Ingersoll Rand
Industrial Technologies

IREDA - WORLD BANK

ALL INDIA ENERGY EFFICIENCY CAPACITY BUILDING PROGRAMME

MAY 4-5 , 2007, Unitech Country Club , Gurgaon

Organized By :

IRG SYSTEMS SOUTH ASIA PVT. LTD **&** **NCR CHAMBER OF COMMERCE & INDUSTRY**

Energy Conservation in Compressed Air Systems

suresh kaul
head business development
industrial technologies
ingersoll rand india limited

Contents

- Understanding the Context
  - Need for EnCon
  - Saving Potential
- Areas to Attack
  - Supply
  - Distribution
  - Demand
  - Quality
  - O&M
- Energy Saving Solutions
  - Compressor Selection
  - VFD’s
  - New Products
- Concluding Remarks
  - Execution - the Key
  - Total Participation for Desired Results

Understanding the Context

Indian Industrial Scenario

- Exciting Opportunities
  - Robust economy , 4th largest at PPP
  - Good Growth , Next $1 trillion economy by 2012 – Goldman Sachs
  - Agriculture now smallest segment of our economy
- Numerous Challenges
  - Global competition
  - Inefficiencies, cost competitiveness

EnCon : An Industrial Perspective

- The industrial sector uses about 50% of the total commercial energy available in India

- The main sources of commercial energy are coal, lignite, and oil and natural gas are all non-renewable

- The Indian industrial sector is highly energy intensive and efficiency is well below that of other industrialized countries.

- Most industries , some more than others , offer considerable scope for improving energy efficiency

Source : TERI Findings
http://edugreen.teri.res.in/explore/n_renew/industrial.htm

EnCon : An Industrial Perspective

• Energy management is gaining importance primarily to reduce an organization's energy bills and minimize the damage to environment.

• The two main energy management strategies are conservation and efficiency. This requires the establishment of a system of collection, analysis, and reporting on the organization's energy consumption and costs.

• In the industrial sector, the major consumers of energy are fertilizer, textile, sugar, cement, and steel. It has been estimated that the total conservation potential of this sector is around 25% of the total energy used by it.

Source : TERI Findings
http://edugreen.teri.res.in/explore/n_renew/industrial.htm

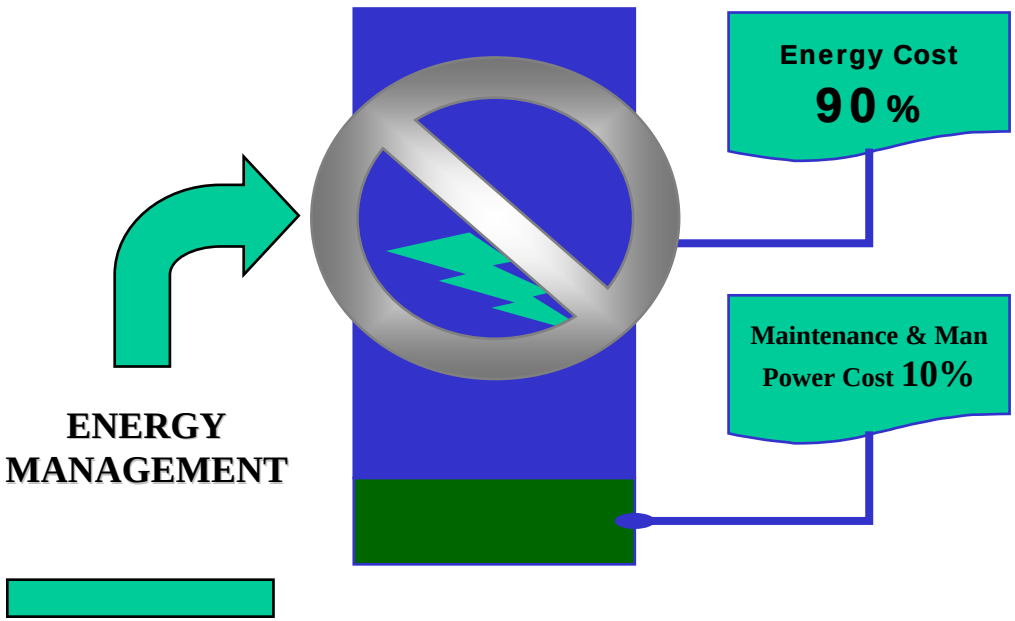
Compressed Air Systems Offer Huge Energy Saving Opportunities

- As Fourth Utility has one of the widest industry usage .
- By far the most Energy Intensive
- Scope of Energy Conservation spans right from point of generation to point of use.
- Compressed Air is a unique utility where plant has complete control over its production & distribution

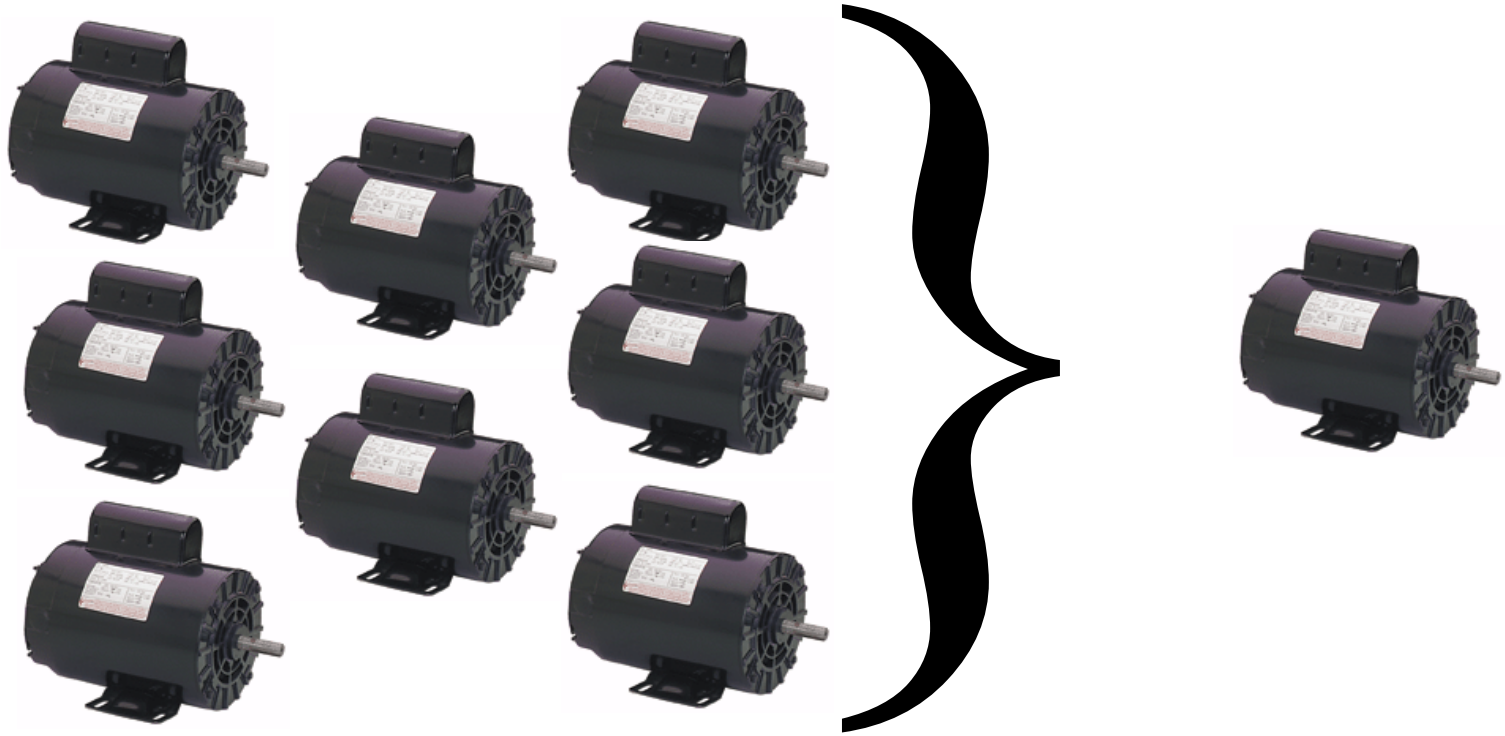
A sampling of Industries Using Compressed Air ..... and the list is only partial

Air System Costs

- It's the most expensive energy available to us.
  - (8 times more expensive than electricity)
- 10 to 20 % of the power consumed is for generating compressed air.
- Determine the cost of compressed air in your plant
  - Compressed air is a onsite generated utility. …Rs./cfm
  - A 100 kw compressor working for 300 days a year could consume Rs.32.40 lacs (100x300x24xRs.4.50)



- Inefficient power source even if well maintained



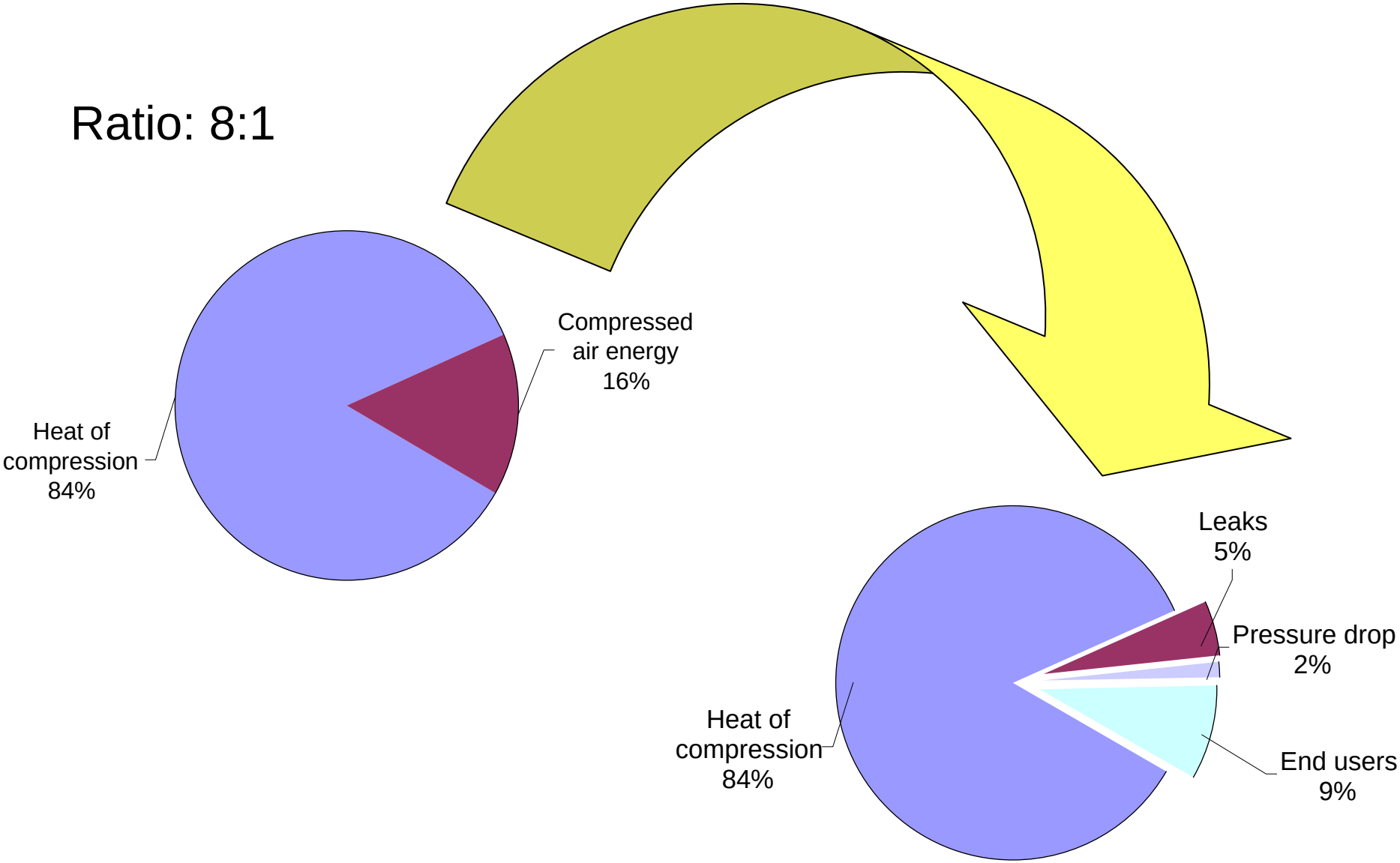
Eight compressor horsepower

yields . . .

One horsepower of compressed air

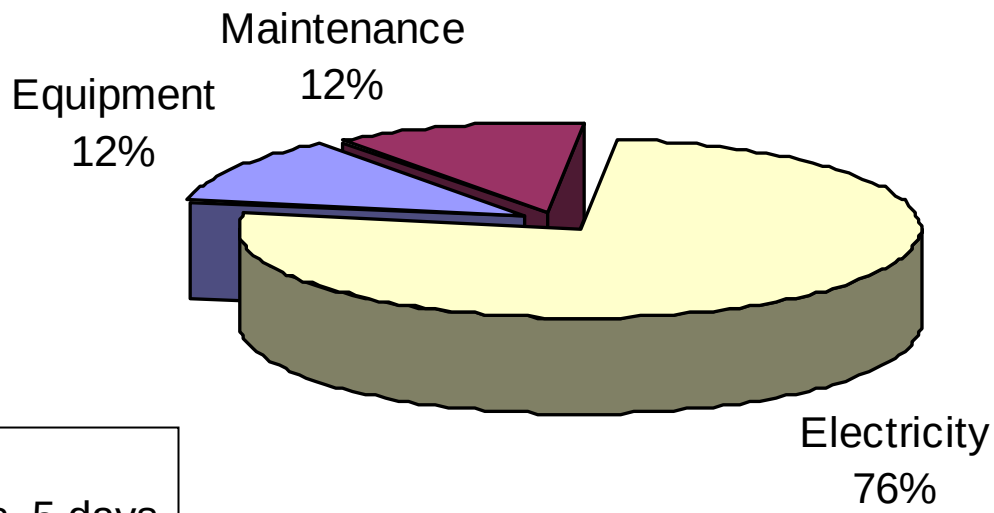
Compressed Air – Energy Utilization

Ratio: 8:1



Lifetime Operation vs. Initial Cost

Typical Lifetime
Compressed Air Costs
Over 10 years



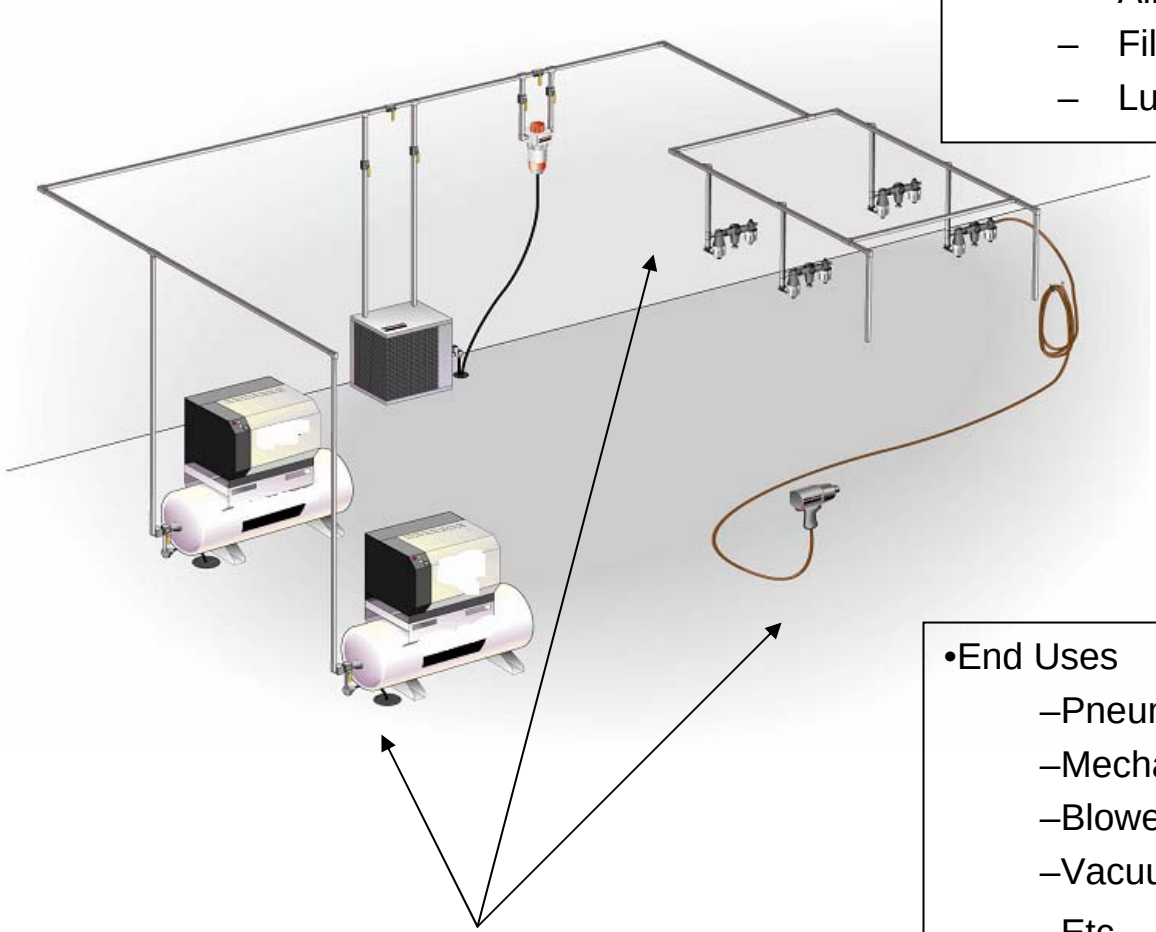
Assumptions include a 75-hp compressor operated two shifts, 5 days a week at an aggregate electric rate of $0.05/kWh over 10 year equipment life.

Source: US Dept of Energy, Office of Industrial Technologies: Compressed Air Tip sheet #1.
http://www.oit.doe.gov/bestpractices/pdfs/compressed_air1.pdf

Areas To Attack

Compressed Air Systems

- Supply
  - Compressor
  - System Controls
  - Air Dryer
  - Aftercoolers
  - Air Filters
  - Primary Storage
  - Flow controls



- Distribution
  - Air piping
  - Filters
  - Lubricators

- End Uses
  - Pneumatic tools
  - Mechanical drive
  - Blowers
  - Vacuum generators
  - Etc . . .

All elements of Compressed Air System provide opportunity for energy savings

Possible areas of improvement in the compressed air system

•10-12% at Generation

Poor sequencing
Inefficient equipment (Compressors, air treatment devices)
Compressors not controlled efficiently

•4-6 % Transmission & Distribution

Leaks
High differential pressure
Lack of system capacitance
High co-efficient of friction due to MOC inside pipe
Improper piping layout

•6-8 % Point of use

Running the system at too high a pressure
Leaks and wastage of compressed air
Artificial demand & poor practices.

Supply :

- Compressors efficiency (Specific power)
- Load/unload dead band
- Operating pattern - Unloaded power
- Multiple compressor controls
- Wet & Dry storage
- Air Treatment devices
  - Driers,Filters & it effectiveness
- Condensate drains & leaks
- Cooling water system

- **Distribution :**
  - Pressure drops
  - Piping layout
  - Quantification of air Leaks
  - Velocity
  - Corrosion inside pipelines
  - Number of points into distribution
  - Quality of Compressed Air

- **Demand :**
  - Piping layout
    - Headers & tapings
  - Artificial Demand
  - Demand pattern
  - Leaks & operating pressure
  - FRL, Quick release coupling, hose pipes
  - Leaks within the machines
  - High volume & high pressure consumers
  - Momentary high volume consumers
  - Coincidental events
  - Poor practices

ISO 8573.1 Air Quality Classes

Maintaining air quality is so important that the International Standards Organization (ISO) developed six compressed air quality classes, as defined by ISO 8573.1.

ISO 8573.1 Air Quality Classes

Quality Classes	Solids (Particle Size in Microns)	Water Pressure Dewpoint (°F)	Oil Solids and Vapor (mg/m3)
1	0.1	-94	0.01
2	1	-40	0.1
3	5	-4	1
4	15	37.4	5
5	40	44.6	25
6		50	

Air quality at a price

- Power costs, Initial investment & maintenance costs in Two stage Oil free rotary screw compressor v/s two stage oil flooded screw compressor.

  (A two stage oil free 1000 cfm rotary screw compressor at 7 barg discharge pressure will consume 175 kw as against 161 kw of two stage oil flooded rotary screw compressor. Savings of Rs. 4.5 lacs per year in power cost alone.)

- High differential pressure filtration systems. Timely replacement of filter elements.

  (Every 1 bar increase in operating pressure increases power consumption by 7 %)

- Replacement of desiccant type dryers with Refrigerated type.

  (Save purge loss of >10% by replacing heat-less type dryers)

- Variable capacity & thermal mass refrigerated dryers

- Inadequate/Delayed maintenance will reduce efficiency
  - Operate at Peak efficiency & minimize the unscheduled down time
- Strategy for Air ends & Crank/Drive end.
  - Screw, Reciprocating & Centacs,
  - Condition monitoring & efficiency tests
- Effect of intake air.
  - High temp, low mass flow - additional compr + power
  - Low Pressure drop filtration at suction
  - Dirt & moisture

- Software
  - Tools for selection of pipeline,compressors, driers.
  - Artificial demand
  - System Capacitance
  - Saving calculators - VFD,System controls
  - CDS/SPM analyser

- Hard ware
  - Instruments
    - Air Flow meters
    - Data Loggers
    - Energy meters
    - Dew point meter
    - CDS/SPM analysers for condition monitoring

Air system analysis

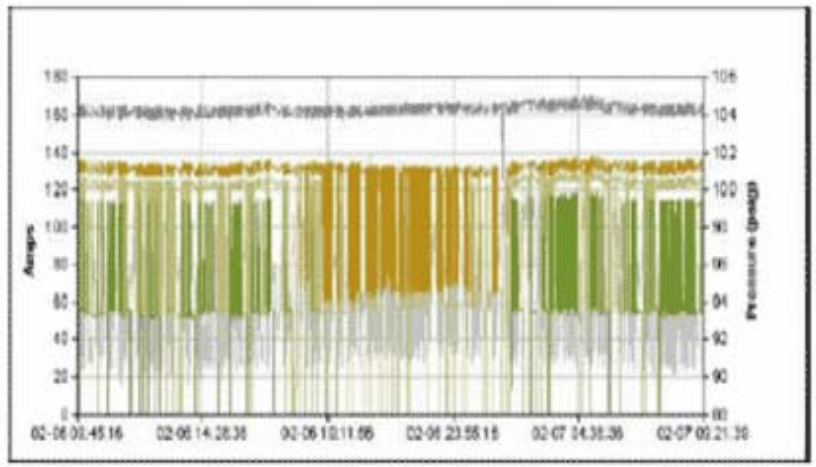
Flow Analysis

	QSI500	QSI245	QSI245	QSI245	System Pressure
Minimum	20.7	2.3	78.3	78.8	63.5
Maximum	502.0	246.0	206.8	209.1	118.8
Average	318.8	98.8	127.1	123.6	102.0

* Flow is based on extrapolated amp data, utilizing manufacture's published engineering data. Flow is for representation only.

Amps

	QSI500	QSI245	QSI245	QSI245	System Pressure
Minimum Measured	4.3	11.2	46.2	46.3	63.5
Maximum Measured	153.8	75.7	66.3	66.4	118.8
Average	127.5	51.0	57.8	56.9	102.0
Standard Deviation	4.7	10.0	3.4	3.7	4.4
Full Load Amps	140.0	69.0	69.0	69.0	N/A
Average % Amp Load	91.1	73.9	83.8	82.6	N/A



- Simultaneous measurement of flow, power & pressure
- Pressure profile at major consumer points
- Air system & process knowledge
- Air quality analysis
- Solutions neutral approach
- Implementation & validation

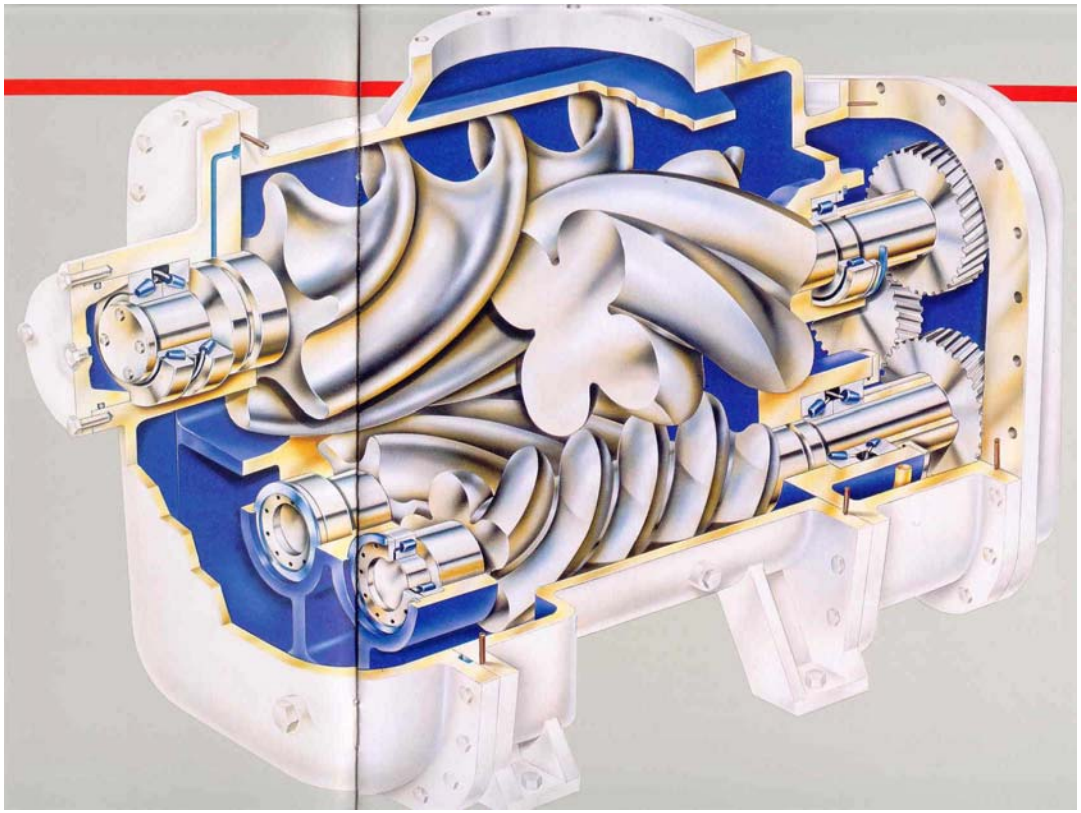
Energy saving solutions

Energy saving solutions

- Centrifugal Air compressors with Heat recovery units. (Capacity >1000 cfm)
- Two stage Rotary screw compressors. (Capacity < 1500 cfm)
- Single Stage rotary screw compressors with integrated VFD (5 to 50 hp), Refrigerated Dryer & Air receiver
- Screw Compressors with Hybrid Permanent Magnet motors (50hp to 350 hp)
- Skid packaged Reciprocating Air compressors for Oil free Air (50 to 1000 cfm)
- Properly sized air receivers & Air Treatment Components (Variable capacity ref dryer & Heat of compression dryers)

Centac with Heat Recovery Unit

Save upto 40% of the power consumption using heat recovered thru the water (intercooler & after cooler)



- COMPRESSION RATIO

⇒ The compression is shared between the first & second stages flowing in series.

⇒This drastically reduces the load (i.e. compression ratio) on each air-end.

⇒ This increases the overall compression efficiency up to 15% of the total full load power consumption.

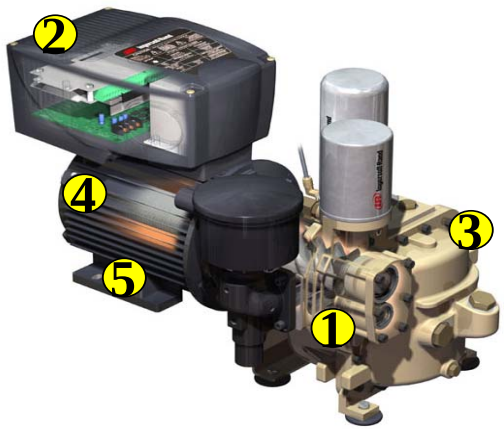
- 69 dBA Sound Enclosure
- IntelliDrive integrated motor & VSD
- Maintenance Indicator & Electronic Display
- Standard 225 psi rated tank
- Package Discharge Cooling Air
- Quick Lift-Off Service Hatch
- Easy to access consumable maintenance items

UNIGY

The IntelliDrive Power System incorporates:

UNIGY

1. Direct driven high performance rotary airend
2. Integrated motor mount variable speed drive
3. Fully Integrated Compression Module
4. High efficiency induction motor
5. Automatic Soft-starting



Customer Benefits:

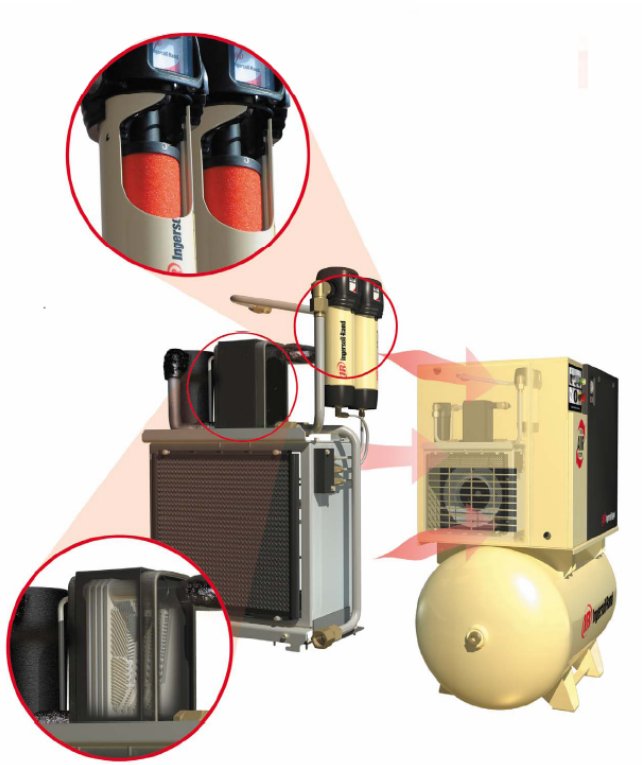
- Reduced Maintenance Costs
- Simplicity By Design
- Elimination of Complex VSD Field Wiring
- Inherent Reliability Through Elimination of Parts

Performance By Design: Highest output at the lowest energy levels.

Basically Every Single Component …

- Refrigerated Cycling Dryer
- Smart Integrated Controls
- Hot side / Cold Side Technology
- Advanced Cooling
- Dual Filtration
- Single Point Condensate Drain System
- The entire fully integrated, fully linked system

UNIGY - TAS



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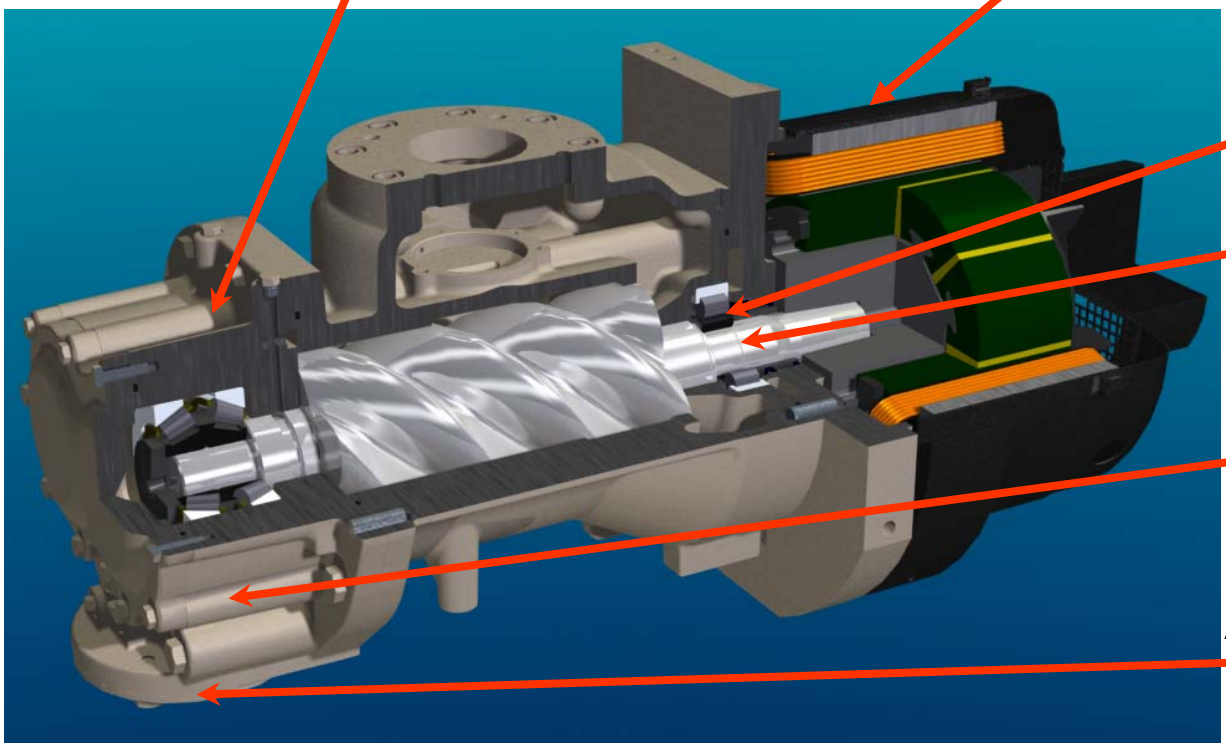
NIRVANA

Hybrid Permanent Magnet motors for Rotary Screw Compressors

Duplex Tapered Roller Bearing

Direct drive – Motor stator mounted on primary rotor shaft



Cylindrical Roller Bearing

Triple Lip Shaft Seal Aspirated, Scavenged

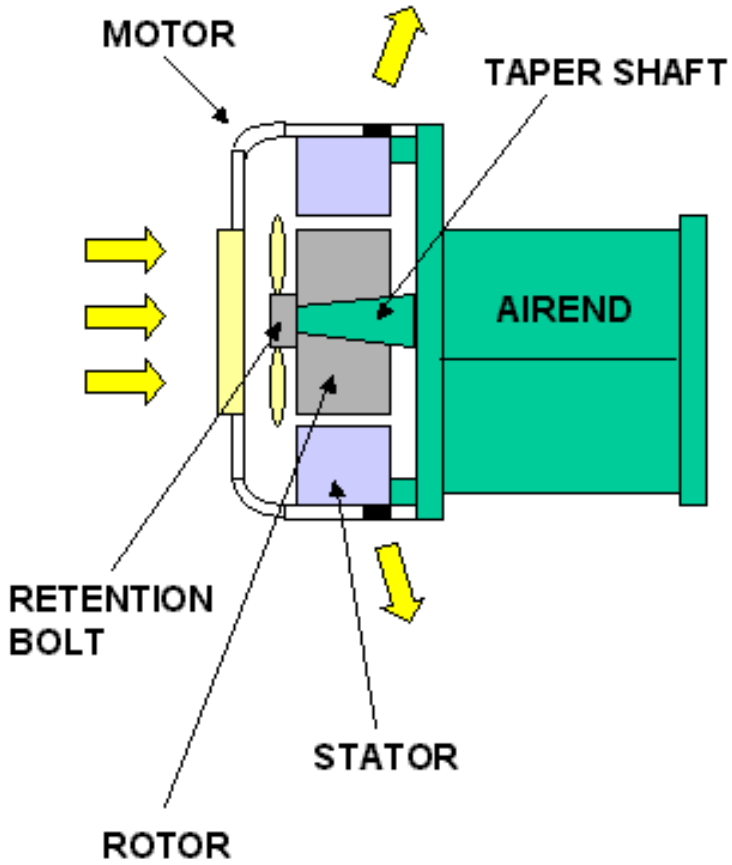
Bearing Coolant Dam

Airend Discharge Connects directly to Separator Tank

95% efficiency, .96 power factor at all load points

Nirvana HPM Drive

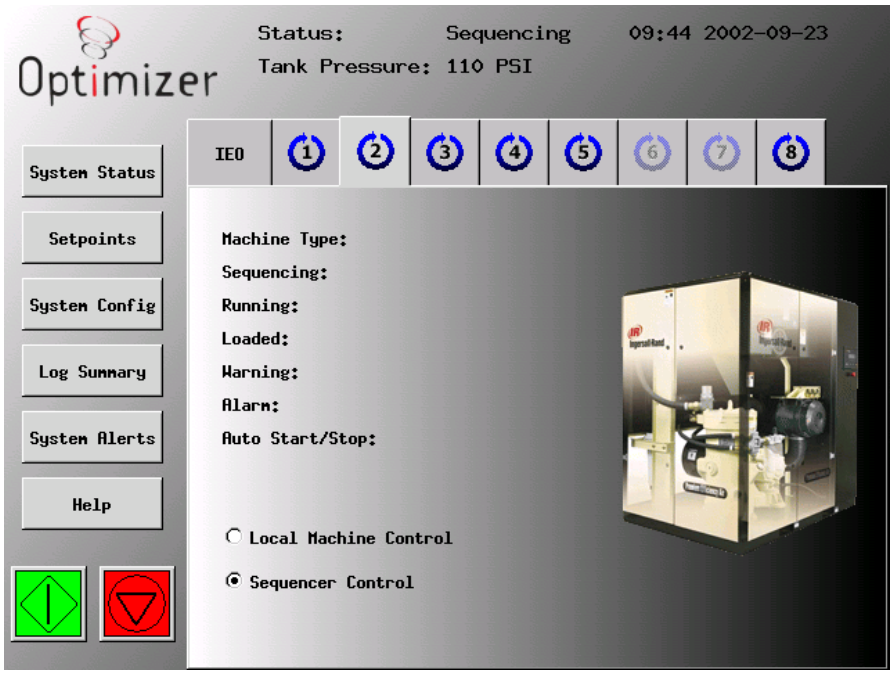
- no gears
- no bearings
- no shaft seal
- no seal housing
- no gear case
- no alignment



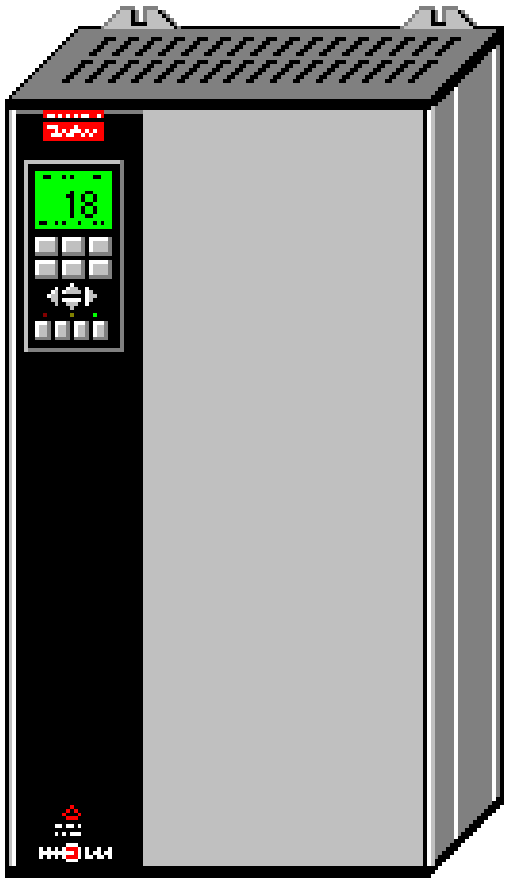
- Multiple compressor & accessories controls.
  - Positive displacement & centrifugal compressors
- Variable frequency drive for Trim rotary screw compressor.
- Remote monitoring

- Standard configuration includes:
  - Up to 8 Rotary & Reciprocating compressors
  - Manage PID model Demand side controller
  - Monitor dewpoint
  - Ability to communicate out to customer
  - Display OEM contact information
  - Eliminate conventional cascade pressure control

Intelligent Energy Optimiser



- 8 programmable sequences
- 9 programmable events for compressors
- 9 programmable events for Intelliflow
- Ability to rotate basis running hours or real time clock
- 2 common alarm contacts (dryer, pump, etc..)
- Modbus communications port
- Ethernet port



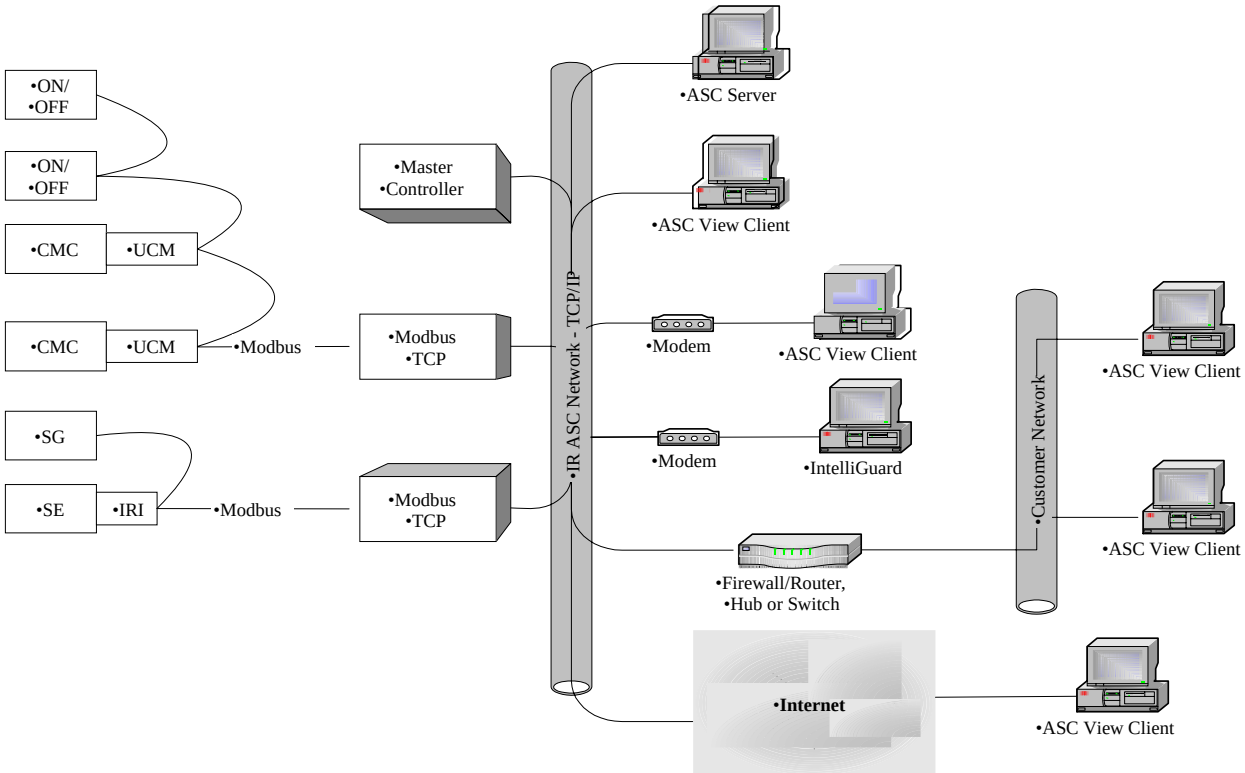
- Variable Frequency Drives (VFD)
- Adjustable Frequency Drives (AFD)
- Adjustable Speed Drives (ASD)
- Variable Speed Drives (VSD)
- Frequency Inverter (FI)

VFD retrofit = Good performance + Savings

Air System Controller

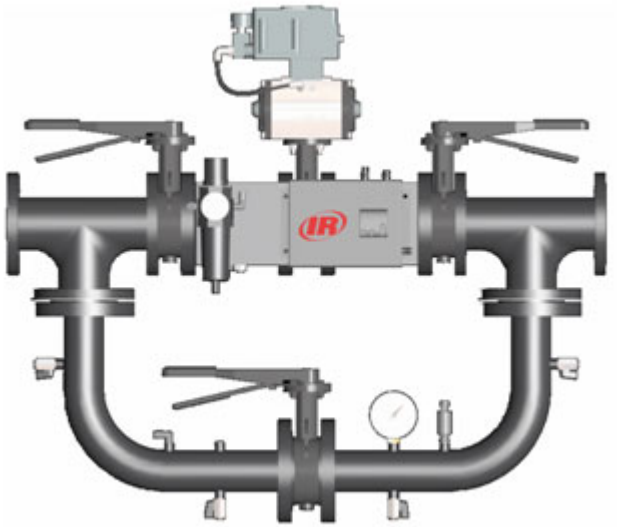
Integration of all equipments in the compressed air system

Air compressor - all types & makes Dryers, cooling towers, flowmeter, dewpoint meter, water pump , Demand side control valves and etc



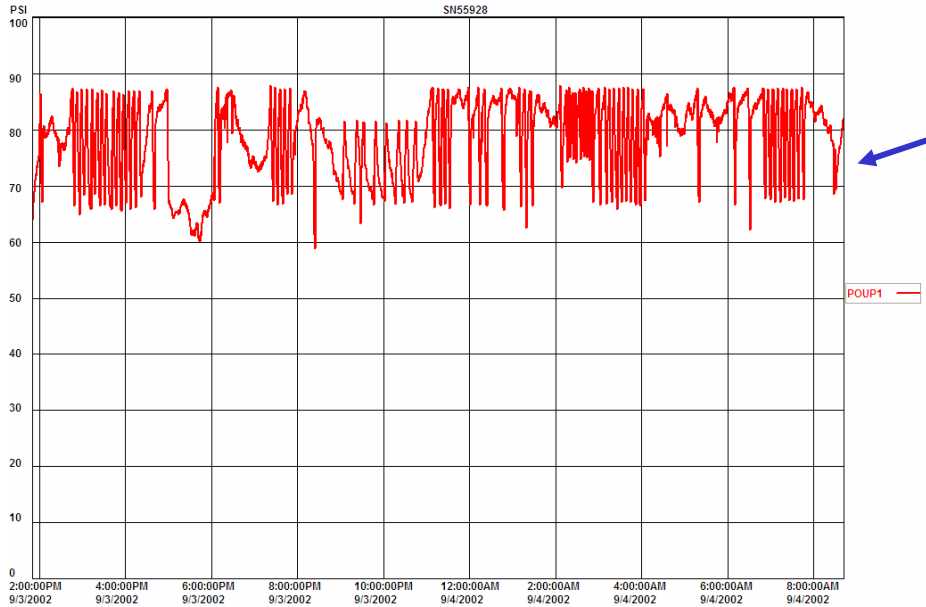
Air demand controllers

IntelliFlow



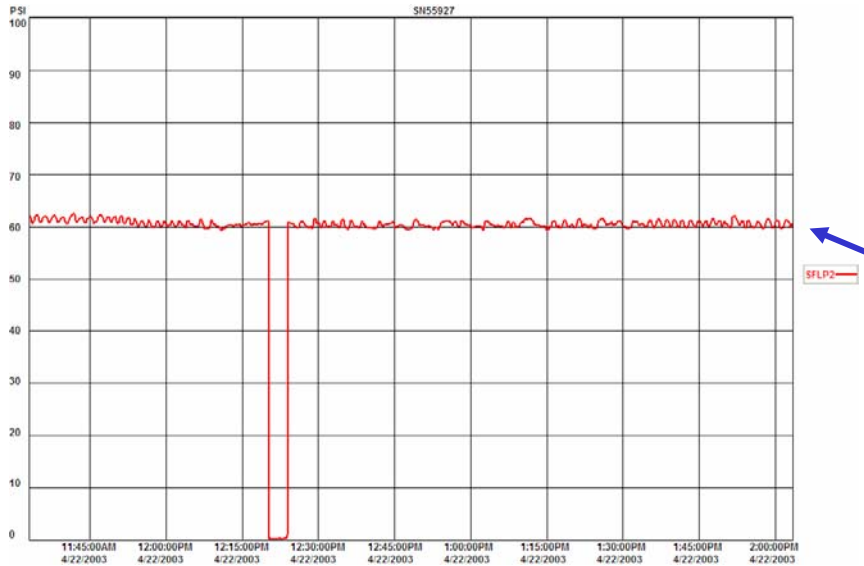
- ✓Precisely Controls System Pressure +/- .75 psig
- ✓ Dramatically improves effectiveness of air storage to handle system events
- ✓ Enables precise reduction of system pressure
- ✓ Reduces Air Leaks and Artificial Demand

Pressure profile with demand controller



Pressure variation from 60 to 88 psig before before installing the controller

Required pressure was 60 psig



Pressure stabilized at 60 psig with varying demand including a system shut down

.

- Analysis of existing system
- Design of customized system
- All types & makes of compressors & system component
- Operation & Maintenance
- Reduced power costs & parts consumption.
- Point of use engineering for better productivity

Increase

- **Productivity**
- **Reliability**
- **& Efficiency**

Decrease

- **Operating Costs**
- **Maintenance Costs**
- **Total Cost Of Ownership**

Concluding Remarks

As Picked by our Audit & Customer Facing Teams World Wide

Two-thirds of all the fuel used to make electricity in US is generally wasted by venting unused thermal energy into the air or discharging into water streams

90% of companies use air in their operations , two thirds have problems with systems providing this air

Given a choice customers would like to stay focussed on their Core Businesses and Competencies

Customers increasingly willing to outsource maintenance

The main expectations of customers with respect to their Compressed Air Systems fall neatly under following categories :

- Productivity
- Reliability
- Environment, Health & Safety
- Energy

Industry Revelations

Energy accounts for 25-30% of operating costs in manufacturing facilities - the single largest non-human expense.

Cost saving opportunities of 30-55% exist in most air systems , though 68% of audited customers initially believe that cost saving opportunities are small to non existent

Majority of audited air systems are oversized by up to 30 %

Customers generally want implementation payback periods of 2 years or less

Technology shifting to complex equipment & solutions … e.g. electronics , controls , oil-free

Growing markets for identification,security , asset tracking technology

System Focus v/s Individual compressors

Productivity Improvement driving reduction in traditional uses of compressed air

Compressed Air Requirements differ

Process

- *Air Separation*
- *Petrochemical*
- *Iron & Steel*
- *Wastewater treatment*
- *PET Blow Molding*

- Continuous use
- 24 / 7 / 365
- 98 – 99% Service Level

Industrial

- *Auto Assembly*
- *Pharmaceutical*
- *Food & Beverage*
- *Electronics*
- *Utilities*
- *Manufacturing*

- 5-7 days per week
- Multiple shifts
- 85 – 95% Service Level

Commercial

- *Auto Service*
- *Hotels*
- *Hospitals*
- *Laundry*
- *Auto Painting*

- Less than 7 days per week
- < one shift
- > 80% Service Level

How do we optimize the performance of compressed air system?

❖Systems approach (supply and demand)

- Improving system performance
  - Assessing the entire system
  - Identifying opportunities
  - Quantifying benefits and costs
  - Implementing most feasible projects

- Implementation requires participation
  - Production
  - Maintenance
  - Management

IAC* implementation trends and analysis

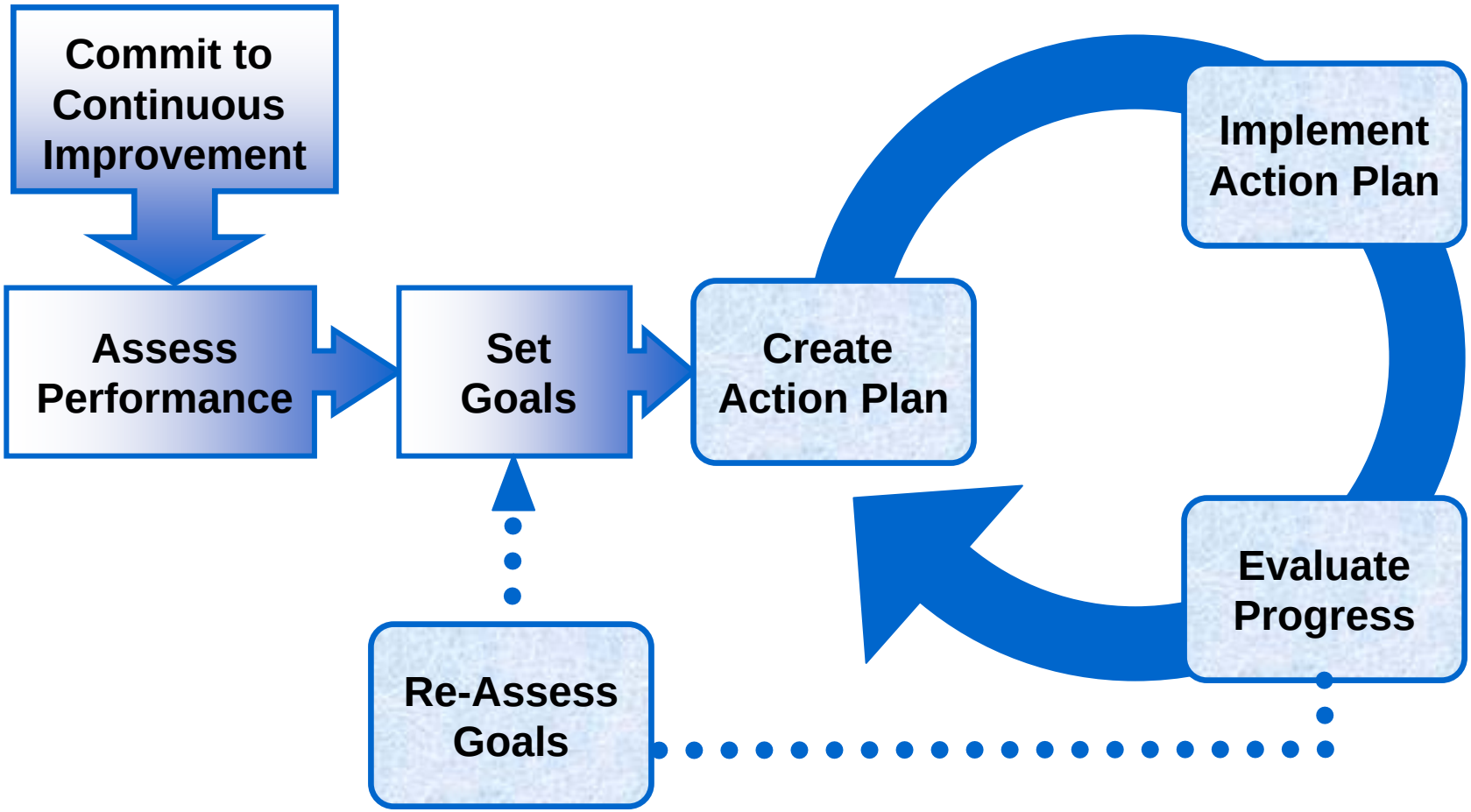
Description	*Times Recommended*	*Implementation Rate*	*Average Simple Payback (yrs)*
Eliminate leaks in compressed air lines/valves	4,529	74%	0.3
Reduce the pressure of compressed air to the minimum required	2,193	42%	0.3
Eliminate or reduce compressed air used for cooling, agitating liquids, moving product, or drying	568	44%	0.7
Eliminate permanently the use of compressed air	127	41%	1.2
Remove or close off unneeded compressed air lines	53	42%	1.2
Cool compressor air intake with heat exchanger	22	36%	1.5
Substitute compressed air cooling with water or air cooling	20	35%	0.9
Do not use compressed air for personal cooling	18	50%	0.7

*The Industrial Assessment Center (IAC) is a federally sponsored industrial energy efficiency program operating within the Center for Energy Efficiency and Renewable Energy (CEERE) at the University of Massachusetts.

Source : DOE , USA

Benchmarking revisited

Benchmarking should be part of a larger plan



Need All Round Mindset Change

Compressed Air System Suppliers

•Transition from selling products to providing solutions
•Develop competencies
•Invest in innovation
•Share best practices

User Community

•Avoid commoditisation of offers
•Evaluate paybacks and not first costs

Government And Other Institutions

•Incentivise energy and environ efforts of users and supplier

Remember :

Air is Free

but ……..

Compressed Air is Not !

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Thank you!

If you require any assistance in your Air System Audit & Analysis, please email us at

airsolutionsindia@irco.com