Case Study: Johnson Controls Inc., Hoover Automotive Division

The Johnson Controls plant, located in Cadiz, Kentucky, has produced metal automotive seat frames for major domestic and import automotive manufacturers for over thirty years. The factory employs about 550 people, covers over 280,000 square feet, and generated approximately $120 million in gross sales in 1999.

Johnson Controls requested that KPPC perform a pollution prevention assessment at the facility with the primary purpose of addressing a wastestream of oily water.

Waste Profile

The primary wastes generated at the plant and disposal methods used are summarized in **Table 1**.

Table 1: Wastes and Method of Disposal

Waste	Disposal Method
Oily Wastewater	Off-Site Treatment
Oily Absorbent	Landfill
Pallets and Scrap Wood	Recycled
Copper Welding Rod Waste	Recycled
Welding Air Filters	Landfill
Copper-Coated Welding Wire	Landfill
Gloves	Landfill
Cardboard	Recycle

The company currently generates about 12,000 gallons of oily water monthly. The mixture is stored in three tanks adjacent to the plant, pumped and disposed at a cost of $0.22 per gallon or $31,680 annually. Company personnel stated that the mix is approximately 95 percent water. The primary oil present has a specific gravity of 0.88 and should therefore separate relatively easily from the water. Testing will need to be performed to determine the effectiveness of separation to assure local clean water standards are reached.

KPPC Recommendations

KPPC recommended an oil/water separator as an alternative to the current $31,700 annual cost for disposal (Johnson Controls estimates total disposal costs, including associated charges, at over $40,000). The company, using a vendor list supplied in our report, found equipment that should perform the separation for a purchase cost of about $12,000. This should yield a favorable payback period of approximately 4 months!

During the process of assessing the facility, KPPC found 5 additional recommendations to propose. The recommendation of most economic importance is to change the electric utility rate charged by the local electric cooperative. Johnson Controls pays approximately $1,000,000 per year for electricity supplied by Pennyrile Rural Electric Cooperative Corporation (PRECC). The company is eligible for a rate charge generally reserved for large industrial customers. This change has reduced the electric bill by about 10% in the 2-month period of implementation. That will translate to approximately $100,000 in savings annually! The Cadiz, Kentucky plant has passed this information on to other Johnson Control facilities for even more potential savings.

We also recommended cleaning and reusing at least a portion of the 17,000 pairs of gloves per month that the plant used once and then discarded. Cost data were not available at the time of the assessment, but Johnson Controls has since determined the recommendation to be economically feasible. The company is currently discussing a contract with a washing service provider.

Other recommendations included recycling both office paper and waste copper-coated welding wire. Neither of these has yet proved economically viable.

With an increased attention focused on P2, the company looked closer at purchasing options and discovered that much of the grease wasted as residuals in container bottoms could be eliminated. They are currently implementing a bulk purchasing program.

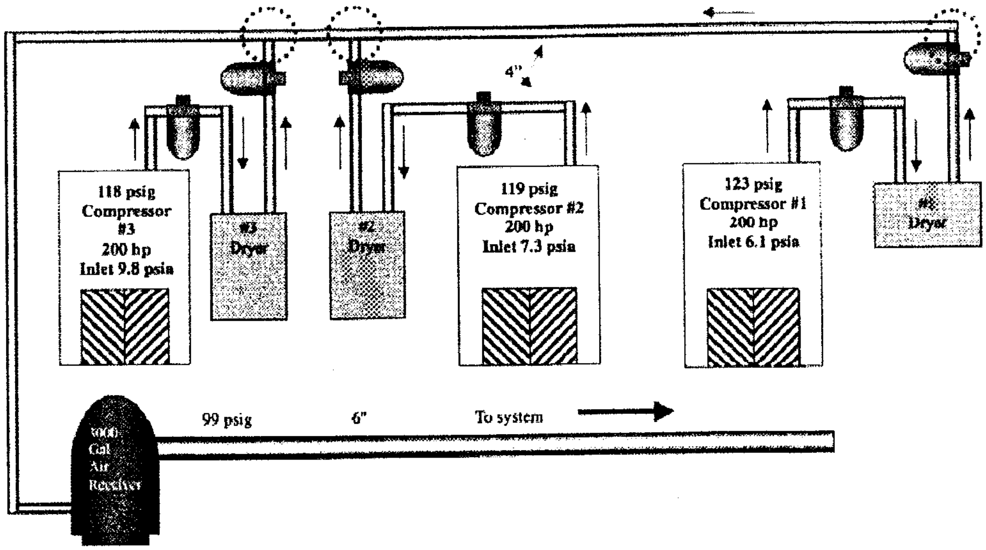
Conclusion

With the cooperation and commitment of the plant requesting an assessment, KPPC tries to look beyond the immediate needs to find further opportunities for pollution prevention and other savings. In the case of the Johnson Controls plant, the total savings from opportunities suggested in our report amount to over $130,000 annually.

KPPC offers continuing assistance in assessing and successfully implementing pollution prevention ideas for all companies in Kentucky. Please feel free to contact the center for a free, nonregulatory, and confidential P2 assessment at (502) 852-0965.

Air Compressor Case Study 1

Medium Sized Manufacturing Plant



System Information:

Mot. Eff. = 0.9; Operated 6240 hrs/yr
Blended Power Rate=$0.05/KWh

3-200 HP Compressors @ 850CFM each
Lubricant cooled single stage rotary screws

Problem: Two units cannot hold minimum system pressure of 95 psig required. The user assumes all 3 units are running at full load (2550 acfm). He "needs" all 3 units to run plant and is considering adding another 200 HP unit as trim machine.

Investigation:

Measured inlet pressure to the rotors at each unit was:

#1	6.1 psia	40% capacity
#2	7.3 psia	50% capacity
#3	9.8 psia	76% capacity
Total Load		**157% capacity of one (1) unit or 1334 CFM**

Why does it take three units hold a minimum pressure of 95 psig when two units should be able to supply up to 1700 cfm??

Full load BHP: 214 BHP @120 psig, Motor Efficiency = 0.9

	% Capacity	%FL BHP	Actual BHP
#1	40%	82%	176
#2	50%	85%	182
#3	76%	90%	193
Totals	**157%**	**257%**	**551 BHP**

Estimated Annual Power Cost = $144,097/yr

<u>(HP)*(0.746)*($0.05)*(6240 hr/yr)</u> → <u>(551)(0.746)($0.05)(6240)</u> → $144,097/yr

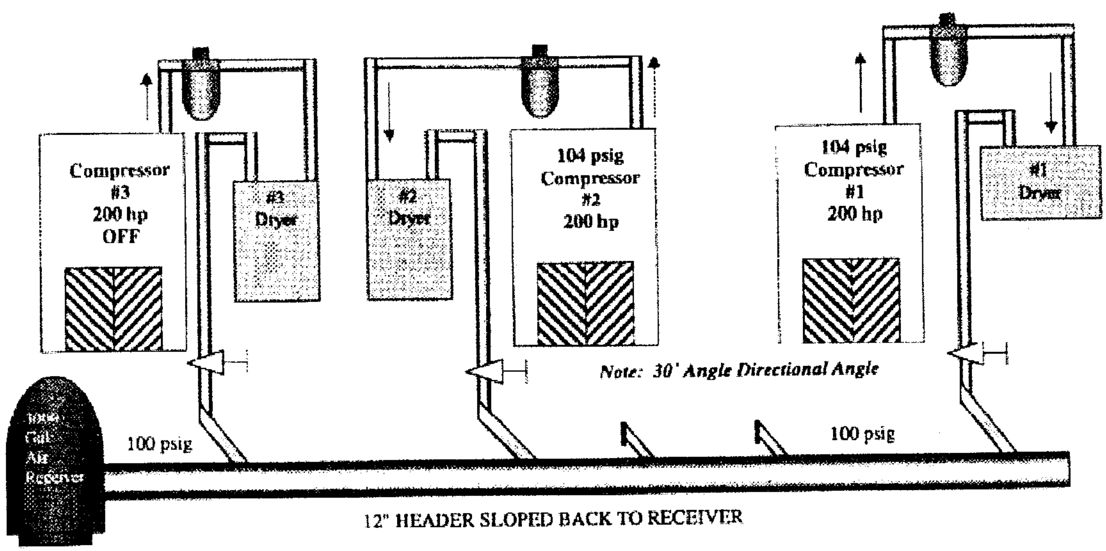
Conclusion:
Total Pressure drop for #1 to the main system header is 24 psi. This is primarily caused by:

- The small 4" header
- The full flow/crossing tee connections to the header. Each compressor has to fight its way back the next flowing connection. This back pressure (15-20 psi) causes high turbulance and back pressure that the compressor control senses as a signal to unload and it does.

In order to get all three units fully loaded into the air system, the system pressure will have to fall a minimum of an additional 6 psi getting even further from the target pressure.

Modifications made to the system:

- Interconnecting pipe changed to 6" diameter.
- Each connection to the new 12" header was made with a 30 degree directional. There is no backpressure.
- Dryers are already oversized refrigeration cycling type. Pressure at full load 23 psig
- Total system pressure drop now is 4 psig to system header.



New Results:
Full load BHP: 198 BHP @104 psig

	% Capacity	%FL BHP	Actual BHP
#1	79%	92%	182
#2	80%	92%	183
#3	0	0	0
Totals	**159%**	**184%**	**365 BHP**

Estimated Annual Power Cost = $95,455/yr

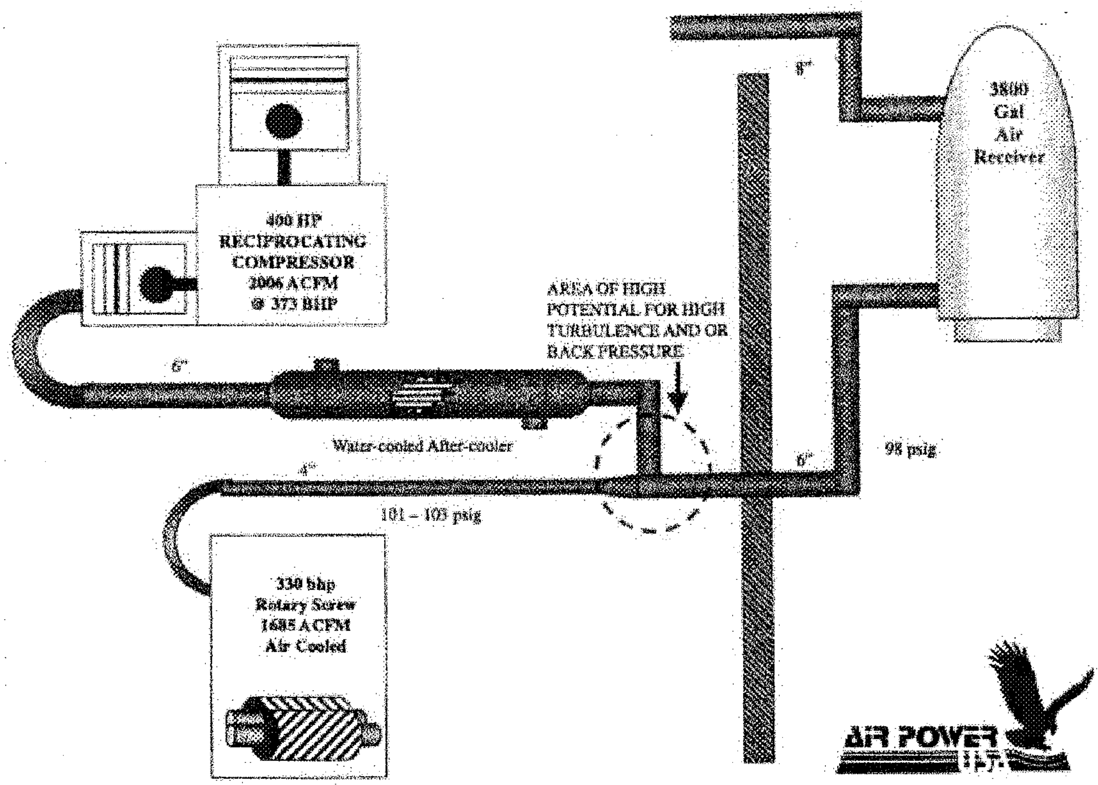
Estimated Annual Energy Savings = $48,642/yr

Expenditure on piping = $31,000 for less than one year payback.

Source: Air Power USA, 11520 Woodbridge Lane, Baltimore, OH 43105
(740) 862-4112; hankvanormer@aol.com; www.airpowerusainc.com

Air Compressor Case Study 2

Auto Parts Manufacturer



System Information:

Operated 6240 hrs/yr   Blended power cost = $0.045 kWh   Motor Eff. = 0.93
Air compressors available 1 – 400 HP double acting reciprocating @ 2006 cfm
1 – 350 HP lubricant cooled two stage rotary screw @ 1685 cfm
Controls: Reciprocating – 5 step control
Rotary – Modulation/Dual with ACS
Average demand: 3000 – 3200 cfm

Problem:

The most power efficient mode to run these units is to **base load** the rotary screw compressor and trim with the reciprocating compressor. Controls were set accordingly to hold a minimum 95-psig system pressure. This is the classic setting for a trim unit. **However**, as soon as the reciprocating unit loads in, it takes over as **Base load** putting the 350 HP rotary unit into trim with modulation.

Why does this happen?

The reciprocating unit loads in at 95 psig and begins to add extra air, raising the system pressure. At 105 psig, the reciprocating unit is supposed to unload and the rotary continues on as base load unit.

Investigation:

The actual sensed pressure in the pipe, although registering as 99 psig at the compressor panel gauges, was actually bouncing back and forth in the 101 to 103 psig range. This was caused by the reciprocating unit 6" discharge line feeding into the rotary's 4" discharge line with a "crossing tee". This area of high turbulence created back pressure to both units.

However, each control reacts differently. The rotary senses system pressure at the exit point from the unit in its discharge line. The reciprocating unit senses system pressure at the air receiver. The back pressure in the discharge line affects the rotary but not the reciprocating unit.

The more the rotary tried to load in, the higher the back pressure goes pushing it to unload. When the system pressure would once in a while get high enough to unload the reciprocating unit, it would only do so momentarily and reload because the turbulence holds the rotary back from full load.

Therefore when the sensed pressure reaches 101 psig, the rotary modulation control immediately starts to back down and make less air. This continues on until the **sensed system pressure** reaches 105 psig and the rotary is at 50% load (842 cfm) and the reciprocating unit is still at full load (2006 cfm) with a total flow of 2848 cfm.

	% Capacity	%FL BHP	Actual BHP
Reciprocating	100%	100%	373
Rotary	50%	85%	280.5
Total	**150%**	**185%**	**653.5 BHP**

Estimated Annual energy cost $\frac{(653.5)(0.746)(\$0.045/KWh)(6240\ hrs/yr)}{\text{Motor eff. of } 0.93}$ → **$147,197/yr**

What is the energy costs if controls were corrected?

	% Capacity	%FL BHP	Actual BHP
Reciprocating	43%	47%	175
Rotary	100%	100%	330
Total	**143%**	**147%**	**505 BHP**

Estimated Annual energy cost $\frac{(505)(0.746)(\$0.045/KWh)(6240\ hrs/yr)}{\text{Motor eff. of } 0.93}$ → **$113,748/yr**

Estimated Annual energy cost savings $33,448/yr

Correction Implemented:
There were a number of ways this control problem could be corrected – including moving the rotary's pressure sensing line to the air receiver (which must be done with caution). However:

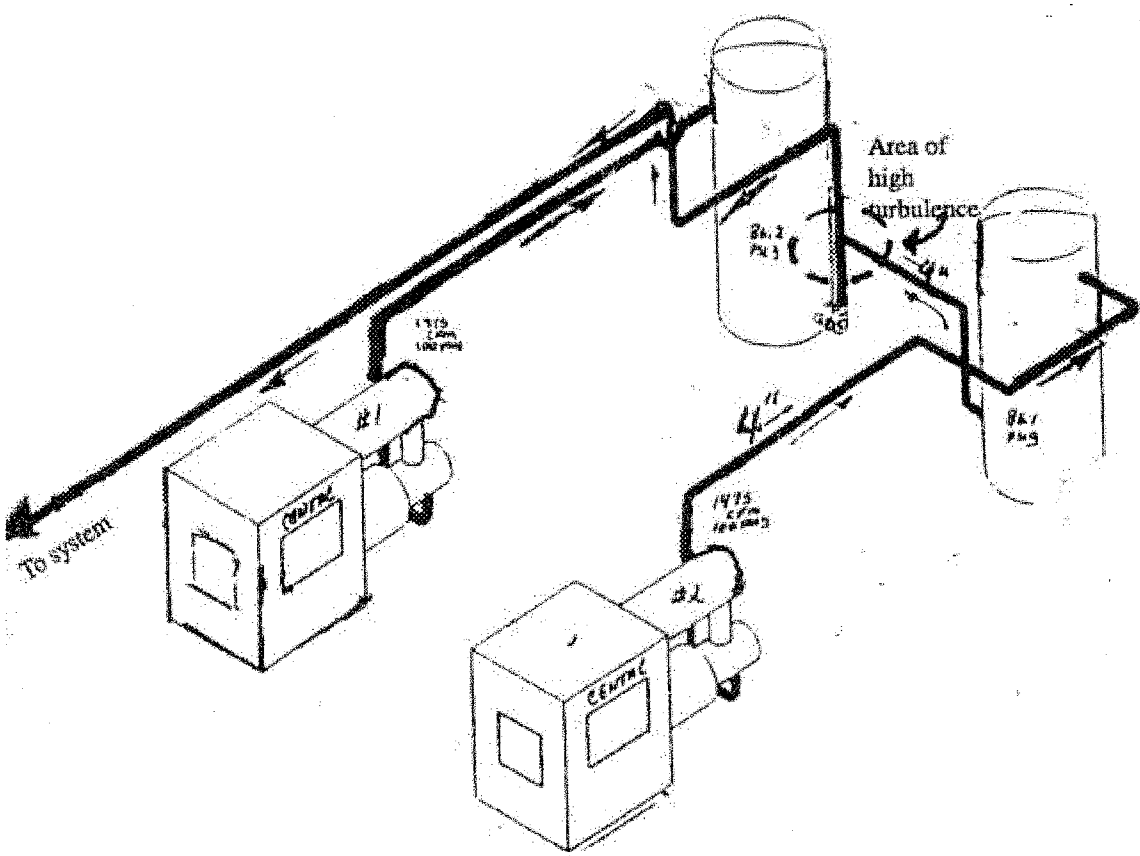
- The extra pressure would still be there, causing lost energy.
- There are other operational problems that occur when reciprocating units and rotaries are piped together that seriously affect the integrity of the rotary.

Therefore, the "crossing tee" connection was eliminated by each unit running a separate discharge line to the air receiver (actually the rotary went to a second air receiver that was already in place). Everything worked.

Source: Air Power USA, 11520 Woodbridge Lane, Baltimore, OH 43105
(740) 862-4112; hankvanormer@aol.com; www.airpowerusainc.com

Air Compressor Case Study 3

Electrical Apparatus Plant:



System Information:

The plant has two centrifugals (300 and 400 HP) compressors with "turndown" (Modulation) controls and Blow Off. When one unit runs, it goes to full load. When more air is needed, the second unit is turned on; both units go to "blow off" and the system pressure collapses. Plant has installed a third unit at the other end of the building (300 HP) to carry system. They now run 2 – 300 HP and 1 – 400 HP compressors to serve demand.

Operational hours – 6240 hrs/yr; blended power cost $0.05/kWh

Investigation:

	% Capacity	%BHP	Actual BHP
300 HP	100%	100%	300
300 HP	50%	80%	240
400 HP	50%	80%	320
Total	**200%**	**260%**	**860 BHP**

Estimated Annual energy cost $\frac{(860)(0.746)(\$0.05/KWh)(6240\ hrs/yr)}{\text{Motor eff. of } 0.78}$ → **$258,279/yr**

Conclusion:

Turndown of the two units caused by:

- 4" discharge line from #2 "crossing tee" connecting to 4" diameter discharge line from #1. Both units flowing through a 4" line to the system. Note: When running the two units together, there are also "surge" problems.

Correction:

Run two separate 6" discharge lines from each unit through their own receiver and tie into a new 8" main header with 30 degree angle directional connections. Both units will now run at full load and results in the shut off of the 300 HP unit at the other end of the building.

	% Capacity	%BHP	Actual BHP
300 HP	100%	100%	300
300 HP	0%	0%	0
400 HP	100%	100%	400
Total	**200%**	**200%**	**700 BHP**

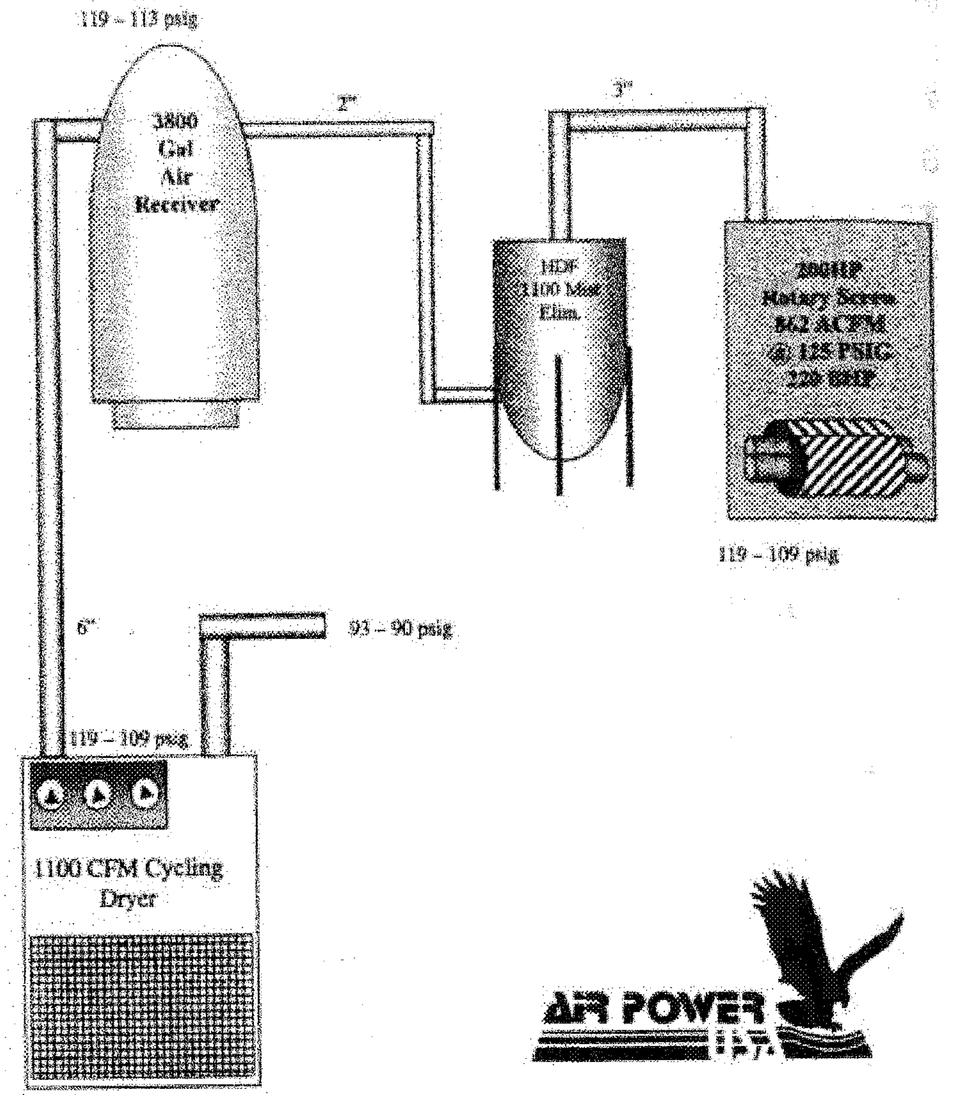
Estimated Annual energy cost → $210,227/yr

Estimated Annual energy savings→ $ 48,052/yr

Source: Air Power USA, 11520 Woodbridge Lane, Baltimore, OH 43105
(740) 862-4112; hankvanormer@aol.com; www.airpowerusainc.com

Air Compressor Case Study 4

Paper Processing Plant:



System Information:

1 – 200 HP single stage lubricant cooled rotary screw @862 acfm running on two step/load – no load control. Blended energy cost: $0.05/kWh; Operating 6240 hrs/yr; Motor efficiency 0.90%

Unit is short cycling – 30 second load, 12 second unload; 30 second load, 9 second unload; 35 second load, 10 second unload.

$$\text{Capacity} = \frac{T1*100}{(T1+T2)} = \frac{95*100}{(95+31)} = 75\% \text{ load or } 0.75*862 \text{ cfm} = 647 \text{ cfm}$$

Other Pertinent Facts:

Unit bleed down time = 25 seconds
Estimated power draw @ 100% load is 220 HP
Estimated Annual energy cost = **$56,895/yr**

Investigation:

Effective storage volume

• 75' of 3" diameter pipe	= 29 gallons
• 50' of 2" diameter pipe	= 9 gallons
• 100' of 6" diameter pipe	= 150 gallons
• 339 gallon air receiver	= 330 gallons
Total	**= 578 gallons or 0.67 gallons per cfm.**

Note: Dryer has 16 psi pressure drop at full load indicating a plugged dryer. This reduces the effective storage volume to only the pipe and the small receiver before the dryer.

There is a 3800 gallon receiver where the compressor supply enters the main header system. There is 1000 feet of 8" diameter header piping in the main plant (2596 gallons).

Modifications made to the system:

Changed piping to the following:

- 2" line changed to 4" diameter
- 3" line changed to 3" diameter
- Dryer replaced with new cycling oversized dyer with a pressure drop of 2-3 psi.

Results:

- Air is now entering the main air receiver and headers at 2-3 psi loss and well with-in the operating band.
- Total effective storage is now 6917 gallons (8.02 gallons/cfm).
- Cycle time now averages 2 minutes 58 seconds loaded and 59 seconds unloaded.

Energy cost reduction:

Total idle time:	59 seconds
Bleed down time:	-25 seconds
Net full idle time:	34 seconds

Total 237 seconds – 34 seconds low power draw = 14.3 % time at low idle

6240 * .143 = 892 hrs @ est. average HP 55 HP @0.89 ME (HP is estimated during bleed down)

Current Estimated Load profile:

892 hrs @ 55 HP @0.89 ME	= $ 2,079
5348 hrs @ 220 HP @0.90 ME	= $48,762
Total	**= $50,841**

Power Savings = $6,054/yr

Source: Air Power USA, 11520 Woodbridge Lane, Baltimore, OH 43105
(740) 862-4112; hankvanormer@aol.com; www.airpowerusainc.com

Compressor Sitesheet
(used for all compressor ARs)

Company Name: ______________ Date of Audit: __________ Outdoor Temp _____

	Compressor #1	Compressor #2
Location		
Make and Model # Size of compressor (hp)		
Screw or Reciprocating		
Max. Operating Pressure (value on nameplate)		
Actual Operating Pressure		
Operating Schedule		
Intake Diameter (inches)		
Distance from Intake to Exterior Wall (ft)		
Distance to Duct Recovered Heat to Needed Area		
Compressor Inlet Temp		
Compressor Room Temp		
Are compressors using inside air?		
Air drier/dehumidifier installed?		

Light Inventory

Company Name: ____________________ Date of Audit: ____________________

Area	Bulb Type	Bulb Watts	BallastType (Al, Cu, Elec)	Bulbs per fixture	Light level (fc)	Number of fixtures	Current usage time (hr/yr)	Comments
OFFICE								

BOILER DATA SHEET

Plant Name:______________________________ Operator:__________________________

GENERAL DESCRIPTION: (Hot Water, Steam)_____________________________________

Manufacturer:____

Model/Serial:_______________________________________ Age: _______________

Burner Size: ______________________________ hp ____________________ Btu/h

Type: (Water tube, Fire tube, Forced, Natural):___________________________

Fuel Type(s): ____

Type of Controls: ____

Loads Served: ____

Rated Pressure/Temp.: ______________ psi (Steam) _____________ °F (Water)

Operating Press/Temp: ______________ psi (Steam) _____________ °F (Water)

Stack Diameter: ________ Clear Stack Ht: ________ Intake Ht: __________

Boiler Diameter: ________ Boiler Length: _________

DEAREATOR: Type:___________________________ Press:_______ Temp:_______

FEEDWATER: Feed Temp:________ Makeup Temp:________ Cond. Temp:________

BLOWDOWN: Type(s):___________________________ Rate:________________________

NOTES: