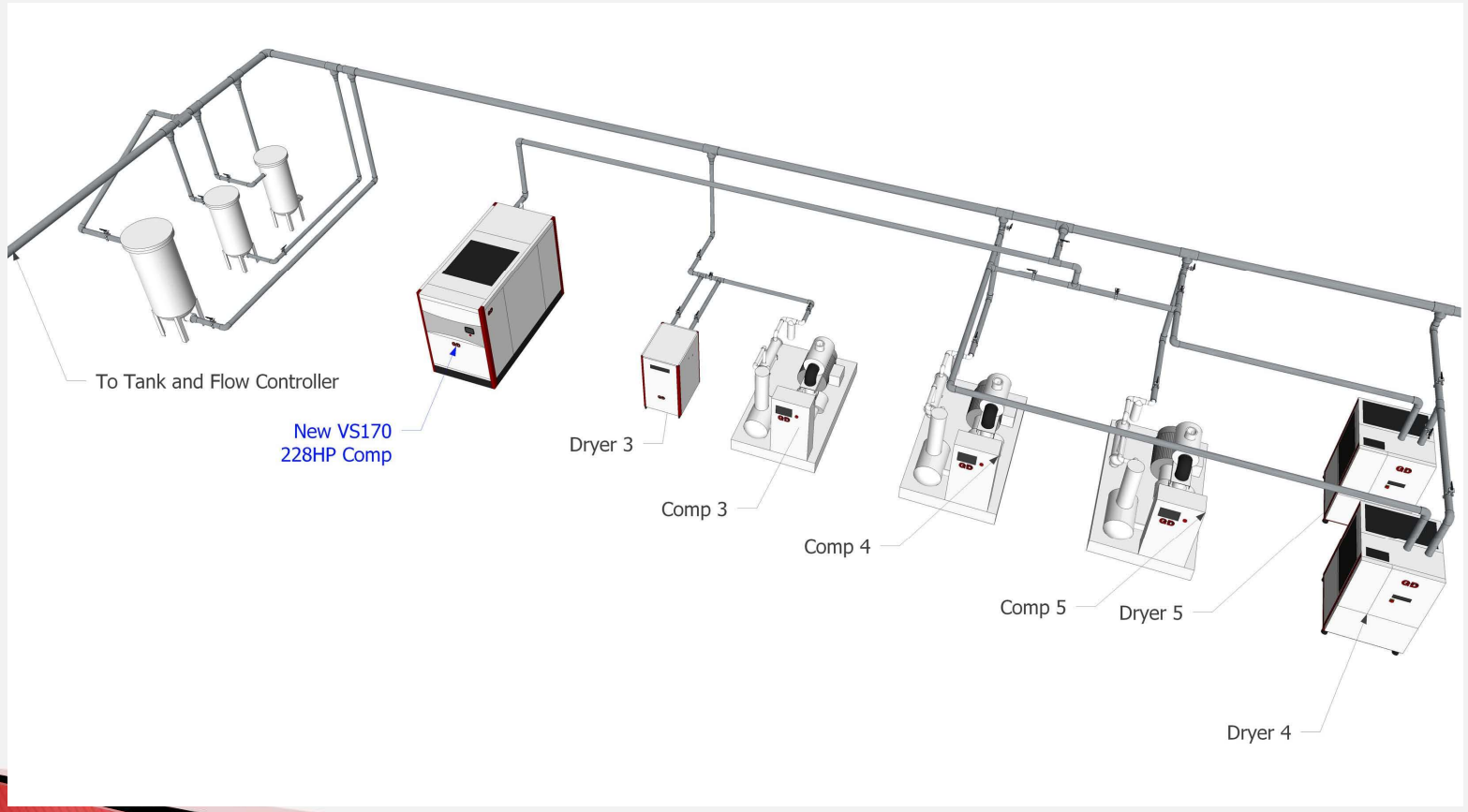
Schedule 40 Black Iron Pipe

	CFM	CFM
Pipe Size	20 FPS	40 FPS
1"	45	89
2"	178	356
3"	401	801
4"	712	1,425
6"	1,603	3,206
8"	2,850	5,699
10"	4,453	8,905

Aluminum Pipe

	CFM	CFM
Pipe Size	@ 125 PSIG	@ 150PSIG
25mm	76	81
50mm	476	526
90mm	2,162	2,364
115mm	4,205	4,591
168mm	11,194	12,153
220mm	23,169	25,279
273mm	36,010	39,356

Block Diagram what should you look for?



Block Diagram what should you look for?

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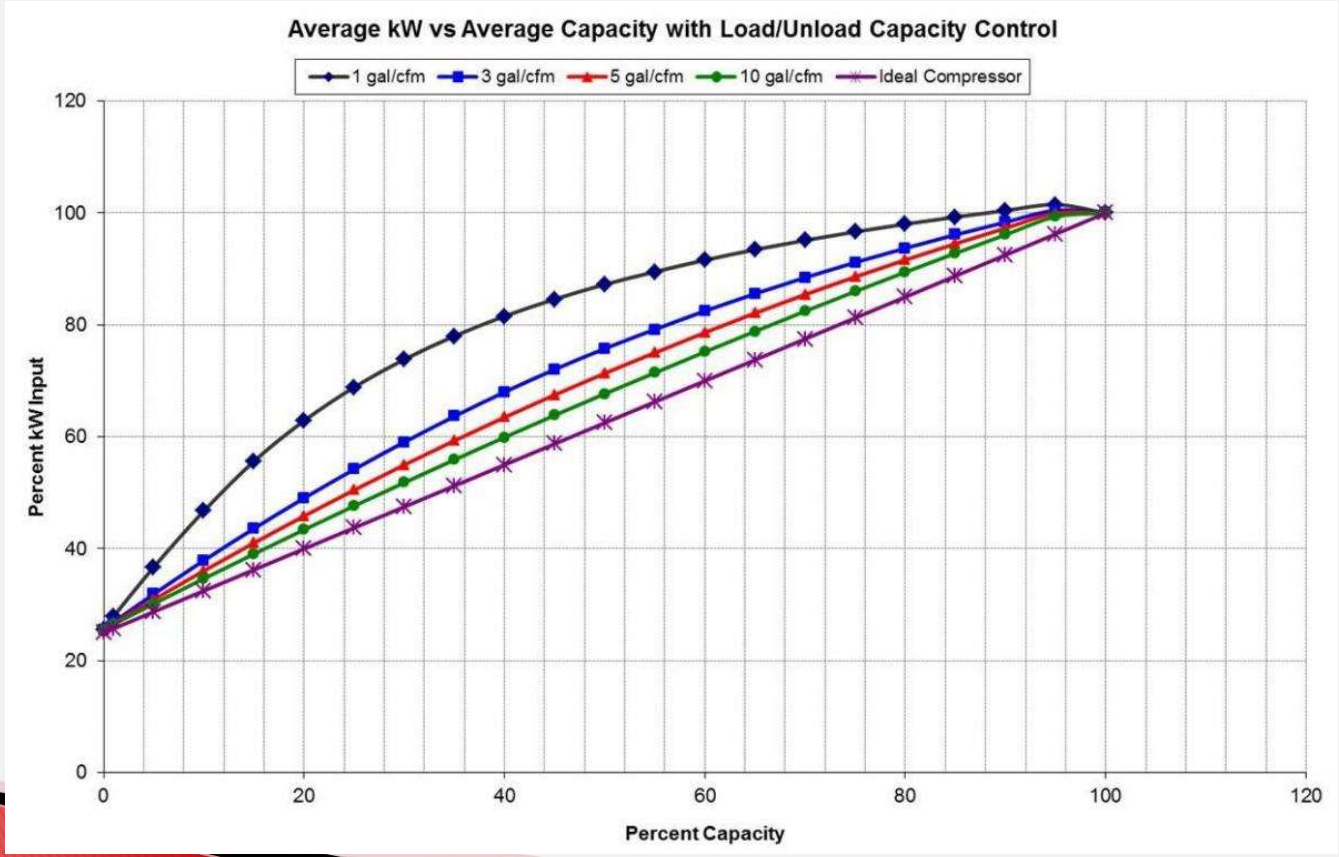


Who designed and piped this air system?

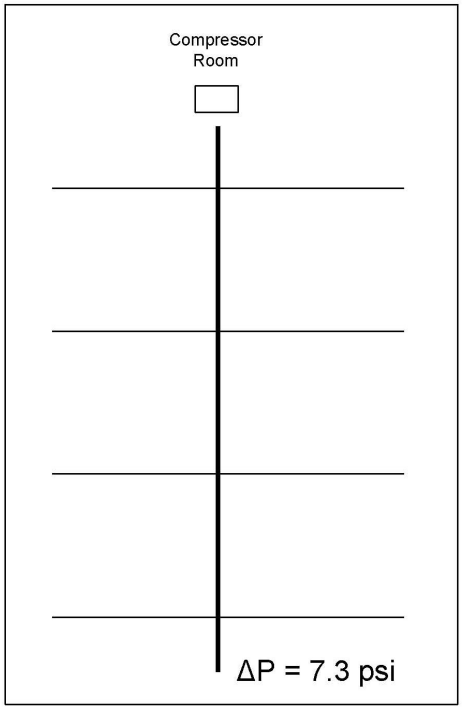
- Do you have a Johnny Cash special one different size pipe for each year and expansion?
- Do you have a central loop or a dead end header?
- Are your headers sized for current peak demands?
- Have your checked your dynamic point of use pressures?
- Are you using smooth wall non-corrosive pipe to reduce pressure loss?

Who designed and piped this air system?

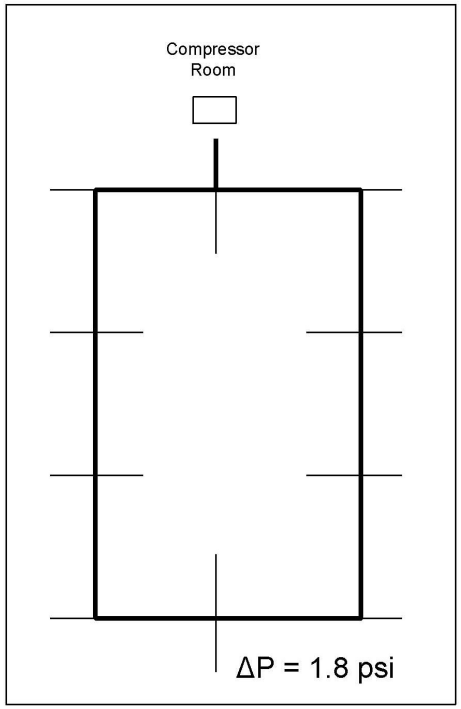
Johnny Cash Special – Different Size Pipe for each Year & Expansion

Who designed and piped this air system?

Central Loop or Dead End Header?



Straight Line Distribution Piping With Branches to End Uses
Air Supplied From One Direction Only

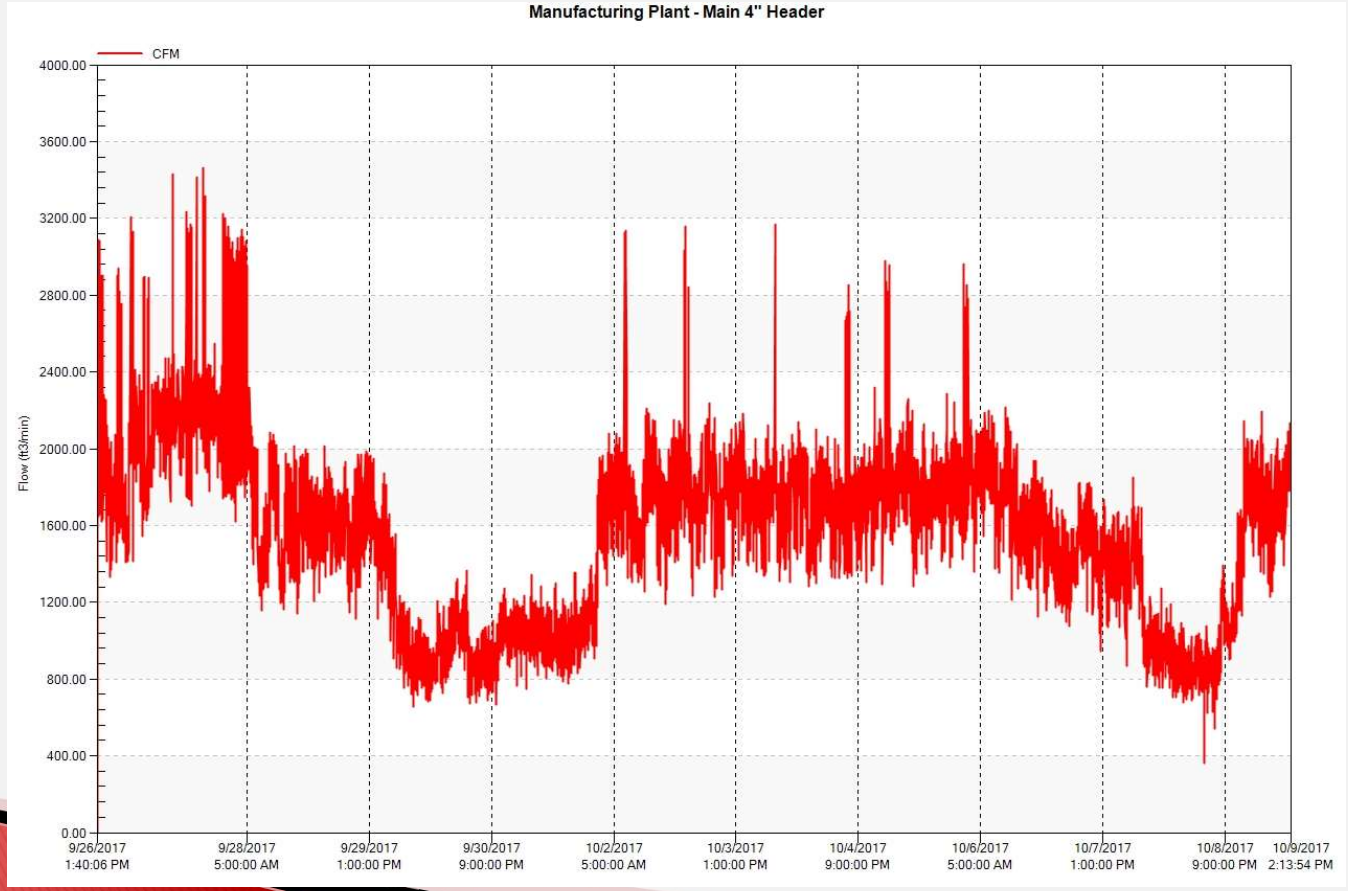


Looped Distribution Piping With Drops to End Uses
Air Supplied From Two Directions

Example: 2000 CFM Flows through 4 inch headers from the Compressor Room to the opposite end of the Plant. The straight line system has a pressure drop of about 7.3 psi, while the loop system has a pressure drop of only about 1.8 psi.

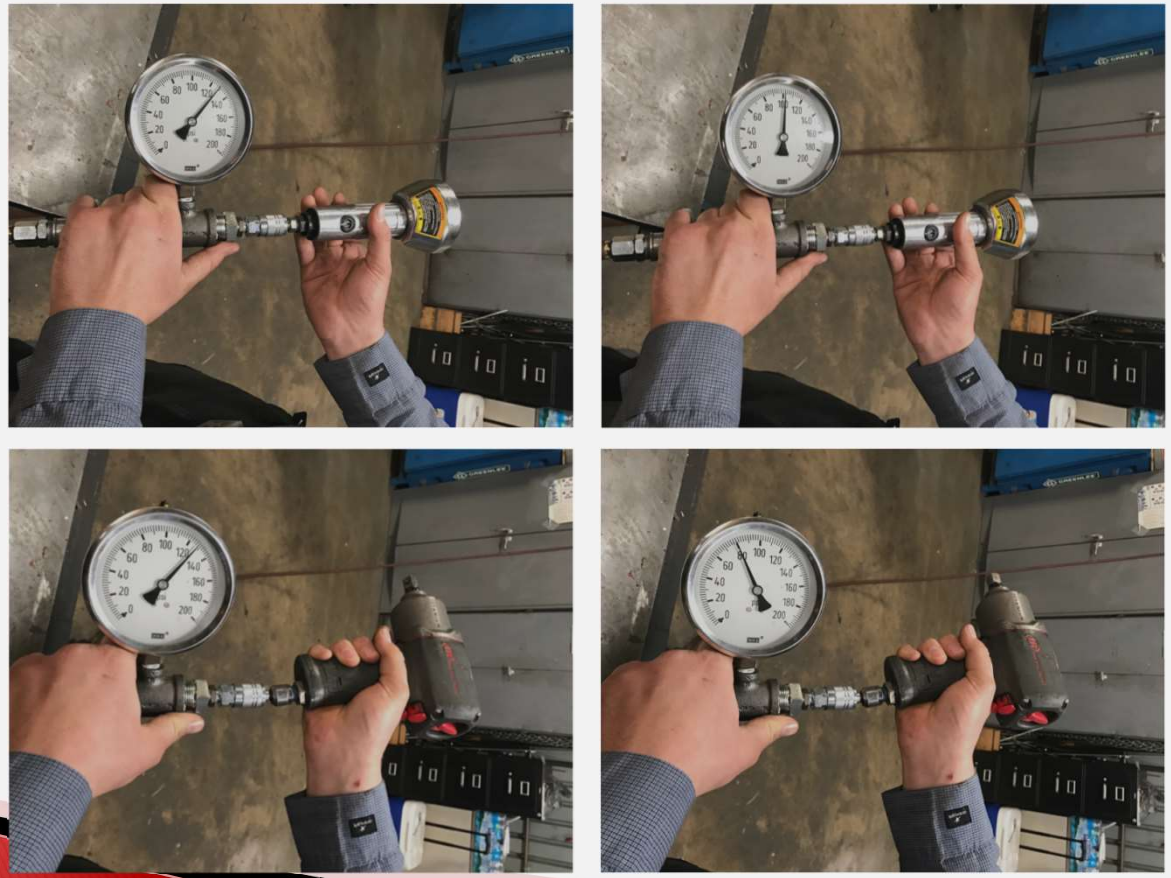
Who designed and piped this air system?

Are your headers sized for current peak demands?



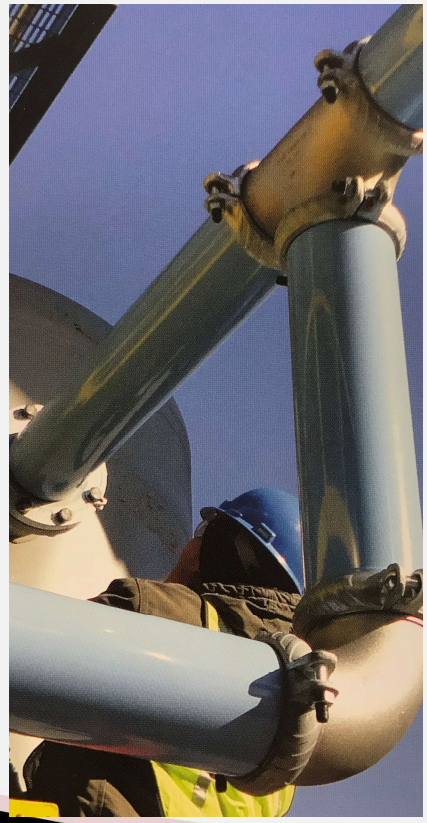
Who designed and piped this air system?

Have you checked your dynamic point of use pressures?



Who designed and piped this air system?

Are you using smooth wall non corrosive pipe to reduce pressure loss?



How to squeeze out every ounce of energy savings

- Measure plant air fluctuations 2 PSI = 1%
- Check the plant air piping & determine ΔP
- Decrease the time interval of compressor inlet filters
- Decrease the interval on clean up filtration (Kraft 104)
- Consider adding storage & pressure controls
- Consider adding VSD & storage

How to squeeze out every ounce of energy savings

Measure plant air fluctuations 2PSI = 1%

Kraft - Supply Side Analysis - Existing System

	Compressor Data							
	Comp 1	~~Comp 2~~	Comp 3	Comp 4	Comp 5	Comp 6	Comp 7	Comp 8
Nom HP	350	~~100~~	300	350	350	350	350	350
Max CFM	1671.00	~~450~~	1481	1671	1528	1528	1671	1671
Max kW	261.60	~~89.5~~	234.4	253.3	296.8	296.8	238.8	242.5
Max BHP	326.1	~~111.6~~	292.2	315.8	370.0	370.0	297.7	302.3
Control	LNL 25%	~~LNL 40%~~	LNL 25%	LNL 25%	LNL 35%	LNL 35%	LNL 25%	LNL 25%
Ctrl #code	2	~~5~~	2	2	4	4	2	2

Col Ref							Comp 1	~~Comp 2~~	Comp 3	Comp 4	Comp 5	Comp 6	Comp 7	Comp 8
W:W	Flow Profile		Range	freq	%	cfm req	CFM	~~CFM~~	CFM	CFM	CFM	CFM	CFM	CFM
h	8069	2600	<2600	867	2	2300				1671.0			629.0	
l	2473	3200	2600-3200	7419	15	2900				1671.0			1229.0	
a	5667	3800	3200-3800	2549	5	3500				1671.0			1671.0	158.0
		4400	3800-4400	1747	3	4100				1671.0			1671.0	758.0
		5000	4400-5000	3704	7	4700				1671.0			1671.0	1358.0
		5600	5000-5600	7251	14	5300				1671.0		287.0	1671.0	1671.0
		6200	5600-6200	3699	7	5900				1671.0	887.0		1671.0	1671.0
		6800	6200-6800	1262	3	6500				1671.0	1200.0	287.0	1671.0	1671.0
		7400	6800-7400	10116	20	7100				1671.0	559.0	1528.0	1671.0	1671.0
		8000	7400-8000	11645	23	7700				1671.0	1528.0	1159.0	1671.0	1671.0
			>8000	141	0	8300				1671.0	1528.0	1528.0	1671.0	1671.0
				50400	100									

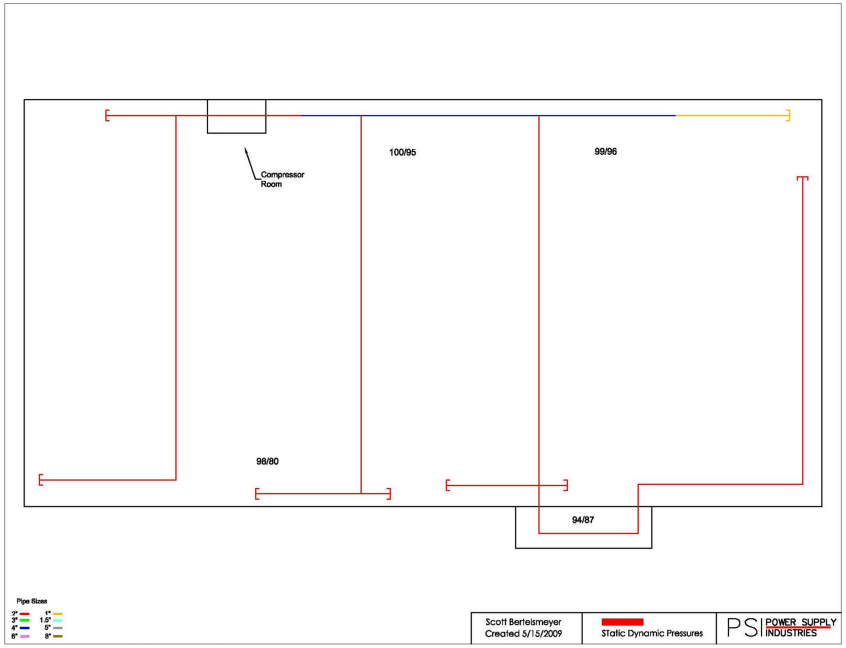
Col Ref						Comp 1	~~Comp 2~~	Comp 3	Comp 4	Comp 5	Comp 6	Comp 7	Comp 8		
C:C	Pressure Profile		Range	freq	%	%FL kW	~~%FL kW~~	%FL kW	%FL kW	%FL kW	%FL kW	%FL kW	%FL kW	Total kW	Total kW*%
h	108	91	<91	492	1	0.0	~~0.0~~	0.0	100.0	0.0	0.0	53.5	0.0	381.1	6.6
l	90	93	91-93	12499	25	0.0	~~0.0~~	0.0	100.0	0.0	0.0	80.5	0.0	445.5	65.6
a	95	95	93-95	23493	47	0.0	~~0.0~~	0.0	100.0	0.0	0.0	100.0	31.8	569.1	28.8
		97	95-97	3910	8	0.0	~~0.0~~	0.0	100.0	0.0	0.0	100.0	58.8	634.6	22.0
		99	97-99	972	2	0.0	~~0.0~~	0.0	100.0	0.0	47.4	100.0	85.8	700.0	51.4
		101	99-101	2496	5	0.0	~~0.0~~	0.0	100.0	72.7	0.0	100.0	100.0	950.4	69.8
		103	101-103	2739	5	0.0	~~0.0~~	0.0	100.0	86.4	47.4	100.0	100.0	1131.4	28.3
		105	103-105	2024	4	0.0	~~0.0~~	0.0	100.0	59.1	100.0	100.0	100.0	1206.7	242.2
		107	105-107	1467	3	0.0	~~0.0~~	0.0	100.0	100.0	84.4	100.0	100.0	1281.9	296.2
		109	107-109	308	1				100.0	100.0	100.0	100.0	100.0	1328.2	3.7
			>109	0	0				253.27	130.74	145.11	229.21	186.37		940.4
				50400	100				253.3	126.8373	142.0181	230.0352	188.2543		
									0.0%	-3.0%	-2.1%	0.4%	1.0%		

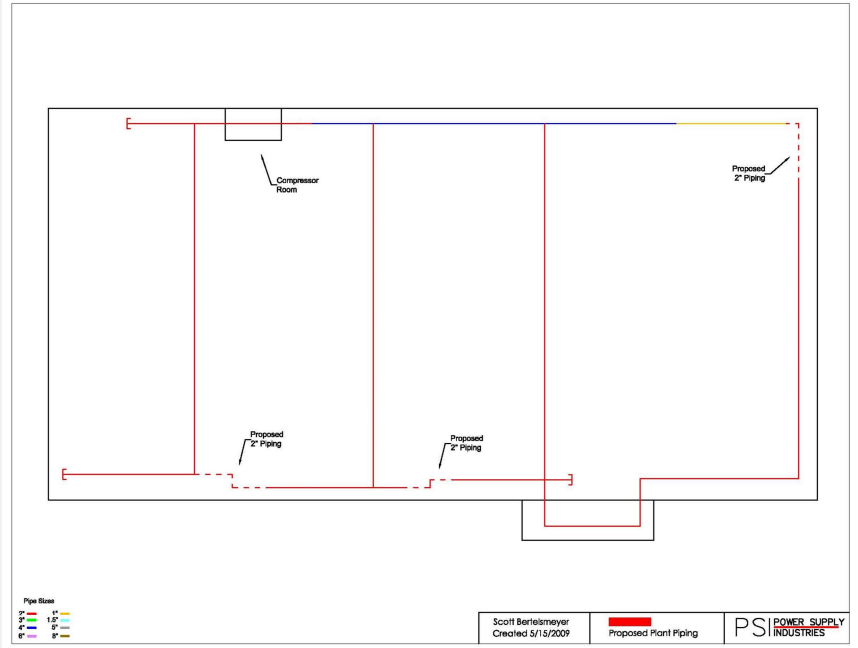
System Energy Summary

940.4	kw=from analysis at left
1172.4	hp=hp*(1kw/.746hp)*(.93eff)
5,667	cfm=from avg cfm above
0.06	$/kwh=from customer
8760	hours/yr
8,238,298	kwh=kw*(hours/yr)
6.0	cfm/kw=cfm/kw
$494,298	$/Year=kwh*$/kwh

How to squeeze out every ounce of energy savings

Check plant air piping & determine ΔP



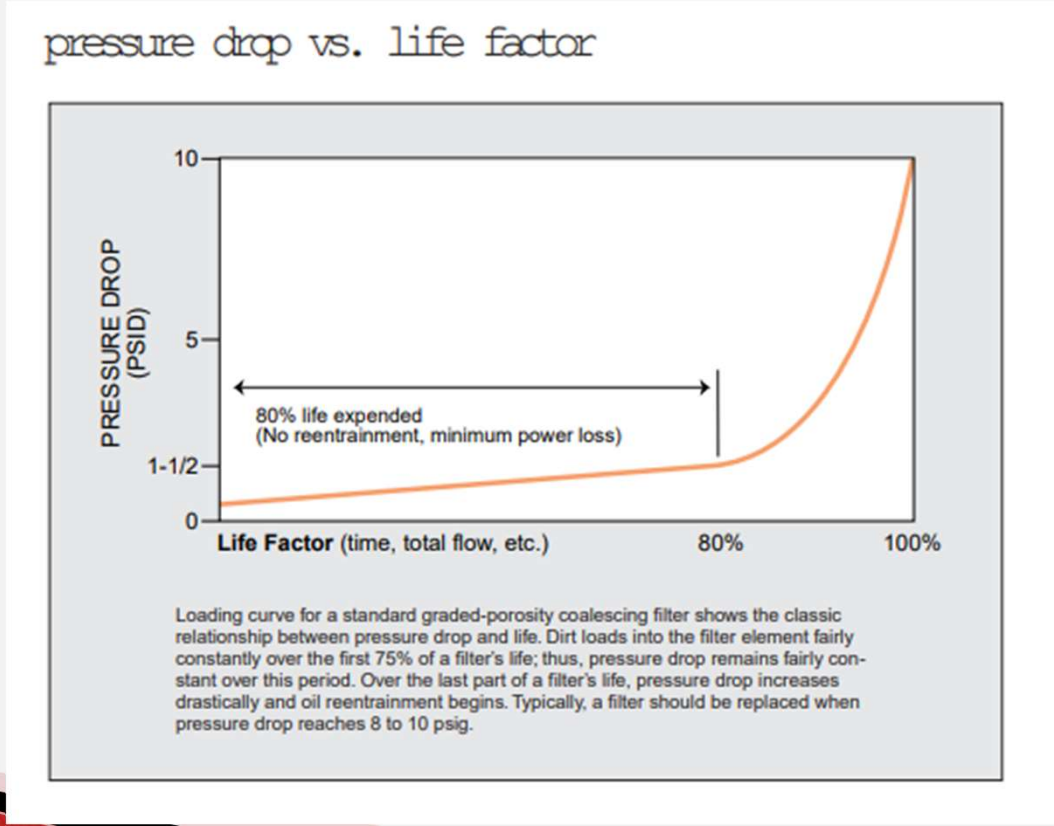


HOW TO SQUEEZE OUT EVERY OUNCE OF ENERGY SAVINGS

Decrease the time interval on compressor inlet filters

HOW TO SQUEEZE OUT EVERY OUNCE OF ENERGY SAVINGS

Decrease the interval on clean up filtration



HOW TO SQUEEZE OUT EVERY OUNCE OF ENERGY SAVINGS

Decrease the interval on clean up filtration

Supplying Air Under Pressure in Contact With Products and Product Contact Surfaces – Compressed Air

Kraft Foods Sanitary Accepted Practice Number 104

It is the purpose of the KF Sanitation and Engineering Departments in connection with the development of the KF Sanitary Standards Program to allow and encourage full freedom for inventive genius or new developments. Equipment specifications heretofore or hereafter developed which so differ in design, materials, and fabrication, or otherwise, as not to conform to the following standards, but which, in the manufacturer's or fabricator's opinion, are equivalent or better, may be submitted for the joint consideration of the KF Sanitation, and Engineering Departments at any time.

This standard shall be used for ALL Kraft Foods products (in all divisions) where compressed air will contact Products and/or Product Contact surfaces. This standard will be used in place of 3A-604- Supplying Air Under Pressure, as it meets or exceeds the 3A-604 compressed air standards.

D5 *Moisture Removal*

D5.1 Air under pressure system in excess of 15 psig or 1.03 bar shall be provided with methods of moisture removal. The removal of moisture may be achieved by condensation and coalescing filtration, or absorption into filter (desiccant), or equivalent to prevent free water in the system.

D5.2 Compressed Air shall be dried to a pressure dew point of 37degrees Fahrenheit or to 20 degrees Fahrenheit below the lowest temperature the distribution piping system will be exposed to, whichever dew point is lower.

Table A - Compressed Air Filtration Standards by Finished Product Type Application
Applies to all Applications Receiving through Final Packaging

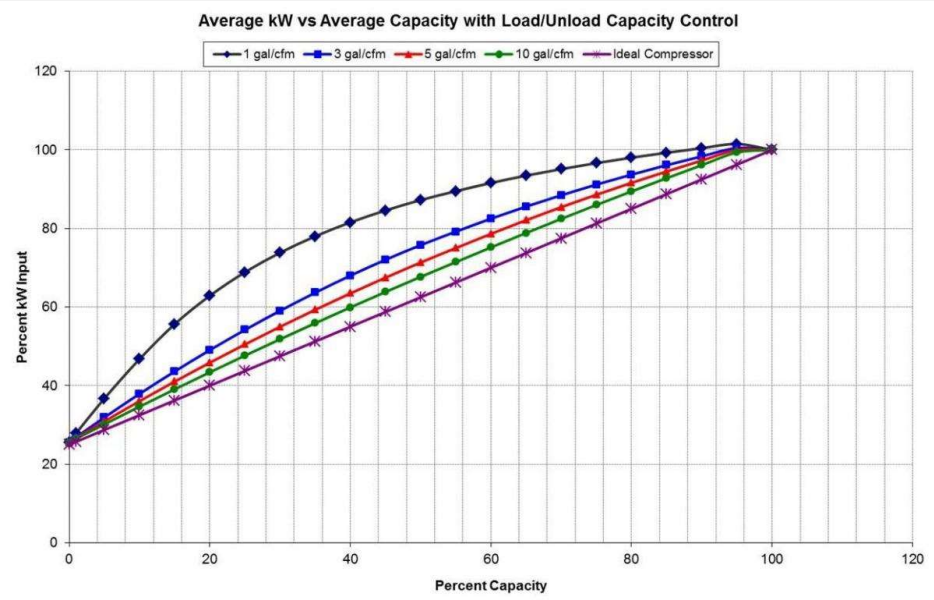
	C2.8	D5.2	C2.9	
Finished Product Type	**Final Filter Size @ 99% efficient (Micron)**	**Pressure Dewpoint* (°F)**	**Maximum Oil & Vapor Content** (mg/m^3)**	**Comments**
Bakery and Cereal				
Breakfast Cereals	0.3	*	**	
Cookies / Crackers	1	*	**	
Cookies with icing or filling –and - cookies with chocolate or confection coating	0.3	*	**	
Beverages				
Coffee (Ground, Instant), Postum	5	*	**	
Flavored Coffee, GFIC, Hot Cocoa	0.3	*	**	
PSD Beverages (Kool-Aid, etc.)	1	*	**	
Beverages + Mr. Freeze	0.3	*	**	
Confections and Nuts				
Chocolate, Confections and Candies with peanuts	0.3	*	**	Including peanut brittle
Hard Candies (Sugar/Water)	1	*	**	
Soft Candy , Caramels, Marshmallows	1	*	**	
Nuts, Roasted	0.3	*	**	
Dairy and Cheese				
Cold Pack Cheese	0.3	*	**	
Cream Cheese Refrigerated	0.3	*	**	
RTE Cream Cheese snacks	0.3	*	**	
Cool Whip	0.3	*	**	
Ice Cream	0.3	*	**	
Natural Cheese	0.3	*	**	
Powdered Dairy and Imitation Dairy	0.3	*	**	
Process Cheese, Shelf-Stable	0.3	*	**	
Process Cheese, Refrigerated	0.3	*	**	
Dips, Dairy & Non-Dairy	0.3	*	**	
Cultured products: Yogurt, Sour Cream, Cottage Cheese	0.3	*	**	
Dry				
Baking Powder	1	*	**	
Coconut	0.3	*	**	
Certo, Pectin	1	*	**	
Dry Blends – Stove Top, GSSD	0.3	*	**	
Dry Dessert Mixes	0.3	*	**	
Instant Rice	1	*	**	
Pasta (Dry)	1	*	**	
Spices (Dry + Liquid)	1	*	**	

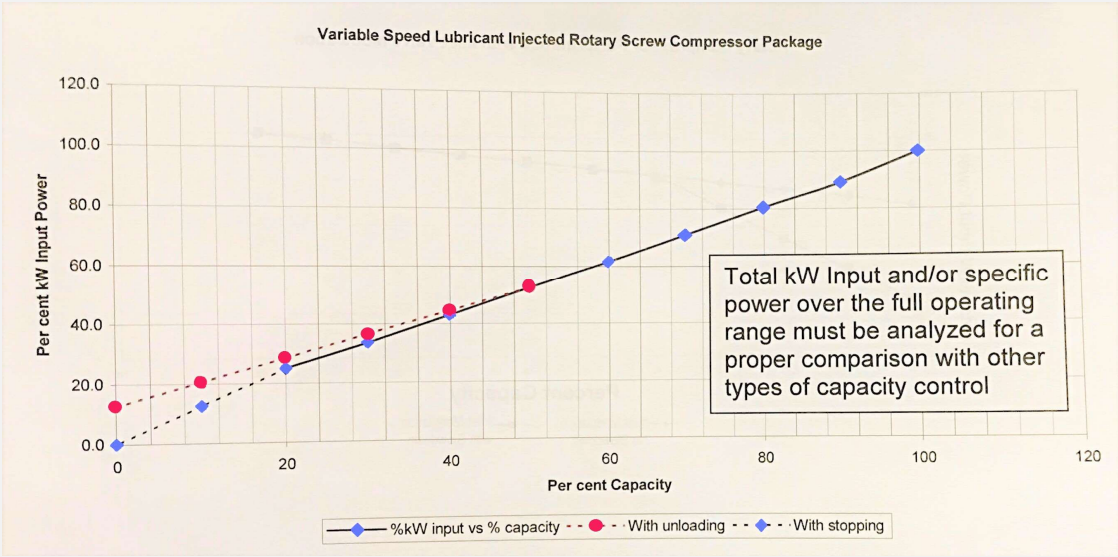
HOW TO SQUEEZE OUT EVERY OUNCE OF ENERGY SAVINGS

Consider adding storage & pressure controls

How to squeeze out every ounce of energy savings

Consider adding VSD & Storage



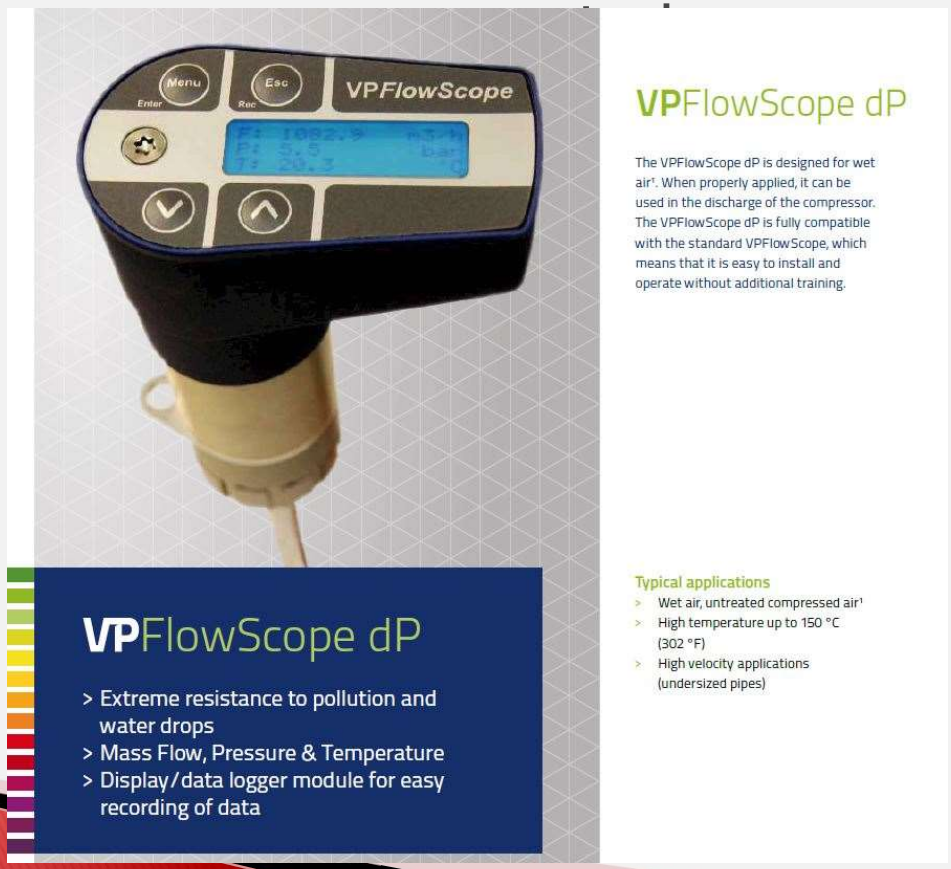


How to test your existing compressors for efficiency

- Measuring your compressors at the discharge prior to the air dryers…WET?!?
- Pump up testing using existing storage
- Measuring power & pressure at design conditions
- Various compressors require different types of testing

How to test your existing compressors for efficiency

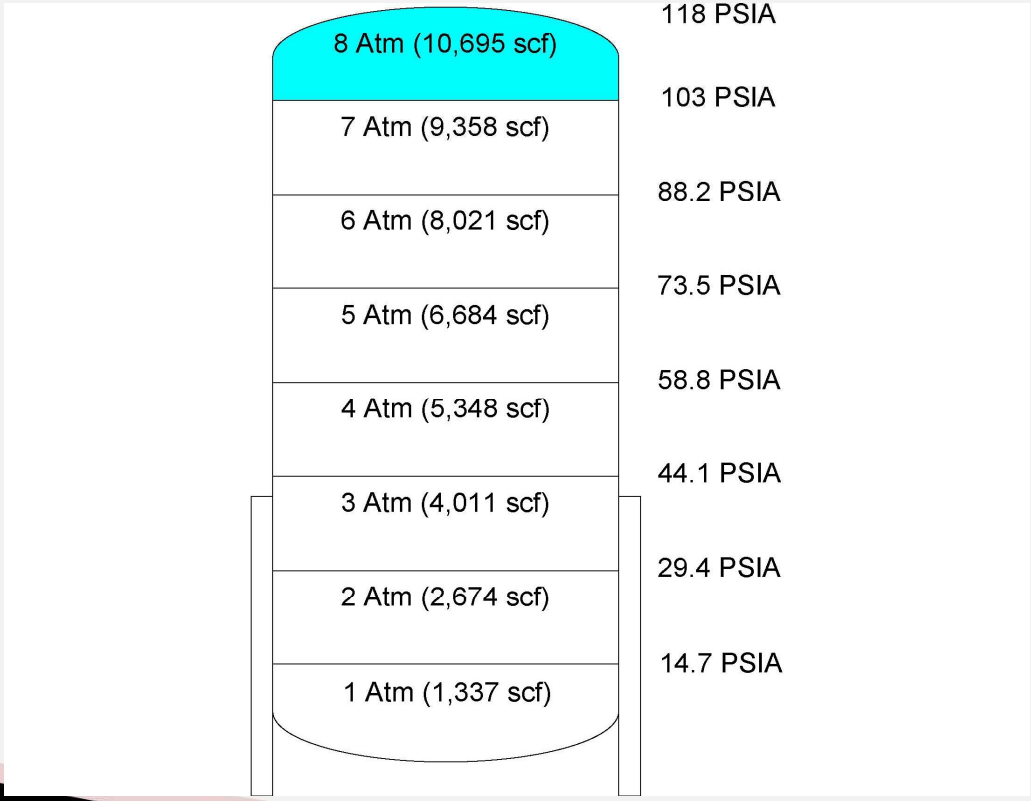
Measuring your compressors at the discharge prior to the



Do You Have WET Air?!?

How to test your existing compressors for efficiency

Pump up testing using existing storage

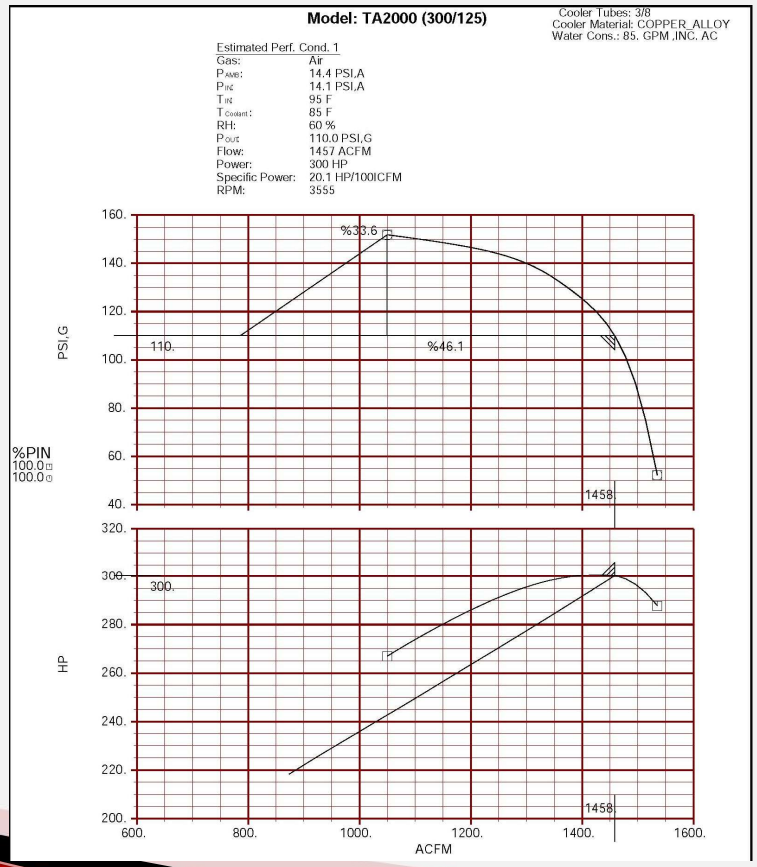


How to test your existing compressors for efficiency

Measuring power & pressure at design conditions

How to test your existing compressors for efficiency

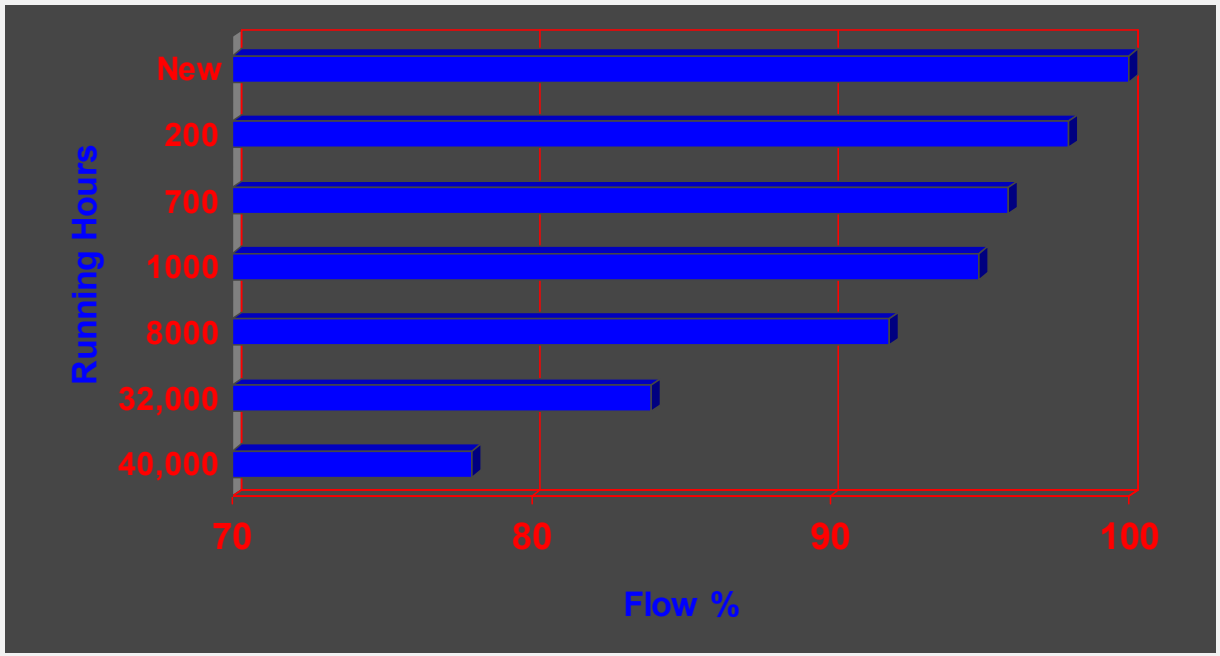
Various compressors require different types of testing



How to test your existing compressors for efficiency

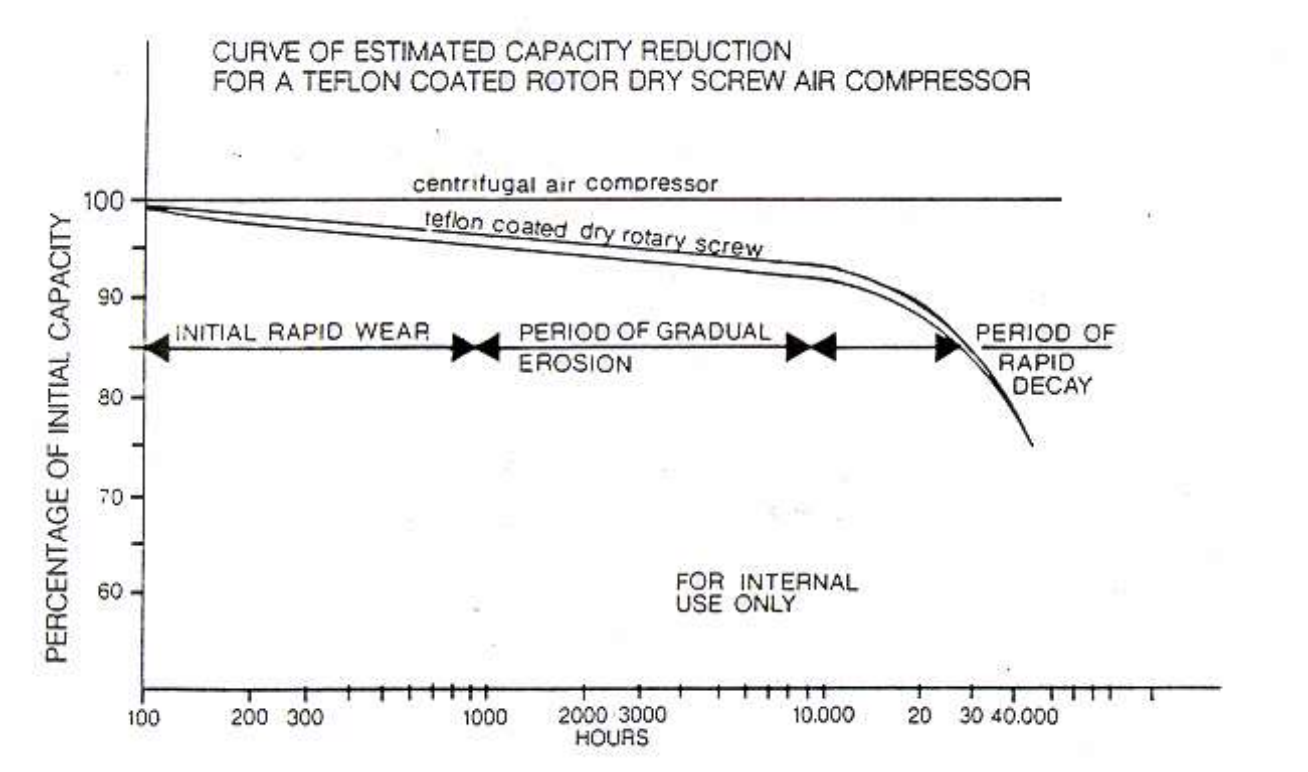
Various compressors require different types of testing

With a centrifugal compressor this wear problem does not exist. Also as the rotors in the two stage rotary screw compressor wear, the flow decreases but the power consumption remains constant.



How to test your existing compressors for efficiency

Various compressors require different types of testing



Why is my compressor room so hot???

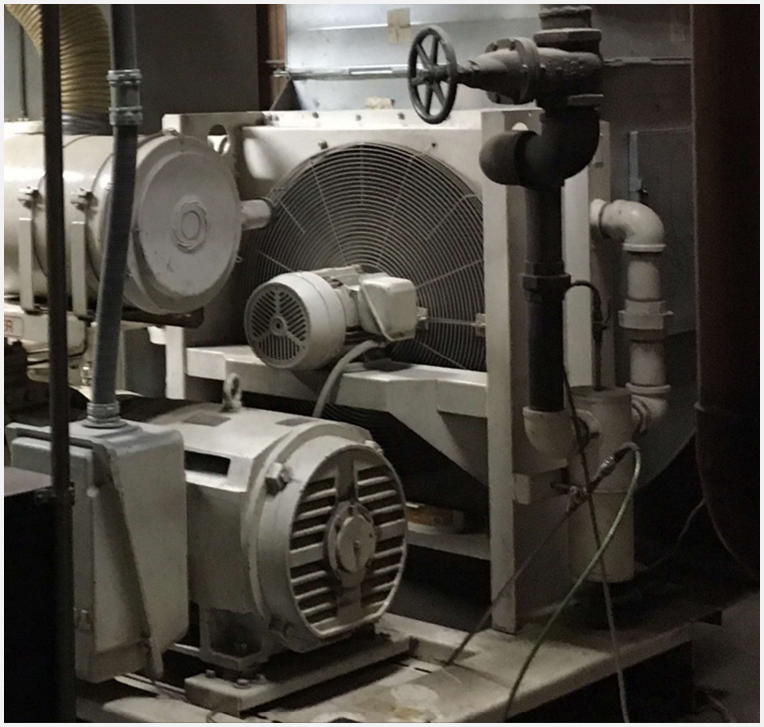
- Compressor horsepower x 2545 BTUh = A Big Furnace
- Water Cooled vs. Air Cooled
- Air Dryer performance in Boiler Room conditions
- Example of savings conversion to refrigerated from regenerative air dryer

Why is my compressor room so hot???

Compressor Horsepower x 2545 BTUh = A Big Furnace

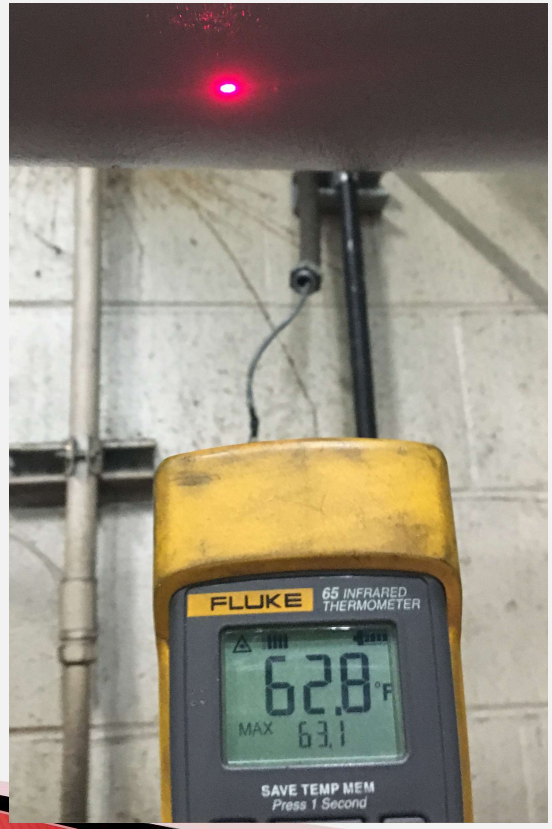
Why is my compressor room so hot???

Water Cooled vs. Air Cooled



Why is my compressor room so hot???

Air Dryer Performance in Boiler Room conditions



Why is my compressor room so hot???

Air Dryer Performance in Boiler Room conditions

Option	Project List	Project Cost	Estimated Therm Savings	Ameren Incentive	Customer Net Investment	Annual Savings	Net Payback Before Incentive (Years)	Net Payback After Incentive (Years)
Boiler Project	Preheat Boiler Feed Water With Second Stage Aftercooler Water. Water Temperature will be raised from 60F to 77F. Pre-heat Boiler Combustion Air with 200F Compressor Discharge Air.	$281,133	156,168	$140,535	$140,598	$66,348	4.2	2.1

Notes:
- Energy Cost = $.4249/Therm, 8760hrs/yr
- Ameren Incentive at $.90/Therm

Why is my compressor room so hot???

Savings conversion to Refrigerated from Regenerative Air Dryers

Option	Project List	Project Cost	Annual kWh Savings	Annual Therm Savings	Ameren Incentive	Customer Net Investment	Annual Savings	Net Payback After Incentive (Years)
Dryer Project	8 Dessicant Dryer will be replaced with Cycling Refrigerated Dryers. A large amount of Compressed Air, Electricity, and Steam is currently used to heat and dry the Dessicant Beds. The new Dryers will use a fraction of the energy.	$986,265	4,053,801	152,046	$378,171	$608,094	$184,625	3.3

Notes:
- Electric Cost = $0.045/kwh, 8760hrs/yr
- Ameren Electric Incentive at $.06/kwh for Custom, $.02/kwh for RCx
- Energy Cost = $.042/Therm, 8760hrs/yr
- Ameren Gas Incentive at $.90/Therm for Custom

Where did all this water come from?

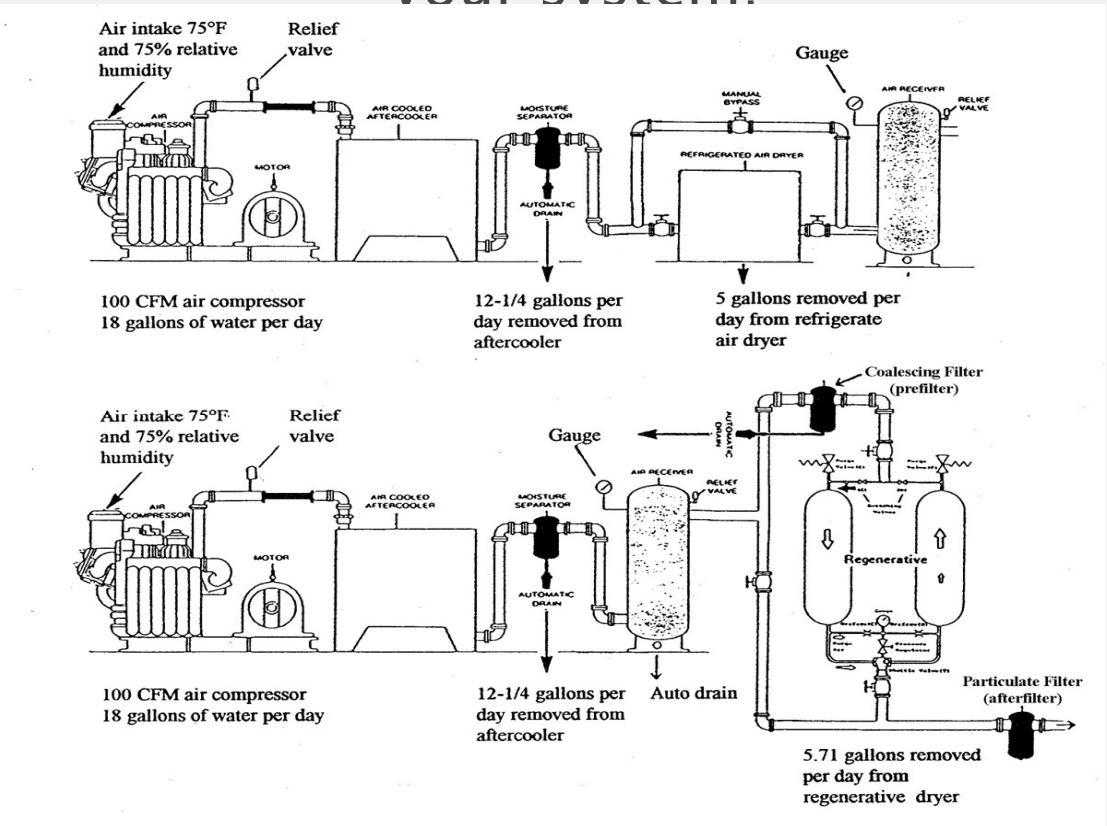
- Do you monitor dew point from your supply side?
- When the plant complains about water you could have hundreds of gallons in the system
- Who turned off the air dryers? The most neglected part of the air system
- Who is responsible to inspect drains daily?
- Incentives are available for better quality air

Where did all this water come from?

Do you monitor dew point from your supply side?

Where did all this water come from?

Water complaints could equal HUNDREDS of gallons in your system!



Why is compressed air so wet & dirty?!?

Where did all this water come from?

Typical Concentration of Contaminants in the Atmosphere

Location	Concentration/cm^3
Stratosphere	0.1
Antarctic	1.0
Marine Surface Background	400
Clean Continental Background	2,000
Average Background	9,000
Average Urban	140,000
Urban Freeway	2,000,000

Where did all this water come from?

Effects of Air Contaminants

- Plug orifices and block clearances between moving parts
- Erode surfaces, wear out seals, and increase leakage
- Foul heat transfer surfaces
- Reduces adsorptive capacity of desiccant used in compressed air dryers
- Lower efficiency in pneumatically operated equipment, such as air tools and valves
- Reduced system performance and an increase energy consumption

Where did all this water come from?

Moisture Content of Air

Dew point		Grains ft³ wet air	Dew point		Grains ft³ wet air	Dew point		Grains ft³ wet air
°C	°F		°C	°F		°C	°F	
-101	-150	0.0000005	**-40**	**-40**	**0.0525**	7.2	45	3.414
-96	-140	0.000038	-37	-35	0.0708	10	50	4.076
-90	-130	0.000058	-34	-30	0.0945	17.8	55	4.849
-84	-120	0.00016	-32	-25	0.1261	15.6	60	5.745
-82	-115	0.00020	-29	-20	0.166	18.3	65	6.782
-79	-110	0.00036	-26	-15	0.218	21.1	70	7.980
-76	-105	0.00050	-23	-10	0.285	23.9	75	9.356
-73	-100	0.00077	-21	-5	0.370	26.7	80	11.04
-71	-95	0.0012	-17.8	0	0.481	29.4	85	12.73
-68	-90	0.0019	-15	5	0.640	32.2	90	14.94
-65	-85	0.0029	-12.2	10	0.776	35	95	17.12
-62	-80	0.0037	-9.4	15	0.986	37.8	100	19.95
-59	-75	0.0051	-6.7	20	1.235	41.5	105	22.75
-57	-70	0.0074	-3.9	25	1.551	43	110	26.34
-54	-65	0.0100	-1.1	30	1.935	46.1	115	30.14
-51	-60	0.0147	0	32	2.113	49	120	36.21
-48	-55	0.0200	**1.7**	**35**	**2.366**	54	130	44.68
-46	-50	0.0283	**3.9**	**39**	**2.746**	60	140	58.21
-43	-45	0.3865	4.4	40	2.849	66	150	74.83

Where did all this water come from?

Calculating Moisture Content of Air

80°F Dewpoint = 11.04 Grains/Ft^3 @ 80%RH = 8.83 Grains/Ft^3

500 SCFM x 8.83 Grains/Ft^3=4415 Grains / Min

4415 Grains/Min x 60 x 24 = 6,357,600 Grains per day (Intake)

6,357,600 / 58,417 = 108.83 Gallons per day

8.83 Grains/Ft^3 x 7.8 (100 PSIG Comp. Ratio) = 68.87 Grains/Ft^3

68.87 Grains/Ft^3 = Saturated Conditions @ 148°F

Aftercooler reduces temperature to 100°F and = 19.95 Grains/Ft^3 then 48.92 Grains of liquid would be left over.

Where did all this water come from?

Oil Carryover by Compressor Type

Rotary Screw:

5-75 PPM oil @ 200° F

Reciprocating:

5-400 PPM oil @ 350°F

Centrifugal:

5-15 PPM oil (Air-Borne Through Inlet)

A lubricated 25HP compressor(100 SCFM) with a 35 PPM carryover will pass about 2 oz. of oil every 8 hours!

Where did all this water come from?

The Basics of Coalescing Filtration Facts & Definitions

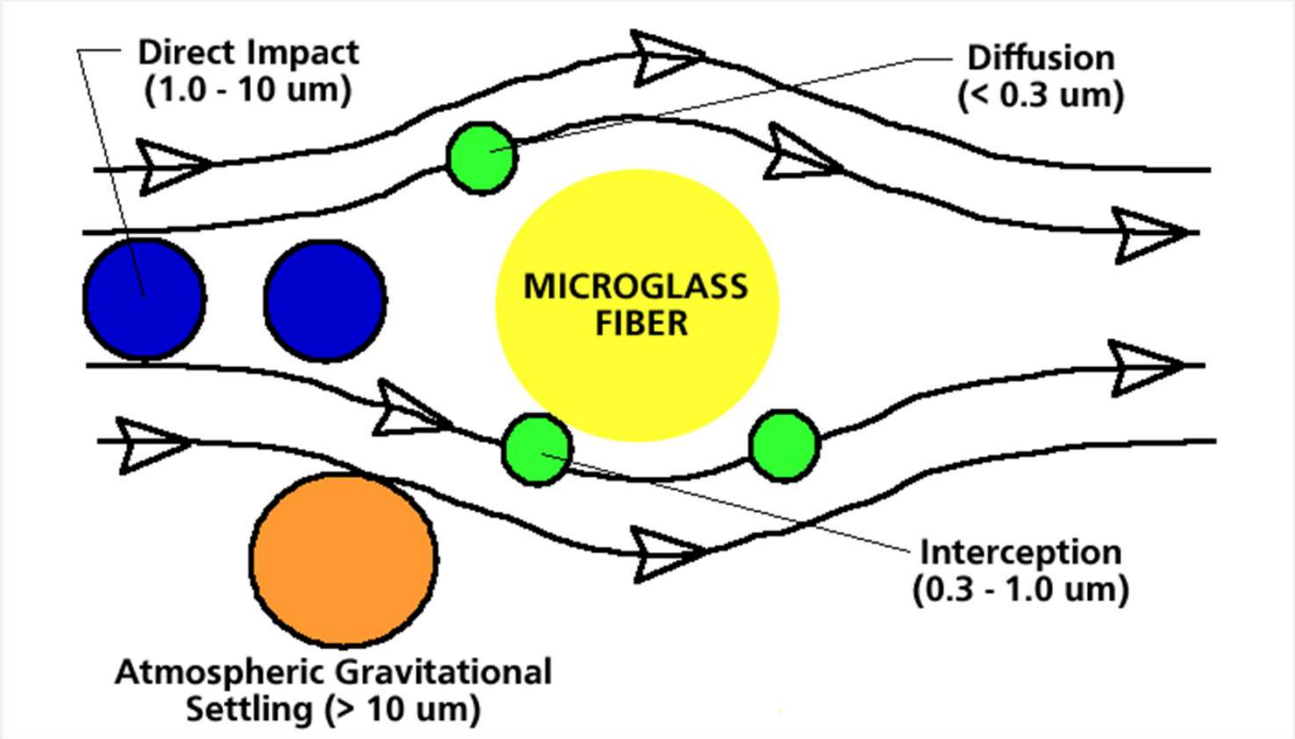
Micron or Micrometer: A micron is a physical dimension equal to a millionth of a meter or .000039 inches.

Visibility: The unaided human eye cannot usually discern objects much smaller than 40 microns or .00156 inches.

Aerosol: An aerosol is any small (usually smaller than 10 microns) suspended object, liquid or solid (i.e. mists, clouds, dust, etc.)

Where did all this water come from?

Coalescing Theory



Where did all this water come from?

Coalescing Collection Mechanisms

Direct Impact: Gets the “big stuff” typically that is about 1 micron and larger; aerosol is big enough that it literally runs into a fiber or fiber matrix; pores are smaller than some of these particles; this is highly efficient; 99.999+%

Where did all this water come from?

Contaminant Content Particulate

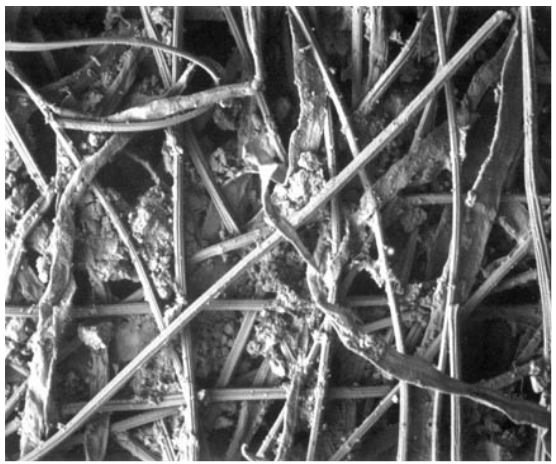
Particulate:

- Pipe Scale / Rust
- Desiccant Dust
- Rocks
- Pollen
- Yeast Cells
- Airborne Carbon
- Mold
- Welding Flash
- Penicillin

Where did all this water come from?

Interceptor & Adsorber Filter Media

"GP" Pleated Cellulose
Interceptor Media



"GA" Activated Carbon
Adsorber Media

Where did all this water come from?

Non Standard Condition Capacity

Inlet Temperature °F		90			100			110			120		
Ambient Temperature °F		90	100	110	90	100	110	90	100	110	90	100	110
Inlet Air Pressure	70 psig	1.10	1.01	0.86	0.81	0.74	0.63	0.60	0.55	0.47	0.45	0.42	0.35
	80 psig	1.23	1.13	0.96	0.90	0.83	0.70	0.67	0.62	0.52	0.51	0.47	0.40
	90 psig	1.35	1.24	1.06	1.00	0.91	0.78	0.74	0.68	0.58	0.56	0.51	0.44
	100 psig	1.48	1.36	1.15	1.09	**1.00**	0.85	0.81	0.75	0.63	0.61	0.56	0.48
	110 psig	1.61	1.47	1.25	1.18	1.09	0.92	0.88	0.81	0.69	0.66	0.61	0.52
	120 psig	1.73	1.59	1.35	1.09	1.17	0.99	0.95	0.87	0.74	0.72	0.66	0.56
	130 psig	1.86	1.70	1.45	1.37	1.26	1.07	1.02	0.94	0.80	0.77	0.71	0.60
	140 psig	1.98	1.82	1.55	1.46	1.34	1.14	1.09	1.00	0.85	0.82	0.75	0.64
	150 psig	2.11	1.93	1.64	1.55	1.42	1.21	1.16	1.06	0.90	0.87	0.80	0.68

To obtain flow capacities at conditions other than standard, locate the multiplier at the interception of actual operating conditions. Multiply the standard rated capacity of the dryer by the selected multiplier. The result is the flow capacity of that dryer under corrected conditions. Flow rates in excess of design due to capacity correction can result in increased pressure drop.

Where did all this water come from?

Who turned off the air dryers? Your system's most neglected part!

Where did all this water come from?

Who is responsible to inspect your drains daily?

Where did all this water come from?

Incentives are available for better quality air

Replace Non-Cycling Refrig. Dryer with Cycling Dryer

Baseline System
- 2000 CFM Non-Cycling Refrig. Dryer

Dryer	Capacity (CFM)	Load (CFM)	Refrig. kW	Hours/Yr	kWh	kWh Calc
GSRN-2000	2000	1109	14.705	8628	126,875	=(+ 14.705kW) * 8628H
				Total kWh:	126,875	
				Avg kW:	14.7	

Proposed System
- 2000 CFM Cycling Refrig. Dryer

Dryer	Capacity (CFM)	Load (CFM)	Refrig. kW	Hours/Yr	kWh	kWh Calc
GTRC-2000	2000	1109	15.208	8628	72,759	=(+ 15.208kW) * 1109CFM / 2000CFM * 8628H
				Total kWh:	72,759	
				Avg kW:	8.4	

$/kWh:	$ 0.07
$/kWh (Incentive):	$ 0.08
kW Saved:	6.3
kWh Saved:	54,116
$ Saved:	$ 3,950
Incentive:	$ 4,329
Project Cost:	$ 28,637
ROI Before Incentive:	7.25
ROI After Incentive:	6.15

Cycling Dryer

Where did all this water come from?

Incentives are available for better quality air

Replace Heatless Dryer with Heated Blower Purge Dryer

Baseline System
- Heatless Regen Dryer

Dryer	Capacity (CFM)	Purge (CFM)	Purge % Time On	Sys. Eff. (CFM/kW)	Heater Size (kW)	Avg Heater (kW)	Blower HP	Blower % Time On	Load (CFM)	Hours/Yr	kWh	kWh Calc
GHLD3000	3000	450	100.0%	6.5					3000	8760	606,462	=(450CFM / 6.5CFM/kW) * 8760H
										Total kWh:	606,462	
										Avg kW:	69.231	

Proposed System
- Heated Blower Purge Dryer

Dryer	Capacity (CFM)	Purge (CFM)	Purge % Time On	Sys. Eff. (CFM/kW)	Heater Size (kW)	Avg Heater (kW)	Blower BHP	Blower % Time On	Load (CFM)	Hours/Yr	kWh	kWh Calc
GBPD3000	3000	0	0.0%	6.5	67	28	9.0	100.0%	3000	8760	308,522	=(28kW + 9HP * .746kW/HP * 1/.93) * 8760H
										Total kWh:	308,522	
										Avg kW:	35.2	

$/kWh:	$ 0.046
$/kWh (Incentive):	$ 0.06
kW Saved:	34.0
kWh Saved:	297,940
$ Saved:	$ 13,705
Incentive:	$ 17,876
Proj. Cost	$ 68,580
Payback Before Incentive	5.0
Payback After Incentive	3.7

Heated Blower Purge Dryer

How can I avoid or postpone buying a new compressor?

- Keep leakage at a minimum
- Eliminate wasted blow off air convert to centrifugal blowers
- Shut off open valves that drain water in the compressor room & the plant
- Eliminate compressed air as a band aid to make production equipment work properly
- Manage peak demand using storage & pressure controls

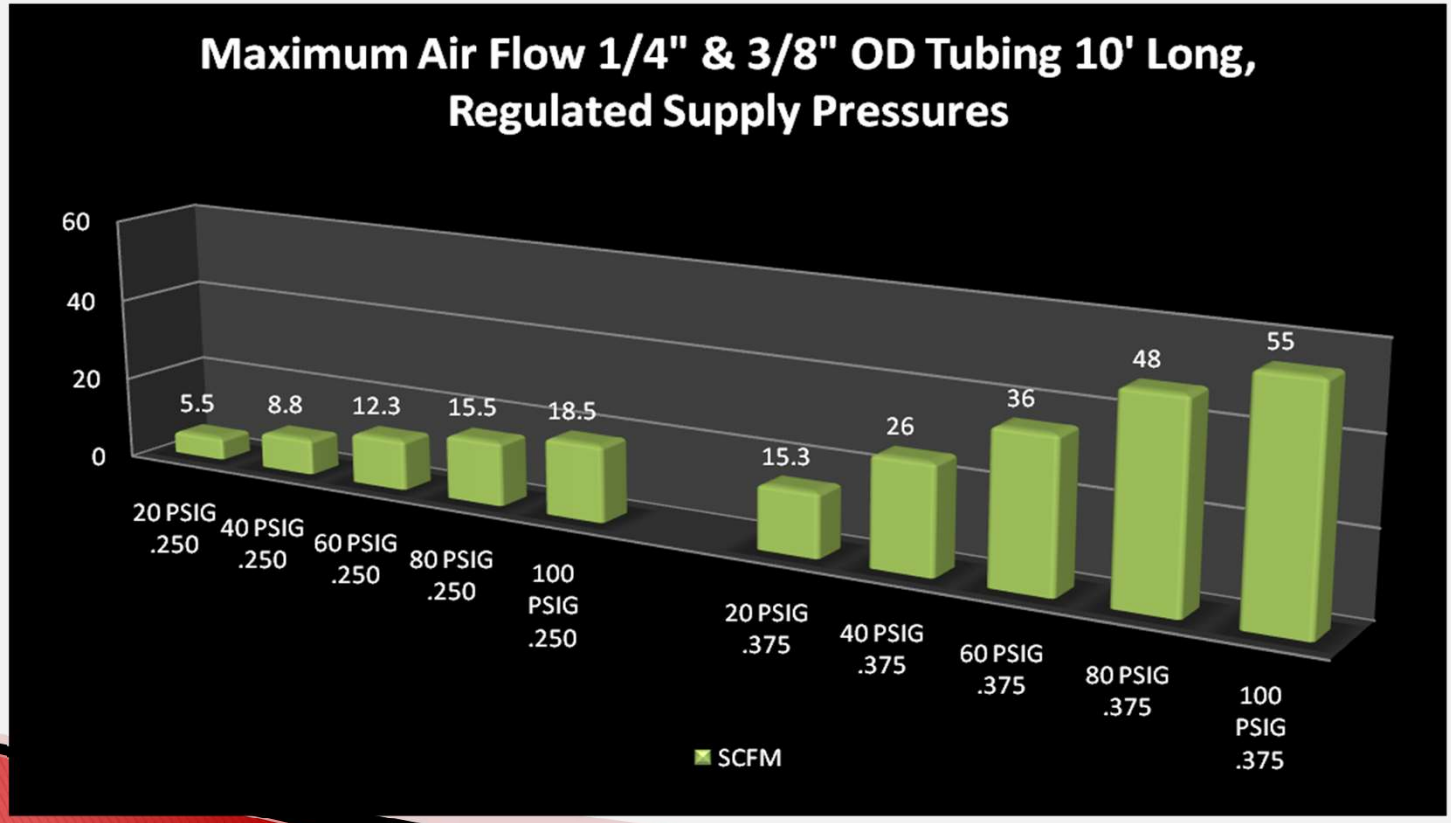
How can I avoid or postpone the purchase of a new compressor?

Keep your leakage at a minimum

ID#	Location	Description	Size	CFM	DOLLARS
334	F15, old Valve 1/2", with electrical tape, behind sprinkler	1/2" Valve	S	5	$508.12
335	F7 P25-451B	Filter Lubricator Block	M	10	$1,016.24
336	G10, sand booth exhaust stacks, dry pipe system	Red Solenoid for Sprinkler System	M	10	$1,016.24
337	G8	bottom of filter bulb, green sulfur filter	S	5	$508.12
338	G2 and H2, P8-521-4012	Back of Regulator	M	10	$1,016.24
339	J9, Purge Solvent Tank	Tutone Agitator	L	15	$1,524.36
340	K9 to K10	regulator for sealant paint	S	5	$508.12
341	L11, other side of aisle	paint mixer regulator, grate coat pump	ML	13	$1,321.11
342	N5-M5	Blow Off Zone, stainless steel 3/4" elbow	M	10	$1,016.24
343	M14, exhaust fan 15	1/4" clear hose next to booth	M	10	$1,016.24
344	K19, inside booth 8' high	quick connect fitting to 1/2" clear fitting	S	5	$508.12
345	K27 P15-4136SV	stop valve	S	5	$508.12
346	K22 to K23, inside booth	elbow prior to sander	M	10	$1,016.24
347	H24-J24, P214154SV	lubricator bowl	M	10	$1,016.24
404	J21-J20, Inside Booth	Quick Connect at 1/2" clear hose	S	5	$508.12
348	H25-J25, Inside Booth	hinge in air ratchet	S	5	$508.12
349	H26, P22-422-3573501	top of lubricator on outside of booth	M	10	$1,016.24
350	H25, inside paint booth between conveyors	top of regulator	ML	13	$1,321.11
351	H21, near cabinet	T in hoses on floor	L	15	$1,524.36
352	H20, outside of booth	guage on regulator	M	10	$1,016.24
353	F20, other side of booth	connection at sander	S	5	$508.12
354	F20, same side of booth	elbow prior to sander	S	5	$508.12
355	H2, Paint Baskets, P6-258A	lubricator bowl	S	5	$508.12
356	G3, Paint Basket, P17 stop 3554	bottom of lubricator	S	5	$508.12
357	F11, paint basket, P17 stop 3555	top of regulator	L	15	$1,524.36
358	H14, Paint Basket near P20 Take up pressure	under handle of 3/4" valve	M	10	$1,016.24
359	H14, P20 Take up air pressure	seals in cylinder leaking	M	10	$1,016.24
360	H14, Paint Basket Two Tone Base Coat Bell 13	muffler venting	S	5	$508.12
361	H12, Paint baskets, P6 stop 256A	bottom of lubricator	SM	7	$711.37
362	M30, P36 open stop s16	between lubricator and regulator	M	10	$1,016.24
363	N29, Paint Basket P36 TS13	top of regulator	M	10	$1,016.24
364	K3, Over Paint Booth	regulator leaking near adjustment knob	S	5	$508.12
365	Ash House A	lubricator, bottom of bowl	L	15	$1,524.36
366	Between Ash House 7 & 8	sprinkler 4" pipe at coupling	L	15	$1,524.36
367	Ash House 1, Chilled Water Station	honeywell valve, control air	L	15	$1,524.36

How can I avoid or postpone the purchase of a new compressor?

Eliminate wasted blow off by converting to centrifugal blowers



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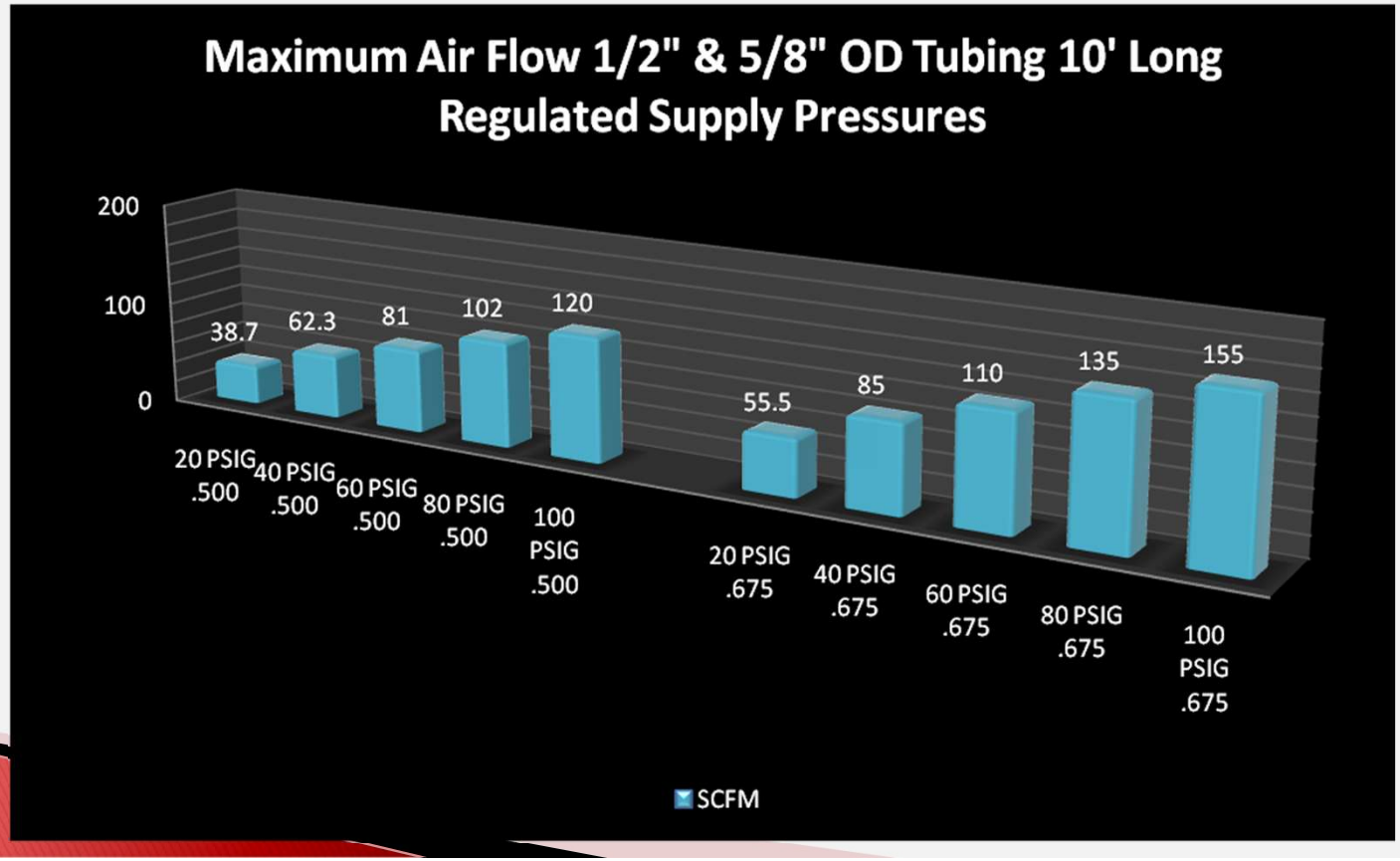

How can I avoid or postpone the purchase of a new compressor?

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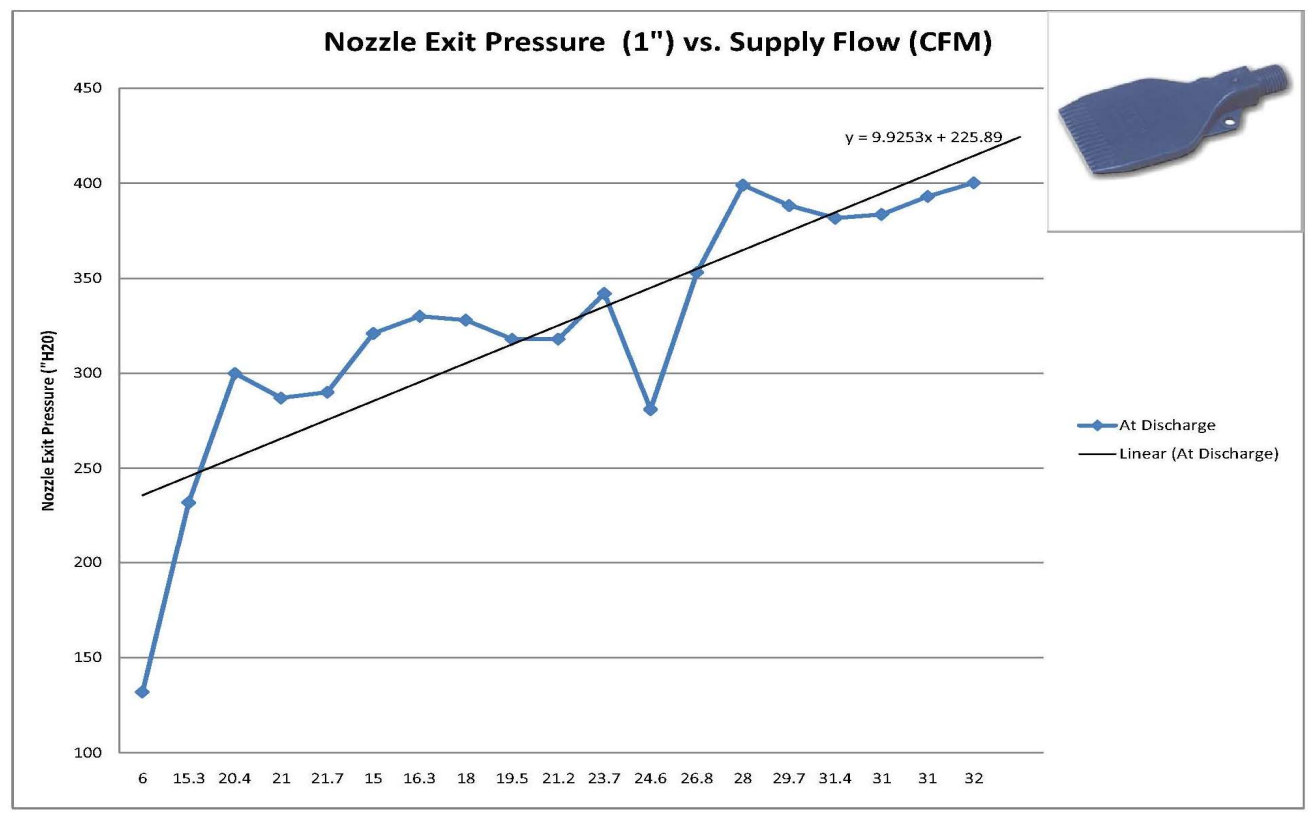


How can I avoid or postpone the purchase of a new compressor?

Shut off open valves that drain water into your air system

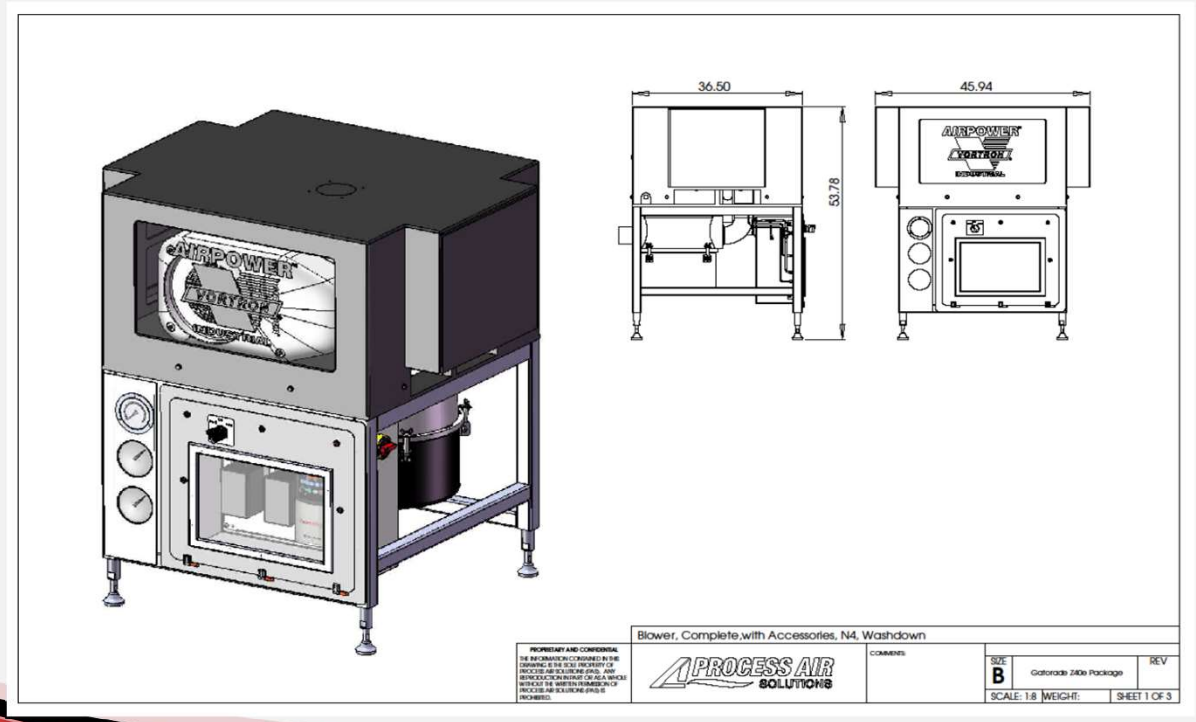
Gauge Pressure Before Orifice (psi)	Discharge (cfm free air)[1]										
	1/64	1/32	1/16	1/8	¼	3/8	½	5/8	¾	7/8	1
1	0.028	0.112	0.450	1.80	7.18	16.2	28.7	45.0	64.7	88.1	115
2	0.040	0.158	0.633	2.53	10.1	22.8	40.5	63.3	91.2	124	162
3	0.048	0.194	0.775	3.10	12.4	27.8	49.5	77.5	111	152	198
4	0.056	0.223	0.892	3.56	14.3	32.1	57.0	89.2	128	175	228
5	0.062	0.248	0.993	3.97	15.9	35.7	63.5	99.3	143	195	254
6	0.068	0.272	1.09	4.34	17.4	39.1	69.5	109	156	213	278
7	0.073	0.293	1.17	4.68	18.7	42.2	75.0	117	168	230	300
9	0.083	0.331	1.32	5.30	21.1	47.7	84.7	132	191	260	339
12	0.095	0.379	1.52	6.07	24.3	54.6	97.0	152	218	297	388
15	0.105	0.420	1.68	6.72	26.9	60.5	108	168	242	329	430
20	0.123	0.491	1.96	7.86	31.4	70.7	126	196	283	385	503
25	0.140	0.562	2.25	8.98	35.9	80.9	144	225	323	440	575
30	0.158	0.633	2.53	10.1	40.5	91.1	162	253	365	496	648
35	0.176	0.703	2.81	11.3	45.0	101	180	281	405	551	720
40	0.194	0.774	3.10	12.4	49.6	112	198	310	446	607	793
45	0.211	0.845	3.38	13.5	54.1	122	216	338	487	662	865
50	0.229	0.916	3.66	14.7	58.6	132	235	366	528	718	938
60	0.264	1.06	4.23	16.9	67.6	152	271	423	609	828	1,082
70	0.300	1.20	4.79	19.2	76.7	173	307	479	690	939	1,227
80	0.335	1.34	5.36	21.4	85.7	193	343	536	771	1,050	1,371
90	0.370	1.48	5.92	23.7	94.8	213	379	592	853	1,161	1,516
100	0.406	1.62	6.49	26.0	104	234	415	649	934	1,272	1,661
110	0.441	1.76	7.05	28.2	113	254	452	705	1,016	1,383	1,806
120	0.476	1.91	7.62	30.5	122	274	488	762	1,097	1,494	1,951
125	0.494	1.98	7.90	31.6	126	284	506	790	1,138	1,549	2,023

[1]Based upon 100 percent coefficient of flow. For well-rounded entrance, multiply by 0.97.
For sharp-edged orifices, multiply by 0.65.
For accurate measurements, refer to ASME Power Test Code.

Table A.1.f. Discharge of Air through an Orifice, by Diameter in Inches

How can I avoid or postpone the purchase of a new compressor?

Eliminate compressed air as a band aid to make production equipment work properly



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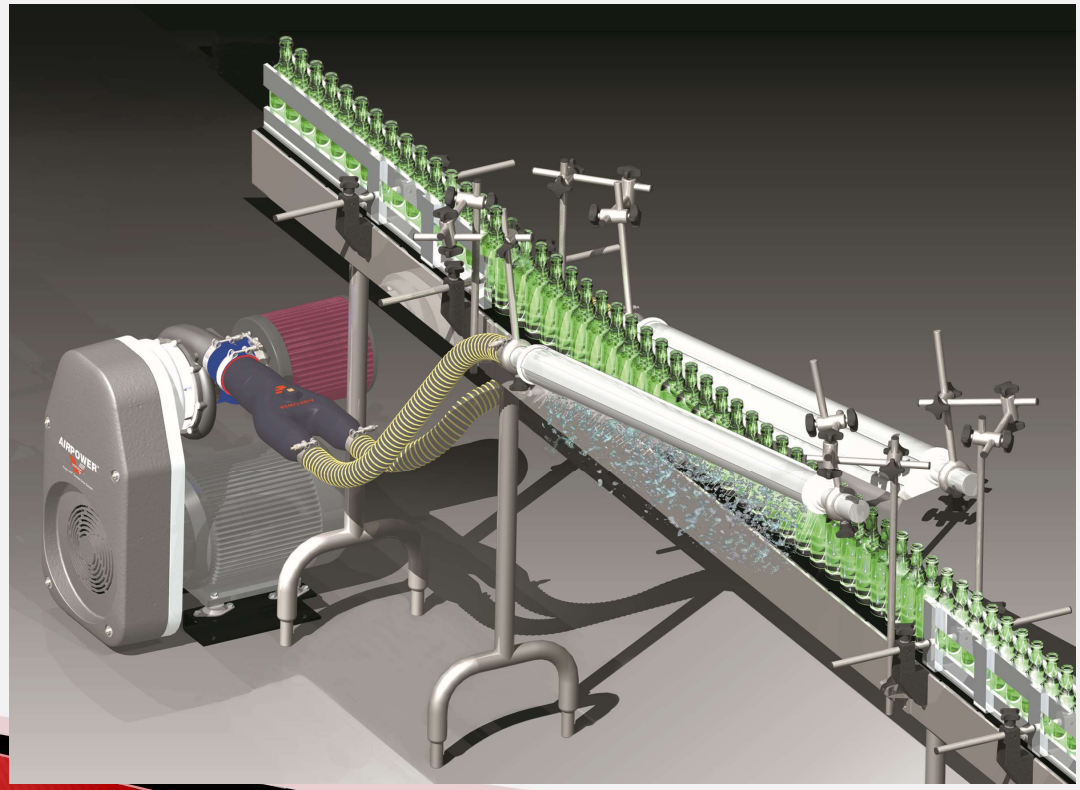

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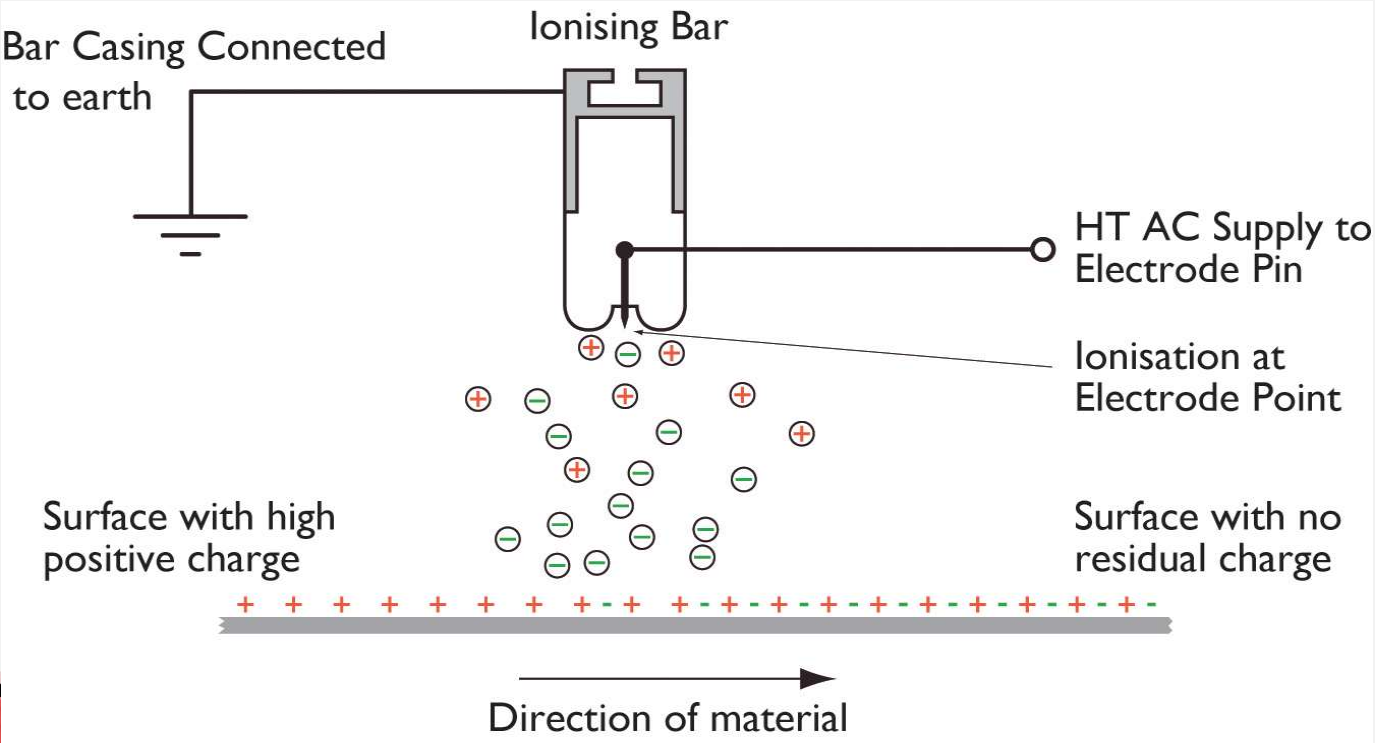


How can I avoid or postpone the purchase of a new compressor?

Eliminate compressed air as a band aid to make production equipment work properly

USE THIS MODULE TO SIZE AND CALCULATE SIMPLE BLOWER APPLICATIONS

YELLOW Hi-Lited items require data entry

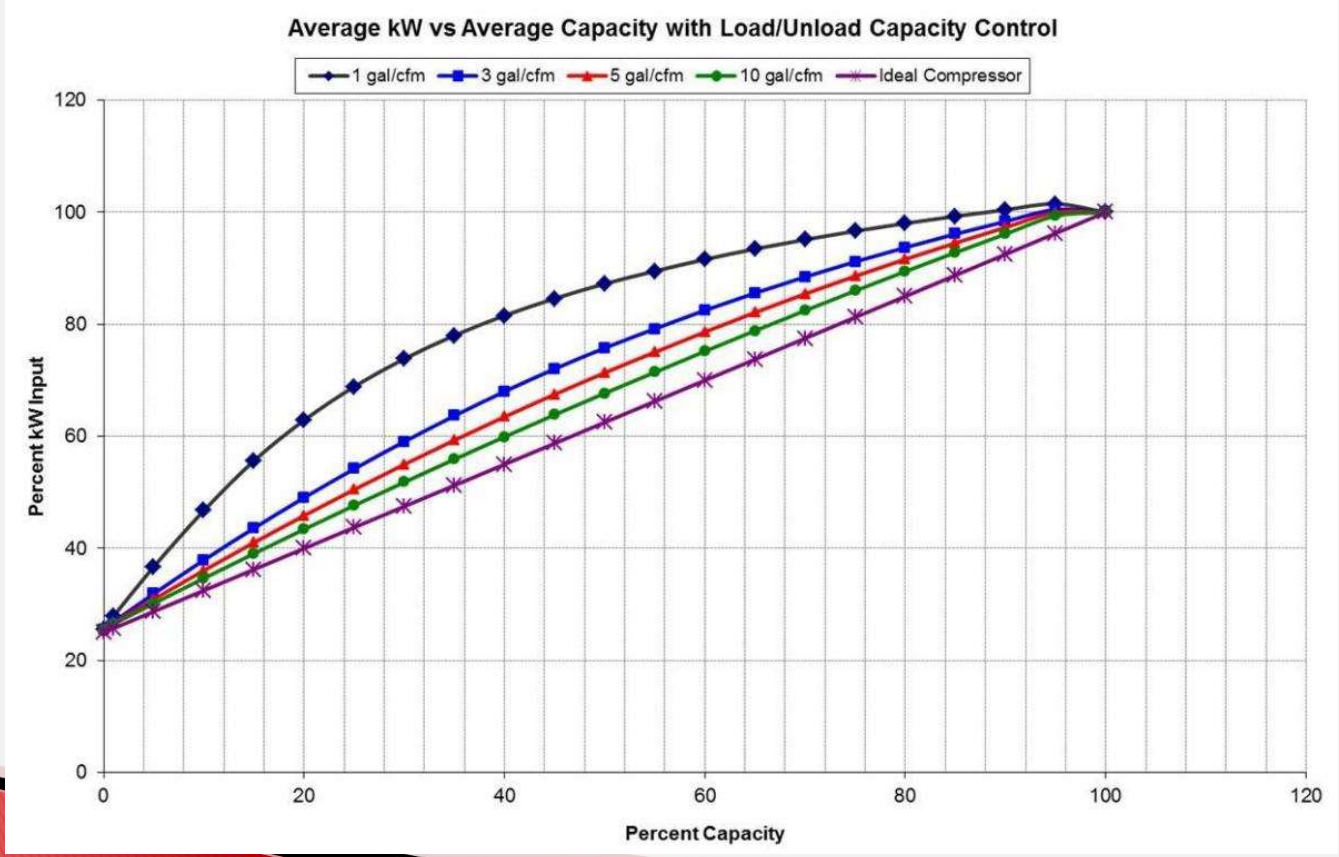
Customer:	EP Minerals	**Quote:**		
Project:	**Dust Removal Blower**	**Date:**	**21-Apr-09**	
BLOWER:	**2C381-190-201**			
Inputs:				
1	**System Inlet Temperature (Ti):**	**80**	**F**	
2	**Local Atmospheric Pressure (Pb):**	**14.5**	**psia**	
3	**Desired System Pressure (Po):**	**3.25**	**psig**	
4	Calculated System Pressure:	6.617	in-Hg	
5	Calculated System Pressure:	90.025	in-Wc	
6	**Desired Flowrate:**	**1162**	**SCFM**	
7	**"Standard" Pressure:**	**29.23**	**in-Hg**	**(J1723)**
8	**"Standard" Temperature:**	**537**	**R**	**(J1723)**
9	Air Density at Std/Corr. Conditions:	0.0722	lbm/ft^3	
10	Inlet Air Density, Blower Nozzle:	0.0725	lbm/ft^3	
11	Air Mass Flowrate, Corr:	83.88	lbm/min	
12	**Air Mass Flowrate, Actual:**	**84.51**	**lbm/min**	
13	Discharge Temperature:	120.2	F	
14	**Air Volumetric Flowrate, Actual:**	**1165**	**ACFM**	
15	**Blower Operating PR (PR-tt):**	**1.224**		
16	**Blower Effy (Eta-tt):**	**0.8**		
17	**Estimated blower power:**	**19.21**	**HP**	
18	**Suggested Minimum Motor Size**	**20**	**HP**	

Vortron **Process Air Solutions**

636-343-2021, fax 636-343-1285

How can I avoid or postpone the purchase of a new compressor?

Manage peak demand using storage & pressure controls



How can I correctly pick the size of my new compressor?

- Determine the need is for base load capacity or trim requirement
- Use the chart to determine the capacity short
- Determine the pressure required
- Oil Free or Oil Flooded
- VSD / 2 Stage Screw / Centrifugal / VFD Centrifugal

How can I correctly pick the size of my new compressor?

Determine if need is for base load capacity or trim requirement

System Capacitence Analysis

Date: Jul 22 2002

Customer: **Sample**

Project: Compressor Addition

Pipe Size	CF / ft run	Length	cf / bar	cf/psig
1	0.0055		0.0	0.0
2	0.0218		0.0	0.0
3	0.0491		0.0	0.0
4	0.0872	500	43.6	3.0
5	0.1363		0.0	0.0
6	0.1963	600	117.8	8.1
8	0.3489		0.0	0.0
10	0.5451		0.0	0.0
12	0.7850		0.0	0.0
Total Piping Capcitence			161.4	11.1

Rec Gals	Rec CF	Qty	cf / bar	cf / psig
200	26.7		0.0	0.0
400	53.5		0.0	0.0
600	80.2		0.0	0.0
1000	133.7		0.0	0.0
1500	200.5		0.0	0.0
2000	267.4	2	534.8	36.9
3000	401.1		0.0	0.0
4000	534.8		0.0	0.0
5000	668.4		0.0	0.0
Total Receiver Capacitence			534.8	36.9
Total System Capacitence			**696.1**	**48.0**

How can I correctly pick the size of my new compressor?

Use the chart to determine the capacity short

Receiver Selection and Sizing Analysis

Date: Jul 22 2002

Cust: **Sample**

Proj: Compressor Addition

Rec Gal	Qty	Tot Gal	Tot CF/bar	Tot CF/psig
2000	2	4000	534.8	36.88

	A	B
Compressor FL capacity (cfm)	720	
Control Unload Set (psig)	120	
Control Load Set (psig)	100	100
Min. system Pressure (psig)	90	90
Control Differential (psig)	20	
Storage @ differential (CF)	737.6	

System Demand	49%	350	750
Decay Time (min.)		2.107	
Pump Time (min.)		1.994	
Total Cycle Time (min.)		**4.101**	
Differential Load to Min Press		10	10
Storage Load to Min (CF)		368.8	368.8
Time Load to Critical Press (min)		**1.054**	**0.492**

How can I correctly pick the size of my new compressor?

Determine the pressure required

How can I correctly pick the size of my new compressor?

Oil Free vs Oil Flooded

No Air Inlet Valve required

Ultima uses 50 to 68% less energy than a conventional 2 stage compressor & a 160kW compressor uses only 8kW while running in idle

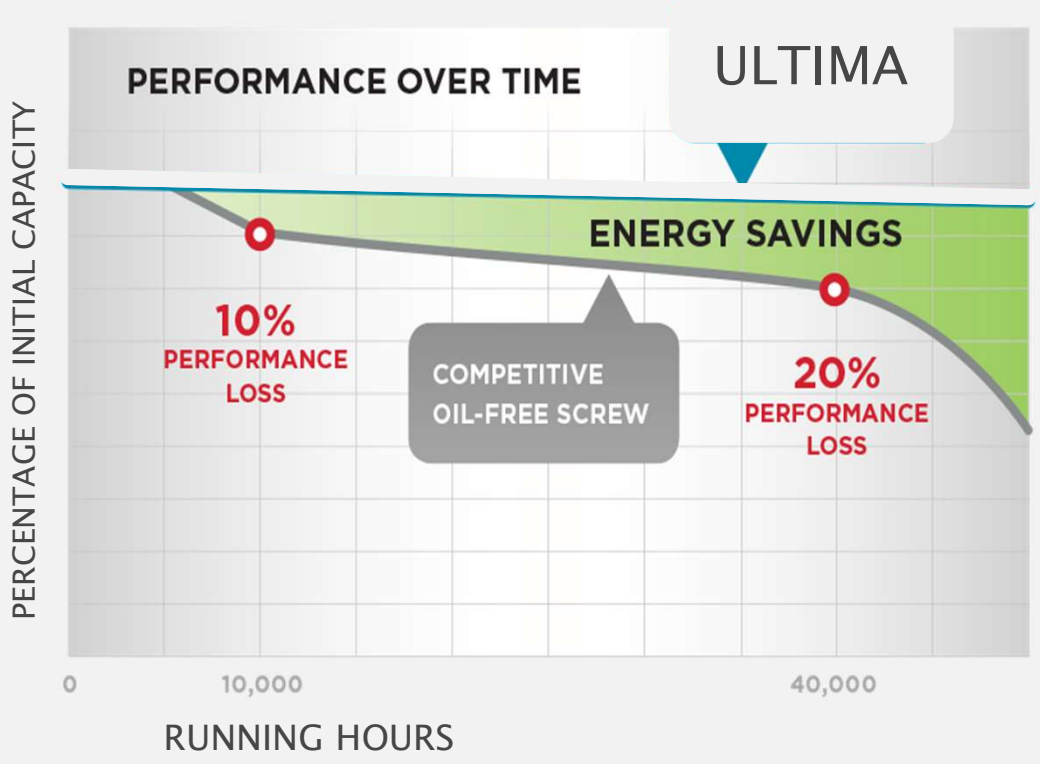
How can I correctly pick the size of my new compressor?

Oil Free vs Oil Flooded

2 Stage dry screw air end rotors are coated to:

- •Prevent Corrosion
- •Maximize Efficiency
- •Protect against Rotor Wear

Ultima – Guaranteed maximum efficiency throughout its life



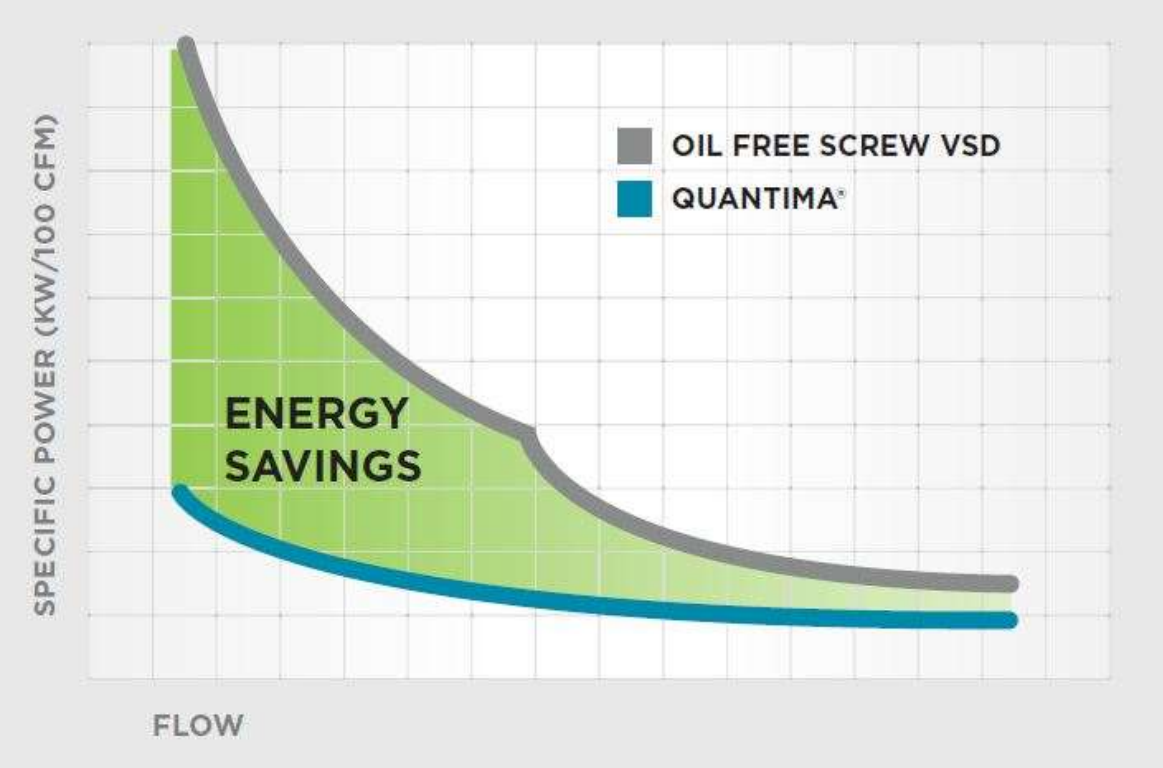
How can I correctly pick the size of my new compressor?

VSD / 2 Stage Screw / Centrifugal / VFD Centrifugal

QUANTIMA

Lower energy consumption than Two-Stage Dry Screw

Variable Speed & Efficient Compressor Control



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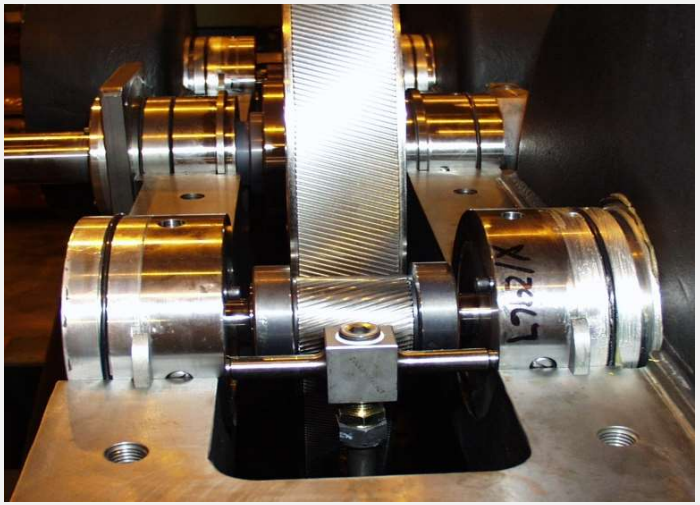
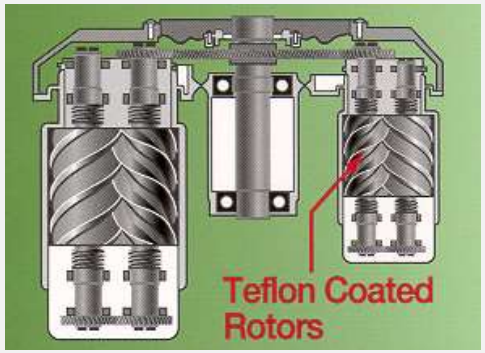
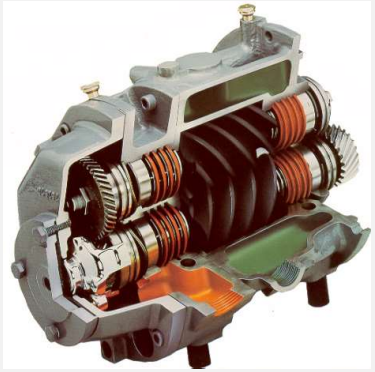
VSD / 2 Stage Screw / Centrifugal / VFD Centrifugal



CAMERON





DRY SCREW

How can I correctly pick the size of my new compressor?

VSD / 2 Stage Screw / Centrifugal / VFD Centrifugal

MAESTRO UNIVERSAL

DRY SCREW

Main points to remember

- Compressor Controls including VSD
- Denote VSD & Load Unload
- Central Loop or a Dead End Header
- VSD / 2 Stage Screw / Centrifugal / VFD Centrifugal