Fixing the Leaks is Only Half the Battle: Capturing and Sustaining Energy Savings

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Kaeser Compressors, Inc.
U. S. Department of Energy estimates that half of all compressed air is wasted.

- Artificial Demand – 10-15%
- Inappropriate Use – 5-10%
- Leaks – 25-30%
- Productive Use – 50%
Capturing and Sustaining Energy Savings

9,500 CFM in Production

3,200 CFM Leak Load
Capturing and Sustaining Energy Savings

1000 CFM Average Production

882 CFM Leak Load
### Capturing and Sustaining Energy Savings

<table>
<thead>
<tr>
<th>Energy</th>
<th>Total Energy Consumption (kWh/yr)</th>
<th>933,901</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum kW Draw (kW)</td>
<td>218</td>
</tr>
<tr>
<td></td>
<td>Average kW Draw (kW)</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>Annual Energy Cost ($/yr) at 0.100 $/kWh</td>
<td>$93,390</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow</th>
<th>Total Flow (CF/yr)</th>
<th>240,319,616</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Available Capacity (CFM)</td>
<td>2,060</td>
</tr>
<tr>
<td></td>
<td>Peak Supply Flows: Excluding Startup (CFM)</td>
<td>870</td>
</tr>
<tr>
<td></td>
<td>Duration of Peak Supply Flow (Minutes)</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Average Supply Flow (CFM), while the compressors were online</td>
<td>642</td>
</tr>
<tr>
<td></td>
<td>Minimum Supply Flow (CFM), while the compressors were online</td>
<td>520</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Pressure Sensor Location</th>
<th>Main Compressor Room</th>
<th>Sullair 75L Pressure</th>
<th>Sullair 75H Pressure</th>
<th>Remote Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum Pressure (PSIG)</td>
<td>113</td>
<td>122</td>
<td>115</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>Minimum Pressure (PSIG), while the compressors were online</td>
<td>71</td>
<td>80</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Average Pressure (PSIG), while the compressors were online</td>
<td>105</td>
<td>108</td>
<td>103</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>Minimum Perceived Pressure (PSIG)</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Capturing and Sustaining Energy Savings
This is an automatic drain that did not appear to be leaking. However, the valves were closed and the handles removed. When the handles were reinstalled and the valves opened, the drain leaked.
Capturing and Sustaining Energy Savings

Leak Repair

1st priority - Leaks to repair as soon as possible

• Leaks that represent a safety problem due to blowing air, noise, etc.
• Leaks that have the potential to interrupt production or cause equipment failure.
• Large leaks with air loss that could cause local or total system drawdown.
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Leak Repair

2nd priority - Leaks to schedule first, repair within 1-2 weeks

• Leaks that are in the top 20% for air volume being lost from the system. The technician will gain a sense of relative leak size, noticeably large leaks fall into this category. Hopefully over time the top 20% of leaks are getting smaller in size.
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Leak Repair

3rd priority - Leaks that should be repaired within 3-4 months

-Leaks that account for significant air loss but are not in the top 20%.

-Small leaks that are a direct result of poor piping practice. For example poorly constructed hose, plastic tubing, or any other leak that is small at the present time but is sure to get bigger unless corrective action is taken.
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Leak Repair

4th priority - Leaks to Repair Only if They Move Up in Priority

- Leaks that are small and located in otherwise sound piping. A leak that is not likely to get larger as time goes on.
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Prevention of Compressed Air Leaks

• Isolate compressed air lines and pneumatic equipment from sources of physical damage, heat, and vibration.

• Establish piping practice and equipment connection standards, which provide for strong and durable connection to the compressed air system.

• Avoid use of plastic tubing, and push-on connectors.
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Key Points

- Compressed air leaks are expensive and can represent 20% to 50% of all air demand.
- Non-production air demand can be measured, calculated from compressor load cycles, or calculated based on pressure drawdown rates. After subtracting residual valid air demands, the system leakage can be estimated.
- Artificial Demand is a component of leakage, as well as any unregulated air demand. If leaks are repaired and system pressure is allowed to increase, the leakage repaired can be consumed by artificial demand. Controlling and/or reducing system pressure will minimize the amount of loss to artificial demand.
Percent of Electricity Consumed by Compressed Air Systems

- 0-5%
- 5-6%
- 6-7%
- 7-8%
- 8-9%
- 9+%

Map showing the distribution of electricity consumption by compressed air systems across the United States.
Percent of Electricity Consumed by Compressed Air Systems

With system optimization
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• Most motor-driven systems are initially designed with:
  – The assumption that “more” is better, where supply is concerned
  – Little or no thought given to system efficiency
  – No plan for increases or decreases in system demand
  – A “lowest first cost” goal

• Changes to existing systems face the same issues
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• The size of a system has little influence on the savings potential, as a percentage of current consumption

• Small, medium and large systems have similar savings potential
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Key to accomplishing efficient operation of multiple compressor installations is a master controller that automates the compressed air system. This assures that the correct compressors are running to meet the air demand in the most efficient manner.
Capturing and Sustaining Energy Savings

Up to one year’s worth of data recorded including:
- Flow
- Pressure
- Load/Idle cycles
Capturing and Sustaining Energy Savings

Up to one year’s worth of data recorded including:

- Graphed Power Cost
- Load/Idle Power
- Specific Power
- Tabular Power Costs
Capturing and Sustaining Energy Savings

- Competitive
  - 75 hp, 326 cfm at 125 psig
  - Modulation Control

- Competitive
  - 75 hp, 360 cfm at 110 psig
  - Dual Control with service issues

- Competitive
  - 75 hp, 360 cfm at 110 psig
  - Unit was offline and not operational during testing period

- 500 cfm Refrigerated Dryer
  - Only dryer online during the testing period

- 400 cfm Refrigerated Dryer
  - Maintenance issues and the unit was offline during the testing period

- 3 inch Copper piping

- Looped 3" Copper distribution piping

- kW Meter
- Motor Signal
- Load Signal
- Pressure Transducer

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Averaged over 5 minutes. This graphic represents the flow supplied to the plant from the compressor station, as measured after the dryers. Typical production levels have a base line of 50 cfm with peak demands about 250 cfm. These events are short in duration but could increase to 630 cfm.

Peak demand of ~630 cfm

Base line of about 50 cfm could be due to leakage and could be quantified via a separate leak audit.
Based on the load and motor signals for Compressor #2, this unit was idling during this entire day except for a few brief periods. The average power consumption during these idling periods was approximately 48 kW for Compressor #2 for no output flow.

Data averaged over 5 minutes.
Capturing and Sustaining Energy Savings

<table>
<thead>
<tr>
<th>air delivery CFM</th>
<th>power requirement full load kW</th>
<th>power requirement idling kW</th>
<th>model and operating pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>325</td>
<td>68.0</td>
<td>20.4</td>
<td>Competitive 75 hp at 125-psig</td>
</tr>
<tr>
<td>360</td>
<td>65.4</td>
<td>19.6</td>
<td>Competitive 75 hp at 110-psig</td>
</tr>
<tr>
<td>360</td>
<td>65.9</td>
<td>19.8</td>
<td>Competitive 75 hp at 110-psig</td>
</tr>
</tbody>
</table>

Calculation based on data collected between 12/11/2008 - 12/17/2008
(Interval of Calculation: 5 minutes)

Existing Installation

<table>
<thead>
<tr>
<th>24 h running period per day</th>
<th>364 Working days per year</th>
<th>0.080 Power costs $/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>$28,904.98 Annual Energy Costs ($/yr)</td>
<td>$361,312 Annual Energy Consumption (kWh/yr)</td>
<td>$32,391,598 Annual Supply Flow (CF/yr)</td>
</tr>
<tr>
<td>66.93 Specific Power (kW / 100 cfm)</td>
<td></td>
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</table>

Recommended Kaeser Compressed Air Station

<table>
<thead>
<tr>
<th>24 h running period per day</th>
<th>364 Working days per year</th>
<th>0.080 Power costs $/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>$9,261.02 Annual Energy Costs ($/yr)</td>
<td>$115,763 Annual Energy Consumption (kWh/yr)</td>
<td>$32,391,598 Annual Supply Flow (CF/yr)</td>
</tr>
<tr>
<td>21.44 Specific Power (kW / 100 cfm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$19,643.96 Annual Energy Cost Savings ($/yr)</td>
<td>$245,550 Annual Energy Consumption Savings (kWh/yr)</td>
<td></td>
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</table>
Case Study – Improving Performance in a Small Compressed Air System at a Containerboard and Packaging Material Manufacturer
Capturing and Sustaining Energy Savings

- Original compressed air system used two 150 horsepower and one 125 horsepower compressors
- All three compressors operated with modulation controls at an average of 43% of full capacity
- There was no master controller
- Average monthly electrical expense for the compressors was $9,486.00
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- Optimization included four base-load compressors and one variable speed trim compressor.
Supply piping was modified to minimize turbulence and pressure drops.
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• Main header piping was oversized to reduce velocities and allow for future growth of supply
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• A master controller was added that both controls the compressors and has data collection and reporting functions that assure sustainable efficiency
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- The results include:
  - 46% reduction in energy consumption
  - Less than 2-year payback, not including heat recovery savings
  - $4,000 to $5,000 USD savings per month
Capturing and Sustaining Energy Savings

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