AR No. 5

Reduce Air Leaks

Recommended Action

Compressing air is inefficient, with as much as 90% of compressor power dissipated as waste heat. Therefore, leaks can be expensive. Eliminating all leaks in a complex distribution system is unrealistic. However, proper preventive maintenance can minimize the expense associated with leaks. Fixing the leaks in your system will save more than 182,000kWh of energy and reduce compressor operating costs 36.4%.

Assessment Recommendation Summary				
Energy (10^6Btu)	Energy (kWh)	Cost Savings	Implementation Cost	Payback (years)
622	182,300	$7,825	$8,000	1

* 10^6 Btu = 0.0034*kWh

Background

Two Quincy 75-hp compressors with load-unload controls are used for production air needs throughout the plant. Both compressors are used in a single air system. Current equipment specifications are shown in the following table. The total operating hours for both compressors combined is 4,824 hours per year.

Compressor Summary Table	Compressor 1	Compressor 2
manufacturer	Quincy	Quincy
model	QNW-372-D/A	QNW-372-D/A
type	single stage screw	single stage screw
horsepower (hp)	75	75
air capacity (acfm)	370	370
part load control	load-unload	load-unload
unload Point	100%	100%

*Refer to Appendix C.1 for selected definitions of above terms
*Refer to Appendix C.3 for an explanation of various part load controls

System Baseline and Modeling

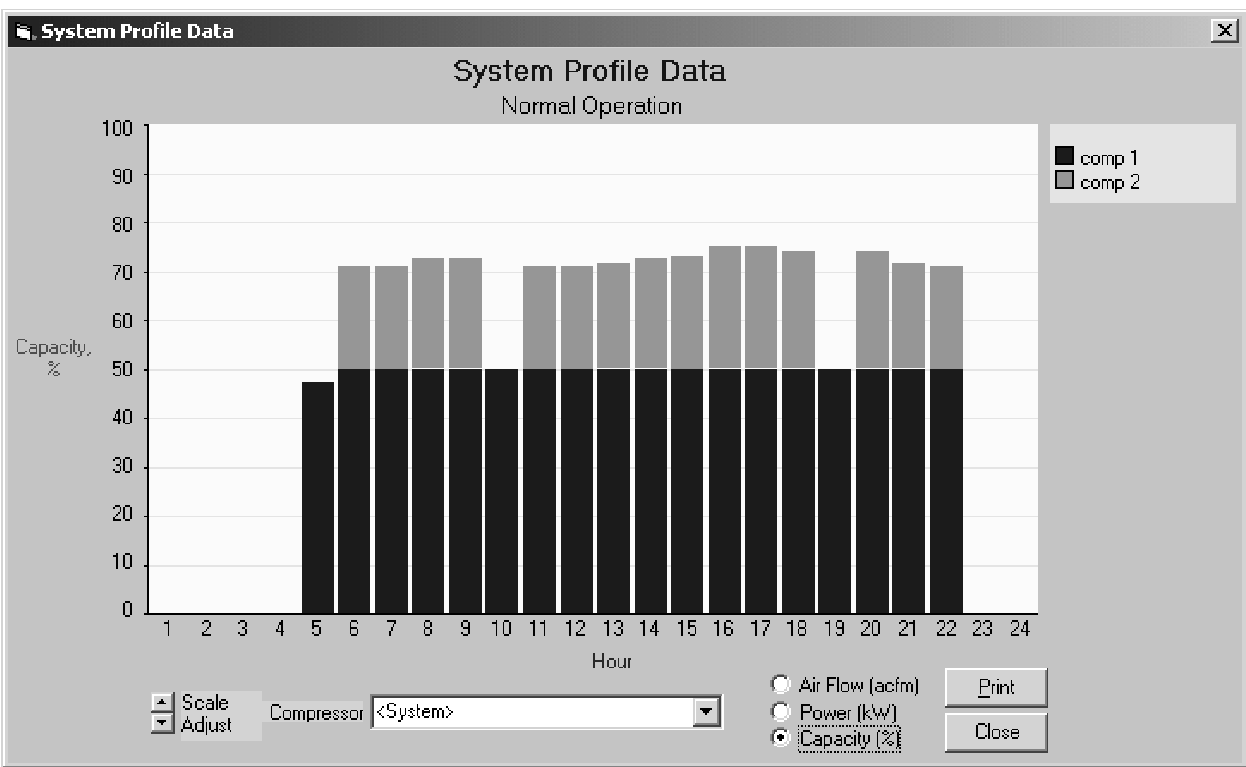
Compressor input current was measured during production and non-production (leak-load) period. Input power and percent of full load power for each operating point was calculated for each compressor based on the operating power demand formula found in Appendix A. Average system airflow and percent of system capacity ($\%C_s$) for each load was determined based on the following power-capacity relationship:

$$\%C = \frac{\%P - \%P_{nl}}{100\% - \%P_{nl}} \times 100\% \qquad (C.3.3)$$

where,

$\%P_{nl}$ = Percent power when no air is delivered
= 30% full load power

A description of low-unload controls and modeling relationships can be found in Appendix C. The profile below is based on information collected at your plant and shows current capacity of the system along with the relative contribution of each compressor. Although your system operates with more variability than is illustrated here, it closely approximates the average operating conditions during each shift. Baseline operating conditions are summarized in the following table.



System Baseline Conditions						
Full load power = 55.9 kW	Compressor 1		Compressor 2		System Average	
Component	Production	Leaks	Production	Leaks	Production	Leaks
Measured (%Capacity)	99.70%	88.00%	41.50%	N/A	69.60%	44.10%
Peak Power (kW)	66.3	55.9	55.7	N/A	122	55.9
Calculated (% Full load Power, eqn C 2.2)	118.50%	100.00%	99.60%	N/A	N/A	N/A
Calculated Airflow (acfm, eqn 2.3)	368.9	326	146.3	N/A	515.2	326

*Compressor 2 was not on while leak measurements were taken

Anticipated Savings

Proposed conditions are based on fixing air leaks throughout the facility. Savings were calculated using Airmaster+, a computer simulation package developed by Washington State University and distributed by the US Department of Energy. Modeling with Airmaster+ is based on the power-capacity relationship described in the system baseline and modeling section. The software accounts for combined changes to multiple compressors in a single air system.

Existing system average plant air use (Plant Load), expressed as a percentage of compressor capacity, can be determined by subtracting the Leak Load from the Average Production Load.

Plant Load = (Average Production Load) – (Leak Load)
= $(\%C) - (\%C_L)$
= 69.60% - 44.1%
= 25.5%

Leak load, expressed as a percent of plant load, is calculated as:

Leak % = Leak Load ÷ Plant Load
= 44.1 % ÷ 25.5%
= 172.9%

For your plant, a relatively clean and accident free environment, it is reasonable to expect no more than a 20% (%L) increase in airflow over peak plant requirements to satisfy leaks during production. We calculate proposed system airflow to support leaks ($\%C_l$) during production by multiplying peak plant requirements by %L using the following formula:

$$\%C_l = (\%C_p) \times \%L$$

Proposed system airflow ($\%C_s$) for all production loads is calculated as peak plant air use plus proposed leak airflow.

$$\%C_s = \%C_p \times (100\% + \%L)$$

Proposed power for production and non-production periods is estimated by rearranging the power-capacity relationship to solve for percent of full load power.

$$\%P = (100\% - \%P_{nl}) \times \%C + \%P_{nl}$$

Proposed power (D) and energy (E_p) are calculated as:

$$D = \%P \text{ x Full load power}$$
$$E = P \text{ x OH}$$

The operating summary table shows current conditions and proposed conditions after leaks have been repaired. Savings are calculated as the difference between current and proposed conditions. Existing and proposed airflows for each compressor during normal operating conditions are also shown in the System Air Flow Profile graphs at the end of this recommendation.

Operating Summary						
	Total OpHrs	Peak Power, (kW)	Annual Energy, (kWh)	Avg. Production Load, (%Cs)	Avg. Plant Load, (%Cs)	Leak Load, (%Cs)
Existing	4,824	119.7	500,580	69.6	24.5	44.1
Proposed	4,824	72.3	318,215	30.7	24.5	6.2
Savings	0	47.4	182,365	37.9	0.0	37.8

Demand Cost savings (DC) for a given operating condition is calculated as the peak demand savings (DS) multiplied by your current demand charge of $4.94/kW-mo and the number of operating months per year. Energy cost savings is the product of annual energy savings (ES) and the incremental rate of $0.04557/kWh.

$$DC = DS \text{ x Demand Charge x 12 months per year}$$

$$EC = ES \text{ x Energy Charge}$$

Total cost savings (CS) is the sum of demand cost savings and energy cost savings.

$$CS = DC + EC$$

Savings for the air compressors are summarized in the Savings Summary table.

Savings Summary				
Source	Quantity	Units	Energy 10^6Btu	Cost $
Electric Energy	182,365	kWh	622	$5,015
Demand	47.4	kW	0	$2,810
Total			622	7,825

Implementation Cost

We estimate that the Implementation Cost (IC) of reducing the leaks to 20% above peak plant airflow is:

IC = $8,000

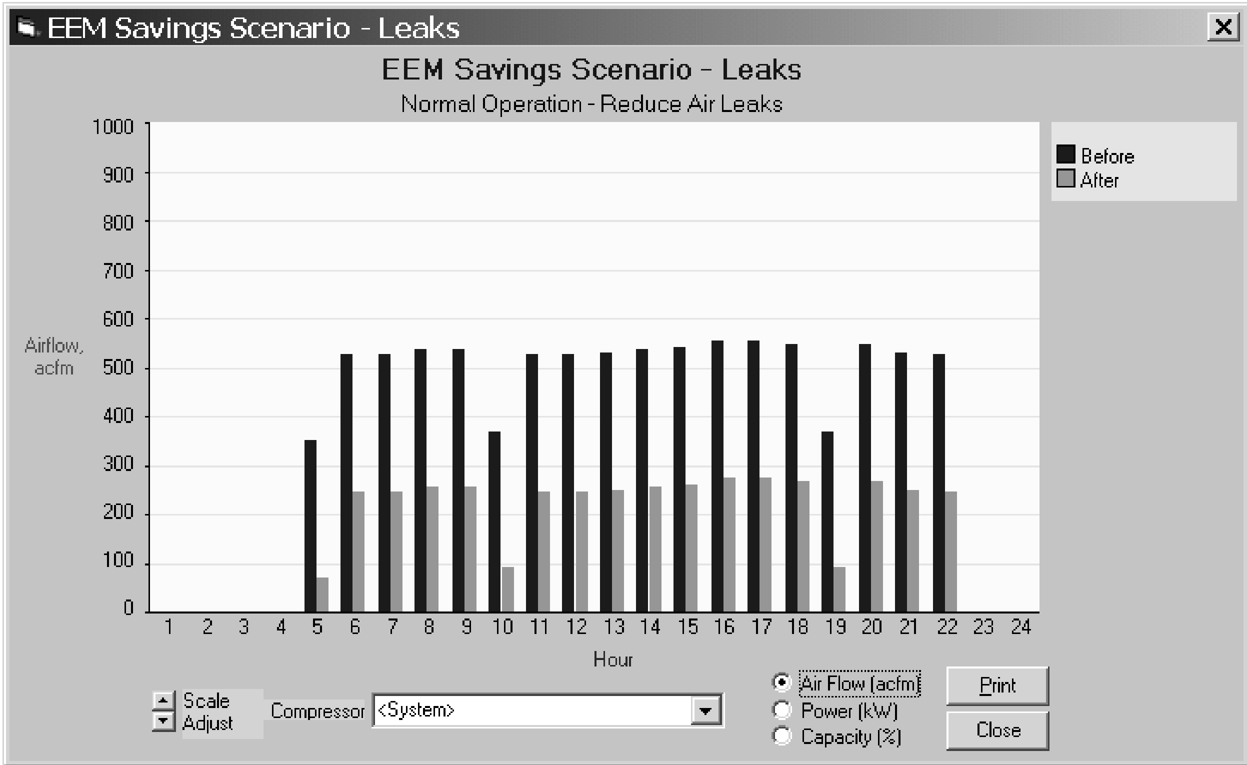
The total cost savings (CS) will pay for the implementation cost in 1.0 years.

Application

- Qualified personnel should repair air leaks in the plant during non-production periods. Many leaks are from faulty fittings, lines, valves, hoses, and pneumatic rams or cylinders. Inappropriate uses such as equipment or personnel cooling can easily be reduced or eliminated.

Potential Barriers

- Pneumatic ram or cylinder rebuild kits and labor can cost several hundred dollars, depending on the size and location of the leak.
- Fixing air leaks may require plant down time.
- After identifying locations of air leaks, it may be possible to valve off sections of the compressed air system allowing partial plant operation while non-operable sections are being repaired.
- Cost of fixing air leaks depends on leak location and necessary safety standards.


EEM Savings Scenario - Leaks
EEM Savings Scenario - Leaks
Normal Operation - Reduce Air Leaks
Airflow, acfm
1000
900
800
700
600
500
400
300
200
100
0
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
Before
After
Scale Adjust
Compressor
<System>
Air Flow (acfm)
Power (kW)
Capacity (%)
Print
Close