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%.

<table>
<thead>
<tr>
<th>Assessment Recommendation Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (10^6Btu)</td>
</tr>
<tr>
<td>622</td>
</tr>
</tbody>
</table>

*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.

<table>
<thead>
<tr>
<th>Compressor Summary Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor 1</td>
</tr>
<tr>
<td>manufacturer</td>
</tr>
<tr>
<td>model</td>
</tr>
<tr>
<td>type</td>
</tr>
<tr>
<td>horsepower (hp)</td>
</tr>
<tr>
<td>air capacity (acfm)</td>
</tr>
<tr>
<td>part load control</td>
</tr>
<tr>
<td>unload Point</td>
</tr>
</tbody>
</table>

*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:

$$\%C = \frac{\%P - \%P_{nl}}{100\% - \%P_{nl}} \times 100\%$$  \hspace{1cm} (C.3.3)

where,

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

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Compressor 1 Production</th>
<th>Leaks</th>
<th>Compressor 2 Production</th>
<th>Leaks</th>
<th>System Average Production</th>
<th>Leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured (%Capacity)</td>
<td>99.70%</td>
<td>88.00%</td>
<td>41.50%</td>
<td>N/A</td>
<td>69.60%</td>
<td>44.10%</td>
</tr>
<tr>
<td>Peak Power (kW)</td>
<td>66.3</td>
<td>55.9</td>
<td>55.7</td>
<td>N/A</td>
<td>122</td>
<td>55.9</td>
</tr>
<tr>
<td>Calculated (% Full load Power, eqn C 2.2)</td>
<td>118.50%</td>
<td>100.00%</td>
<td>99.60%</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Calculated Airflow (acfm, eqn 2.3)</td>
<td>368.9</td>
<td>326</td>
<td>146.3</td>
<td>N/A</td>
<td>515.2</td>
<td>326</td>
</tr>
</tbody>
</table>

*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.

\[
\text{Plant Load} = (\text{Average Production Load}) - (\text{Leak Load})
\]

\[
= (%C) - (%C_l)
\]

\[
= 69.60\% - 44.1\%
\]

\[
= 25.5\%
\]

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

\[
\text{Leak \%} = \frac{\text{Leak Load}}{\text{Plant Load}}
\]

\[
= 44.1\% ÷ 25.5\%
\]

\[
= 172.9\%
\]

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:

\[
D = \%P \times \text{Full load power}
\]
\[
E = P \times \text{OH}
\]

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.

<table>
<thead>
<tr>
<th>Operating Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Existing</td>
</tr>
<tr>
<td>Proposed</td>
</tr>
<tr>
<td>Savings</td>
</tr>
</tbody>
</table>

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.

\[
DC = DS \times \text{Demand Charge} \times 12 \text{ months per year}
\]
\[
EC = ES \times \text{Energy Charge}
\]

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.
<table>
<thead>
<tr>
<th>Source</th>
<th>Quantity</th>
<th>Units</th>
<th>Energy $10^6$Btu</th>
<th>Cost $</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Energy</td>
<td>182,365</td>
<td>kWh</td>
<td>622</td>
<td>$5,015</td>
<td></td>
</tr>
<tr>
<td>Demand</td>
<td>47.4</td>
<td>kW</td>
<td>0</td>
<td>$2,810</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>622</td>
<td>7,825</td>
<td></td>
</tr>
</tbody>
</table>

**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.