AABC Commissioning Group
AIA Provider Number 50111116

Energy Savings Opportunities on Compressed Air Systems

Course Number: CXENERGY1922

Joe Ghislain
Compressed Air Challenge,

April 18, 2019

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

TRAINING • EDUCATION • EFFICIENCY

COMPRESSED AIR CHALLENGE

GOE

LEAN. GREEN. EFFICIENT.

CONTINUING EDUCATION AIA

Course Description

If you are looking for additional areas of energy savings opportunities to add to your commissioning or retro commissioning activities, then compressed air systems and this presentation might just be what you are looking for. This presentation provides an overview of how taking field-tested approach and applying best practices can improve a compressed air system, giving you energy savings using real world examples that lead to better energy management.

Learning Objectives

At the end of the this course, participants will be able to:

1. Establishing a baseline of energy consumption due to compressed air systems.

2. Understanding your energy demands and where to look to identify energy/cost savings actions.

3. To understand the challenges of purchase/design/build as it relates to commissioning.

4. Recognize the importance of employee awareness/involvement in saving energy and reducing cost.

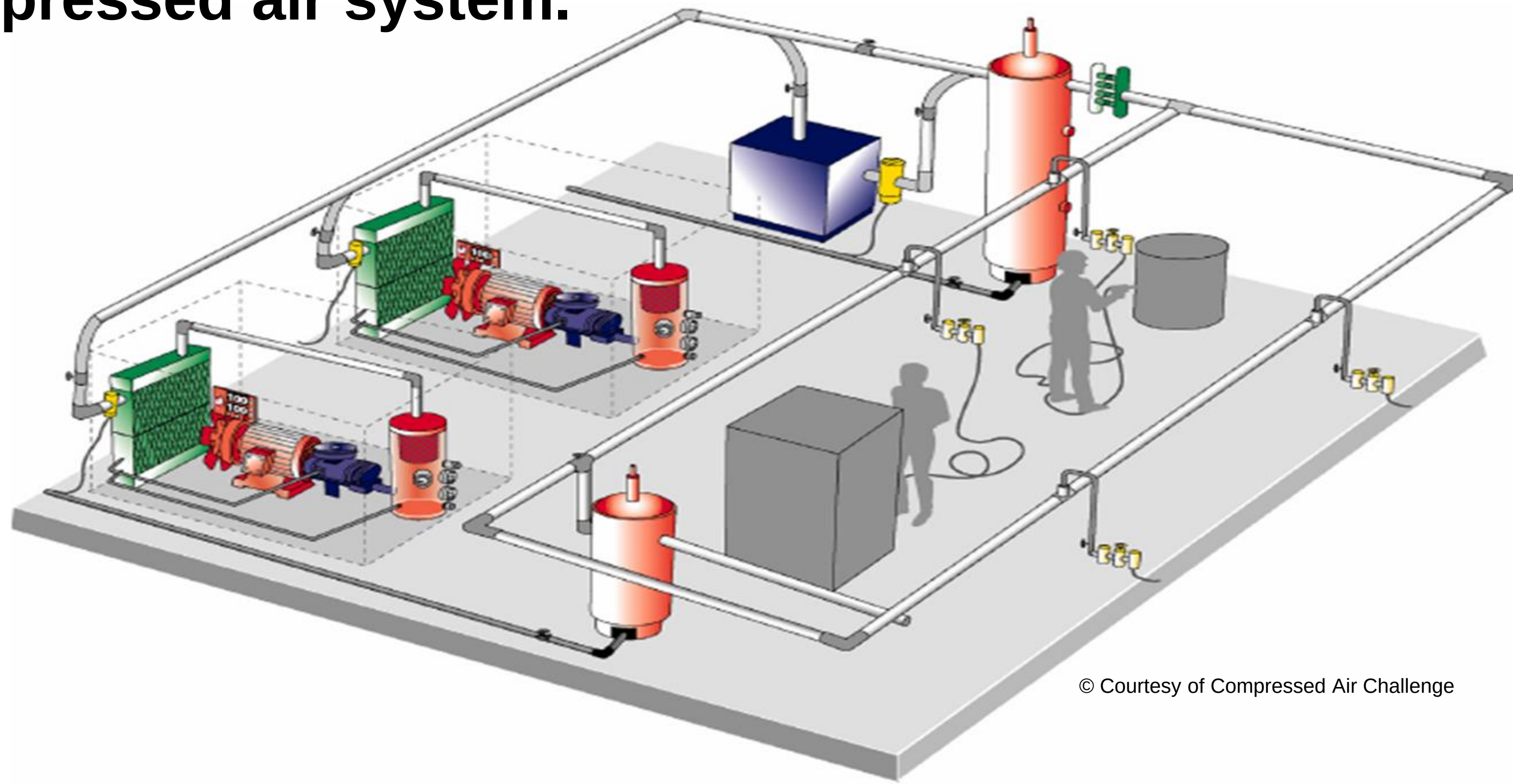
Compressed Air Challenge

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

CAC has one purpose in mind…

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



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.

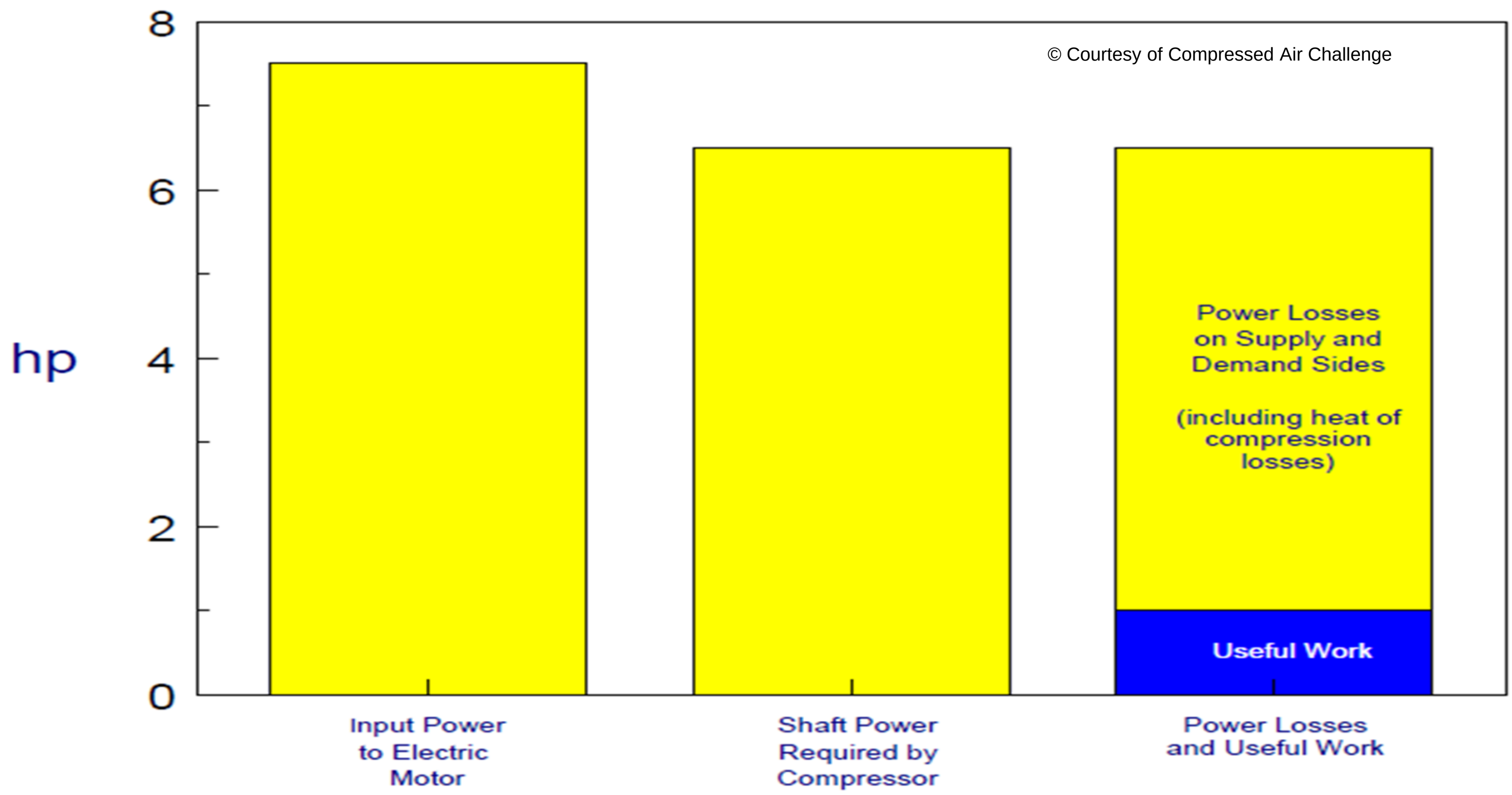
Contrary to popular opinion–

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

- 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

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

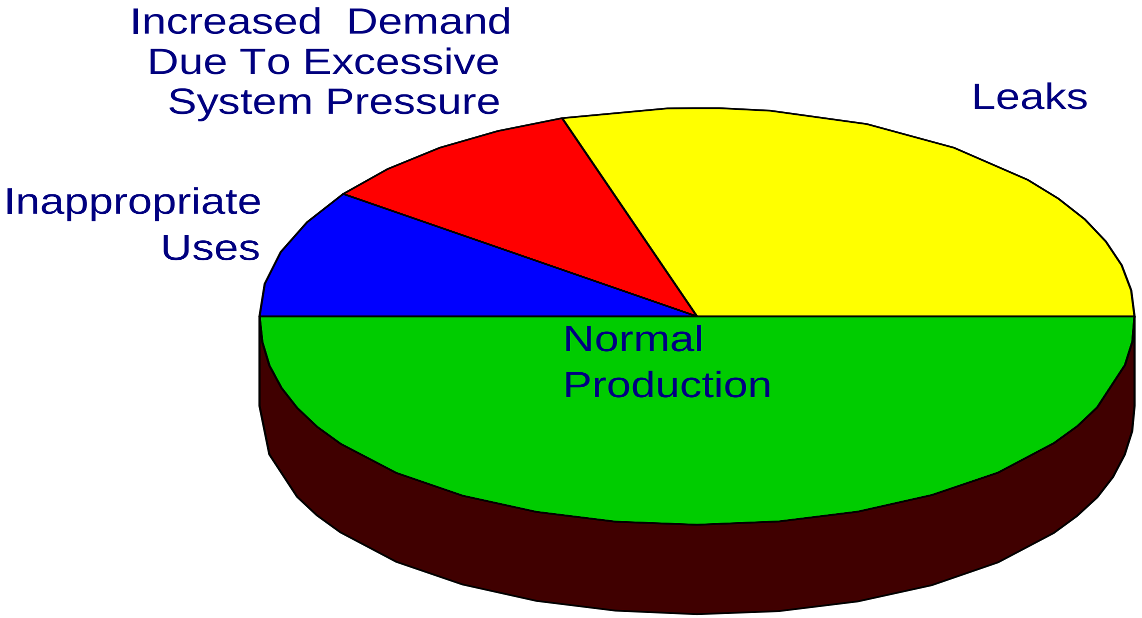
- Rotary compressors with modulating capacity control should be run fully loaded.
- Variable speed machines should only be used for trim.
- Centrifugal Compressors are efficient base load machines but have limited modulation.
- Double Acting Reciprocating Compressors have very efficient part load operation.

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 100 hp compressor running 24/7 at 80 psi rather than 100 psi would save over

$6,500 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:

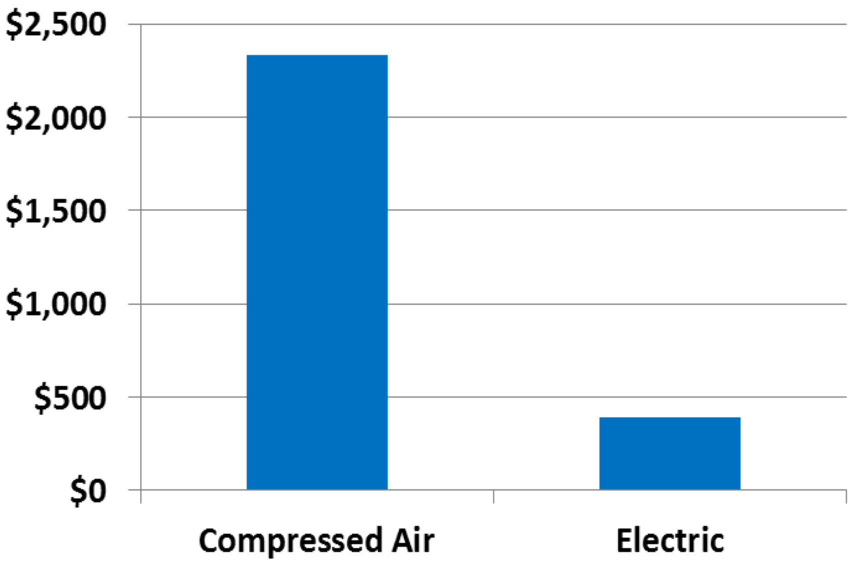
- Compressed air is produced by electricity, making it a costly energy source.
- Electrically-driven rather than compressed air-driven tools can perform most of these tasks.

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?

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

Pneumatic Controls

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

- Inlet air filters
  - 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

How to Reduce Air Leaks?

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

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

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

Remember …

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.

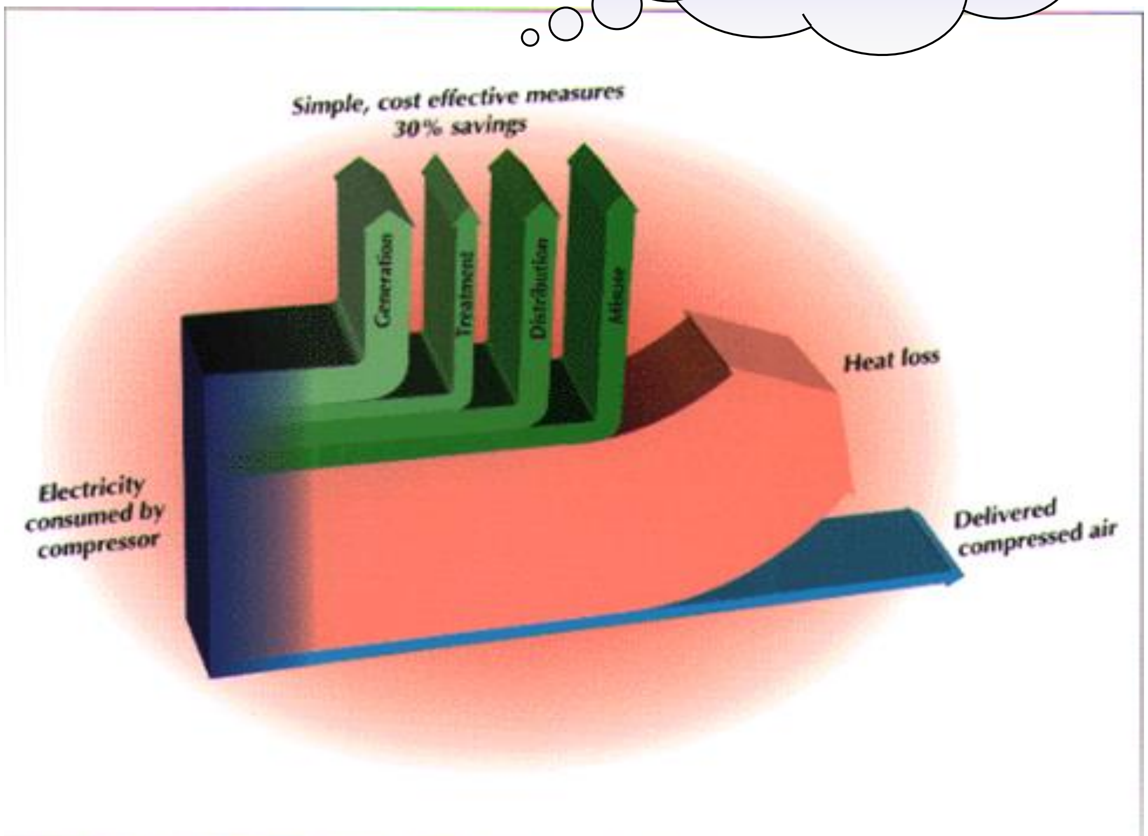
- Pressure drops/higher pressure requirements due to improper piping, hose size/length, FRL, and improperly maintained tools.
- Largest number of leaks also occur in this area.

Heat Recovery

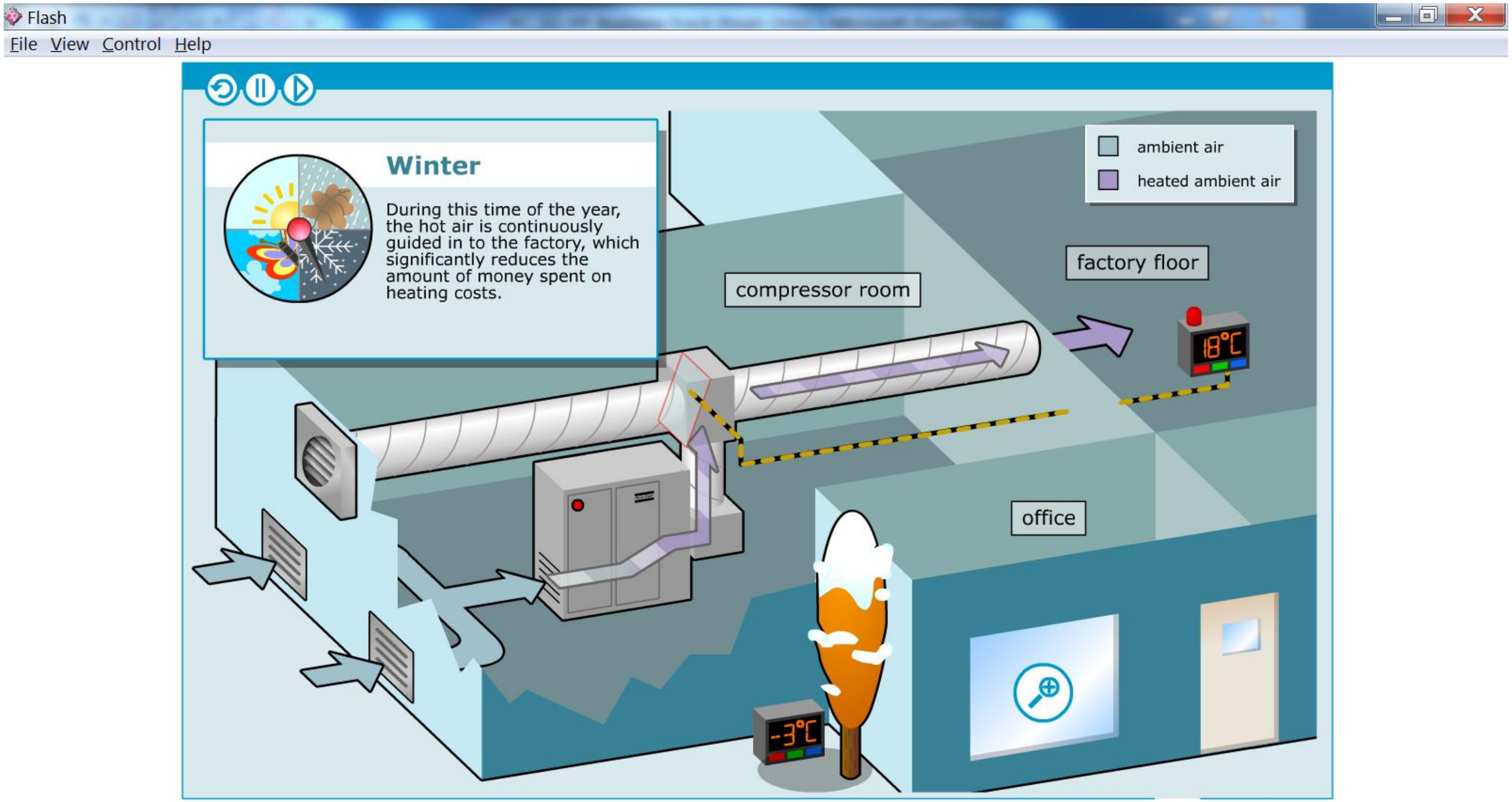
Compressed Air's Inefficiency

- **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

Approximately 10% gets to the point of use!!



Heat Recovery



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

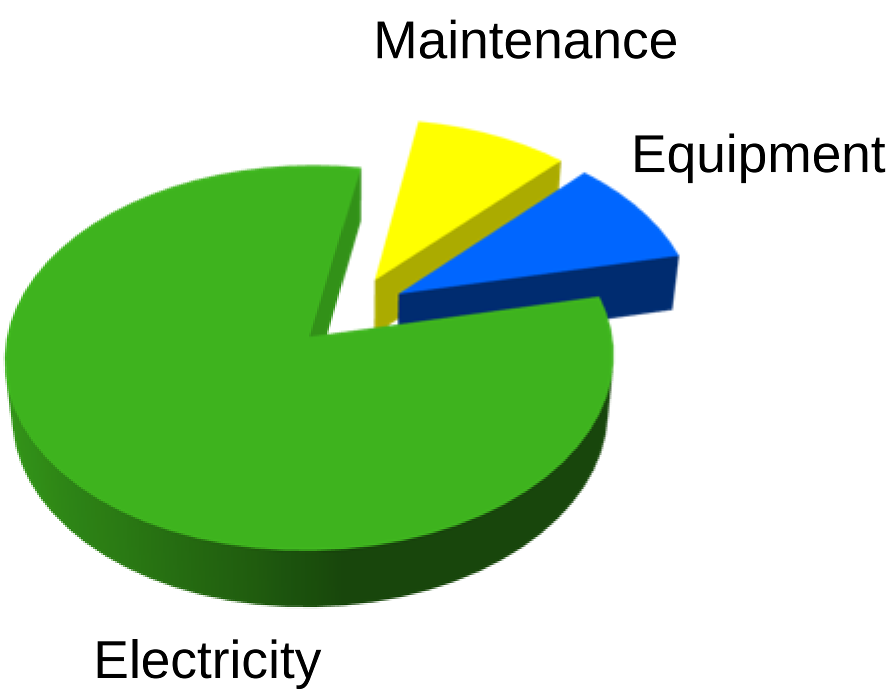
- Heat can be recovered from exhaust stream to make hot water or steam

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**



75 hp compressor, 5-day per week, 2 shift operation
Electricity rate of $0.10/kWh

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 –
Energy Savings "Pitfalls"….

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

People Are Key in Finding, Implementing and Sustaining Energy Reduction.

If I told you that you could reduce 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

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

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!

Key Components of a Compressed Air Awareness

- Target operators/end-users with the training
- Use site specific examples
- Overview of a compressed air system
- Understanding of demands, i.e. leaks, inappropriate uses
- Compressed air is inefficient and very expensive
- **They are the key to using it wisely to save energy and money**

CAC Example: Compressed Air, It's Not Free!

Operator Awareness Training

- Includes all of the Key elements
- Training customized to the site/facility
- Delivered 30-45 min depending on content
- Perfect for team meetings /tool box talks
- Flexible delivery options:
  - Delivery and presentation modified 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).

Final Thought

For Lasting Energy Efficiency

Make It Part Of What You Do

Not Additional To What You Do

Process Integration

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

For More Compressed Air and System Approach Information:

www.CompressedAirChallenge.org

- Case Studies, Articles, Fact Sheets,
  DOE/CAC Source Book etc.
- 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

Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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, EPI ISO 50001 Lead Auditor

Cell (313) 585-9564

e-mail - JoeG@GOE-LLC.com

TRAINING • EDUCATION • EFFICIENCY
COMPRESSED AIR CHALLENGE
INSTRUCTOR

GOE
LEAN. GREEN. EFFICIENT.

acg

CONTINUING EDUCATION AIA