THE SYSTEM ASSESSMENT

Furniture Factory Expands Production While Reducing Energy Costs

By Hank van Ormer, Air Power USA

Introduction

This furniture factory, located in the Midwest, was spending $47,000 annually on energy to operate the air compressors in their five production buildings. The factory calculates energy costs using a blended electric rate of $0.077 /kWh and runs on average only 2400 operating hours per year.

The demand for compressed air was primarily made up of many small users (pneumatic tools). The demand profile, therefore, is relatively stable overall and does not have any major, intermittent "demand events". Demand was only averaging 2400 hours per year at the time of the system assessment.

A key component to this system assessment, however, was to help this factory design the compressed air system for a planned expansion in production within twelve months.

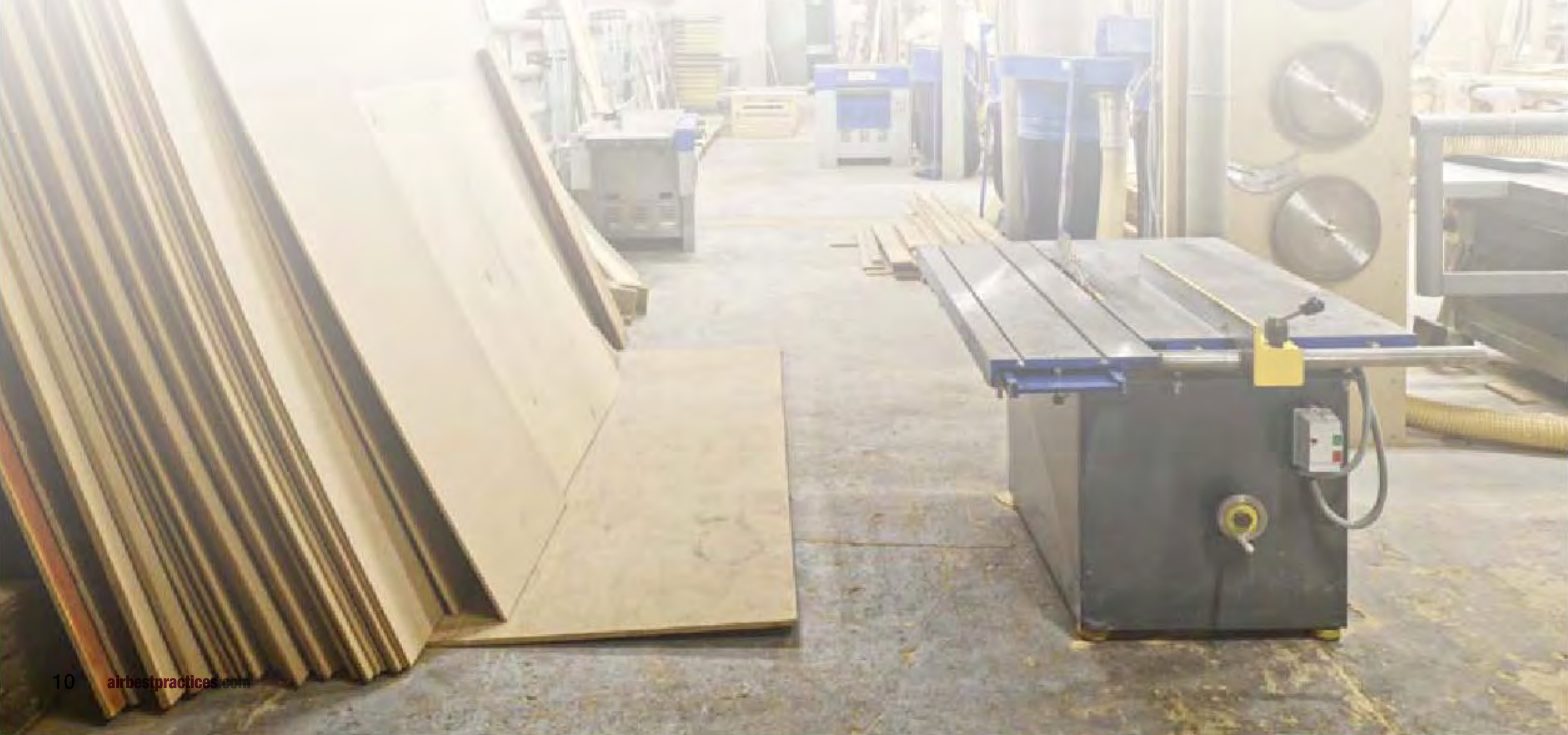
This company has grown over the years and has four separate production buildings. Each building has it's own compressed air system that is significantly oversized. The goal of this project will be to evaluate the existing systems, forecast the future air demand of each building, and to prepare the compressed air systems for that future demand.

Due to article length space constraints, we will only show parts of the supply-side evaluation that was done, details from the leak audit, and how we forecasted future compressed air demand.

TABLE 1. KEY AIR SYSTEM CHARACTERISTICS — CURRENT SYSTEM*

Measure	BUILDING 1	BUILDING 2	BUILDING 4	BUILDING 5	TOTAL
Average System Flow	248 cfm	101 cfm	244 cfm	108 cfm	701 cfm
Avg Compressor Discharge Pressure	109 psig	110 psig	119 psig	110 psig	110 psig
Average System Pressure	107 psig	105 psig	115 psig	105 psig	108 psig
Input Electric Power	107 kW	30.8 kW	68 kW	49 kW	254.8 kW
Specific Power	2.32 cfm/kW	3.28 cfm/kW	3.59 cfm/kW	2.20 cfm/kW	2.75 cfm/kW
Ann'l Elec Cost for Compressed Air	$19,774 /year	$5,692 /year	$12,026 /year	$9055 /year	$47,097 /year

*Based on a blended electric rate of $0.077 per kWh and 2400 operating hours per year.



Supply-Side System Overview

The production facilities are comprised of Production Buildings (#1, #2, #4, and #5). In the past, each of these operations has tended to operate as separate profit centers. Now, all the production facilities will work together as one.

Reviewing the current operating profile of each building's compressed air system and analyzing the opportunities is a key component of the system assessment. As this company has grown over the years, a multitude of different air compressors and dryers, from different manufacturers, have been added to the system. Installed are rotary screw air compressors from Gardner Denver, Sullair, and Palatek, and a reciprocating air compressor from Champion. A variety of refrigerated air dryers and filters are installed from VanAir, AirTek, Ultrafilter, Deltech, and Arrow.

In general, plant personnel state that they do not have problems with air pressure or flow and that the air compressors have been reliable. As we will see, this is due to a significant over-supply situation in a plant where the air compressor are all running part-loaded and are seeing only 2400 hours of duty per year.

Plant personnel do say they have recurring problems with the presence of moisture in the compressed air system. The system assessment will identify several dryers that are not functioning properly or at all.

Compressed Air Leak Survey

A survey of compressed air leaks was conducted in each building and 55 leaks were identified, quantified, tagged, and logged. Potential savings totaled 116 cfm for the 55 leaks that were identified (Plant #1 — 66 cfm; Plant #2 — 10 cfm; Plant #4— 30 cfm; and Plant #5 — 10 cfm). In a system such as this one, 90 to 95% of the total leaks were located

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in the pneumatic circuits of the machinery — not in the distribution system.

We recommended an ultrasonic leak locator be purchased so the plant can implement an ongoing leak management program. With a few minor exceptions, most of the leaks could not have been found without the use of an ultrasonic leak detector and a trained operator. Leak locating during production time with the proper equipment is very effective and often shows leaks that are not there when idle. However, a regular program of inspecting the systems in "off hours" with "air powered up" is also a good idea..

TABLE 2. BUILDING #1 PLANNED DEMAND

CURRENT PRODUCTION	TOOLS	CURRENT PRODUCTION TOTAL AIR USAGE	PLANNED PRODUCTION ADDITIONAL TOOLS	PLANNED PRODUCTION TOTAL AIR USAGE
Framing	13	248 cfm total air usage. Subtract sewing air 40 cfm = 208 cfm ÷ 40 tools = **5.2 cfm / tool**	21	Total additional tools @ 5.2 cfm each = **400 cfm** additional air required
Upholstering	27		56	
Sewing	25		0	

TABLE 3. BUILDING #1 COMPRESSED AIR LEAKS

NO	LOCATION	DESCRIPTION	EST SIZE	EST CFM
1	Button Machine	Cylinder	Medium	4
2	Cutting Room	QDC	Small	2
3	Sewing room	Hole in tube	Small	2
4	Sewing room	Lubricator	Small	2
5	Trap	Drain / Wall	Small	2
6	Machine 11	Filter / Regulator	Small	1
7	Machine 43	Filter / Regulator	Small	1
8	Machine 40	Hole in tube	Medium	4
9	Zipper Slider	Filter / Regulator	Small	2
10	Panel area	Hole in tube	Small	1
11	Panel area	QDC	Small	2
12	Line 4	QDC	Small	2
13	Main line expansion	Valve	Medium	4
14	Line 1 cushion	QDC	Small	1
15	Line 1 cushion	QDC	Small	2
16	Line 1 cushion	QDC	Medium	4
17	End of Line 1	Hole in tube	Medium	4
18	Line 2	QDC	Small	2
19	Line 2	QDC	Small	2
20	line 2 Framing	QDC	Medium	3
21	line 2 Framing	QDC fitting	Medium	4
22	Line 6	Manifold	Medium	4
23	Line 6 upholstery	Hole in tube	Small	2
24	Line 6 upholstery	Hole in tube	Medium	8
25	Outside wall	QDC fitting	Small	1
			Estimated Total cfm	**66**

Air Compressor Controls

The two most effective ways to run air compressors are at "Full Load" and "Off."

The two reciprocating compressors are single-acting, air-cooled units with two-step unloading. This is an efficient compressed air unloading system. Reciprocating two-step unloading will efficiently translate the percentage reduction in air usage of "less air used" into nearly the same proportional reduction in energy cost. The current system has two-step controls on the 25 hp tank-mounted Champion compressor in Plant #5.

The two most common controls used for rotary screw compressors are **modulation** and **online/offline.** Modulation is relatively efficient at very high loads, but **is inefficient at lower loads.**

Online/offline controls are very efficient for loads below 60%, when properly applied with adequate time for blow down. There are several other control types — e.g., "variable displacement" (75% to 100% load) and "variable speed drive" (25% to 75% load) — that have very efficient turn down from when applied correctly. These controls must be installed correctly to operate efficiently. Piping and storage should be available close to the unit with no measurable pressure loss at full load to allow the signal to closely match the air requirements.

The current system has modulation controls on all the rotary screw compressors. They are currently applied at medium or low loads, and therefore, are relatively inefficient — particularly in Plants #1, #4, and #5. We recommend realignment as required. Adding increased demand may alleviate this. No action should be taken until after the new production loads are in place and the compressor control action can be reviewed at the new levels.

Building #1 System Assessment

Average system flow, in building #1, is 248 cfm at an average system pressure of 107 psig. Compressed air is supplied by two lubricated, rotary screw, air compressors using modulation/blowdown controls. The Sullair is a 150 horsepower machine rated for 690 acfm at full load and the Gardner Denver compressor is a 200 horsepower unit rated for 760 acfm at full load. Due to the low-load conditions, the Sullair compressor is running and the GD unit is off. Specific power is 2.32 cfm/kW and the energy costs are $19,774 per year.

The VanAir refrigerated air dryer is plugged into the wall and consuming energy but the unit has not been serviced in years and it is not doing any drying. The AirTek dryer is functioning well and is handling the low load conditions well.

TABLE 4. BUILDING #2 PLANNED DEMAND

CURRENT PRODUCTION	TOOLS	CURRENT PRODUCTION TOTAL AIR USAGE	PLANNED PRODUCTION ADDITIONAL TOOLS	PLANNED PRODUCTION TOTAL AIR USAGE
Framing	13	101 cfm total air usage. 101 cfm ÷ 33 tools = **3.1 cfm / tool**	3	Eleven additional tools @ 3.1 cfm each = **43 cfm** additional air required
Upholstering	20		8	

TABLE 5. BUILDING #2 COMPRESSED AIR LEAKS

NO	LOCATION	DESCRIPTION	EST SIZE	EST CFM
1	Pillow Stuffer	Lubricator	Small	2
2	Button Punch	Inside	Small	1
3	Tack Mach	Regulator	Small	1
4	Ottoman	QDC	Small	1
5	Ottoman	QDC	Small	1
6	Back Assy	QDC	Small	1
7	Back Assy	QDC	Small	1
8	Arm Upholstery	Foot pedal	Small	2
			Estimated Total cfm	**10**

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The impact of the future planned expansion, in plant #1, includes the addition of twenty-one (21) framing tools and fifty-six (56) upholstering tools. We established the increase in future compressed air demand at 400 cfm.

Demand-side air conservation efforts will reduce compressed air demand, in plant #1, from 248 cfm to 120 cfm. The demand-side efforts include air flow reductions from 66 cfm in identified compressed air leaks and 50 cfm in a new control system using receiver tanks and pressure/flow controllers.

The future compressed air demand, of 520 cfm, will be managed by either the Sullair or the Gardner Denver air compressor. Either one will operate much more efficiently, than today, with the higher percentage load. We do not recommend making any compressor control changes until the new air demand profile is verified and established. The Airtek dryer will likely be too small and a new cycling type refrigerated dryer may be required. Immediate actions recommended were to disconnect the non-functioning VanAir refrigerated air dryer and to implement the demand reduction projects.

TABLE 6. BUILDINGS #4 AND #5 PLANNED DEMAND

CURRENT PRODUCTION	TOOLS	CURRENT PRODUCTION TOTAL AIR USAGE	PLANNED PRODUCTION ADDITIONAL TOOLS	PLANNED PRODUCTION TOTAL AIR USAGE
Framing	55	352 cfm total air usage. Subtract sewing air 40 cfm = 312 cfm ÷ 156 tools = **2.26 cfm / tool**	27	Total additional tools @ 2.26 cfm each = **224 cfm** additional air required
Upholstering	101		72	
Sewing	24		0	

TABLE 7. BUILDING #4 COMPRESSED AIR LEAKS

NO	LOCATION	DESCRIPTION	EST SIZE	EST CFM
1	Line 9	Hole in hose	Small	2
2	Line 9	Hole in hose	Small	2
3	Line 3	Hole in hose	Small	2
4	Line 3	Hole in hose	Small	1
5	Line 4	Hole in hose	Small	2
6	Line 5	Hole in hose	Small	1
7	Line 5	Hole in hose	Small	2
8	Line 5	Fitting	Small	1
9	Line 6	Fitting	Small	1
10	Line 7	Fitting	Small	2
11	Line 7	Fitting	Small	1
12	Line 8	Fitting	Small	2
13	Line 8	Fitting	Small	1
14	Line 8	Hole in hose	Small	2
15	Line 8	Fitting	Small	1
16	Framing Dept	Hole in hose	Small	2
17	Framing Dept	Hole in hose	Medium	5
			Estimated Total cfm	**30**

Building #1 Compressed Air Demand Planning

Current Air Demand:	248 cfm
Demand Reduction Projects:	-128 cfm
Plant Expansion:	+400 cfm
Future Air Demand:	520 cfm

Building #2 System Assessment

Average system flow, in plant #2, is 101 cfm at an average system pressure of 101 psig. Compressed air is supplied by two lubricated, rotary screw, air compressors using modulation controls. Compressor #1 is a Sullair is a 40 horsepower machine rated for 150 acfm at full load and Compressor #2 is a Sullair 50 horsepower unit rated for 210 acfm at full load. Compressor #1 is running and #2

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>
> — Hank van Ormer, Air Power USA

is OFF. Specific power is 3.2 cfm/kW and the energy costs are $5,692 per year.

The Ultrafilter refrigerated air dryer is broken and out of order. This explains the complaints about moisture in the compressed air system. The timer drain on the aftercooler separator is broken and leaking approximately 8 cfm.

The impact of the future planned expansion, in plant #2, includes the addition of three (3) framing tools and eight (8) upholstering tools. We established the increase in future compressed air demand at 43 cfm.

Demand-side air conservation efforts will reduce compressed air demand, in plant #2, from 101 cfm to 65 cfm. The demand-side efforts include air flow reductions of 10 cfm in identified compressed air leaks and 13 cfm in a new flow-control system using receiver tanks and pressure/flow controllers.

The future compressed air demand, of 108 cfm, will be managed by either one of the Sullair rotary screw air compressors. Both will operate much more efficiently, than today, with the higher percentage load. We do not recommend making any compressor control changes until the new air demand profile is verified and established. Immediate actions recommended were to replace the Ultrafilter dryer with a new cycling-type refrigerated dryer, replace the timed solenoid drain with a no air-loss demand drain, and to implement the demand reduction projects.

Building #2 Compressed Air Demand Planning

Current Air Demand:	101 cfm
Demand Reduction Projects:	- 36 cfm
Plant Expansion:	+ 43 cfm
Future Air Demand:	108 cfm

Buildings #4 and #5 System Assessment

The recommendation of this system analysis is to create one supply-side system to supply Buildings #4 and #5.

Average system flow, in building #4, is 244 cfm at an average system pressure of 119 psig. Compressed air is supplied by three lubricated, rotary screw, air compressors using modulation controls. Compressor #1

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TABLE 8. BUILDING #5 COMPRESSED AIR LEAKS

NO	LOCATION	DESCRIPTION	EST SIZE	EST CFM
1	Rocker Assy	Tubing	Medium	5
2	By Band Saw	QDC	Small	1
3	Pillow Fill	Fitting	Small	1
4	Line 10	Holes in Hose	Small	3
			Estimated Total cfm	**10**

is a 100 horsepower Palatek machine rated for 420 acfm. Compressor #2 is a 50 horsepower Sullair machine rated for 210 acfm at full load and Compressor #3 is a Sullair 40 horsepower unit rated for 150 acfm at full load. Compressor #1 is running at part load compressors #2 and #3 are OFF. Specific power is 3.59 cfm/kW and the energy costs are $12,026 per year.

The Deltech refrigerated air dryer, in building #4, has a 35 psid pressure loss due to a fouled pre-cooler. This is a larger dryer rated for 1000 cfm and no maintenance has been performed on the unit in years. The Arrow dryer is functioning properly.

Building #5 has an average system flow of 108 cfm at an average system pressure of 105 psig. A Sullair 75 horsepower rotary screw compressor is supplying the system using modulation controls. There is a Champion 25 horsepower reciprocating air compressor acting as a back-up. This machine is OFF.

The impact of the future planned expansion, in building #4 and #5, includes the addition of twenty-seven (27) framing tools and seventy-two (72) upholstering tools. We established the increase in future compressed air demand at 224 cfm.

Demand-side air conservation efforts will reduce compressed air demand, in buildings #4 and #5, from 352 cfm to 233 cfm. The demand-side efforts include air flow reductions of 40 cfm in identified compressed air leaks and 55 cfm in a new flow-control system using receiver tanks and pressure/flow controllers.

The future compressed air demand, of 457 cfm, will be managed by the 100 horsepower Palatek rotary screw air compressor. The Champion 25 horsepower reciprocating compressor with two-step controls can supplement the demand running flat out. This compressor, however, may eventually be replaced by the Sullair 40 hp machine.

Buildings #4 and #5 Compressed Air Demand Planning

Current Air Demand:	352 cfm
Demand Reduction Projects:	- 119 cfm
Plant Expansion:	+ 224 cfm
Future Air Demand:	457 cfm

TABLE 9. KEY AIR SYSTEM CHARACTERISTICS — FUTURE SYSTEM*

Measure	BUILDING 1	BUILDING 2	BUILDINGS 4 & 5	TOTAL
Average System Flow	520 cfm	108 cfm	457 cfm	1,085
Avg Compressor Discharge Pressure	95 psig	95 psig	95 psig	95 psig
Average System Pressure	90 psig	90 psig	90 psig	90 psig
Input Electric Power	122.6 kW	31.2 kW	92 kW	245.8 kW
Specific Power	4.24 cfm/kW	3.46 cfm/kW	4.97 cfm/kW	4.41 cfm/kW
Ann'l Elec Cost for Compressed Air	$22,656 /year	$5,766 /year	$11,002 /year	$39,424 /year

*Based on a blended electric rate of $0.077 per kWh and 2400 operating hours per year.

Conclusion

The compressed air system assessment provides this furniture factory with a road map to be able to increase compressed air production from 701 cfm to 1,085 cfm — while reducing annual energy costs by $8,000. The key to this project was to find ways to best use the existing equipment while also implementing demand-reduction projects. BP

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