Managing Compressed Air In The Manufacturing Environment

TMA Compressed Air Webinar

The slides from this webinar will be made available to the attendees via email later today.

5/5/2020
Welcome and Introductions

Your Presenters:

Steve Byrd – Technical Director – Air Services – TMA Affiliate Member - Supplier Network Committee Member

Eric Iversen – Outreach Coordinator – ComEd Energy Efficiency Program

Thank you to the TMA for production, outreach and technical assistance in this production.
Q&A Format

- Panelists will answer your questions during the Q&A session at the end of the Webinar.
- Please post your questions in the Questions Window in your GoToWebinar interface.
- Direct all questions to Air Services Company.
All rights are reserved. The contents of this publication may not be reproduced in whole or in part without consent of Air Services Company or the TMA. Air Services and the TMA does not assume and hereby disclaims any liability to any person for any loss or damage caused by errors or omissions in the material contained herein, regardless of whether such errors result from negligence, accident, or any other cause whatsoever.

All materials presented are educational. Each system is unique and must be evaluated on its own merits.
Overview

I The “Fourth Utility”
II The Supply Side
III The Demand Side
IV System Evaluation and Typical Opportunities
V Leveraging Utility Programs
VI Conclusion and Q&A
The Fourth Utility

Electricity, Gas and Water are all utilities the customer relies on outside sources for, Compressed Air is the 4th Utility of industry and the only one the customer takes responsibility of supplying and maintaining. It's important that we manage it well to help keep the bottom line healthy.
Compressed air is generated by a very inefficient transfer of one power source to another. Consider – It takes 8HP of compressor to run a 1HP air motor. Compressed air usage should be constantly scrutinized to make sure it provides the best power source for the application. It can take a significant portion of the total electricity cost of the plant.
First – A Questionnaire

True or False

1. Production staff thinks that compressed air is free ______
2. Compressed air is an efficient source of energy in the plant _____
3. Compressed air is often the biggest end-use of electricity in the plant ______
4. Customers know exactly how much compressed air their plant uses ______
5. Adding horsepower is the best way to increase system pressure ______
6. Compressed air systems that waste air frequently have reliability problems that affect production __________

7. There are actions that I can take to save more than 20% of my current cost of compressed air __________
The Plastic Extruder

Compressed Air Cost Per Year – 1,937,443 KWH

$149,183.00 per Year at $0.077/Kwh

Blended cost

Total Plant Consumption – 3,202,977

60% of Plant Total Electricity
The Fourth Utility - Costly

The Tool & Die

Compressed Air Cost Per Year – 218,671 KWH

$\textbf{21,867.00}$ per Year at $0.10$/KwH Blended cost

Total Plant Consumption – 544,803

40% of Plant Total Electricity
The Fourth Utility - Costly

The Steel Pipe Fabricator

Compressed Air Cost Per Year – 322,979 KWH

$28,422.00 per Year at $0.088/KwH Blended cost

Total Plant Consumption – 1,314,518

25% of Plant Total Electricity
Simple Formula –

Running Brake (Applied) Horsepower x .746 (Kw/HP) x Hours Run Per year

Motor Efficiency (%)

Example – 50HP Compressor running One Shift at Cost of $0.10/KWH

55 BHP x .746 x 2000 = 86,379 KWH x $0.10 = $8,638/Year

.95

This cost must be managed and controlled
The Fourth Utility Myths – Busted!

**Myth #1 – Air is “free”**

**Answer** It takes a significant portion of the plant electricity to produce, up to 25-50%, and is extremely inefficient

**Myth #2 – More pressure is always preferable**

**Answer** Running the system at optimal pressure helps promote system efficiency and ensures lower strain on the supply equipment, also helps with leak management

**Myth #3 -**

- Generic replacement parts and compressor lubricants are the same as manufacturer proprietary parts and lubricants.

**Answer**

Maintenance kits and manufacturer proprietary replacement parts and lubricants offer the best overall performance. They are designed to maintain unit efficiency and reliability. Generic parts increase liability, decrease performance, and may void manufacturer warranties.
A typical compressed air system consists of supply equipment that includes (in order of flow):

1. Air Compressor (s)
2. Wet tank
3. Prefilter
4. Air Dryer
5. Coalescing Filter
6. Dry Tank
7. Oil/Water

Not all systems look the same!
The Supply Side - Compressors

Three Types of Positive Displacement Compressors

1. Air Cooled Reciprocating
2. Rotary Vane
3. Rotary Screw
The Supply Side - Air Cooled Reciprocating Compressors

Simplest Type of Compressor Available

1. Theory of Operation

Piston draws air in through intake filter and inlet valve, piston pushes back to discharge air through discharge valve as inlet valve closes off.

2. Controls

Controls are either start/stop based on a pressure switch or constant speed where the machine either pumps or idles with constant rotation of the motor and pump.

3. Typical Applications

Automotive repair, dry cleaners, car washes, light manufacturing

4. Advantages

Low first cost, inexpensive to maintain, simple controls that turn off when it is not needed, good for sporadic use

5. Disadvantages

Noisy, inefficient, less Cubic Feet per Minute (CFM) at rated pressure than Rotary, hotter discharge temperature, cannot run continuous duty. Why?
The Supply Side – Rotary Vane Compressors

Typical Applications

Small Manufacturing, granite shops, woodworkers, tool and dies

Advantages

**Continuous Duty, Why?**

Lower costs than rotary screw to maintain and first cost.

Quieter than any other types

Disadvantages

Less efficient than rotary screw at lower pressures, limited size range (about 5-60HP)
The Supply Side - Rotary Screw Compressors

Air is drawn in through the intake valve.

Air is contained between two intermeshing rotors. Air is compressed by decreasing volume. Lubricant is continually injected to cool, seal and lubricate.

**Continuous Duty – Why?**

High pressure air passes into the primary oil separator.

Remaining traces of lubricant are removed in a final separator element, ensuring high quality air.

System air passes through the aftercooler, removing most of the condensate.

Lubricant is circulated by differential air pressure. It passes through an air blast lubricant cooler and filter prior to being returned to the compressor.
The Supply Side - Lubricant-Injected Rotary Screw Compressors

1. Inlet air filter
2. Compressor air end - where compression takes place
3. Motor - drives the compressor air end
4. Air/oil separator tank (reservoir)
5. Separator element inside
6. Oil cooler
7. Oil filter
8. Water cooled aftercooler and oil cooler - air cooled systems are available
9. Moisture separator/trap
10. Compressed air
The Supply Side - Rotary Screw Compressors

Typical Applications
Small to large manufacturing

Advantages
Most efficient at low pressures 100-125 PSIG

Disadvantages
Most costly to maintain
Higher noise level than rotary vane
More leak points
The Supply Side - Variable Speed Rotary Vane and Rotary Screw Compressors

Takes inlet modulation out and uses variable frequency drive that is run by the pressure transducer. Pressure goes up, speed comes down, pressure goes down, speed goes up.

Constantly dialed in to a set pressure, maintenance people love it, production people love, it and ownership loves it – saves significant energy $$\$$. 

AIR SERVICES COMPANY
COMPRESSED AIR SPECIALISTS
In a rotary screw or rotary vane system a receiver tank is used to provide an initial moisture removal prior to a refrigerated air dryer. A large enough tank can also offer power savings on a load/no load rotary compressor by allowing it more idle time. In many systems it can also be placed downstream of the dryer to prevent sudden surges in demand from affecting dryer performance.
The Supply Side - Drains

Common accessory to many components – Found on:

- Compressors
- Moisture Separators
- Dryers
- Filters
- Tanks
- Drop Legs
The Supply Side - Drains

Zero air loss drain, bowl fills up with condensate, level sensor allows the solenoid to open when full – Energy Saver

Timer Drain - a controlled leak – adjustable valve open and interval timers, common, reliable

A ball valve either cracked open or manually opened periodically also works!
The Supply Side – Air Treatment Equipment

Air is “Free until you mess with it”

Air treatment consists of filtration, dryers either in the compressor room or out at the point of use. Appropriate selection of treatment equipment is critical to maintaining reliable production equipment and defect free products, as well as controlling cost of compressed air.

Costs to consider include:

• Pressure drop through treatment equipment
• Electricity to run treatment equipment
• Cost to maintain
The Supply Side – Air Treatment Equipment

Most applications are well suited with a refrigerated air dryer, prefilter and coalescing filter in the compressor room. If dewpoint or filtration needs are more critical in point of use applications, then treat further or provide redundant protection there. **Strategy –** provide proper general protection and then proper point of use in order to keep costs to a minimum.
ISO 8573.1 Quality Classes

ISO 8573.1 was developed in 1992 by ISO (International Organization for Standardization) to help plant engineers specify desired compressed air quality globally by providing “Quality Classes” for solid particulates, humidity and oil. Quality classes provide engineers with an internationally accepted unit of measure. A typical pharmaceutical plant, for example, would have a compressed air specification of ISO Quality Classes 1.2.1. This is equivalent to 0.1 micron solid contaminates, -40°F (-40°C) dew point, and 0.008 ppm (0.01 mg/m³) oil content filtration.

No matter what language is spoken and what unit of measure is used, using ISO 8573.1 Air Quality Classes ensures that your factory will get the compressed air quality you specified.

<table>
<thead>
<tr>
<th>QUALITY CLASSES</th>
<th>SOLID CONTAMINANTS (MAX. PARTICLE SIZE)</th>
<th>MAXIMUM PRESSURE DROPLETS (F, °C)</th>
<th>MAXIMUM OIL CONTENT (DROPLETS, AEROSOLS, VAPOR) PPM W/W (MG/M³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>-94 (-70)</td>
<td>0.008 (0.01)</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>-40 (-40)</td>
<td>0.08 (0.1)</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>-4 (-20)</td>
<td>0.8 (4)</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>38 (3)</td>
<td>4 (5)</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
<td>45 (7)</td>
<td>21 (25)</td>
</tr>
<tr>
<td>6</td>
<td>-</td>
<td>50 (10)</td>
<td>-</td>
</tr>
</tbody>
</table>

SEVEN FILTRATION GRADES PROVIDE ISO 8573.1 STANDARD AIR QUALITY

<table>
<thead>
<tr>
<th>FILTER GRADE</th>
<th>DESCRIPTION</th>
<th>WATER DROPLETS* PPM W/W</th>
<th>FILTRATION</th>
<th>SOLID PARTICULATES MICRON</th>
<th>OIL REMOVAL PPM W/W</th>
<th>QUALITY CLASSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Water Separator</td>
<td>30,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>Separator/Filter</td>
<td>25,000</td>
<td>3</td>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C</td>
<td>General Purpose</td>
<td>2,000</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>D</td>
<td>Dry Particulate</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>E</td>
<td>High Efficiency Oil Removal</td>
<td>1,000</td>
<td>0.01</td>
<td>0.008</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>F</td>
<td>Maximum Efficiency Oil Removal</td>
<td>1,000</td>
<td>0.01</td>
<td>0.008</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>G</td>
<td>Oil Vapor Removal</td>
<td>-</td>
<td>0.01</td>
<td>0.001</td>
<td>-</td>
<td>5</td>
</tr>
</tbody>
</table>

*Tested to CAGI ADF400 & ADF500. 2 Maximum inlet liquid load.
The Supply Side - Air Treatment Equipment – ISO Classes and Application

Create a Custom Air Treatment System

Maximize system air quality by choosing the combination of Gardner Denver air treatment products which perfectly match your applications requirements.

Quality Class – 1.6.1
- Pneumatic tools
- Spray painting

Quality Class – 1.4.1
- Food and beverage laboratories

Quality Class – 1.3.1
- Pharmaceutical chemical

Quality Class – 1.2.1
- Food and beverage high-tech clean rooms

Grade A

Grade B

Grade C

Grade D

Grade E

Grade F & G

Grade F & G

Heatless Desiccant Dryers

High Temp. Refrigerated Dryers

Wet Air Receivers

Lubricated Rotary Screw Compressor
And Now….. Some Thoughts About Safety with Compressed Air

A Few Areas to Watch (by no means complete!)

• **Receiver Tanks** – Relief valve should be set for the max CFM rating of the compressors upstream of it and the max PSI rating of the receiver tank.

• **Blow Guns** – OSHA rated blow guns have no more than 30 PSI discharge. “Due to the serious injuries than can be caused by compressed air, OSHA requirements pertaining to the safe use of safety air guns for cleaning purposes focus on pressure and chip guarding. The federal OSHA requirement can be found in 29 CFR Part 1910.242(b) pressure at the nozzle to less than 30 psi..” Sources OSHA (1910.242; 1910.242(b); 1917.154)

• **Piping** – PVC is never recommended and should be avoided at all costs. PVC has adequate pressure and temperature ratings but will explode on contact causing severe injury due to breakage of fibrous materials. Black iron, Copper tubing or Extruded Aluminum are preferred.

• **Leaks** – Leaks in hoses, fitting that can eventually come loose are real safety concerns that should be addressed when found, as well as a good source of energy waste.
The cost to produce compressed air depends on the efficiency of the equipment that supplies the compressed air and the demand for it that can be controlled. In a typical compressed air system the demand looks like this, with 20% on average in compressed air leaks, 15% in artificial demand, or excess pressure beyond what is needed, and 15% inappropriate usage, with 50% left for productive demand. When you consider that it takes 8 horsepower of compressed air power to run a 1 horsepower air motor, you can see that compressed air is quite an inefficient but necessary power source.
Artificial Demand

Supply

115 psig
- Operating range of compressors

105 psig
- Pressure drop from: dryer and filter

98 psig

Demand

What are the associated pressure drops through this system?

Comp. operating range: 115-105
FRL 7 psid
Filter 3 psid
Hose and Disconnects 4 psid
Dryer 4 psid
Distribution System 3 psid

Pressure Drop
- Distribution System
- FRL, Valve, Hose, and Disconnect

Unregulated End-Use
Regulated End-Uses
Artificial Demand - Where can We Take Excess Pressure Drop out of the System?

**Dryers** – Pressure drop can be up to 5 PSI

**Filters** – Pressure drop can be initially 1-3 PSI with change indicator at 8-10 PSI

**Piping** – Usual acceptable velocity of 20 Feet Per Minute or less is the standard for main supply header, 30 Feet Per Minute on the drops

**“Dirty 30”** – The last 30 feet between the end use and the supply piping examine for properly sized FRL’s, hose feeds, couplers, everything counts!
Leaks

- Leaks are a function of the supply pressure in an uncontrolled system
- Higher pressure = greater leak flow
- Lower pressure = less leak flow
- Control the waste due to leaks by minimizing the supply pressure
- All unregulated end uses will use more air when pressure increases
Leaks - Common Locations

- Pipe joints
- Couplings, hoses, fittings
- FRL’s
Leaks - Potential Problem Areas

- Couplings, hoses, tubes, and fittings
-Disconnects
- Filters, regulators and lubricators (FRLs)
- Open condensate traps
- Pipe joints

- Control and shut-off valves
- Point of use devices
- Flanges
- Cylinder rod packing
- Thread sealants
Leaks - a Source of Waste

Sometimes wasting 20-30% of a compressor’s output

In addition to being a source of wasted energy, leaks can also contribute to other operating losses. Leaks:

Cause a drop in system pressure, which makes tools function less efficiently, adversely affecting production

Shorten the life of supply system equipment

Or can increase the running time which leads to additional maintenance requirements and increased unscheduled downtime

Can lead to adding unnecessary compressor capacity and increased cost
Inappropriate Usage – A Source of Waste

Can be as much as 15% or more of Compressed Air Consumption

Problem Areas Can be:

1. Open Blowing
   cooling, drying, clean-up
2. Vacuum Generation
   using air with venturi effect
3. Personal Cooling
   comfort cooling with air
4. Open hand-held blow guns or lances
   any unregulated hand-held blowing
5. Diaphragm Pumps
   commonly found installed without regulators and speed control valves
6. Cabinet Cooling
   cooling of electrical panels with open tubes
Examples

- Machine Tools
- Blow Off stations
- Painting
- Shipping Tools (staplers, banders, nailers)
- Air wipes
- Mixers in Explosion Proof Environment
Final Step – Make The Improvements

Leaks Fixed
Pressure Reduced
Wasteful usage removed
Now What?

Put your compressor room to work for you and make it a source of Energy Savings. Measure usage in your compressor room to determine how efficiently it is handling the load, consult with your compressed air specialist and study it carefully using trended data logging equipment.
The Process

Develop a basic block diagram of the system

Measure the baseline and determine the costs

Implement an appropriate control strategy

Once controls adjusted, re-measure to get more accurate readings of KW and pressure, and to determine leak load

Walk through to check for obvious PM items and other opportunities to reduce costs and improve performance

Identify and fix leaks and correct inappropriate uses, then re-measure and adjust controls
Controls - Compressors

Compressor Control Comparison

% Full Load Average BHP vs. % of Compressor Capacity

- Modulation
- Geometry
- 1 Gal/CFM
- 3 Gal/CFM
- 5 Gal/CFM
- Variable Speed
Leverage Utility Programs

Work with an Energy Efficiency Service Provider endorsed by the ComEd Energy Efficiency Program to create projects that are partially funded by the Program.
ComEd is the largest electrical utility company in Illinois, providing electricity to over 4 million people in northern Illinois. In an attempt to reduce the energy usage and environmental impact to service all of these customers, the Energy Efficiency Program was launched over ten years ago. This program is funded through a fee on all non-residential bills, totaling over 350 million dollars available each year to incentivize customer energy efficiency projects. The goal of this program is to reduce energy usage through improving their customer's energy efficiency in all areas from lighting to compressed air.

Implementers which are private firms work on behalf of ComEd in order to execute the programs it sponsors. At nearly a million dollars a day to spend, they are quite eager to spend the money and are constantly growing and expanding the program offering.
All customers who are part of the ComEd distribution system are eligible as all pay into this program. Buying your power through third party brokers does not disqualify you for incentives available in the Energy Efficiency Program. Think of the incentives as a refund of money paid into the program for years as it is a line item amount on the bill you pay each month.

Customers can either apply for incentives for various projects themselves or Energy Efficiency Service Providers (EESP’s) can assist them by helping with the applications and approval process in order to get the incentives they are entitled to based on the project contemplated.

Incentives are either Standard or Custom. Standard incentives are a fixed rebate for a given measure such as a lightbulb or light fixture of a certain wattage. Custom incentives are either not on the Standard offering or potential project savings have been documented for a given project and presented to ComEd for consideration. Custom incentive amounts are based on verified savings.
ComEd Energy Efficiency Program – How it Works

Present Suite of Offerings for Industrial Customers – Compressed Air – Work the Process and Get Results

Step 1 – Utilize ComEd Fix it Now Program to identify and repair leaks. In this process other opportunities are identified such as timer drains, inefficient blow guns, inefficient fixed speed compressors that can be replaced, filters that have excessive pressure drop and pressure lowering to decrease power consumption. KwH results from this step are recorded and documented. When the project is complete the customer can either turn in their receipts for reimbursement (non-internal labor only can be reimbursed) or turn over payment to the EESP and not worry about the paperwork. Typically there is no out of pocket expense to the customer.

Step 2 – If further capital projects are identified, the customer can work with the EESP to apply for additional incentives for projects with a longer life, otherwise each customer is eligible to repair leaks again under the program in 9 months from completion. In some cases there is a further opportunity take advantage of a ComEd funded Comprehensive Compressed Air Study in which capital measures (compressor, dryer, system upgrades) are identified and quantified as to the potential KwH savings. Upon completion of the Study money is reserved for incentive for the identified projects. Incentives from study projects pay up to 100% of the project value. Many customers have taken advantage of this program.
ComEd Energy Efficiency Program – The Process

• Many customers have taken advantage of the Fix it Now Program and Achieved Significant Results

• Many have taken further steps to investigate potential opportunities available to their company on longer term Capital Projects which were not previously contemplated. On the Comprehensive Study Program ComEd pays the bill for the audit.

• Savings of 20-50% or more have resulted in the compressor room of many clients from working this process.

• Here are three examples from earlier in this presentation
The Plastic Extruder* – Worked the Process

The Plastic Extruder

Compressed Air Cost Per Year – 1,937,443 KWH

Leaks Repaired – New Cost Per Year 1,869,830 KWH (Leak Id and Repair funded by ComEd Energy Efficiency Program)

Project: Replacement of 2 -20+ year old 200HP fixed speed compressors by 300HP two stage variable speed compressor (a 10-year asset) – Cost $196,929.00 installed – yielding 356,538 KWH Savings Per Year

ComEd Incentive - $0.12/KwH saved - $42,784.56 in earned incentive

Net Cost of Project: $154,144.44 - a discount of 22%

New Plant KWH Spend – 1,513,292 KWH

Was - $149,183.00 per Year at $0.077/KwH Blended cost

Now - $116,523.00 per year at $0.077/KwH Blended Cost

Savings Per Year - $32,660.00

Simple Payback - $154,144/$32,660 = 4.7 years!

* Project in Progress
The Tool and Die* – Worked the Process

The Tool and Die

Compressed Air Cost Per Year – **218,671 KWH**

Leaks Repaired – New Cost Per Year **140,545 KWH** (Leak Id and Repair funded by ComEd Energy Efficiency Program)

Project: Replacement of 23-year-old 25HP fixed speed compressor by 30HP variable speed compressor (a 10-year asset) and non-cycling dryer with special cycling dryer – Cost $33,000.00 installed – yielding 47,556 KWH Savings Per Year

ComEd Incentive - $0.12/KwH saved - **$5,706.72** in earned incentive

Net Cost of Project: **$27,293.28** - a discount of 17%!

New Compressed Air KWH Spend – **92,989 KWH**

**Was** - $21,867.00 per Year at $0.10/KwH Blended cost

**Now** - $9,290.00 per year at $0.10/KwH Blended Cost

Savings Per Year - $12,577.00

Simple Payback - $27,293.28/$12,577.00 = 2.2 years!

* Project in Progress
The Steel Fabricator – Worked the Process

The Steel Fabricator

Compressed Air Cost Per Year – **322,979** KWH

Leaks Repaired – New Cost Per Year **312,294** KWH (Leak Id and Repair funded by ComEd Energy Efficiency Program)

Project: Replacement of 15+ year-old 50HP fixed speed compressor by 35HP variable speed compressor (a 10-year asset) and non-cycling dryer with special cycling dryer – Cost $31,000.00 installed – yielding 200,519 KWH Savings Per Year

ComEd Incentive - $0.12/KwH saved - **$24,062.28** in earned incentive

Net Cost of Project: **$6,937.72** – a discount of **78%**!

New Compressed Air KWH Spend – **111,775** KWH

**Was** - **$28,422.15** per Year at $0.088/KwH Blended cost

**Now** - **$ 9.836.20** per year at $0.088/KwH Blended Cost

Savings Per Year - **$18,585.95**

Simple Payback - **$6937.72/$18,585.95** - .37year payback!

(Project Complete and Verified)
What is Your Story?

Questions?

Steve Byrd
Technical Director
Air Services Company
sbyrd@airservicesco.com
Office (847)725-2100
Cell (630)664-9882