Recommendation

Reduce compressed air pressure to 105 psig. This will reduce the compressed air load, and associated annual energy consumption by 3.5%.

Annual Savings Summary

Source	Quantity	Units	Cost Savings
Electrical Consumption	41,986	kWh (site)	$2,325
Electrical Demand	72	kW Months / yr	$660
Total	**143**	**MMBtu**	**$2,985**

Implementation Cost Summary

Description	Cost	Payback (yrs)
Before Incentives	$500	0.2
No Incentives Found	-	-

Facility Background

The facility has three compressors to accommodate compressed air demand. A 150 hp load-unload compressor #1, is used as the primary compressed air source for the facility and runs continuously. The 100 hp compressor #2 is used as a back up compressor and does not operate under normal conditions. The 50 hp on/off compressor #3 is used to trim, providing additional compressed air during times of high demand. Analysts took live voltage and amperage readings on compressor #1 during the assessment. Analysts also measured a live system pressure reading of 112 psig. Dataloggers were placed on all compressors to record amperage data for one week. Details regarding the compressor and motor nameplate data were collected on site during the day of the assessment.

Opportunity Background

Compressing air is inefficient, with as much as 90% of compressor energy dissipated as waste heat. Maintaining a high system pressure increases the work the compressors must perform for a given volume of compressed air. This high system pressure can also increase air demand of unregulated end uses such as leaks, blow-off wands, and some production applications. With higher than necessary pressure, the system consumes more air and the compressors use more energy with little added benefit. Reducing system pressure will reduce compressor full-load power by approximately half of one percent for every psi pressure reduction [1]. A local receiver near high use applications is sometimes needed to reduce air pressure.

Proposal

Reduce the current pressure set point for the air compressors to 105 psig. This will reduce the compressor load, and lower associated annual energy consumption by 41,986 kWh per year and demand by 71.7 kW-month. This results in an annual cost savings of $2,985 with an implementation cost of $500, resulting in a simple payback of 0.2 years.

Calculation Methodology

The Motor Analysis Tool (MAT) was used to determine the average power draw for each compressor motor. The MAT uses both nameplate information and live power measurements to calculate motor energy consumption, load, shaft power output, and efficiency. MAT information was used with the Compressed Air Baseline Analysis Tool (CABAT) to calculate compressor performance using current motor readings collected with a data logger. CABAT information was then used to determine the savings associated with reducing compressor air pressure. Analysts assumed that 0.5% of total energy is saved per psig dropped.

Notes

Reduce air pressure incrementally to ensure production is not affected.

References

[1] "Energy Saving in Compressed Air Systems." Kaeser. Kaeser Compressors, 10 May. 2010. Web. 25 Apr. 2016.

[2] "Reduce the Pressure of Compressed Air to the Minimum Required." IAC. IAC Missouri, 22 Jun. 2009. Web. 25 Apr. 2016.

General Data

Utility Data

Incremental Electricity Cost	(IC_E)	*$0.05538*	/kWh	**(Rf. 1)**
Incremental Demand Cost	(IC_D)	*$9.20*	kW	**(Rf. 1)**

Compressor Data

Energy Reduction Per PSIG	(η_{psig})	*0.5%*	/psig	**(Rf. 2, N. 1)**
Pressure Set Point	(p_C)	*112*	psig	**(Rf. 3)**
Pressure Ratio	(β_{RC})	*1.85*		**(Eq. 1, Rf. 4)**

Pressure Reduction Analysis

# (i)	Proposed Pressure (p_P) (psig)	Proposed Consumption: Energy (E_P)**(Eq. 2)** (kWh)	Proposed Consumption: Pressure Ratio (β_{RP})**(Eq. 1)**	Proposed Consumption: Demand (D_P)**(Eq. 3)** (kW-month)
1	*110*	*1,187,594*	*1.84*	*2,026*
2	*105*	*1,157,604*	*1.82*	*1,974*
3	*100*	*1,127,615*	*1.80*	*1,921*

# (i)	Proposed Pressure (P_P) (psig)	Energy Savings (E_S)**(Eq. 4)** (kWh)	Energy Cost Savings (S_E)**(Eq. 5)**	Demand Saving (D_S)**(Eq. 6)** (kW-month)	Demand Cost Savings (S_D)**(Eq. 7)**
1	*110*	*11,996*	*$664*	*20*	*$186*
2	*105*	*41,986*	*$2,325*	*72*	*$660*
3	*100*	*71,975*	*$3,986*	*125*	*$1,148*

Energy Analysis

Current Conditions

Energy Consumption	(E_C)	*1,199,590*	kWh/yr	**(Rf. 5)**
Electrical Demand	(D_C)	*2,045.7*	kW-mo/yr	**(Rf. 5)**

Proposed Conditions

Pressure Set Point	(p_P)	*105*	psig	**(N. 2)**
Pressure Ratio	(β_{RP})	*1.82*		**(Rf. 4, Eq. 1)**
Energy Consumption	(E_P)	*1,157,604*	kWh/yr	**(Rf. 6)**
Electrical Demand	(D_P)	*1974*	kW-mo/yr	**(Rf. 6)**

Savings

Energy Savings	(E_S)	*41,986*	kWh	**(Rf. 6)**
Demand Savings	(D_S)	*71.7*	kW-mo/yr	**(Rf. 6)**

Equations

Eq. 1) Pressure Ratio ($\beta_{[RC,RP]}$)

$$\left(\frac{p_{[C,P]} + 14.7\,psi}{14.7\,psi}\right)^{0.286}$$

Eq. 2) Proposed Energy Consumption (E_P)

$$E_C(1-(p_C - p_{P,i})\times\eta_{psig}$$

Eq. 3) Proposed Demand Consumption (D_P)

$$D_C\left(1-\left(\frac{\beta_{RC}-\beta_{RP,i}}{\beta_{RC}-1}\right)\right)$$

Eq. 4) Energy Savings (E_S)

$$E_C - E_{P,i}$$

Eq. 5) Energy Cost Savings (S_E)

$$E_{S,i}\times IC_E$$

Eq. 6) Demand Savings (D_S)

$$D_C - D_{P,i}$$

Eq. 7) Demand Cost Savings (S_D)

$$D_{S,i}\times IC_D$$

References

Rf. 1) Average incremental energy costs devoloped in the Utility Analysis, located in the Site Data section of this report.

Rf. 2) Percentage reduction per psig referenced from Kaeser [1].

Rf. 3) Data collected on site by analysts during facility visit.

Rf. 4) Pressure ratio equation referenced from IAC [2].

Rf. 5) Developed in the CABAT, located in the Site Data section of this report.

Rf. 6) Developed in the Pressure Reduction Analysis, located in the following page of this recommendation.

Notes

N. 1) Percent energy saved per psi pressure reduction is a general rule of thumb. Actual savings will vary.

N. 2) Facility personnel noted that 100 psig is the minimum pressure requirement to operate production machinery. A conservative value of 105 psig was chosen for the proposed pressure set point.

3 - AR No. 1 - Analysis

Original template March 2017, style 2015

Economic Results

Annual Cost Savings	(S)	***$2,985***	/yr	**(Eq. 8)**
Implementation Cost	(C_I)	***$500***		**(N. 3)**
Simple Payback		***0.2***	years	**(Eq. 9)**

Notes

N. 3) Implementation cost based on analyst assumption. Analysts assume a possible down time while adjusting the pressure set point.

Equations

Eq. 8) Annual Cost Savings (S)

$$E_S \times IC_E + D_S \times IC_D$$

Eq. 9) Simple Payback (t_{PB})

$$\frac{C_I}{S}$$

Pressure Reduction Analysis

#	Proposed Pressure	Proposed Consumption: Energy	Proposed Consumption: Pressure Ratio	Proposed Consumption: Demand
(i)	(p_P)	(E_P)**(Eq. 2)**	(β_{RP})**(Eq. 1)**	(D_P)**(Eq. 3)**
	(psig)	(kWh)		(kW-month)
1	*110*	*1,187,594*	*1.84*	*2,026*
2	*105*	*1,157,604*	*1.82*	*1,974*
3	*100*	*1,127,615*	*1.80*	*1,921*

#	Proposed Pressure	Energy: Savings	Energy: Cost Savings	Demand: Saving	Demand: Cost Savings
(i)	(P_P)	(E_S)**(Eq. 4)**	(S_E)**(Eq. 5)**	(D_S)**(Eq. 6)**	(S_D)**(Eq. 7)**
	(psig)	(kWh)		(kW-month)	
1	*110*	*11,996*	*$664*	*20*	*$186*
2	*105*	*41,986*	*$2,325*	*72*	*$660*
3	*100*	*71,975*	*$3,986*	*125*	*$1,148*

Notes

This section of the recommendation calculates the demand and energy savings associated from various pressure reduction set points. The recommendation assumes, from conversations with facility personnel, that the pressure can be reduced to 105 psig. Additional savings are possible if the pressure is reduced below 105 psig.

Equations

Eq. 2) Proposed Energy Consumption (E_P)

$$E_C(1-(p_C-p_{P,i})\times\eta_{psig}$$

Eq. 3) Proposed Demand Consumption (D_P)

$$D_C\left(1-\left(\frac{\beta_{RC}-\beta_{RP,i}}{\beta_{RC}-1}\right)\right)$$

Eq. 4) Energy Savings (E_S)

$$E_C-E_{P,i}$$

Eq. 5) Energy Cost Savings (S_E)

$$E_{S,i}\times IC_E$$

Eq. 6) Demand Savings (D_S)

$$D_C-D_{P,i}$$

Eq. 7) Demand Cost Savings (S_D)

$$D_{S,i}\times IC_D$$

3 - AR No. 1 - Incentive Analysis

Incentive Analysis template September 2016, Style 2016

Incentive Data

Annual Cost Savings	(S)	***$2,985***	/yr	**(Rf. 1)**
Implementation Cost	(C_I)	***$500***		**(Rf. 1)**
Simple Payback	(t_{PB})	***0.2***	years	**(Rf. 1)**

No Incentives Found

Analysts did not consider incentives because recommendation has a payback of less than one year. This does not necessarily mean incentives are unavailable; custom incentives can sometimes be arranged.

References

Rf. 1) Developed in this recommendation on the previous pages.

3 - AR No. 1 - Financial Analysis

Oregon State University | Energy Efficiency Center

Financial Analysis template September 2016, Style 2016

Recommendation Data

Economic Results

Annual Cost Savings	(S)	*$2,985*	/yr	**(Rf. 1)**
Implementation Cost	(C_I)	*$500*		**(Rf. 1)**
Incentives Total	(I)	*$0*		**(N. 1, Rf. 1)**
Cost Basis	(C_B)	*$500*		**(Eq. 1)**
Simple Payback	(t_{PB})	*0.2*	years	**(Rf. 1)**
Simple Payback after Incentives	(t_{PBI})	*0.2*	years	**(Rf. 1)**

Capital Information

Class Life	(t_L)	*12*	years	**(N. 2, Rf. 2)**
Estimated WACC^{ADJ}	(r)	*8.40%*		**(N. 3, Rf. 3)**
Estimated Corporate Tax Rate	(T_C)	*35%*		**(Rf. 4)**

Economic Analysis

No Depreciation Schedule

Initial After Tax Cash Flow (t = 0)	($CF_{N,0}$)	*-$325*	**(Eq. 2)**
After Tax Cash Flow (t = 1, 2,…t_L)	($CF_{N,t}$)	*$1,940*	**(Eq. 3)**
Net Present Value	(NPV_N)	*$13,998*	**(Eq. 4)**
Annual Internal Rate of Return	(IRR_N)	*597%*	**(N. 4, Eq. 5)**

Notes

N. 1) No incentives were found for this recommendation.

N. 2) Class Life may differ if analysts found a better known estimate. The Salvage Value of any equipment is assumed to be zero as it is out of the scope of this analysis and provides a further conservative estimate.

N. 3) WACC^{ADJ} is Weighted Average Cost of Capital Adjusted for Taxes. Cost of Capital is different for every business, and accurately estimating it for this facility is beyond the scope of this analysis. An industry average of WACC^{ADJ} is used **(Rf. 3)**, and is considered a conservative estimate. Analysts may adjust the WACC^{ADJ} if a more accurate estimate is identified in **(Rf. 3)** or it is given.

N. 4) An IRR greater than the WACC^{ADJ} (r) is an attractive investment option.

Equations

Eq. 1) Cost Basis (C_B)

$$C_I - I$$

Eq. 2) Initial A.T. Cash Flow (t = 0) ($CF_{N,0}$)

$$(-C_B) \times (1 - T_C)$$

Eq. 3) A.T. Cash Flow (t =1, 2,...t_T) ($CF_{N,t}$)

$$S \times (1 - T_C)$$

Eq. 4) Net Present Value (NPV$_N$)

$$CF_{N,0} + \sum_{t=1}^{t_L} \frac{CF_{N,t}}{(1+r)^t}$$

Eq. 5) Internal Rate of Return (IRR_N)

$$NPV = 0 =$$

$$CF_{N,0} + \sum_{t=1}^{t_L} \frac{CF_{N,t}}{(1+IRR)^t}$$

References

Rf. 1) Developed in this recommendation on the previous pages.

Rf. 2) Recovery Period and Class Life are referenced from IRS publication 946, Table B-2, based on the best-fit industry sector. https://www.irs.gov/pub/irs-pdf/p946.pdf.

Rf. 3) Cost of Capital is based on New York University's Stern School of Business' *Cost of Capital by Sector*, data from January 2016. Industries not related to the IAC were omitted, and an average was calculated. http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/wacc.htm

Rf. 4) Based on Tax Rate Schedule from: www.irs.gov/pub/irs-pdf/i1120.pdf