Why so much focus & effort on energy savings?

- **Compressed Air** is widely considered Industry’s 4\textsuperscript{th} Utility.

- **Department of Energy** initiated the Compressed Air Challenge in 1997 to develop and provide resources that educate industry on the opportunities to increase net profits through compressed air system optimization.

- **The DOE / CAC** then came up with training for industrial plants and compressed air professionals to qualify them to perform a certain level of audit that met a minimum standard.

- **Utility companies** started promoting energy efficiency and partnered with local companies that specialize in these areas.
Why so much focus & effort on energy savings?

- DOE/CAC air audit assessment standard
  - ASME EA-4 standards (compressed air, steam, process heating, pumping)
  - ANSI/MSE 2000-2008 energy efficiency standard
  - ISO 50001 energy efficiency standard
  - CAGI 11011 air audit assessment standard
  - Goal to create energy efficient “certified plant”
Why is compressed air such a consistent opportunity?

The problem:
- Historical lack of technical compressed air systems training
- Unreported costs means any solution has the same cost
- Only data is a pressure gauge so higher pressure is the solution to all problems

The results:
- This condition creates dramatically higher operating costs
- Also creates less repeatability in production processes and a host of other issues including higher temperatures, wet air, reliability issues…
What are the real costs of compressed air?

- Compressed air is the most inefficient utility in the plant
  - to get 1 hp work from an air motor requires approximately 30 scfm inlet air at 90 psig
    - which requires 6-7 hp at the compressor shaft to produce this compressed air
  - assuming a 90% efficient motor, this translates into 7-8 hp of electrical power to deliver 1 hp of compressed air to the plant floor
    - Net efficiency is >12.5% of the input energy is available for useful work energy
Only 50% of the compressed air produced is appropriately utilized based on national averages.

Artificial Demand: 10-15%

Inappropriate Uses: 5-10%

Leaks: 25-30%

Production: 50%
A sample in terms of energy costs at 8760 hrs/yr and $0.065 /kWh:

- 50 hp operating = $22,500
- 100 hp operating = $45,000
- 200 hp operating = $90,000
- 500 hp operating = $227,000
- 1000 hp operating = $455,000
But energy is only 70% of the story. Total operating costs also include:

- Cooling costs, water, sewer, chemical treatment
- Maintenance, parts, inside labor, outside contractors.
- Major repairs and rebuilds
- Rentals costs as required
- Operating labor and supervision
- Depreciation and capital costs
- These costs are typically 25-30% of total costs; energy is 70%.

- Total annual operating costs represented = energy costs / .7 = $
**Estimated Compressed Air Operating Costs**

<table>
<thead>
<tr>
<th>compressors</th>
<th>bhp</th>
<th>kW</th>
<th>dryers</th>
<th>capacity</th>
<th>kW</th>
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<tr>
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<tr>
<td>#8</td>
<td>.746/.92</td>
<td></td>
<td>#8</td>
<td>/ 200</td>
<td></td>
</tr>
</tbody>
</table>

**compressor kW subtotal**

**dryer kW subtotal**

**cooling costs at 3% of compressor kW =**

**compressor+dryers+cooling = total kW**

x operational hours per year 8,760 hrs
or 2000 hrs per shift (6000 hrs)
x $0.065 per kW or local rate $ 0.065 per kWh

= estimated annual energy costs $ divided by 0.70 = est. annual operating cost $

savings potential of 30% = $

at 10% net profit this is equivalent to sales of $
RULE OF THUMB – Compressed air costs

- TOTAL COMPRESSED AIR COSTS @ $0.065 /kWh
- $1.95 per 100 scfm per hour optimally
  - A 100 scfm application costs $1.95 per hour to support or $17,000 per year at 8760 hrs
- Or, $0.325 per 1000 scf

- 1 HP air motor costs - $5,070 per year (8760 hrs)
- 1 HP electric motor - $450 per year
  - Energy savings on the use side of the system are at a factor of > 10X because of the inherent inefficiency of compressed air vs. electric
If we can figure out why compressed air systems are consistently an opportunity for energy savings & performance & reliability improvements, we should be able to capitalize on those opportunities.
Why is compressed air such a consistent opportunity?

The physics and dynamics of a compressible fluid are technically more difficult, particularly in the production areas.

- The relationships between rate of flow, pressure, and pressure drop in a system are difficult to analyze.
- Higher pressure becomes the solution to all problems at the cost of exponential increases in energy.
What factors drive the cost of the compressed air system?.....is it compressor type or brand?

- Compressor types @ 100 psig  
  - Non-lube rotary screw 4.2  
  - Single stage lubricated rotary screw 4.5  
  - Two stage lubricated rotary screw 4.9  
  - Non- lube Multi stage centrifugal 5.2  
  - Two stage reciprocating 5.5 (no longer practical)

- Practical energy savings based upon compressor type is:  
  - 7-8% for lubricated compressors  
  - 18-19% for non-lubricated compressors  
  - But this only applies if the compressors are fully loaded, at part load, all values change
The primary factor driving the supply side costs of the compressed air system - Compressor Controls.

- COMPRESSOR CONTROLS CREATE >90% OF THE SUPPLY SIDE OPPORTUNITY IN COMPRESSED AIR
  - Part loaded compressors can be the result of control conflicts which make the compressor appear to be loaded
- However multiple partially loaded compressors may be on purpose:
  - Part loaded compressors allow higher pressures
  - Part loaded compressors provide on line power for peaks
  - Part loaded compressors provide backup for failures

- PART LOADED COMPRESSORS ARE VERY INEFFICIENT
What factors drive the cost of the compressed air system? ..... Compressor controls.

- **Lubricated rotary screw compressors**
- **Standard rotary screws** relative to other compressor types, are low first cost, simple, straightforward maintenance, relatively reliable(?), easily automated.

1. **Inlet valve modulation** – standard and simplest but least efficient

2. **Load / Unload** – standard but requires proper control setup to be efficient and requires storage

3. **Variable displacement** – optional but efficient but requires proper maintenance and monitoring work effectively.

4. **Variable Speed Drive** – optional and costly but efficient and has a 3 - 5% energy penalty at full load
Comparison of Rotary Screw Compressor Capacity Controls

POWER vs. CAPACITY

Suction Throttle - No Blowdown
Suction Throttle - Tank Blowdown
Variable Displacement - Tank Blowdown
Ideal Compressor
Ideal Load/Unload

VSD

Suction Throttle - No Blowdown
Suction Throttle - Tank Blowdown
Variable Displacement - Tank Blowdown
Ideal Compressor
Ideal Load/Unload

POWER vs. CAPACITY

CAPACITY - %

POWER - % of Full Load

0 10 20 30 40 50 60 70 80 90 100
Impact of Proper Control Storage on Energy Costs

Average kW vs Average Capacity with Load/Unload Capacity Control

![Graph showing the impact of proper control storage on energy costs. The graph plots average kW vs average capacity with load/unload capacity control. The graph includes lines for different gas per cfm inputs: 1 gal/cfm, 3 gal/cfm, 5 gal/cfm, and 10 gal/cfm. Key points include 87% and 71% theoretical efficiencies at 50% capacity.](image-url)
Capturing the Supply Side Opportunity

Requires coordinating compressor controls & accurately controlling system pressure

- Auto start and stop is required for a system to be efficient long term
  - Allows compressors to turn off rather than run part loaded
  - Provides automatic response to a system failure which prevents the backup from running “just in case”

- Staggering control bands can be effective for smaller systems
  - Practical limitation based on the # of compressors required (2-3)
  - Manufacturer’s network sequencers perform this function

- Automation and/or Pressure Flow Controller required for optimal efficiency
  - Prevents pressure from rising in the plant to provide room for control bands to function
  - Especially critical for larger systems
Capturing the Supply Side Opportunity
Requires coordinating compressor controls & accurately controlling system pressure

Automation Recommended Features

Rate of Change / Storage Range Logic

Capable of Base and Trim Distinction and Multiple Pressure Profiles to Properly Utilize Centrifugals and Remote Compressors

Compatible with 2-step or 3-step controls, Rotary screws, Recips, and Centrifugals

Cell Modem Remote monitoring for technical support and efficiency monitoring

PLC Automation: recommended to maximize long term supply efficiency by eliminating control conflicts and providing appropriate response to peaks and failures
What really causes air quality problems?

The optimal supply arrangement for reliable, repeatable compressed air

Small to Medium System

- logic based automation
- base
- backup
- trim

Storage and pressure control
Minimize drain points
Redundant drying if possible
Automatic response to peaks and failures

utilizing a single dryer minimizes sources of contamination to the system but can make the system vulnerable to failure; redundant dryers or multiple refrigerant systems are a viable solution
The optimal supply arrangement

Larger or Multiple Entry System

- logic based automation
- trim
- backup
- trim
- backup
- high eff. filter
- thermal storage dryer
- 1" signal
- receiver
- flow controller
- base
- base
Why is compressed air such a consistent opportunity?

The production departments have authority but normally have no responsibility in regards to the air system

- The production personnel can control air system operation in the name of productivity or quality
- The resulting impact on costs and other problems are not their responsibility
- This makes it difficult to challenge this process and its results
- The lack of technical training and the unreported costs makes higher pressure the solution to all problems…at dramatically higher costs
RULE OF THUMB – Cost Reduction Opportunity

• Typically, only 25%-35% of the savings opportunity is on the Supply side or in the compressor room
  – Requires controlling systems pressure
  – Requires coordinating compressor controls

• Most opportunities are out in the plant - 65%-75%
  – At lower capital costs
  – With the potential to immediately improve production processes
  – However, you must have control of the supply side to save energy when these issues are addressed
Why is compressed air such a consistent opportunity?

Waste - created by excessive system pressure

- The input power increases 1% for every 2 psi increase in compressor discharge pressure
- Unregulated consumption increases ~ 1% for every psi increase in system pressure at 100 psig
- If another compressor starts to support the higher pressure it will mean a dramatic increase in input power and energy costs
Why is compressed air such a consistent opportunity?

Increasing header pressure 10 psi in a typical system will result in:

- Increased flow requirement or demand at a ratio of the absolute pressures (114.5/104.5) or approximately 10%.
- The higher discharge pressure increases compressor power at 1% for every 2 psi increase or approximately 5%.
- The increased demand increases the pressure drops in the system in addition to the higher header pressure approximately 2%.
- The higher pressures often makes a compressor modulate to achieve the desired level decreasing efficiency at a rate of 2% less flow to 1% less power.
- Another compressor starting which increases power as much 10% to 20% or more.
- Net result is >15% - 20% increase in operating costs for 10 psi increase in pressure and this does not include the cost of additional compressors.
P1 is inlet pressure

P2 is compressor discharge

Systems Pressure Nomenclature

P2 is filter

P3 is cleanup discharge

filter

dryer

receiver

4"

P4 is final header pressure

3"

P5 is pressure at application inlet

critical application
Determining the actual pressure requirement of the pressure sensitive applications

- This machine has to have 90 psig to work! ..... It is critical to determine where the pressure is referenced.

- The difference between header pressure P4 which shows up on a cranked open regulator and article pressure P5, can be 15-50 psi

- This distinction can easily make the difference in the next compressor running or not

Typical System Pressure Profile

- **Compressor control band**: 125 psig
- **Dryer and filter pressure drop**: 115 psig
- **Piping losses**: 105 psig
- **Pressure fluctuations**: 95 psig
- **Inadequate capacitance**: 85 psig
- **Regulator, filter, lubricator, hose pressure drop**: 75 psig
- **Pressure fluctuations**: 65 psig
- **Inadequate capacitance**: 55 psig

**Reliable header pressure**

**Reliable article pressure P5**
Compressed Air System Pressure Profile

Supply

110 psig
- operating range of compressors

100 psig
- pressure drop on dryers and filters

90 psig

Distribution

desired header pressure

Demand

85 psig
- system droop

70 psig
- pressure drop on regulators and filters
- article pressure
- pressure fluctuations
- inadequate capacitance

70-50 psig

Where is the greatest opportunity to reduce system pressure?

It is not the piping

IZ Systems
What really causes air quality problems?

High point of use pressure drop

The differential of the point of use components is > 30 psi; header pressure has to be 100 psig to deliver 60 psig to the gun.

Existing Drop Details for Screw Gun Air Tools

- Coils hose twice as long as required
- 3/8” quick disconnect
- 10’ 3/8” red rubber hose
- 3/8” quick disconnect
- Drip lubricator
- Regulator cranked wide open
- 1 micron filter
- Master solenoid valve

3/4” drop from supply header

10’ 3/8” red rubber hose
What really causes air quality problems?

Inadequate storage at the point of use
Inadequate storage at the point of use

Reverse Pulse Baghouse or Dust Collector
Proper Installation of Dedicated Storage for Baghouse or Dust Collector

6 cf per pulse = 36 scfm rate of flow for 10 sec
6 cf per pulse = 1,000 scfm rate of flow for 0.1 sec

 regulator
check valve
needle valve

must be min. 2" for peak rate of flow
minimize this distance
must be within 25 ft of manifold for 0.1 sec pulse

30-60 gallon typical

70 psi
60 psi

Inadequate storage at the point of use
Dedicated Storage for a Reverse Pulse Baghouse or Dust Collector
Inadequate storage at the point of use

The Positive Impact of Metered Recovery on the System

- Header pressure at back of Machining bldg

- Metering the recovery to the baghouse eliminates dips and allows header pressure to recover.

- Pressure dips caused by baghouse pulsing which also pulls header pressure down.
Review:
The greatest opportunities to reduce compressed air system operating costs are out in the plant

- Who determines the system operating pressure?
  - What are the cost impacts of raising system pressure?

- Where are the wasteful applications of compressed air?
  - How does the cost to correct an application compare to the energy savings?

- Who is responsible for the energy and operating problems created by the production side of the system?
  - What conclusion should be drawn from this situation?
Review:
You have to examine what happens in systems in real time.

Diagram:
- Normal production day
- 400hp compressor failure
- 15 psi decay in 8 min 18 sec = 118 scfm demand over supply
- Only 30 hp required

iZ Systems
Review:
You have to examine what happens in systems in real time & find out why applications aren’t working correctly.

High resolution instrumentation allows us to understand why the pressure at the point of use is not as high as it appears and needs to be.
Waste - Inappropriate uses of compressed air

Any application that can be done more effectively or more efficiently by a method other than compressed air

Utilize blowers at 25 scfm/hp for:
- Open Blowing – drying, cooling,
- Sparging
- Personnel Cooling
- Atomizing
- Padding
- Vacuum Generation

Utilize Proper Equipment for:
- Mixing or Agitation
- Cabinet Cooling

Utilize Storage to Eliminate Peak Demands for:
- Dilute Phase Transport
- Dense Phase Transport
- Open hand held blowguns or lances
- Diaphragm Pumps
Corrective Measures for Open Blowing
- Engineered Low Pressure Blowers

- Compressors deliver 4 cfm / hp
- Blowers deliver 15-25 cfm / hp but they must be properly applied

Recommended water removal design using low pressure blowers:

- No sidewalls on conveyor to reflect water and air, water should be allowed to
- Existing blow
- Air flow
- Extruded stock
- Conveyor
- Rotate air knife 30° to direction of conveyor
- Gap between air knife and extruded stock must be less
Corrective Measures for Open Blowing
- use Low Pressure Blowers

- Compressors deliver 4 cfm / hp
- Blowers deliver 15-25 cfm / hp but they must be properly applied
Corrective Measures for Open Blowing
- apply engineered nozzles

- Reduces consumption by 30%-60%
- The supply air must be filtered to protect clearances
Corrective Measures for Intermittent Open Blowing
- meter in blowing applications
- eliminates peaks and minimizes power

- Peak demand of 200-500 scfm can be metered down to a small continuous flow
- Eliminates pressure disturbances and modulated compressor power

Proper Installation of Dedicated Storage with Metered Recovery

![Diagram of proper installation]

from control panel

needle valve

10-100 gallon typical
tail blowing
Corrective Measures for peak demands - Air Conveying applications

- Uncontrolled conveying at 600 – 1200+ scfm will require 125 - 300 hp compressor
- If possible, use PD blowers at 15-20 hp
- Intermittent requirements can be metered into the system for 30%-50% reductions in required on-line horsepower

Proper Installation of Storage for Dense Phase Conveying

Tank can be 1,000 to 10,000 gallons and be financially viable
Corrective Measures for peak demands
- filter presses

- Uncontrolled press blowdown can range from at 200 – 600+scfm and will require 50 - 150 hp compressor
- Peak flows can create system pressure disturbances

Proper Installation of Flow Regulation for Filter Presses

- flow meter used to set rate of flow at 50-100 scfm
- metering valve used to set rate of flow
- from air supply
- regulator at min pressure
- check valve
Wasted compressed air is a significant opportunity on the demand side of the system.

## Wasted Air at a smaller steel foundry

<table>
<thead>
<tr>
<th>Constituents of Demand in SCFM</th>
<th>normal production load</th>
<th>peak production load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>existing</td>
<td>proposed</td>
</tr>
<tr>
<td>General Production</td>
<td>2,230</td>
<td>2,230</td>
</tr>
<tr>
<td>Sinto blow cycle</td>
<td>597</td>
<td>597</td>
</tr>
<tr>
<td>Core blow cycle (7)</td>
<td>126</td>
<td>126</td>
</tr>
<tr>
<td>Air driven bin vibrators (6)</td>
<td>215</td>
<td>0</td>
</tr>
<tr>
<td>Cabinet coolers (4)</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Handheld open blowing</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>APK open blowing</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>SPO open blowing</td>
<td>32</td>
<td>13</td>
</tr>
<tr>
<td>Bag houses (5)</td>
<td>180</td>
<td>18</td>
</tr>
<tr>
<td>Artificial demand 95vs80p</td>
<td>450</td>
<td>0</td>
</tr>
<tr>
<td>Leaks</td>
<td>1,764</td>
<td>664</td>
</tr>
<tr>
<td>Drainage</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td><strong>waste = 43%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pressure loss at the point of use is the most significant opportunity in the Demand Side

- High point of use pressure drop
- Inadequate storage at the point of use
  - It is not inadequate piping
- Inadequate & improperly located storage in the compressor room
- Improperly sized and installed dryers and filters
- Low quality condensate drains
Determining if a compressed air systems audit will be beneficial at your plant

- Does your system need an audit?
  - Needs an ROI to justify proper modifications; does the payback need a guarantee in order to have capital allocated?
  - Complex or major production problems
  - Lack of internal resources to dedicate to a project

- Choosing the right audit firm
  - Check references; do they guarantee their work?
  - Confirm their ability to get projects implemented
  - Review actual reports
  - Look for a technically complete audit with documented, recorded energy costs
  - Look for recorded application performance and engineered solutions to demand side performance issues
  - Specify direction for the short and long term goals of the system
A Valid Compressed Air Audit Must Provide:

- An accurate analysis of the existing system performance
  - A simple process flow diagram which communicates the issues
  - Recorded, verifiable energy costs
  - Analysis of production applications which drive the system

- A detailed analysis of the proposed system performance
  - A proposed process flow diagram
  - A detailed plan of action to achieve the projected performance
  - Engineered corrections to the issues in production
  - Calculated supply performance and energy costs

- Projected ROI or simple payback
Existing Process Flow Diagram

#1 rotary screw
1000 acfm, 220 bhp, 100 psid, 231 scfm, 1.15 sf

#2 rotary screw
1000 acfm, 220 bhp, 100 psid, 231 scfm, 1.15 sf

#3 rotary screw
1000 acfm, 220 bhp, 100 psid, 231 scfm, 1.15 sf

#4 rotary screw
2200 acfm, 426 bhp, 100 psid, 451 scfm, 1.15 sf

#5 rotary screw
2200 acfm, 426 bhp, 100 psid, 451 scfm, 1.15 sf

#6 rotary screw
2200 acfm, 426 bhp, 100 psid, 451 scfm, 1.15 sf

Drainage
90 scfm

Leak
100 scfm

Supply capacitance
12.5 cf/psi

Demand capacitance

- Header piping: 34.7 cf/psi
- Demand tanks: 18.0 cf/psi

Heated Blower
6000 scfm, 100 psid, 95°F
130 kW, 25 hp, 1500 psid purge

Steel Foundry Inc

- General production: 2230 scfm
- Sinto blow cycle: 597 scfm
- APK and SPO blowing: 60 scfm
- Handheld blowing: 135 scfm
- Core blow cycle: 126 scfm
- Bin vibrators: 215 scfm
- Cabinet coolers: 80 scfm
- Baghouses: 180 scfm
- Artificial demand: 450 scfm
- Leaks and drainage: 1864 scfm

Compressed Air Systems
Existing Arrangement
Process Flow Diagram

5,849 - 6,745 scfm
75 - 100 psig
1,468 - 1,698 bhp

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### Recorded and Verifiable Performance

<table>
<thead>
<tr>
<th>Normal Production Day</th>
<th>low</th>
<th>mean</th>
<th>high</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td>comp2</td>
<td>53.5</td>
<td>61.6</td>
<td>86.2</td>
<td>32.6 amps</td>
</tr>
<tr>
<td>comp1</td>
<td>114</td>
<td>117</td>
<td>128</td>
<td>15 amps</td>
</tr>
<tr>
<td>Comp 3</td>
<td>65.3</td>
<td>83.6</td>
<td>92.5</td>
<td>27.2 amps</td>
</tr>
<tr>
<td>Comp 4</td>
<td>57.9</td>
<td>66.1</td>
<td>70.6</td>
<td>12.8 amps</td>
</tr>
<tr>
<td>Comp 6</td>
<td>89.1</td>
<td>111.8</td>
<td>122.7</td>
<td>33.6 amps</td>
</tr>
<tr>
<td>comp discharge P2</td>
<td>85.8</td>
<td>92.8</td>
<td>100.2</td>
<td>14.4 psig</td>
</tr>
<tr>
<td>dryer discharge P3</td>
<td>81</td>
<td>88</td>
<td>96.9</td>
<td>16 psig</td>
</tr>
<tr>
<td>Header psig P4</td>
<td>77.6</td>
<td>85.3</td>
<td>95.8</td>
<td>18.2 psig</td>
</tr>
</tbody>
</table>

#### Graphical Representation

- **comp 2,3,5,6 amps**
- **P2, P3, Core Tank**

![Graph of recorded and verifiable performance data](image)
Recorded and Verifiable Performance

comp 2,3 amps
comp 4,5,6 amps
P2
P3

A psi
750 125.0
675 112.5
600 100.0
525 87.5
450 75.0
375 62.5
300 50.0
225 37.5
150 25.0
75 12.5
0 0.0

normal production day

08:52:47 85.0psi
09:32:59 74.9psi
08:59:05 68.0psi

400hp compressor failure

15 psi decay in 8 min 18 sec - 118 scfm demand over supply

only 30 hp required

iz Systems
guaranteed compressed air solutions
Production Application Analysis which identifies the true source of problems
Production Application Analysis with specific solutions

Existing Drop Details for Screw Gun Air Tools

3/4” drop from supply header

Coil hose twice as long as required

3/8” quick disconnect to air tool

3/8” quick disconnect

The differential of the point of use components is > 30 psi; header pressure has to be 100 psig to deliver 60 psig to the gun

3/8” quick disconnect

10’ 3/8” red rubber hose

3/8” quick disconnect

3/8” quick disconnect

10’ 3/8” red rubber hose

3/8” quick disconnect

drip lubricator

regulator cranked wide open

1 micron filter

master solenoid valve

3/8” quick disconnect

IZ Systems
## Detailed Constituents of Demand which identifies the Opportunities

<table>
<thead>
<tr>
<th>Constituents of Demand in SCFM</th>
<th>normal production load</th>
<th>peak production load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>existing</td>
<td>proposed</td>
</tr>
<tr>
<td>1 General Production</td>
<td>2,230</td>
<td>2,230</td>
</tr>
<tr>
<td>2 Sinto blow cycle</td>
<td>597</td>
<td>597</td>
</tr>
<tr>
<td>3 Core blow cycle (7)</td>
<td>126</td>
<td>126</td>
</tr>
<tr>
<td>4 Air driven bin vibrators (6)</td>
<td>215</td>
<td>0</td>
</tr>
<tr>
<td>5 Cabinet coolers (4)</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>6 Handheld open blowing</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>7 APK open blowing</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>8 SPO open blowing</td>
<td>32</td>
<td>13</td>
</tr>
<tr>
<td>9 Bag houses (5)</td>
<td>180</td>
<td>18</td>
</tr>
<tr>
<td>10 Artificial demand 95vs80p</td>
<td>450</td>
<td>0</td>
</tr>
<tr>
<td>11 Leaks</td>
<td>1,764</td>
<td>664</td>
</tr>
<tr>
<td>12 Drainage</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>waste</td>
<td>5,969</td>
<td>3,893</td>
</tr>
</tbody>
</table>

$\text{waste} = 43\%$
Engineered Solutions for Production Applications

high speed cylinder requires 60 psig and is 4" bore x 12" stroke

volume of cylinder = \( 3.14 \times \text{radius}^2 \times \text{length} = (3.14 \times 2^2) \times 12" / 1728 \text{ in}^3/\text{scf} = 0.0843 \text{ cf} \)

\[ 0.0843 \text{ cf} \times (60 \text{ psig} / 14.5 \text{ psia}) = 0.349 \text{ scf of air} \]

0.349 scf per stroke / 5 psid x 14.5 psia x 7.48 gal/scf = 7.8 gallons

with an 8 gallon tank, the pressure will fluctuate < 5 psid
Proposed Process Flow Diagram which Communicates the Solution

Steel Foundry
Compressed Air Systems
Proposed Arrangement
Process Flow Diagram

Supply capacitance
110 cf/psi

Demand capacitance
header piping - 34.7 cf/psi
demand tanks - 30.0 cf/psi

logic based compressor automation

Demand controller
setpoint 80 psig

8000HDF
cooling tower
(2) 10 hp pumps
(2) 3 hp fans

Multiplex 9600HSDM
refrigerated dryer <4 psid

12,000 gallons
82-98 psig

Multiplex 9600HSDM
two 10 hp pumps
(2) 3 hp fans

Steel Foundry

Alton Stokes
(251)-490-4981

General production
2230 scfm

Sinto blow cycle
597 scfm

APK and SPO blowing
60 scfm

Handheld blowing
135 scfm

Core blow cycle
126 scfm

Bin vibrators
0 scfm

Cabinet coolers
80 scfm

Baghouses
18 scfm

Artificial demand
0 scfm

Leaks and drainage
664 scfm

Cooling tower
(2) 10 hp pumps
(2) 3 hp fans
Proposed Supply Power and Volume Analysis
which depicts the Systems Operating Arrangement

<table>
<thead>
<tr>
<th>Proposed Arrangement</th>
<th>normal production load</th>
<th>peak production load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>scfm / bhp</td>
<td>scfm / bhp</td>
</tr>
<tr>
<td>compressor</td>
<td>bhp</td>
<td>kW</td>
</tr>
<tr>
<td>#1 Sullair 32-200L</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>#2 Sullair 32-200L</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>#3 Sullair 32-200L</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>#4 Sullair 32-25 400L</td>
<td>397</td>
<td>296.4</td>
</tr>
<tr>
<td>#5 Sullair 32-25 400L</td>
<td>400</td>
<td>298.5</td>
</tr>
<tr>
<td>#6 Sullair 32-25 400L</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>air cooled after coolers</td>
<td>40</td>
<td>29.8</td>
</tr>
<tr>
<td>cooling water tower</td>
<td>13</td>
<td>9.7</td>
</tr>
<tr>
<td>Refrigerated dryer</td>
<td>19</td>
<td>14.5</td>
</tr>
<tr>
<td>Totals</td>
<td>870</td>
<td>649</td>
</tr>
</tbody>
</table>
## Detailed Action Plan with Short and Long Term Solutions

### Prioritized Costed Action Plan

<table>
<thead>
<tr>
<th>Item</th>
<th>Completed during the audit</th>
<th>Capital</th>
<th>Install</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Install signal line downstream of cleanup equipment and connect the (3) 400 hp compressors</td>
<td>complete</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Replace lubricant on compressors with polyglycol based fluid</td>
<td>complete</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Install Precision drains on (3) 400hp air cooled aftercoolers</td>
<td>complete</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pressure wash air cooled after coolers to reduce CTD and temps to dryer</td>
<td>complete</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Connect (2) 200 hp compressors to downstream signal</td>
<td>complete</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><strong>Short Term</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Install drains in remaining areas to prevent water contamination of system (4)</td>
<td>2260</td>
<td>600</td>
</tr>
<tr>
<td>8</td>
<td>Install valves and meter the recovery of pressure on the core blow tanks and Sinto molder</td>
<td>1500</td>
<td>1000</td>
</tr>
<tr>
<td>9</td>
<td>Install open blowing nozzles for stationary applications</td>
<td>320</td>
<td>500</td>
</tr>
<tr>
<td>10</td>
<td><strong>Project</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Install 12,000 gallons control storage to protect against compressor failure and support peaks</td>
<td>20700</td>
<td>11000</td>
</tr>
<tr>
<td>12</td>
<td>Install 6” single valve fail open demand controller to stabilize header pressure</td>
<td>7000</td>
<td>10000</td>
</tr>
<tr>
<td>13</td>
<td>Install logic based automation system to autostop and start compressors as required to minimize kW</td>
<td>7500</td>
<td>5000</td>
</tr>
<tr>
<td>14</td>
<td>Retrofit compressors for autostart based on automation or pressure</td>
<td>1250</td>
<td>1000</td>
</tr>
<tr>
<td>15</td>
<td>Remove existing Sahara dryer and modify piping as required for new equipment</td>
<td>12000</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Install 8000HDF mist eliminator filter to removal lube carry over and reduce pressure drop by 8-9 psi</td>
<td>12000</td>
<td>3500</td>
</tr>
<tr>
<td>17</td>
<td>Install 9600 HSDM multiplex dryer w multi-disconnect, sentinel system, Savair drains</td>
<td>96500</td>
<td>4500</td>
</tr>
<tr>
<td>18</td>
<td>Install Cooling tower for two 200hp compressors and refrigerated dryer</td>
<td>24000</td>
<td>8000</td>
</tr>
<tr>
<td>19</td>
<td>System startup and checkout by factory technicians</td>
<td>7550</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub Total</th>
<th>173,030</th>
<th>64,650</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Grand Total</th>
<th>237,680</th>
</tr>
</thead>
</table>
### Accurate Energy Calculations based on Recorded Data

<table>
<thead>
<tr>
<th></th>
<th>bhp</th>
<th>kW</th>
<th>Hours</th>
<th>KWH</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing Arrangement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>normal production load</td>
<td>1,615</td>
<td>1,222</td>
<td>7,360</td>
<td>8,991,548</td>
<td>$ 382,141</td>
</tr>
<tr>
<td>peak production load</td>
<td>1,802</td>
<td>1,362</td>
<td>1,400</td>
<td>1,906,569</td>
<td>$ 81,029</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td>8,760</td>
<td>10,898,118</td>
<td>$ 463,170</td>
</tr>
<tr>
<td>based upon an average electrical rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$ 0.0425/kWh</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Hours</th>
<th>KWH</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proposed Arrangement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>normal production load</td>
<td>870</td>
<td>7,360</td>
<td>$ 203,014</td>
</tr>
<tr>
<td>peak production load</td>
<td>1,054</td>
<td>1,400</td>
<td>$ 46,805</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td>8,760</td>
<td>$ 249,819</td>
</tr>
<tr>
<td>based upon an average electrical rate</td>
<td></td>
<td></td>
<td>$ 0.0425/kWh</td>
</tr>
</tbody>
</table>

**projected savings**  

|                  |       | 5,020,033      | $ 213,351 |

---

[iZ Systems](https://www.izsystems.com)
## ROI / Payback Calculations

<table>
<thead>
<tr>
<th>Cost Constituent</th>
<th>Existing</th>
<th>Proposed</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Electricity</td>
<td>463,170</td>
<td>249,819</td>
<td>213,351</td>
</tr>
<tr>
<td>2. Internal Labor &amp; Overhead</td>
<td>15,000</td>
<td>7,500</td>
<td>7,500</td>
</tr>
<tr>
<td>3. Maintenance &amp; Repair</td>
<td>51,000</td>
<td>30,000</td>
<td>21,000</td>
</tr>
<tr>
<td>4. Water and Treatment</td>
<td>19,470</td>
<td>4,415</td>
<td>15,055</td>
</tr>
<tr>
<td>5. Depreciation</td>
<td>33,954</td>
<td></td>
<td>(33,954)</td>
</tr>
<tr>
<td>6. Rental compressors and dryers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Other charges</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>$ 548,640</strong></td>
<td><strong>$ 325,688</strong></td>
<td><strong>$ 222,952</strong></td>
</tr>
</tbody>
</table>

| Cost per hour/100 cfm            | $ 1.0492  | $ 0.9550 | 0.0943    |

| Estimated retrofit costs         | $ 237,680 |
| Estimated simple payback         | 12.8 months |

1. Electrical costs for compressors and dryers.
2. Internal labor and overhead for compressor maintenance
3. Outside maintenance should decrease based on operating 3 to 4 vs 6 compressors
4. Water costs for city water vs makeup water and water treatment chemicals.
5. Depreciation on capital project for 7 years straight line

Please note that the savings require completion of all demand side actions
Before you buy new supply equipment for your system, answer the following questions

- How much can the volumetric demand be reduced by controlling waste in the system?
- Are there persistent system problems which need to be addressed?
- How critical is accurately controlled pressure and useful storage?
  - Pressure / flow controllers
- What is the volumetric trim or turndown requirement in the system?
  - Can the compressors be reasonably matched to the variation in demand?
- Is there any requirement for very low dew point (desiccant dryers)?
- Will an ROI help justify the necessary upgrades?
PLC Based Automation

Maximizes efficiency and sustainable savings
• eliminates control conflicts
• minimizes pressure on the base load power
Trending Screens Provides Real Time Validation of Energy Savings and ROI
Developing an Action Plan for your system

1. Decide if a professional audit makes sense to develop an all inclusive plan
2. Analyze and correct persistent or reoccurring problem applications in production areas
   a) Apply dedicated storage to high speed or high rate of flow applications
   b) Correct high differential problems with proper point of use components
3. Locate and correct wasteful or inappropriate applications
4. Measure and minimize pressure loss in the compressor room
5. Base load larger compressors and minimize the number of trim compressors
6. Minimize system pressure in steps
7. Apply control storage to minimize cycling and support larger events (use vendor support if required to determine volume required)
8. Consider pressure / flow controllers and automation
9. Minimize system pressure further with flow controller
Technical Resources and Articles

- Using Storage in Compressed Air Systems
- Controlling Leaks in the Long Term
- Improving Compressed Air System Performance
- Control Strategies for Rotary Screw Air Compressor Systems
- Point of Use Sizing Chart and Instructions

Contact us at:

- iZ Systems
  - Atlanta, Jacksonville, Denver, Minneapolis, Oakland, Mobile
    251-490-4981; astokes@izsystems.com
  - Phoenix – 480-633-1572

Audits, training, specifications, turn key projects

Systems solutions: automation systems, pressure flow controllers, point of use solutions, drains, blowers, bag house kits