**Recommendation ${REC}: Repair Leaks in Compressed Air Lines**

**Recommended Action**

It is recommended that leaks in the compressed air lines be identified and fixed, resulting in less energy consumption.

**Summary of Estimated Savings and Implementation Costs**

|  |  |
| --- | --- |
| Recommendation Type | Compressor |
| Annual Cost Savings | ${ACS} |
| Implementation Cost | ${IC} |
| Payback Period | ${PB} |
| Annual Electricity Savings | ${AES} kWh |
| Annual Demand Savings | ${ADS} kW |
| ARC Number | 2.4236.2 |

**Current Practice and Observations**

A perfectly sealed compressed air system can never be fully achieved; therefore, it is appropriate to assume that there are leaks in the compressed air lines in any plant. There is an approximate total of ${HP} HP (based on partial load) worth of compressor power at this plant. During the plant visit, several air leaks were realized. Based on the visit and estimations of plant personnel, for this recommendation it is assumed that there are ${LeakString} leaks from production machinery, faulty valves, etc. The cost of compressed air leaks is the energy cost to compress the volume of lost air from atmospheric pressure to the compressor operating pressure. The amount of lost air depends on the line pressure, the compressed air temperature at the point of the leak, the air temperature at the compressor inlet, and the estimated area of the leak. The leak area estimation is based on the velocity of the air from the leak through a restricted air anemometer with negligible compressibility.

**Anticipated Savings**

The parameters listed below affect the cost of compressed air leaks.

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| Air temperature at compressor inlet, °F | ${T0} |
| Air temperature at point of leak, °F | ${T1} |
| Compressor operating pressure, psig | ${P0} |
| Line pressure at point of nozzle, psig | ${P1} |
| Compressor motor size, HP (total) | ${HP} |
| Compressor motor efficiency | ${EM} |
| Compressor type | ${CT} |
| Annual operating hours of nozzles | ${OH} |

**Table 1: Compressed Air System Parameters.**

Using these values, the volumetric flow rate, power lost due to leaks, demand loss, energy lost, and cost for leaks of various sizes were calculated specifically for these conditions. The results are shown in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Hole  Diameter  (inches) | Flow  Rate  (cfm) | Power  Loss  (hp) | Demand  Loss  (kW/yr) | Energy  Loss  (kWh/yr) | Leak  Cost  ($/yr) |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
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|  |  |  |  |  |  |
|  |  |  |  |  |  |

**Table 2: Cost of Compressed Air Leaks.**

As the table above shows, the cost of compressed air leaks increases exponentially as the size of the leak increases. The estimated demand savings, energy savings, and corresponding cost savings for air leaks are listed in the following table. These air leaks are given as a sample to show the amount of savings that can be achieved by a having a rigorous air audit twice per year.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Leak Location** | **Number of Leaks** | **Leak Diameter (inches)** | **Demand Savings (kW/yr)** | **Energy Savings (kWh/yr)** | **Cost Savings ($/yr)** |
| ${LL} |  |  |  |  |  |
| ${LL} |  |  |  |  |  |
| ${LL} |  |  |  |  |  |
| ${LL} |  |  |  |  |  |
| ${LL} |  |  |  |  |  |
| ${LL} |  |  |  |  |  |
| **TOTAL:** | ${SNL} |  | ${ADS} | ${AES} | ${ACS} |

**Table 3: Summary of Savings for Compressed Air Leaks.**

**Implementation Cost**

The cost savings for this recommendation assumes that there are only ${SNL} leaks in the plant. Additional leaks are probable and can most easily be detected and repaired by plant maintenance personnel during non-production periods, when the hiss of the air leaks will be easier to detect. Plant personnel should also be equipped with ultrasonic leak detection equipment, which will make finding leaks very simple. We recommend that periodic detection and repair of air leaks be performed during non-production periods. A suggested maintenance schedule would be a one-time thorough inspection, followed by less intense monthly or weekly inspections of all the compressed air lines in the plant. It is recommended that this be done when the plant is not operational. It is estimated that finding one leak takes about an hour, and fixing one leak also takes an hour. With a labor cost of ${LR} per hour, the total implementation cost to fix these ${SNL} leaks is estimated to be ${FLC}. An ultrasonic leak detector costs ${USLD}. The purchase of an ultrasonic leak detector would increase the cost to ${IC}. This cost assumes the leaks are found by plant personnel.

**Suggestion:** It is recommended that the facility undergo a dedicated air leak survey to locate additional leaks in the compressed air lines. The client can also purchase an ultrasonic leak detection device to undertake in-house leak inspections.

**The annual electricity savings for this recommendation is ${AES} kWh, and the annual demand savings is ${ADS} kW. The annual cost savings is ${ACS} and, with an implementation cost of ${IC}, the payback period will be ${PB}.**

**Implementation Cost References**

The below links are for implementation cost references. We do not endorse/recommend these brands or products. Furthermore, these products may or may not be suitable for the application. The client should contact a vendor(s) to conduct a detailed study of the process, in order to determine the best product for the recommended application.

* [**https://www.trutechtools.com/AccuTrak-VPE-Ultrasonic-Leak-Detector-with-Contact-Probe**](https://www.trutechtools.com/AccuTrak-VPE-Ultrasonic-Leak-Detector-with-Contact-Probe)
* [**https://www.grainger.com/product/SUPERIOR-ACCUTRAK-Ultrasonic-Leak-Detector-35LX64**](https://www.grainger.com/product/SUPERIOR-ACCUTRAK-Ultrasonic-Leak-Detector-35LX64)
* [**https://www.pce-instruments.com/us/index.htm?\_artnr=5845567**](https://www.pce-instruments.com/us/index.htm?_artnr=5845567)

**Equations for Air Flow, Power Loss, and Energy Savings**

The volumetric flow rate of free air exiting the hole is dependent upon whether the flow is choked. When the ratio of atmospheric pressure to line pressure is less than 0.5283, the flow is said to be choked (i.e., traveling at the speed of sound). The ratio of 14.7 psia atmospheric pressure to ${P0} psia line pressure is ${RT}. Thus, the flow is choked. The volumetric flow rate of free air, Vf, exiting the leak under choked flow conditions is calculated as follows:

Vf =

where

Vf = Volumetric flow rate of free air in cubic feet per minute: see table above

Dk = Diameter of the leak: see table above

T0 = Temperature of the air at the compressor inlet: ${T0}°F (see table above)

Pl = Pressure differential at leak in question, equivalent to gage line pressure: ${P1} psi

Patm = Inlet (atmospheric) pressure: 14.7 psi

C1 = Isentropic sonic volumetric flow constant: 28.37 ft/sec-°R0.5

C2 = Conversion constant: 60 sec/min

Cd = Coefficient of discharge for square edged orifice[[1]](#footnote-1): 0.8

π = Mathematical constant: 3.1416

C3 = Conversion constant: 144 in2/ft2

Tl = Average line temperature: ${T1}°F.

The power loss from leaks, estimated as the power required to compress the volume of air lost from atmospheric pressure, Patm, to the compressor discharge pressure, P0, is as follows[[2]](#footnote-2).

L =

where

L = Power loss due to air leaks.

k = Specific heat ratio of air: 1.4

N = Number of stages: ${N}

C4 = Conversion constant: 3.03 × 10-5 HP-min/ft-lb

P0 = Compressor operating pressure: ${P0} psia

Ea = Air compressor isentropic (adiabatic) efficiency, where

Ea = 82% for single stage screw compressors

Ea = 75% for multi-stage reciprocating compressors

Ea = 82% for rotary screw compressors

Ea = 72% for sliding vane compressors

Ea = 80% for single-stage centrifugal compressors

Ea = 70% for multi-stage centrifugal compressors

Em= Compressor motor efficiency: ${EM}%

The annual energy savings, ES, and demand savings, DS, are estimated as follows:

ES = L × C5 × OH,

DS = L × C5 × CF × C6,

where

C5 = Conversion constant: 0.746 kW/ HP

OH = Annual time during which leak occurs: ${OH} hrs/yr (${HR} hrs/day, ${DY} days/wk, ${WK} wks/yr)

CF = Coincidence factor – probability that the equipment contributes to the facility peak demand: 100% per month

C6 = Conversion constant: 12 mos per year

1. A.H. Shapiro, The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. 1, Ronald Press, N.Y. 1953, p. 100. [↑](#footnote-ref-1)
2. Chapters 10 and 11, Compressed Air and Gas Handbook, Fifth Edition, Compressed Air and Gas Institute, New Jersey, 1989. [↑](#footnote-ref-2)