Estimating the Cost of Compressed Air Systems Leaks

Industrial Energy Efficiency Solutions Thursday, March 24th from 9:00-11:00 am

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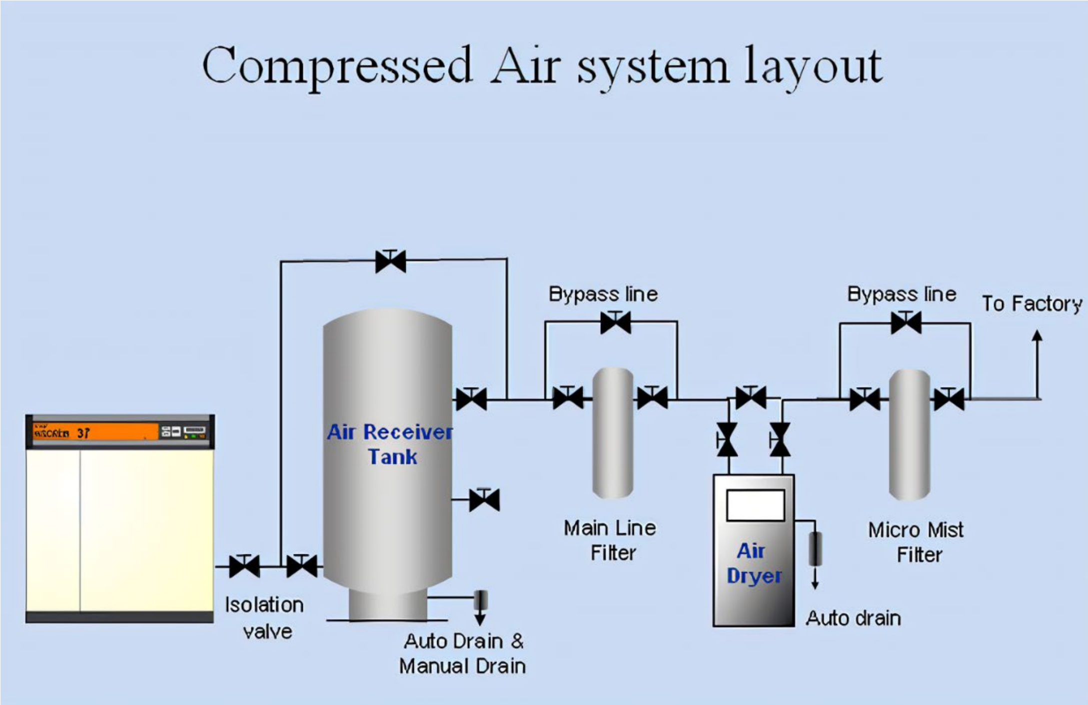
Association of Energy Engineers

Industrial Compressed Air Systems

Compressed air is used widely throughout industry and is often considered the “fourth utility” at many facilities. Almost every industrial plant, from a small machine shop to an immense pulp and paper mill, has some type of compressed air system.

Compressed air is an important medium for transfer of energy in industrial processes and is used for power tools such as air hammers, drills, wrenches and others, as well as to atomize paint, to operate air cylinders for automation, and various pneumatics.



How much does compressed air cost?

Source: https://www.surkontools.com/inline-pneumatic-torque-wrenches

Compressed air is expensive to make. The average compressed air systems operate at an average of 20kW/100 CFM. In dollars, that’s approximately $2.00 for every 100 CFM used every hour.

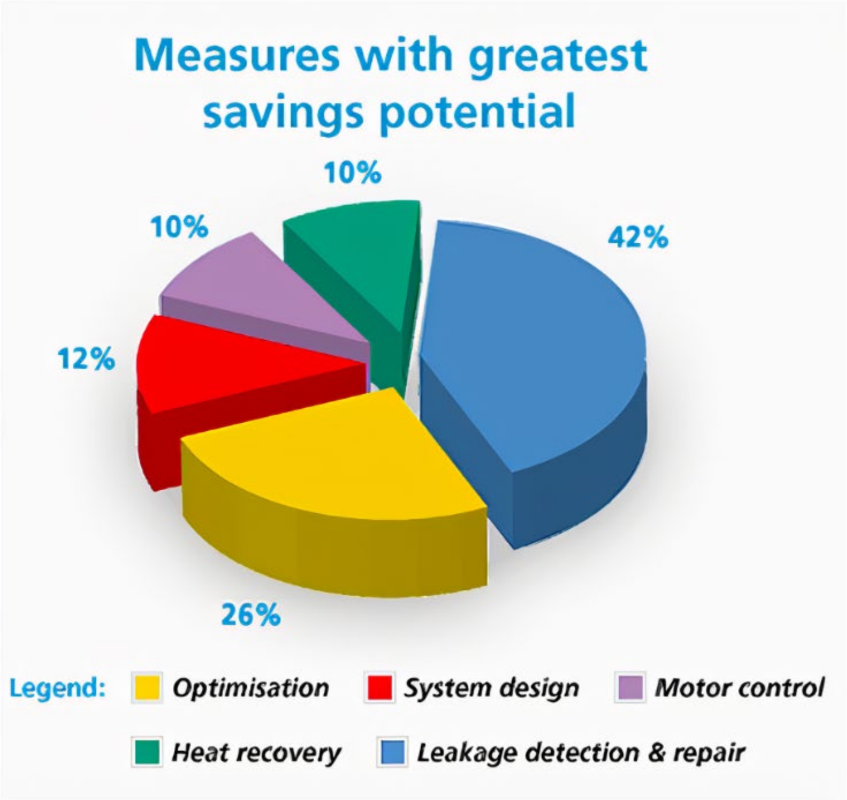
One of the companies I am working with right now uses $5.2M in electricity annually and $602K of that is compressed air (**11%**).

Leaks in compressed air systems can waste thousands of dollars of electricity per year

Source: https://blog.exair.com/2021/07/12/determining-leakage-rate-and-cost-of-compressed-air-leaks/

In fact, in many plants, the leakage can account for up to 30% of the total operational cost of the compressor. Some of the most common areas where you might find a leak would be at connection joints like valves, unions, couplings, fittings, etc. This not only wastes energy, but it can also cause the compressed air system to lose pressure which reduces the end use product's performance.

Energy conservation measures for a typical compressed air system.



Leak reduction and repair ranks highest for potential energy savings and cost effectiveness.

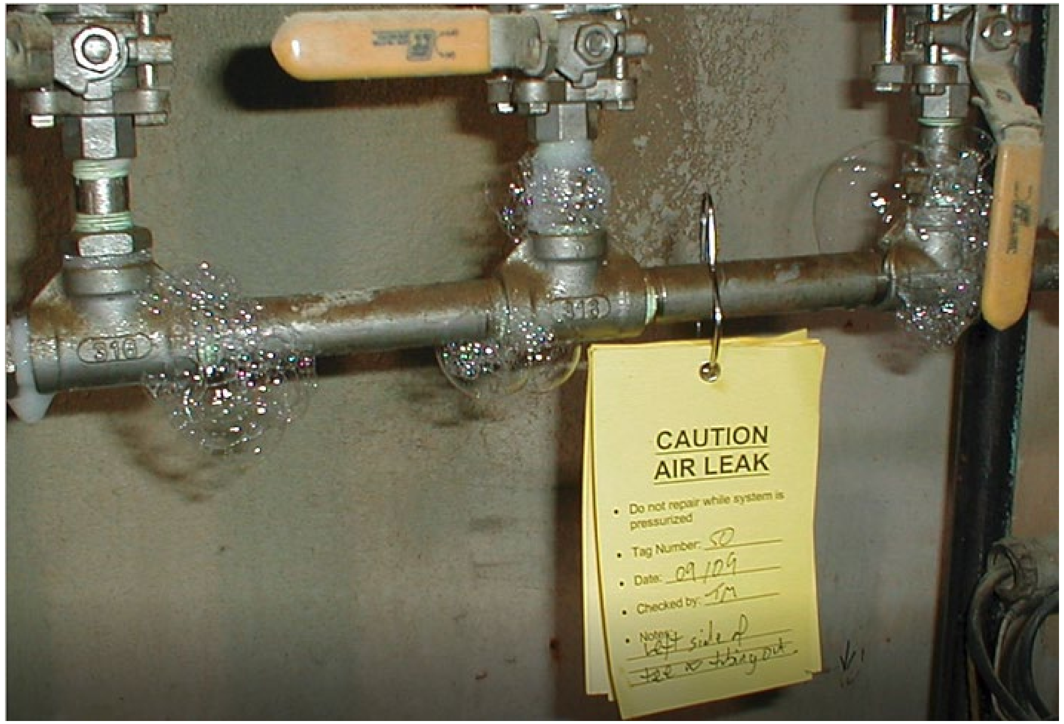
Leaks are calculated based on the size of the leak

Leakage rates[1] (cfm) for different supply pressures and approximately equivalent orifice sizes						
Pressure (psig)	Orifice Diameter (inches)					
	1/64	1/32	1/16	1/8	1/4	3/8
70	0.3	1.2	4.8	19.2	76.7	173
80	0.33	1.3	5.4	21.4	85.7	193
90	0.37	1.5	5.9	23.8	94.8	213
100	0.41	1.6	6.5	26.0	**104**	234
125	0.49	2.0	7.9	31.6	126	284

[1]For well-rounded orifices, multiply the values by 0.97, and for a sharp-edged orifice, multiply the values by 0.61.

Courtesy of: U.S. Department of Energy, Dec. 2000 Tip #3

Compressed air system leaks are typically at fittings and valves.



Determining the size of the opportunity

1. Determine how many leaks you have
2. Estimate the size of the leaks.

General rule of thumb is that leaks average 3 CFM each = $450 per year for each leak.

Source: https://www.maintworld.com/Asset-Management/Best-Practices-for-Ultrasonic-Compressed-Air-Leak-Detection

Determining the size of the opportunity

- One way to estimate how much leakage a system has is to turn off all of the point-of-use devices and pneumatic tools, then start the compressor and record the average time it takes for the compressor to cycle on and off. The total percentage of leakage can be calculated as follows:
- Percentage = [(T x 100) / (T + t)]
- T = on time in minutes
- t = off time in minutes

Determining the size of the opportunity

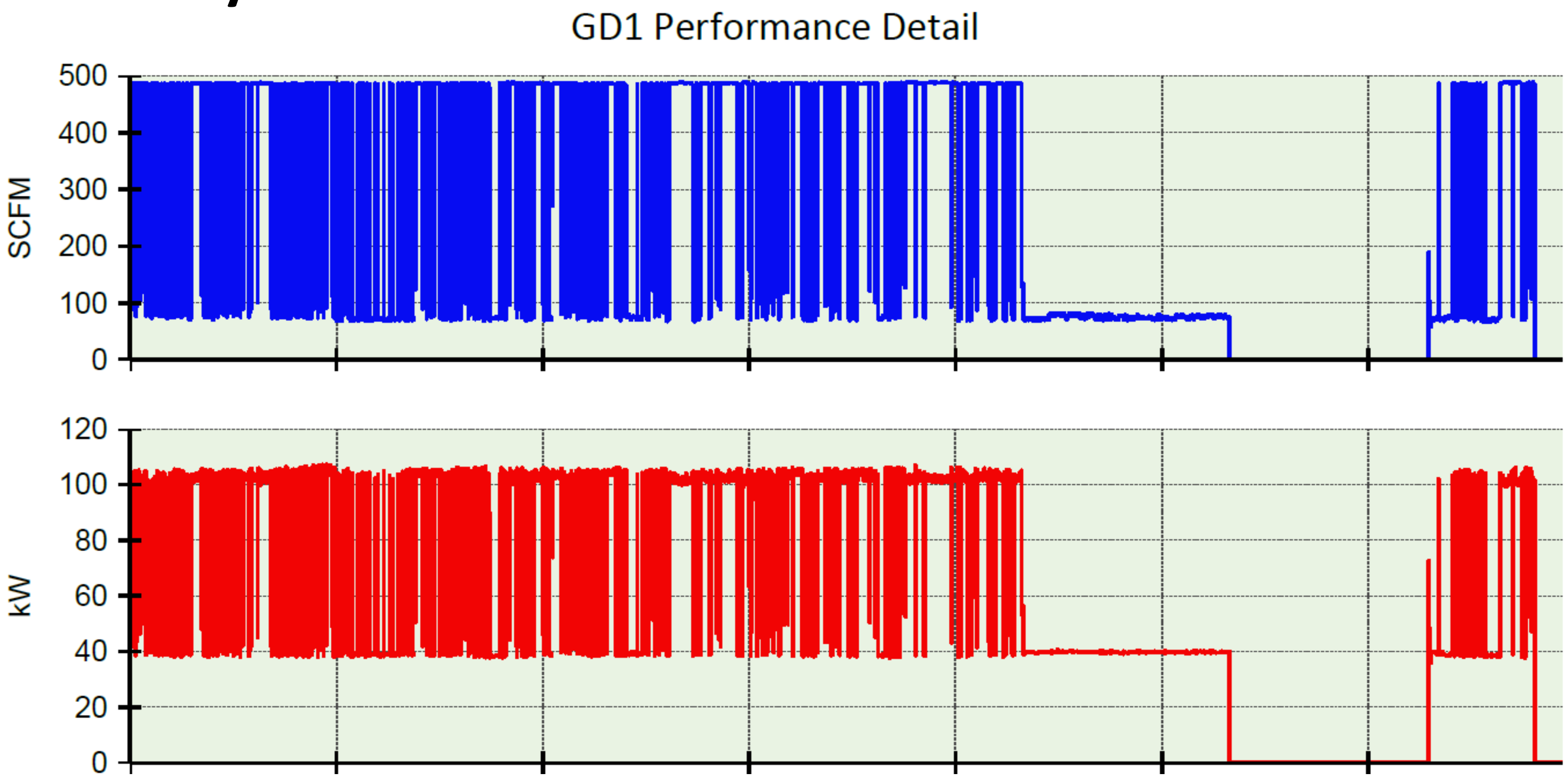
Another method to calculate the amount of leakage in a system is by using a downstream pressure gauge from a receiver tank. You would need to know the total volume in the system at this point though to accurately estimate the leakage. As the compressor starts to cycle on, you want to allow the system to reach the nominal operating pressure for the process and record the length of time it takes for the pressure to drop to a lower level.

Formula:

- $(V \times (P1 - P2) / T \times 14.7) \times 1.25$
- V= Volumetric Flow (CFM)
- P1 = Operating Pressure (PSIG)
- P2 = Lower Pressure (PSIG)
- T = Time (minutes)
- 14.7 = Atmospheric Pressure
- 1.25 = correction factor to figure the amount of leakage as the pressure drops in the system

Determining the size of the opportunity

Estimate the total size of the leaks throughout the plant based on an air study.



In this example, on Friday afternoon the plant shuts down; but the compressed air system is not shut off until noon on Saturday. In the meantime, compressor is still sending 60 CFM out to the plant and drawing 40 kW. The system is potentially wasting $33,200 in compressed air annually.

Sanity check: the potential air leaks represent 12% of total.

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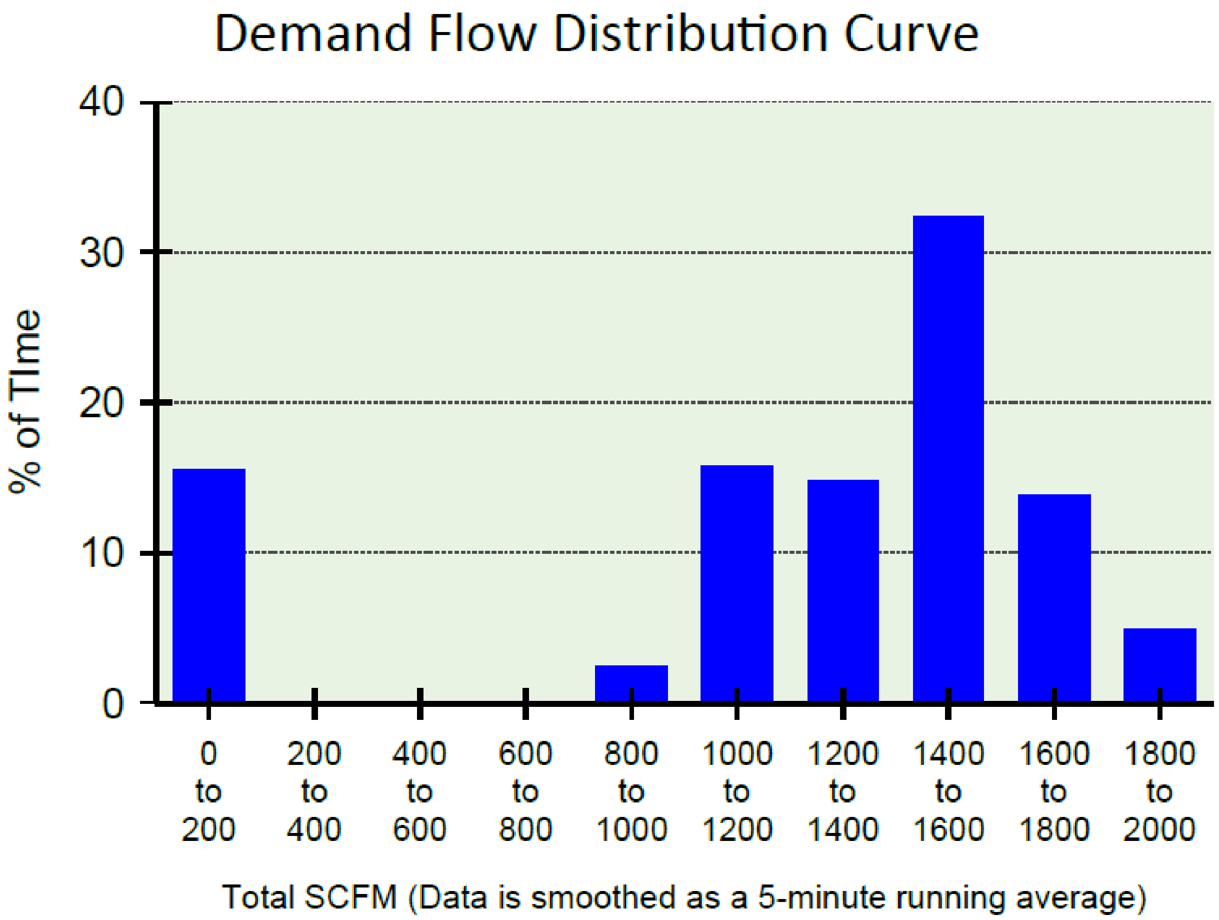
Determining the size of the opportunity

Estimate the total size of the leaks throughout the plant based on an air study.

In this example, ~15% of the time the compressed air system is delivering between 0 to 200 CFM.



Determining the size of the opportunity

Estimate the total size of the leaks throughout the plant based on an air study.

From the Demand Flow Distribution Curve graphic on the previous slide, we observed that 15.52% of the time the compressed air system is delivering between 0 to 200 CFM.

But the average CFM in this bin is actually only 0.2CFM.

This compressed air system has virtually no leaks.

SCFM	Average	Percentage	Hrs/Week	Cumulative %
0-200	0.2	15.52	26.1	15.5
200-400	291.6	0.03	0.1	15.6
400-600	495.6	0.03	0.1	15.6
600-800	753.4	0.17	0.3	15.7
800-1000	939.7	2.50	4.2	18.3
1000-1200	1,134.3	15.82	26.6	34.1
1200-1400	1,311.4	14.78	24.8	48.9
1400-1600	1,531.3	32.43	54.5	81.3
1600-1800	1,669.7	13.81	23.2	95.1
1800-2000	1,824.8	4.91	8.2	100.0

Determining the size of the opportunity

Estimate the total size of the leaks throughout the plant based on an air study.

This air study provided us with a bin analysis of CFM used and annual hours in each bin. At this plant, they run their system only 2700 hours per year and there is never a time when the plant uses less than 210 CFM.

Air leaks for this plant are estimated to be between 103,950 CFM and 623,700CFM annually or between $1,975 and $11,850.

Estimate is based on industry averages: 5-30% of air is lost due to leaks.

Hours per year	CFM	TOTAL	COST
300	1,050	315,000	$ 6,300
282	998	281,647	$ 5,633
265	945	250,147	$ 5,003
247	893	220,500	$ 4,410
229	840	192,706	$ 3,854
212	788	166,765	$ 3,335
194	735	142,676	$ 2,854
176	683	120,441	$ 2,409
159	630	100,059	$ 2,001
141	578	81,529	$ 1,631
124	525	64,853	$ 1,297
106	473	50,029	$ 1,001
88	420	37,059	$ 741
71	368	25,941	$ 519
53	315	16,676	$ 334
35	262	9,265	$ 185
18	210	3,706	$ 74
0	157	0	$ 0
2,700	total annual use	2,079,000	$ 41,580

Determining the size of the opportunity

Estimate the total size of the leaks throughout the plant based on a calculation of total air using an estimated bin analysis.

Load	# Hours	Hours per year	CFM	TOTAL	COST		
100%	6%	533	2,000	1,066,000	$ 21,320	8,760	Facility Hours of Operatio
95%	6%	504	1,900	957,600	$ 19,152	2000	Max Capacity (CFM)
90%	12%	1,021	1,800	1,837,800	$ 36,756		
85%	4%	357	1,700	606,900	$ 12,138		
80%	5%	440	1,600	704,000	$ 14,080		
75%	9%	792	1,500	1,188,000	$ 23,760		
70%	5%	454	1,400	635,600	$ 12,712		
65%	8%	730	1,300	949,000	$ 18,980		
60%	5%	453	1,200	543,600	$ 10,872		
55%	9%	798	1,100	877,800	$ 17,556		
50%	6%	543	1,000	543,000	$ 10,860		
45%	5%	459	900	413,100	$ 8,262		
40%	4%	392	800	313,600	$ 6,272		
35%	6%	555	700	388,500	$ 7,770		
30%	4%	386	600	231,600	$ 4,632		
25%	2%	186	500	93,000	$ 1,860		
20%	2%	155	400	62,000	$ 1,240		
15%	0%	2	300	600	$ 12		
10%	0%	0	200	-	$ -		
5%	0%	0	100	-	$ -		
			total annual use	11,411,700	$ 228,234		
			assumed annual air leaks (15%)			1,711,755	CFM

When multiplied against the total operating hours and full load kW for a given compressor system, the result is a reliable estimate of any small compressor's annual energy consumption.

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Determining the size of the opportunity

COMPRESSOR DATA SHEET

In Accordance with Federal Uniform Test Method for Certain Lubricated Air Compressors

Rotary Compressor: Fixed Speed

Gardner Denver

MODEL DATA - FOR COMPRESSED AIR			
1	Manufacturer: Gardner Denver		
2	Model Number: L132(F)-110#	Date:	12/17/2021
	[X] Air-cooled [ ] Water-cooled	Type:	Screw
		# of Stages:	1
3*	Rated Capacity at Full Load Operating Pressure [a, e]	834.9	acfm [a,e]
4*	Full Load Operating Pressure [b]	100	psig [b]
5	Maximum Full Flow Operating Pressure [c]	117	psig [c]
6	Drive Motor Nominal Rating	180	hp
7	Drive Motor Nominal Efficiency	95.4	percent
8	Fan Motor Nominal Rating (if applicable)	8.8	hp
9	Fan Motor Nominal Efficiency	91	percent
10*	Total Package Input Power at Zero Flow [e]	45.3	kW [e]
11	Total Package Input Power at Rated Capacity and Full Load Operating Pressure [d]	150.21	kW [d]
12*	Package Specific Power at Rated Capacity and Full Load Operating Pressure [e]	17.99	kW/100 cfm [e]
13	Isentropic Efficiency	73.87	Percent

*For models that are tested in the CAGI Performance Verification Program, these items are verified by the third party administrator.

Consult CAGI website for a list of participants in the third party verification program: www.cagi.org

NOTES:

a. Measured at the discharge terminal point of the compressor package in accordance with ISO 1217, Annex C; ACFM is actual cubic feet per minute at inlet conditions.
b. The operating pressure at which the Capacity (Item 3) and Electrical Consumption (Item 11) were measured for this data sheet.
c. Maximum pressure attainable at full flow, usually the unload pressure setting for load/no load control or the maximum pressure attainable before capacity control begins. May require additional power.
d. Total package input power at other than reported operating points will vary with control strategy.
e. Tolerance is specified in ISO 1217, Annex C, as shown in table below:

NOTE: The terms "power" and "energy" are synonymous for purposes of this document.

CAGI Compressed Air & Gas Institute Member

Volume Flow Rate at specified conditions		Volume Flow Rate	Specific Energy Consumption	No Load / Zero Flow Power
m^3 / min	ft^3 / min	%	%	%
Below 0.5	Below 17.6	+/- 7	+/- 8	+/- 10%
0.5 to 1.5	17.6 to 53	+/- 6	+/- 7	
1.5 to 15	53 to 529.7	+/- 5	+/- 6	
Above 15	Above 529.7	+/- 4	+/- 5	

ROT 030.1

12/19 Rev : This form was developed by the Compressed Air and Gas Institute for the use of its members participating in the PVP. CAGI has not independently verified the reported data.

Configurator: L90-132F

To use the estimated load method, you need to know the amount of air used.

The size of the system can be estimated based on the size of the air compressors. This data is available from CAGI data sheets.

If the compressor system has been sized properly, then the max load on the system will be close to the 100% capacity of the compressors.

Determining the size of the opportunity

The size of the opportunity can also be estimated based on the energy use of the compressed air system.

For the company I am working with right that now uses $602K in electricity annually for their compressed air system, savings is estimated to be between $30K (5%) and $180K (30%).

Case Study #1

- Customer has 2 machines with a total capacity of 640 CFM.
- Based on the air study, this customer uses 4,739,131 CFM annually.
- In-house leak repair resulted in 15% reduction in leaks.
- Annual cost savings of $13,500

Compressor Performance Summary									
Compressor Information	Full Load Ratings			Performance Summary					
Name, Manufacturer, Model, Nominal Power, Control Type	Full Load Flow	Rated Pressure	Full Load Package Power	% Run Time	Average Flow*	Average Pressure*	Average Power*	Measured Efficiency*	Annual Energy Cost**
Sullair SN7507S Sullair SN7507S AC 100.00 HP Variable Displacement	500 ACFM	100 Psig	89.4 kW	100%	420.7 SCFM	105.9 Psig	79.8 kW / 106.9 HP	19 kW/ 100 SCFM	$90,569
Sullair 2207 Sullair 2207 30.00 HP Inlet Modulation With Blow Down	140 ACFM	100 Psig	27.7 kW	100%	121.8 SCFM	105.9 Psig	27.3 kW / 36.6 HP	22.4 kW/ 100 SCFM	$30,978
Total (System)	640 ACFM	N/A	117.1 kW	100%	542.4 SCFM	105.9 Psig	107 kW / 143.5 HP	19.7 kW/ 100 SCFM	$121,547
* Averages include data only when compressor was running					**Annual Energy Cost does not include demand charges				

Case Study #2

- Customer has 3 machines with a total capacity of 2,121 CFM.
- Customer had no air study or other calculated estimate of potential savings.
- In-house leak repair resulted in 18% reduction in leaks.
- Customer was able to remove one compressor from the system.
- Annual cost savings of $32,180

Questions?

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