Compressed Air Energy Management

2018 INDUSTRIAL ENERGY CONSERVATION SEMINAR

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DFP
DAKOTA FLUID POWER

TRAINING • EDUCATION • EFFICIENCY
COMPRESSED AIR
CHALLENGE

Presenter

Joe Ghislain

- Ghislain Operational Efficiency (G.O.E.) LLC.
-
- Compressed Air Challenge - Instructor & Board Member
- Ford Motor Company (Retired) – 31+ years

Compressed Air Challenge

The CAC is a voluntary collaboration of:

- Industrial end-users,
- Manufacturers and their associations
- Distributors and their associations
- Facility operating personnel
- Consultants
- Energy research and development agencies
- Energy efficiency organizations
- United States Department of Energy
- Utilities

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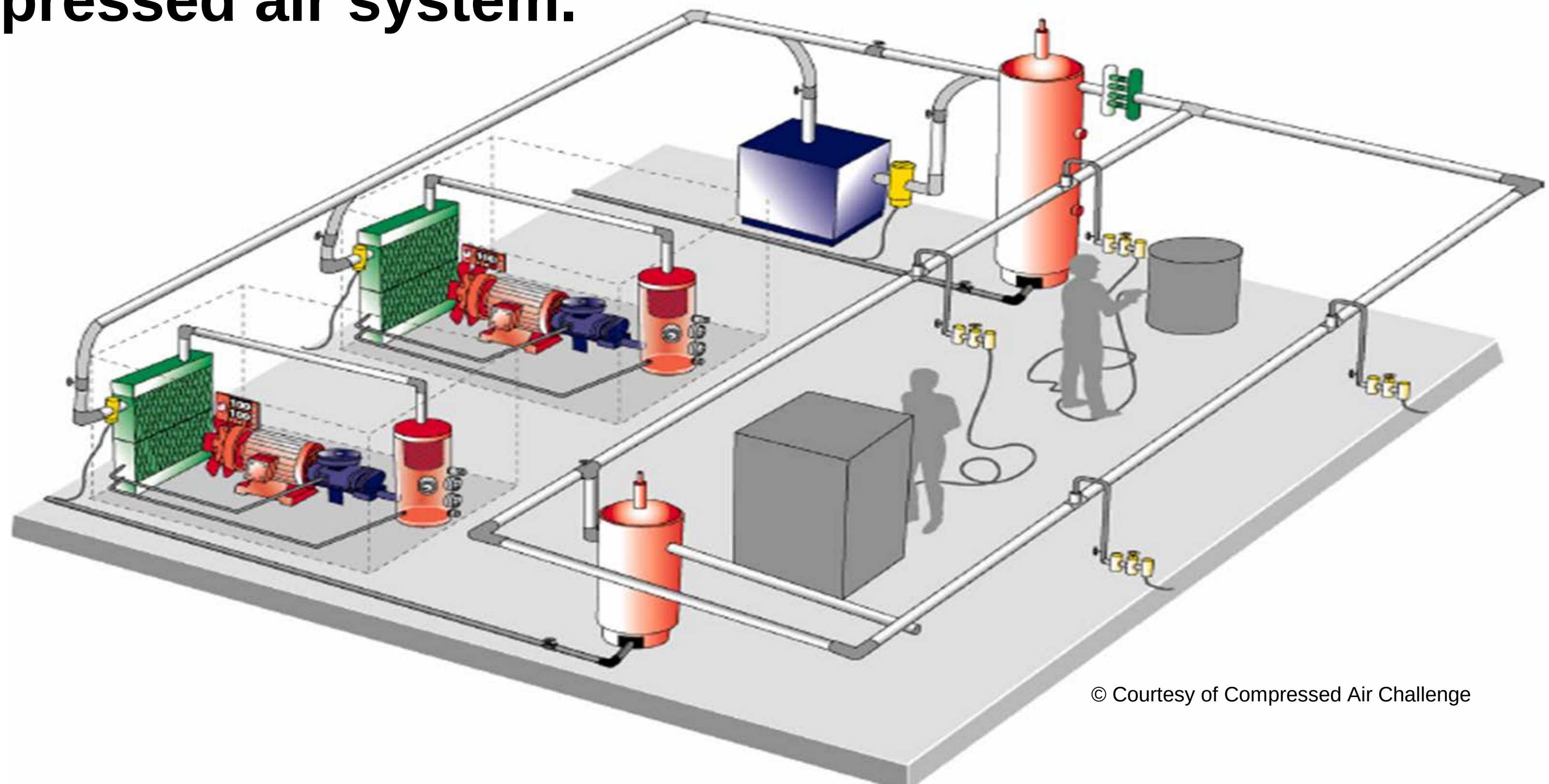
CAC has one purpose in mind…

Helping end-users improve the performance of their compressed air system.



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Training: Solve Problems and Save Energy

- CAC has trained more than 15,000 compressed air users since 1999.
- CAC has developed two levels of training for plant engineers:
  - Fundamentals of Compressed Air Systems (both in-person and online)
  - Advanced Management of Compressed Air Systems.
- And for System Specialists - Qualified AIRMaster+ Specialist
- As well as End-users – Operator Awareness Training

- In 2009, CAC released Best Practices for Compressed Air Systems Second Edition
  - This one-source manual addresses all of the improvement opportunities associated with compressed air systems and provides how-to information that will help users implement recommendations that achieve peak performance and system reliability at the lowest operating cost.

Why CAC cares?……
And you should too

- In the United States, compressed air systems account for $5 billion per year in energy costs.
- Compressed Air represents about 10% of electricity use in North America.
- Accounts for 16% of all motor systems.

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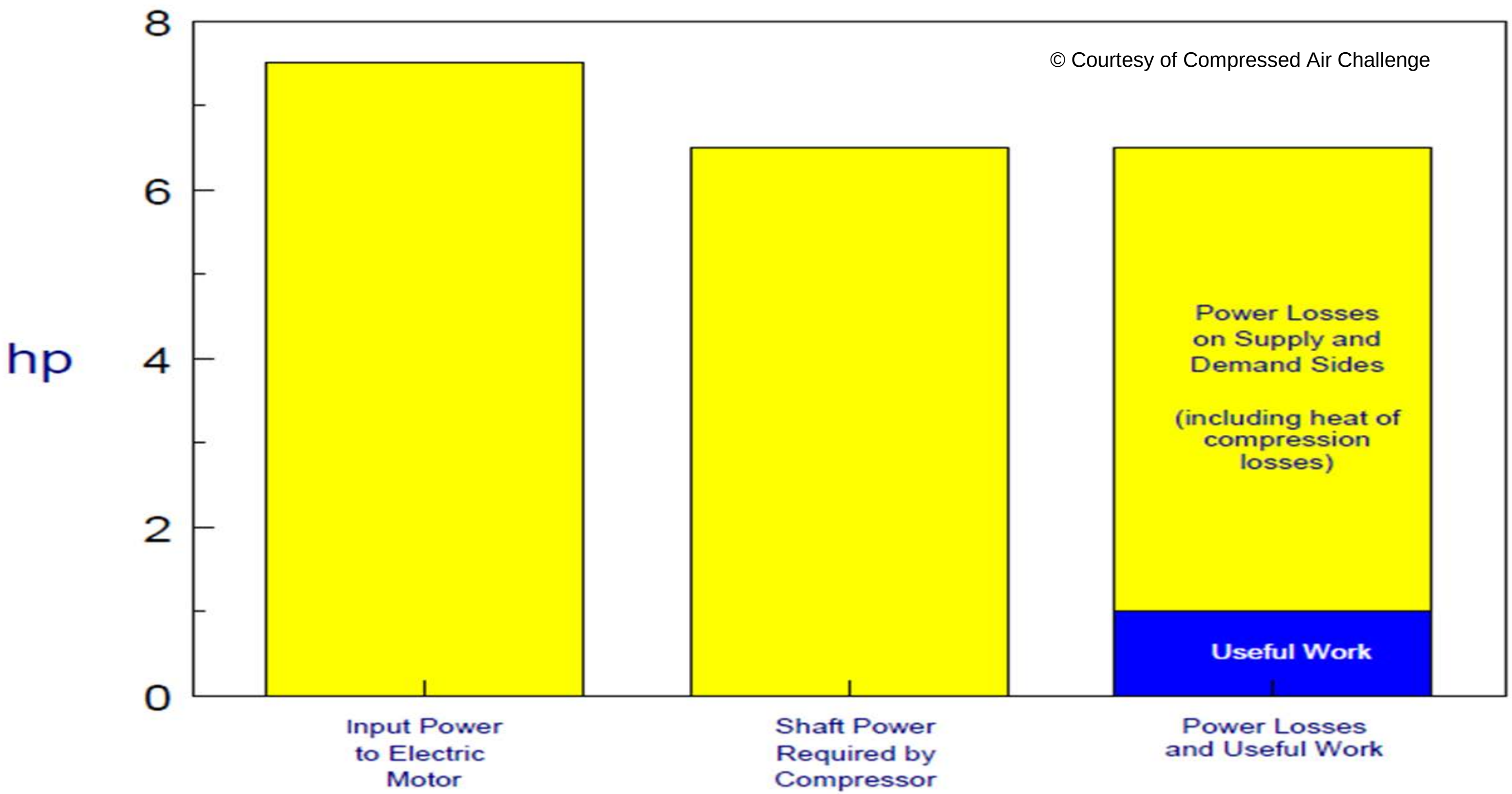
Contrary to popular opinion–

Compressed Air
Is Not Free !!!

Compressed air is a costly energy source

- The total cost of 100 psig compressed air can be in the range of 18 to 32 cents per 100 cubic feet.
- In the automobile industry, it is a significant part of the energy cost, ranging from 10% in component plants to up to 40% in stamping plants.
- Air Leaks can be 20% - 30% and as high as 50%
- In Ford plants, the cost of compressed air can be any where from several hundred thousand dollars to millions of dollars per year.

…..And not very Efficient



Reducing compressed air costs

- To reduce costs, it is very important to maintain the compressed air system efficiency.
- The key to increasing compressed air system efficiency and reducing costs is to apply best practices by using a systems approach.

CAC Principles You Should Apply for System Efficiency

- Awareness Training on Systems Approach
- Establish a Baseline, Calculate the Cost and Savings, and Relate it Back to Production
- Align Supply Side with Demand Side
- Reduce System Pressure
  - Air Quality Requirements
  - High Pressure Applications
  - High Volume, Intermittent Applications
- Eliminate Inappropriate Uses and switch to electric if possible
- Do Maintenance – Air Leaks
- Take Advantage of Heat Recovery
- Use Total Cost for Proper New System Design
- Integrate into current processes

Establishing a Base line

If you can't measure it, you can't manage it

- The key measurements are flow and electric usage and are used to establish a base line, monitor the system operation, determine cost, and to evaluate improvements.
- The efficiency is determined by the rate of flow (scfm) and power consumption (kW).
- Converting compressed air usage into dollars puts it into terms that everyone can understand.
- **Cost per unit is very powerful!**

Establishing a Base line

- A pressure profile determines the system dynamic and pressure readings are taken:
  - Before and after the main supply components.
  - At the beginning and end of the main piping distribution system and at several critical points of use.
- This should be done at over a period of time and different conditions to establish the high, low and average system demand.
- The amount of pressure variation shows how the system responds and what control actions need to be taken.

Align Supply Side with Demand Side

- The system demands drive the supply requirements!
- The operation of the compressors (number, duration, pressure, and flow) is all driven by the end uses and the system's dynamics.
- This relationship requires the monitoring and controlling of not only the air compressors but also the end uses.

Align Supply Side with Demand Side

- Establish a Base line using flow (scfm) and power consumption (kW) and develop a pressure profile.
- Convert compressed air usage into dollars – This puts the system operation and improvements into terms that everyone can understand.
- System control – Implement a strategy to control and monitoring all compressors
- Using storage to control demand – Install storage (Air receivers) both secondary and primary to meet peak demand events. (e.g. Stamping Presses)

System Control

- Type of compressor controls depends on the type of compressors and the system dynamics.
- Controls are used to base load (operate at full capacity) as many compressors as necessary and use only one compressor to "trim" (varying load).
- For multiple compressors of the same type, sequencing can be used to establish the base load and trim and turn compressors off and on based on the system demand.
- More sophisticated sequencing controllers and "global" systems (like energy management systems) are available and can control a mix of compressor types.

System Control

Controls have to operate the right type of compressors under the right condition.

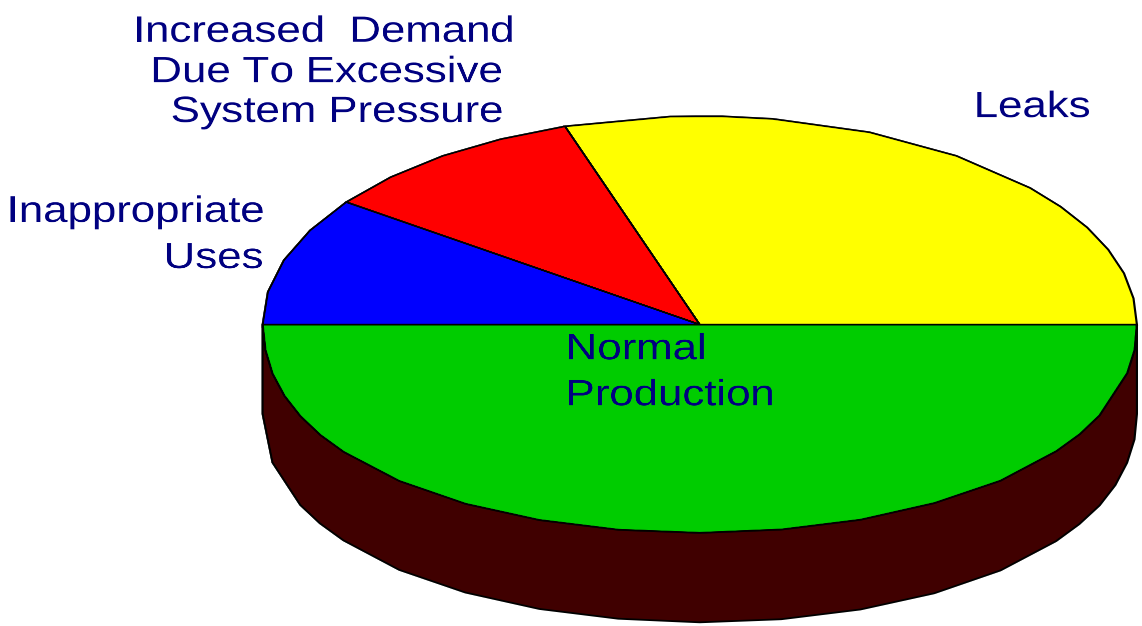
- Rotary compressors with modulating capacity control should be run fully loaded.
- Variable speed machines should only be used for trim.
- Centrifugal Compressors are efficient base load machines but have limited modulation.
- Double Acting Reciprocating Compressors have very efficient part load operation.

System Control

Using Storage to Control Demand

- Storage (Air receivers) are tanks that store compressed to meet peak demand events.
- Primary storage is located close to the air compressors and reacts to any event that happens in the system.
- Secondary storage is located at the end use and is used to minimize the affect that a high volume, low duration occurrence has on the system.
- Pressure/Flow controllers are used with storage for applications that require tight pressure band by monitor downstream pressures and reacting quickly to the demands.

Typical Components of Demand



Demand Side Key Points

- If you want to cut costs, reduce unproductive demands:
  - ✓ Inappropriate Uses
  - ✓ Leaks
  - ✓ Increased demand due to excessive system pressure (Artificial Demand)
  - ✓ End Use Requirements
    - ✓ Air Quality Requirements
    - ✓ High Pressure Applications
    - ✓ High Volume, Intermittent Applications

System Pressure Reduction

- For every 2 psi Decrease = 1% efficiency increase
- At 10¢ /kWh, a 1000 hp compressor running at 80 psi rather than 100 psi would save

$60,000 per year

System Pressure Reduction

To Reduce System Pressure you often have to address End Use Requirements:

- Air Quality Requirements
- High Pressure Applications
- High Volume, Intermittent Applications

The CAC End-Use Audit Checklist along with the CAC End-Use Solution Finder are tools designed to aid in your analysis.

Air Quality

- Adding Filters increases pressure drop in the system Only treat air to the degree required by end use applications and to protect equipment
- Higher quality air usually requires additional equipment and leads to:
  - Increased initial capital investment
  - Higher operational costs
  - Additional maintenance costs
- Use low pressure drop, long-life filters
- Replace elements when the cost of their pressure drop exceeds the cost of a replacement element

High Pressure Applications

- Often a very small percentage of the loads require higher pressure. (NAO Building)
- High pressure end uses need to be addressed.
  - Modify equipment
- Isolate higher pressure loads.
  - Air booster or intensifiers
  - Booster compressors or smaller compressors
  - Separate the system and supply the loads from one compressor

High Pressure Applications

- Test any assumptions regarding pressure
- If a high pressure application can be modified to operate at lower pressure, make the fix
- If a high pressure application is valid, find a better way to serve it
- If a high pressure application requires only a small percentage of the total consumption, do not let it determine the operating pressure for the entire plant

High Volume, Intermittent Applications

- High volume, intermittent applications can cause events that lower system pressure and disrupt system operation
- Storage can be used to minimize the impacts of these events.
  - Adequate primary storage can make systems easier to control and operate more efficiently
  - Secondary storage can:
    - Maintain more stable pressures at points-of-use
    - Improve the speed, thrust or torque of an application
    - Be used to reduce the rate of pressure drop in the system during demand events
    - Be used to control demand events (peak demand periods) in the system by reducing both the amount of pressure drop and the rate of decay
- Inadequate distribution piping can lead to pressure drop and other problems

Inappropriate Uses & Electric Conversion

In the beginning:

- Compressed air was a byproduct of producing electricity being generated by steam engines or turbines that were used to condense the steam. Electrically-driven tools could not perform the tasks.

Now:

- Compressed air is produced by electricity, making it a costly energy source.
- Electrically-driven rather than compressed air-driven tools can perform most of these tasks.

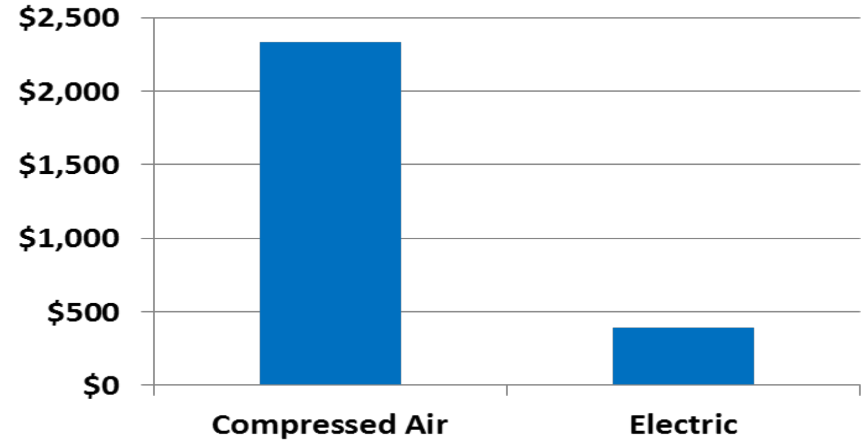
Inappropriate Uses & Electric Conversion

The overall efficiency of a typical compressed air system can be as low as 10-15 percent

Annual energy costs for a 1 hp air motor versus a 1 hp electric motor, 5 day per week, 2 shift operation, $0.10/kWh

$ 2,330 (compressed air)

$ 390 (electric)



What Are Some Inappropriate Uses?

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Inappropriate Uses

Open Blowing - cooling, drying, clean-up

Sparging - aerating, agitation, oxygenating, or percolating liquid with compressed air

Aspirating - using compressed air to introduce the flow of another gas (such as flue gas)

Atomizing - delivering a liquid as an aerosol

Padding - using compressed air to transport liquids and light solids

Dilute Phase Transport - transporting solids such as powdery material in a diluted format

Dense Phase Transport - used to transport solids in a batch format

Vacuum Generation - using air with venturi effect

Personal Cooling -comfort cooling with air

Open hand held blow guns or lances - any unregulated hand held blowing

Diaphragm Pumps - commonly found installed without regulators and speed control valves

Cabinet Cooling - cooling of electrical panels with open tubes

Air Motors

Inappropriate Uses & Electric Conversion

Examples of inappropriate uses/ electric conversions:

- Pneumatic Paint mixers – convert to Electric motors
- Pneumatic tools - DC tools– Energy save & increased quality
- Air blowing in paint shop and parts drying in component plants
  - High efficiency nozzles.
  - Low pressure electric blower
- Personnel cooling and cabinet cooling (Vortex Coolers) replaced with fans and A/C units for cabinets.
- Vacuum generation and vacuum ventures are replaced with high efficiency vortex cups or "Smart Pump" vacuum systems.

Maintenance

- Proper maintenance of both the supply side and demand side is critical to efficient operation.
- Often considered a "necessary evil"
- One of the first places that budgets get cut
- Often is PENNY wise and DOLLAR foolish

Maintenance Losses

- Pressure drops across dryers and filters
  - **2 psi equal to 1% efficiency**
- Increased temperatures and moisture
  - Increases dryer loading
  - Reduces air quality
  - Shortens equipment life
  - Dirty inlet filters reduce air compressor capacity
  - **For every 4 inches of water, pressure drop across the inlet air filters you lose 1% efficiency.**
- #1 is Production Downtime! (CHSP)

Biggest Maintenance Loss – Air Leaks

- Department of Energy study showed that a "tight" system will still have a 10% leak rate.
- Common to find 20% to 30% leakage rate
- Air leaks cause efficiency losses in several areas:
  - The leak itself -At 10₵ per kWh, a ¼ " air leak will cost over $18,000 per year.
- Compressed air leaks cause system pressure drops requiring:
  - Elevated system pressures
  - Increased compressor operation
    - **Higher Energy usage/costs**
    - **Increased maintenance**
  - Unnecessary purchasing of additional compressors

Did You Know?

A $200/year leak can't be felt or heard

A $800/year leak can be felt but probably not heard

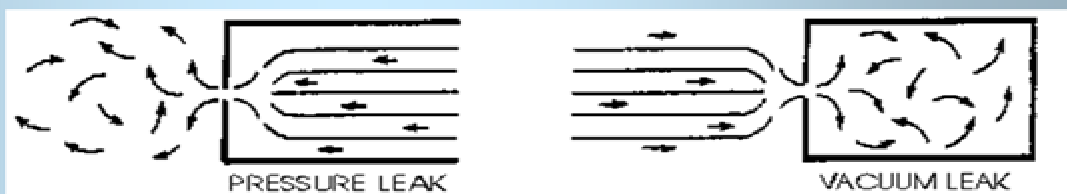
A $1,400/ year leak can be felt and heard

At $0.10 per kWh, 8,760 hours

How Do You Find Them?

How Ultrasonic Leak Detection Works

- During a leak, a fluid (liquid or gas) moves from a high pressure to a low pressure
- As it passes through the leak site, a turbulent flow is generated with strong ultrasonic components which are heard through headphones and seen as intensity increments on the meter
- It can be generally noted that the larger the leak, the greater the ultrasound level



Leak Detection Method

- Ultrasound is a high frequency, short wave signal with an intensity that drops off rapidly as the sound moves away from its source
- The leak sound will be loudest at the leak site, which makes locating the source (i.e. the location) of the leak quite simple

Implement Aggressive Air Leak Program that Identifies and Fixes Air Leaks

Leak Tag Program

- Establish Air Leak Reduction/ Leak Tag program as an Ongoing Process
- Estimate the Cost of Air Leaks
- Use Ultrasonic Leak Detection to find leaks
- Most Important– FIX THE LEAKS
- Publish Savings Results to Management
- Include (or Establish) Compressed Air Costs as Part of Your Energy Awareness

Potential Leak 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

Ford Case Study

Woodhaven Stamping Plant in Michigan

Actions taken:

- Air leak detection correction team was formed
- Leaking seals on stamping press dies repaired
- Pressure drop reduced at various points in the system
- Header pressure reduced
- Satellite compressors & dryers removed

Ford Case Study

Woodhaven Stamping Plant in Michigan

Results:

- Air use reduced by approximately 18%
- One 800 hp compressor shut down and controls adjusted so remaining compressors used less energy
- Six small (~ 30 hp each) compressors shut down
- Reduced system pressure by 5 PSI
- Electricity savings of 7,900,000 kWh with savings of $400,000 per year

The Most Important Thing to Remember About Air Leaks is…FIX THEM !!

And Don’t Forget The Last “Dirty 30”

This Refers to the last 30 ft (10 M) of pipe/hose from the supply header to the demand where most of the problems happen.

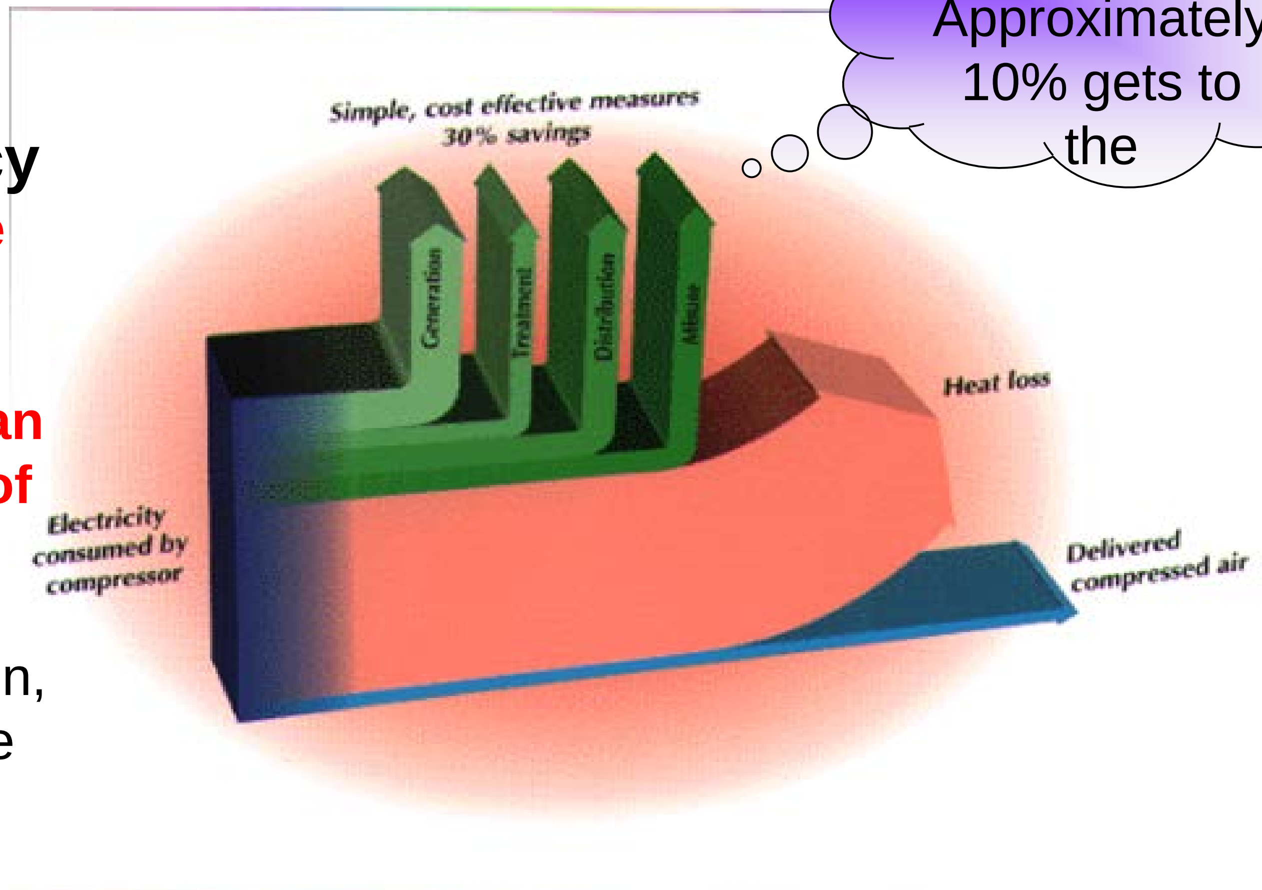
- Pressure drops/higher pressure requirements due to improper piping, hose size/length, FRL, and improperly maintained tools.
- Largest number of leaks also occur in this area.

Heat Recovery

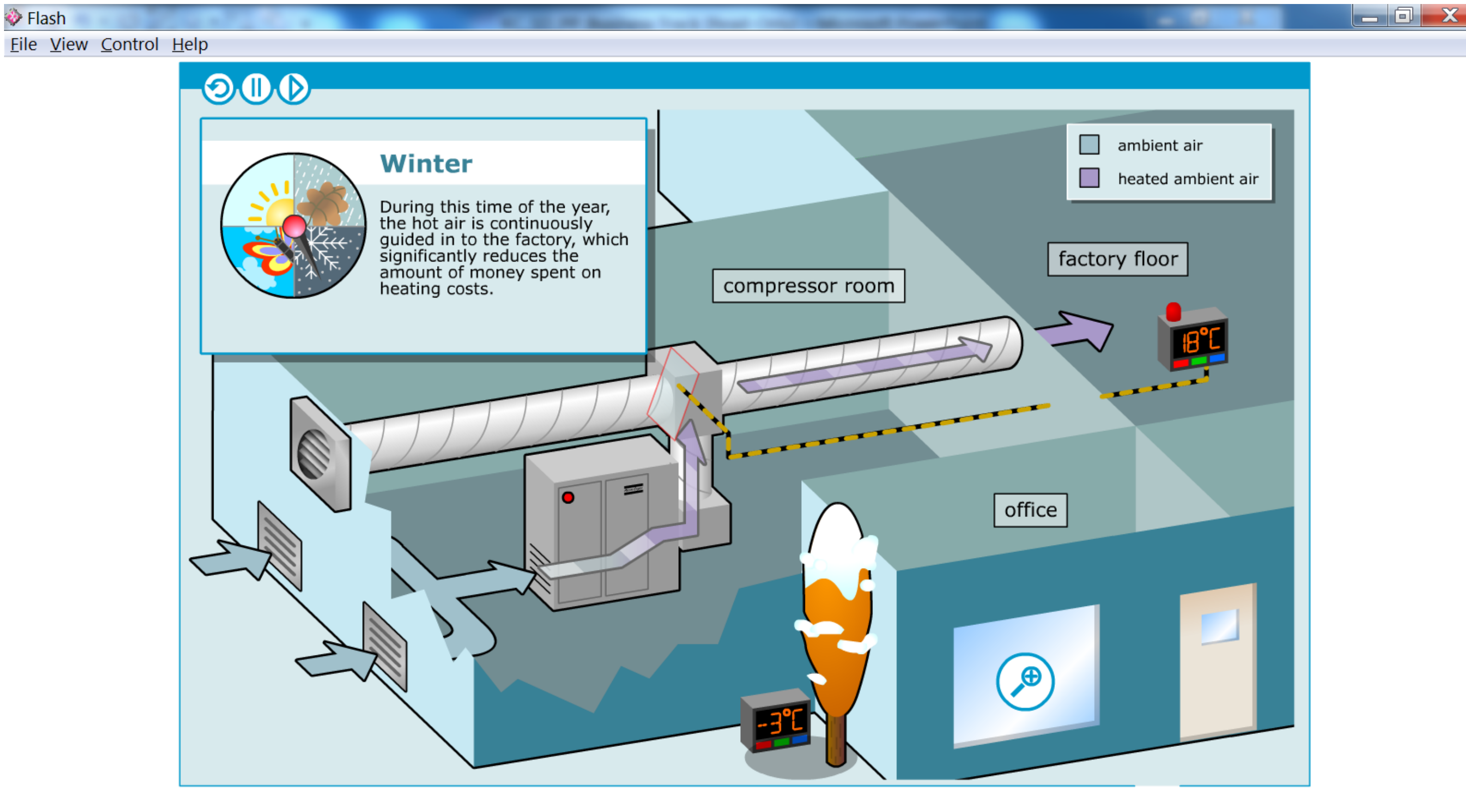
point of use!!
Approximately
10% gets to
the

Compressed Air’s Inefficiency

- **60 to 80% of the power of the prime mover is converted into an unusable form of energy (HEAT)**
- And to a lesser extent, into friction, misuse and noise



Heat Recovery

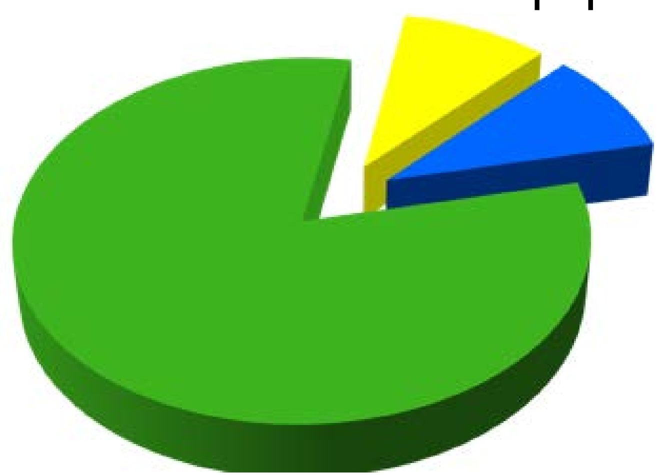


System Design – Total Cost

80%-90% Of The Operational Costs Are Determined By The System Design And The Equipment Purchased

Compressed Air Cost Analysis

Year	Equipment	Maintenance	Electricity
1	$ 30,000	$ 3,000	$ 26,000
2		$ 3,000	$ 26,000
3		$ 3,000	$ 26,000
4		$ 3,000	$ 26,000
5		$ 3,000	$ 26,000
6		$ 3,000	$ 26,000
7		$ 3,000	$ 26,000
8		$ 3,000	$ 26,000
9		$ 3,000	$ 26,000
10		$ 3,000	$ 26,000
Total	**$ 30,000**	**$ 30,000**	**$ 260,000**



System Design – Total Cost

- The total cost and benefits must be weighted and the most cost effect option taken not only for the compressed air system but also for the end uses.
- Air compressors – right type and mix for demand .(e.g. Centrifugal - base load, VSD for variable load)
- End uses also have to be specified to operate at the lowest possible pressure.
- Pressure drops
  - Designing equipment and systems.
  - Across dryers filters or even piping systems (CHSP)
  - Incremental cost of increasing the size to reduce the pressure drop may be small compared to the on going energy cost.
- Design in heat recovery whenever it is cost effective and appropriate.

System Design – Total Cost Example

Two Stamping presses, same size and manufacture, The owner specified the operating pressure at 60 psi and the other used the supplier specified 80 psi.

Result: Because of its size, if the plant that purchased the 80 psi press could have operated at 60 psi, it would have saved over $300,000 per year.

System Design -Energy Savings "Pitfalls"….

- Installing one compressor sized for peak load.
- Not using low pressure drop filters
- Using non cycling dryers for varying or low load conditions.
- Not using Zero loss condensate drains
- Applying the old rule of thumb of 10% PSID for Piping systems
- Not installing enough primary storage for Load/unload machines
- Inadequate ventilation for compressor rooms
- Over drying and filtering

System Design -Energy Savings "Pitfalls"....

- Implementing Capitol Solutions Before Doing The "Low Cost" Opportunities
- Using Average Cost of KWh For Off Peak Savings
- Assuming Pressure Flow Controllers Negate The Need For A Good Compressor Control System/Strategy
- Not Using Utility Rebates
- Buying Only VSD And /Or Using Them As Base Load.
- Assuming All Unregulated Demand When Calculating Artificial Demand
- Using Only Full Load Calculations For Savings
- Not Adjusting Centrifugal Compressor Savings For Winter/Summer Temperature Differences

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Heat Recovery Opportunities

- Supplemental space heating (applicable only in cold weather)
- Industrial process heating
- Water heating
- Makeup air heating
- Boiler makeup water preheating
- Drying compressed air

Heat Recovery Sources

- Air-cooled rotary screw compressors
  - Adding ductwork with auxiliary fans to compressor package
  - Recover to space or reject outdoors with thermostatic controls
- Water-cooled compressors
  - Install heat exchangers to recover to space or reject outdoors
  - Produce non-potable (gray) or potable hot water
  - Compressors using water-cooled motors offer further opportunity
- Engine driven compressors
  - Heat can be recovered from engine jackets and exhaust stream
- Gas turbine driven compressors
  - Heat can be recovered from exhaust stream to make hot water or steam

Three Keys to Success

People • Process • Tools

compressed air usage and energy by buying things like jackets, hats, key chains, pizzas would you buy it?

Well that is exactly what Monroe Stamping Plant Did!

Ford Case Study

Monroe Stamping Plant in Michigan

Actions taken:

- Hourly Energy Team, (in their red jackets so they would stand out) implemented an aggressive energy awareness and air leak repair program.
- Gave away buttons, key chains, hats and tee shirts for reporting and getting air leaks fixed”
- Each quarter the team with the best score in the ”Red Coats” Energy audit got a pizza lunch.
- Posted “Leak Boards” through out the plant to track progress.
- Used Ford Communication Network to broadcast messages on energy costs throughout the plant.

Ford Case Study

Monroe Stamping Plant in Michigan

Results:

- Air use reduced from 17.4 million cubic foot per day to 9 million cubic foot per day.
- Non production usage reduced from 5,400 cfm to less than 600 cfm.
- Electricity savings of over $2,000 per day
- Most importantly, created a cultural change in the plant for awareness of energy cost, usage and waste.

People Use the Compressed Air

Get Them Involved

and

Make Them Aware!

So how can CAC help with this?

Presenting:

Compressed Air, It's Not Free!

Compressed Air, It's Not Free!

Operator Awareness Training

- Training customized to the site/facility
- Delivered 30-45 min depending on content
- Perfect for team meetings /tool box talks
- Cost effective with several delivery options :
  - Delivery and presentation modifiesd by plant/facility person(s).
  - Delivery by plant/facility person(s) and presentation modification assisted by CAC instructor
  - Delivery and presentation modification by CAC instructor with assistance from plant/facility person(s).

Operator Awareness Training

Compressed Air, It's Not Free!

Doug Woodward
D & G Design, Inc.

Joe Ghislain
Ghislain Operational Efficiency

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COMPRESSED AIR CHALLENGE

Three Things to Remember

1. Cost of compressed air is very expensive

2. End uses of compressed air

   Appropriate, inappropriate or air leak?

3. You (end user) are key to the wise use of an expensive utility

Process

For Lasting Energy Efficiency, Make It Part Of What You Do Not Something Additional To Do

Process Integration

- ISO 50001/ISO 14001
- Sustainability Initiatives
- Lean Manufacturing/Continuous Improvement System - FPS - EnMOS
- Plant/Facility Goals and Objectives – Plant Manager's Scorecard

Tools

Use Existing Tools/Systems

- Ford Best Practice Replication
- Ford Six Sigma Program

Or Work Within The System and Develop New Ones

- Ford Performance Contracting

Performance Contract

- Monthly payment is contingent on metered saving
- Monthly payment is variable due to metered savings
- Monthly payment is expense - utility payment
- Monthly savings are guaranteed
- Equipment operation/performance guaranteed
- Accounting Treatment: Not Reflected on Ford Balance Sheet Treated as Expense.

Performance Contacting Benefits

- No Ford capital investment
- Off balance sheet treatment - utility contract
- Project cost paid through savings
- Savings are guaranteed
- Equipment/system performance guaranteed
- After the term of the contract, the plant receives 100% of the savings.

Performance Contract Projects

- H&V Upgrades / Boiler Shutdown
- “Mega Lights” -lighting upgrade at 16 assembly plants
- Air Compressor controls/systems
- Incinerator conversions RTO to RCO.
- Paint Booth upgrades
- Parts washers

Chicago Assembly Plant Steam Elimination / H&V & Air Compressor Upgrade Project

Existing Conditions: H&V

- Central Boilerhouse, Steam Units and Piping over 70 years old.
- Steam System 50% Efficient
- Process Changes have created negative pressure in plant
- Chicago Code has caused inefficient operation of natural gas fired units

Existing Conditions: Air Compressors

- Mix of Oil Free Centrifugal and Lubricated Reciprocating Air Compressors
- Manual control of individual compressors.
- Design and age of compressors are less efficient and require more maintenance than newer designs.
- Pressure drops from central compressors station to end use.

Change Barriers

- Limited Capital Funding
- High Capital Cost(Approx. $8 million)
- High TARR Hurdle Rates(50%)
- Low TARR Project (15%)
- Chicago Codes
- U.A.W. Concerns

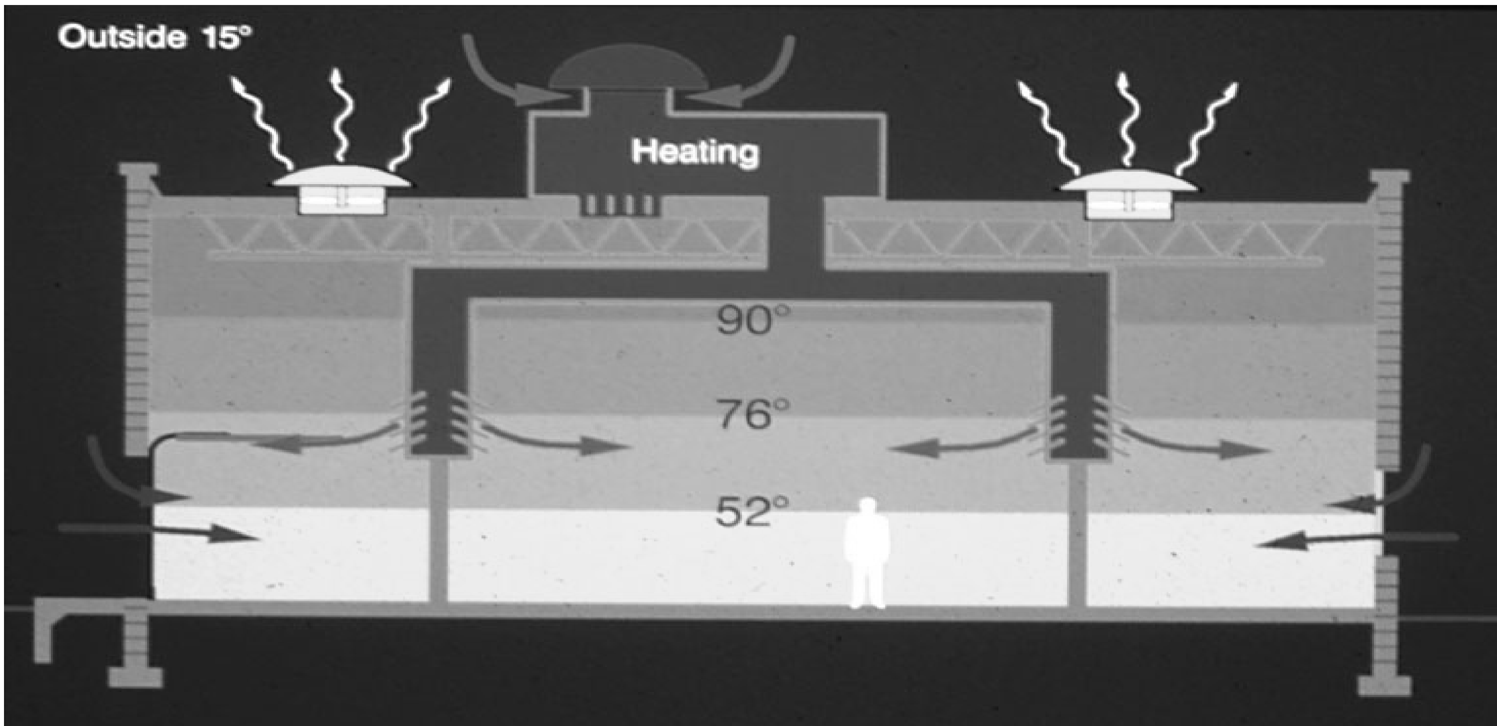
Solution:

Chicago Assembly Plant Performance Contract

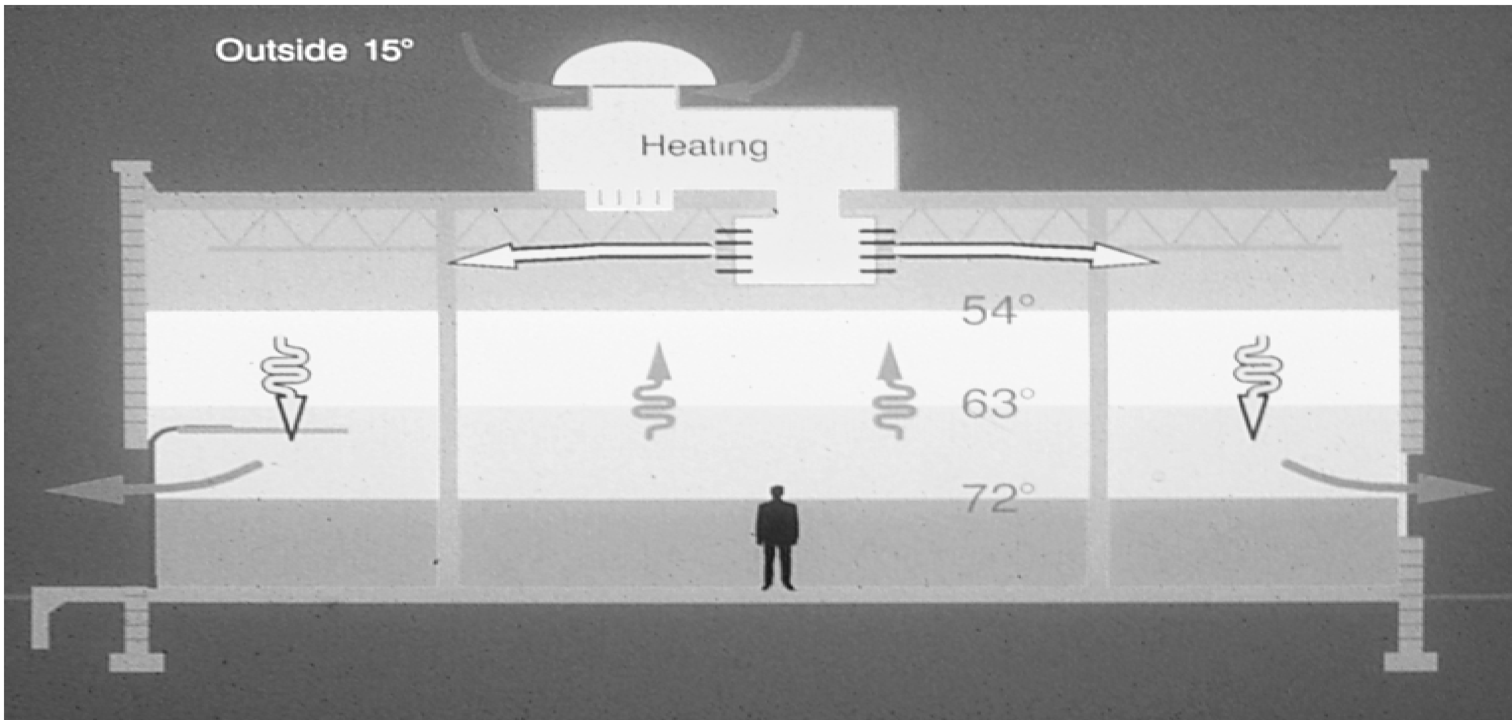
Scope of Project

- Install new (4-200,000 cfm direct fired units, 4 - indirect unit heaters)
- Utilize existing equipment (1 direct fired, 24- indirect fired, 18 unit heaters, 6 infrared.
- Install new direct contact hot water heater.
- Install 3 new 5000 cfm water cooled centrifugal compressors & Dryers
- Install global control system

Negative Building Infiltration



Ductless System



Scope of Project

- Cost: $7.94 Million dollars
- Annual Savings: $2 million ($1.8 energy $200k Manpower)
- 8 year contract (required CEO's signature)
- Actual Annual Savings to Plant : $270 - $250k Guaranteed.
- Project received code deviation for City of Chicago

Energy Savings from:

- Eliminating inefficient Steam System
- Efficient Directed Fired H&V Units and Hot Water Heaters
- More Efficient Air Compressors and Controls
- Elimination of Exhaust Fans
- Heat Recovery from intercooler, aftercooler and motor.

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System Benefits

- New equipment with guaranteed performance
- Guaranteed Savings($270,000 to $250,000) with no investment
- Oil free compressed air system
- Total building H&V and compressor control system

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Remember:

To Maximum Compressed Air Efficiency, Always take a Systems Approach!

- For More Information: **www.CompressedAirChallenge.org**
- Training
  - Fundamentals of Compressed Air Systems
  - Advanced Management of Compressed Air Systems.
  - Compressed Air, It' s Not Free- Operator Awareness Training
  - System Specialists Training - Qualified AIRMaster+ Specialist
- Best Practices Manual
- Case Studies, Articles, Fact Sheets, DOE/CAC Source Book etc.

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Questions?

Presenter contact information:

Joe Ghislain

Principal/Owner, Ghislain Operational Efficiency (GOE)

6-Sigma Black Belt, CEM, REM, CSDP, CP EnMS-Industrial, SEP Performance Verifier, 50001 EnMS Qualified Instructor

Cell (313) 585-9564

e-mail - JoeG@GOE-LLC.com