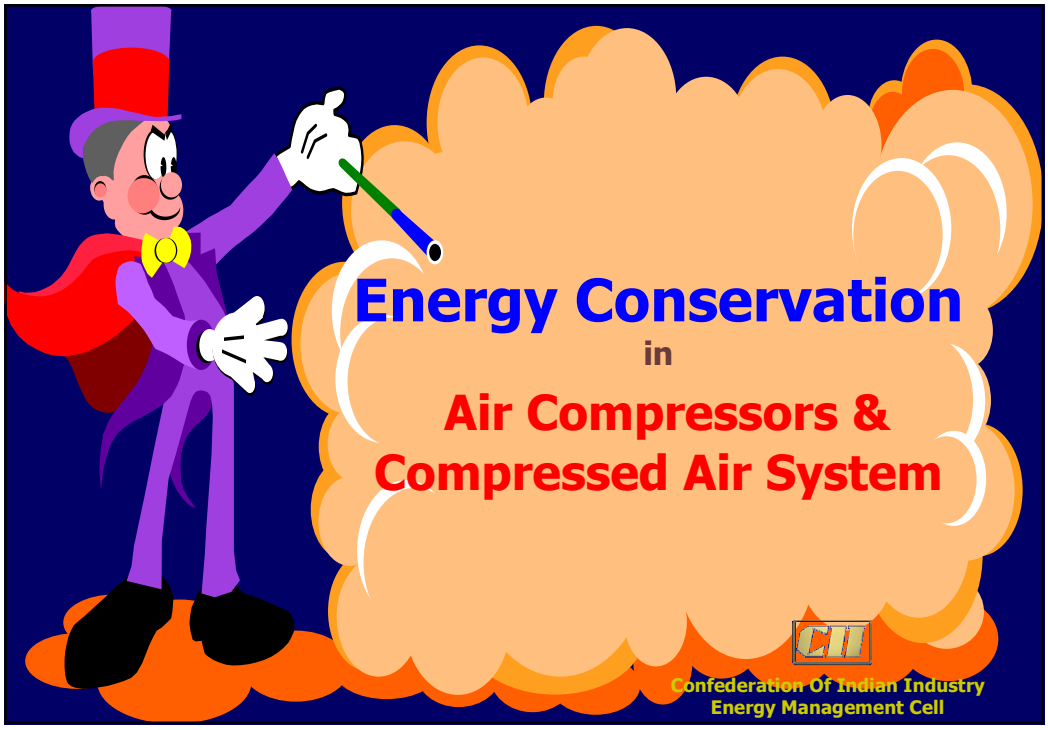
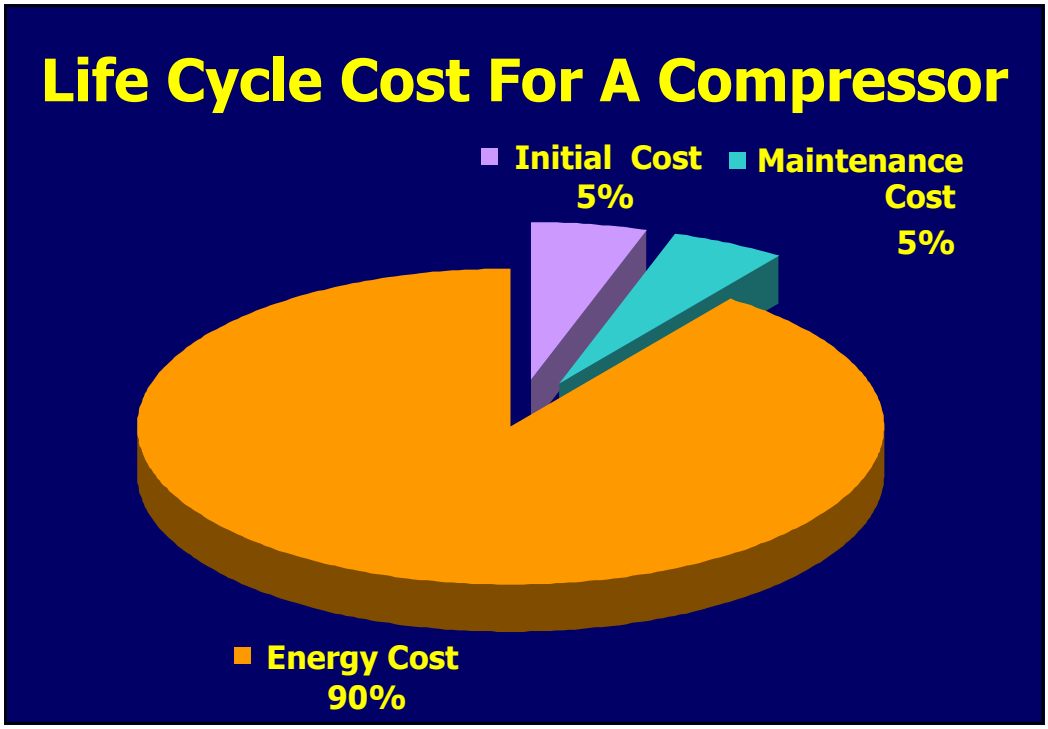
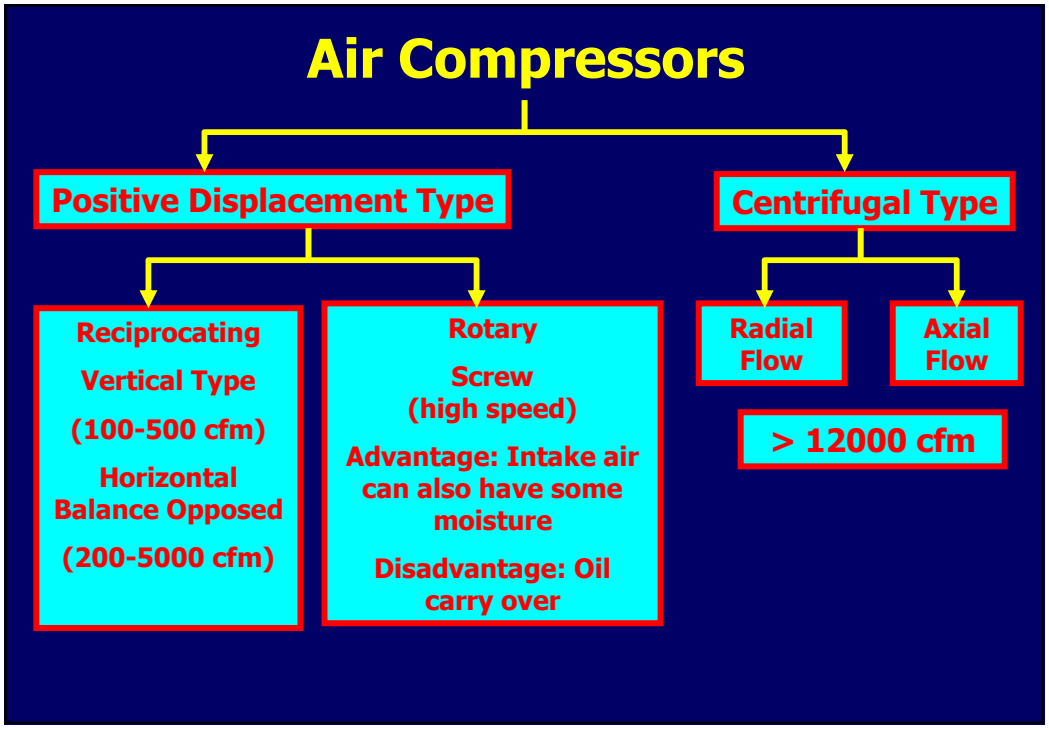
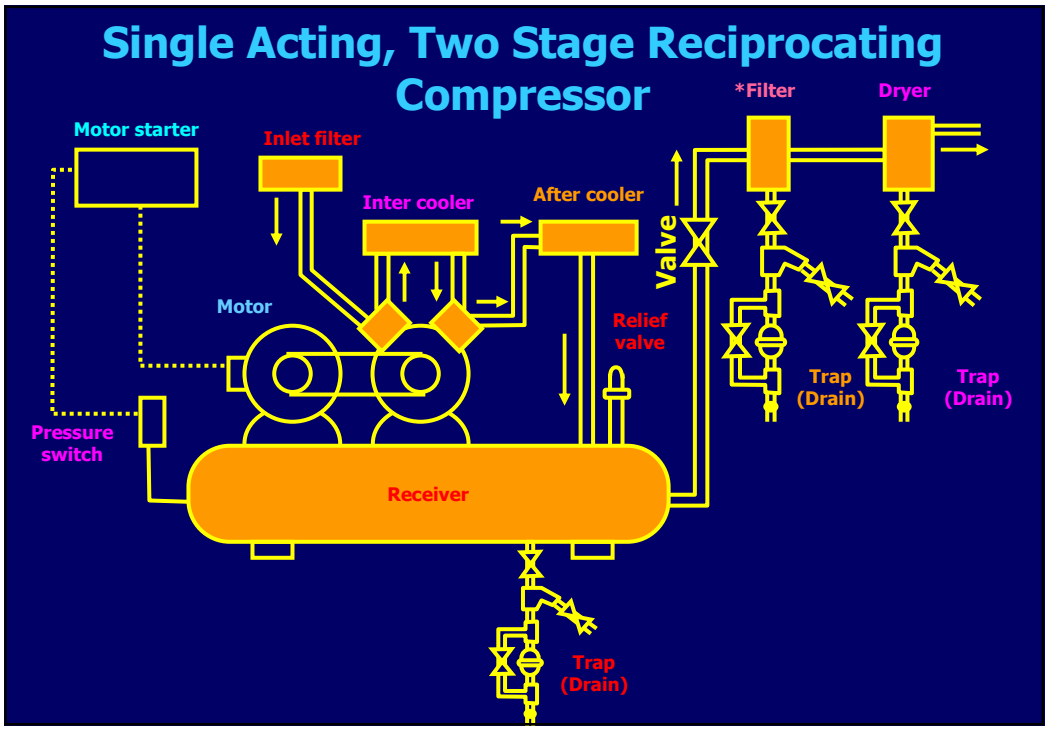

Energy Conservation
in
Air Compressors &
Compressed Air System
Confederation Of Indian Industry
Energy Management Cell


Life Cycle Cost For A Compressor
Initial Cost
5%
Maintenance
Cost
5%
Energy Cost
90%


Air Compressors
Positive Displacement Type
Centrifugal Type
Reciprocating
Vertical Type
(100-500 cfm)
Horizontal
Balance Opposed
(200-5000 cfm)
Rotary
Screw
(high speed)
Advantage: Intake air can also have some moisture
Disadvantage: Oil carry over
Radial Flow
Axial Flow
> 12000 cfm


Single Acting, Two Stage Reciprocating Compressor
Motor starter
Inlet filter
Inter cooler
After cooler
Valve
*Filter
Dryer
Motor
Relief valve
Trap (Drain)
Trap (Drain)
Pressure switch
Receiver
Trap (Drain)

Why Inter-cooler?

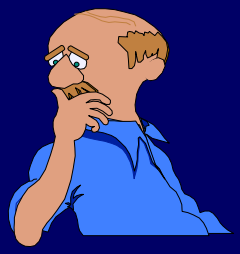
- Compressed air leaves cylinder at high temperature
  - Density is lower
  - Volumetric η decreases
- Inter cooling reduces temperature & volume
- Mass of air delivered increases
- Inter-cooler generally saves 7 %

Why After-Cooler?
How much is the energy savings?

A) Savings same as inter cooler - 7 %

b) Higher than inter cooler

c) Lesser than inter cooler



Why After-Cooler? How much is the energy savings?

- At higher temperature moisture carry over very high
- Condensed water moves with same velocity of air
  - Damage to instrument valves
  - Makes instruments sluggish
- After-cooler saves energy – higher when air dryers are installed

Methodology for Energy Audit

- Is the correct type and size of compressor being used?
- Is the system efficient?
- What is the required operating pressure?
- What is pressure drop between user and compressor?
- Is correct type of dryer used?

Methodology for Energy Audit

- Is compressor cooling water monitored?
- Are auto drain valves provided?
- Can compressed air be substituted?
- Are valves provided at the user points?

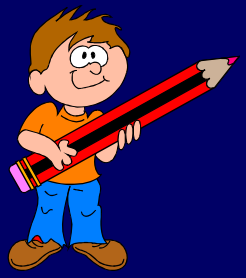
Optimal Utilisation of Compressors

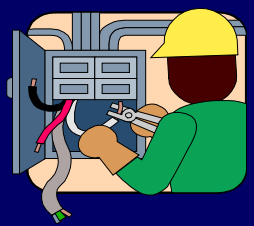
Background

37 kW compressor in operation

At present loading - 30%

Unloading - 70%





Power consumption

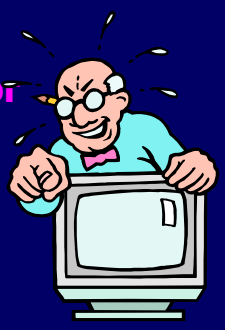
Unload - 9 kW

Loading - 27 kW

Install 15 kW ON/OFF Air Compressor and Use Existing 37 kW Air Compressor as Standby

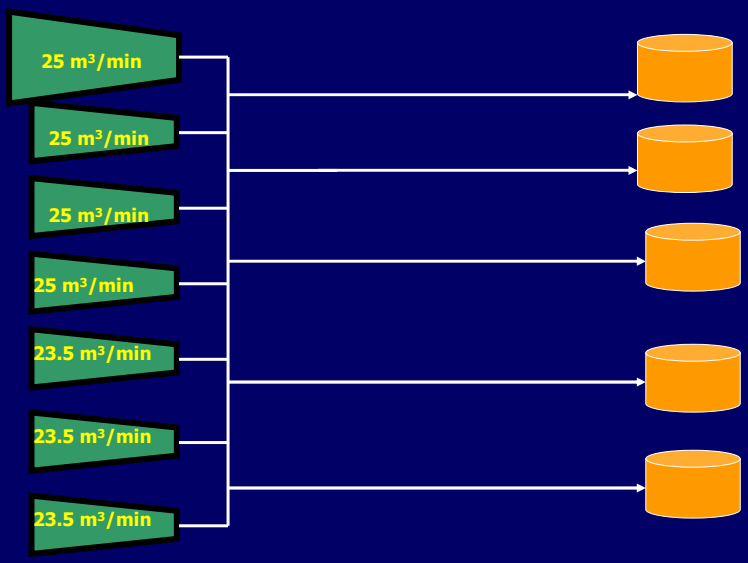
Action

- Install 15 KW package air compressor
- Saves no-load power
- Use existing compressor as stand-by



Savings - Rs.59,000
Investment - Rs.50,000
Payback - 11 months

Optimise the Operating of Pyro Compressors



Optimise the Operation of Pyro Compressors

- Three compressors in operation for catering compressed air requirement
- Two Compressors are loaded for about 100% of the running time
  - One compressor Unloaded for 40%
- Unload power consumption of each compressor is 46 – 50 kW
- No useful work by compressor during unload

Optimise the Operation of Pyro Compressors

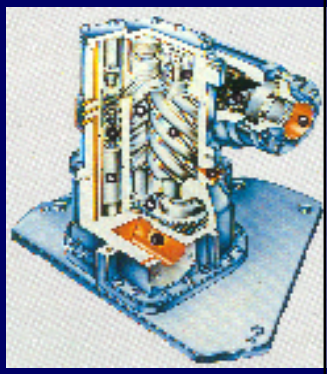
- Good potential to avoid unload power consumption
- As a first step, recommended to switch off two 25 m^3/hr compressor and operate one 25 m^3/hr and two 23.5 m^3/hr
  - One 25 m^3/hr and one 23.5 m^3/hr can be operated in full loading and the other 23.5 m^3/hr can be operated in loading unloading mode

Optimise the Operation of Pyro Compressors

Annual Saving	-	Rs 3.04 Lakhs
Investment	-	NIL

Optimal Utilisation of Compressors

- Air requirement - 100 cfm normal running
- In case of yarn breakage, sudden demand of 600 cfm
  - Compressor : Screw type
  - Capacity : 600 cfm
  - Avg. loading : 17% (during normal running)



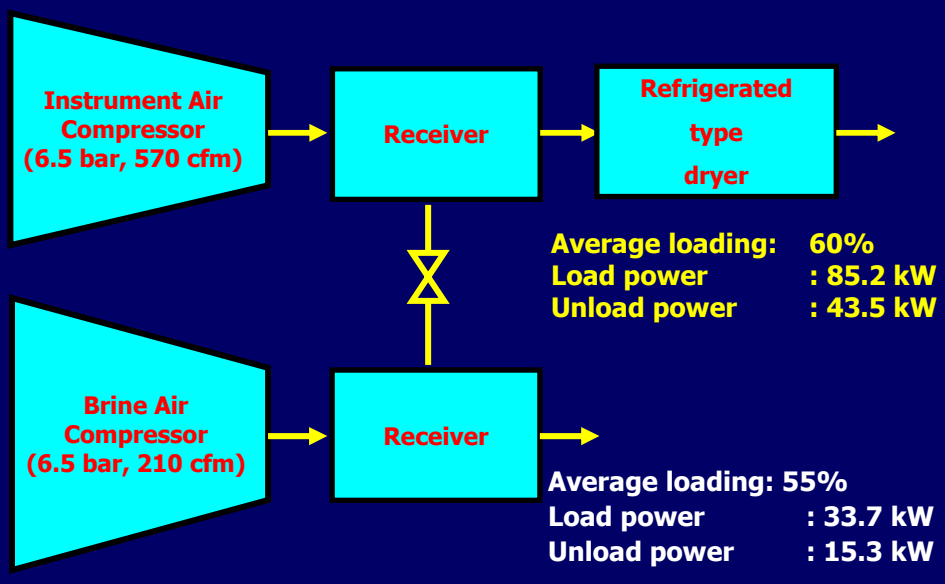
Optimal Utilisation of Compressors

Action

- Installed new air compressor of 125 cfm capacity for normal operation
- When pressure falls in receiver, screw compressor to start automatically

Annual Savings	**: Rs. 5.99 lakhs**
Investment	**: Rs. 1.50 lakhs**
Payback period	**: 3 months**

Manage Available Facility Optimally



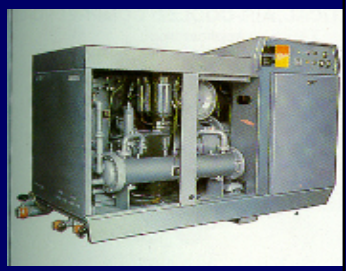
Manage Available Facility Optimally

- Interconnect the two receivers
- Stop Brine compressor

Annual Savings	: Rs.4.28 lakhs
Investment	: Rs.0.02
Payback period	: < 1 month

Utilise the Correct Type of Compressor

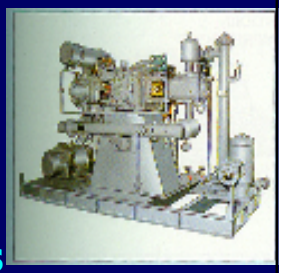
- Battery of screw & reciprocating compressors – 200 kW capacity
  - 2 Screw Compressors
    - One 100% Load
    - Second 40% Load
  - Reciprocating compressor stand by



- Screw compressor operation
  - Load power = 180 kW (40%)
  - Unload power = 60 kW (60 %)

Utilise the Correct Type of Compressor

- Reciprocating Compressor Operation
  - Load power = 165 kW (40%)
  - Unload power = 25 kW (60%)



- Operate Reciprocating Compressor on continuous basis
  - Keep Screw as stand by

Annual Savings = Rs. 4.90 Lakhs

Capacity Test (Pumping Method)

$$\text{Average Compressor Delivery} = \frac{P_2 - P_1}{P} \cdot V_R \cdot \frac{1}{\Delta t}$$

- P_1 = Initial pressure in receiver
- P_2 = Final pressure in receiver
- P = Atmospheric pressure
- V_R = Volume of air receiver
- Δt = Time taken for charging the receiver from P_1 to P_2

Operation of compressors

- 5 compressors available
  - ➲ 660 CFM, 7.5 bar, 110 kW
- 3 compressors are required to be operated

Operation of Compressors

No			
CP1			
CP2			
CP3			
CP4			
CP5			

Operation of Compressors

No	kW		
CP1	110		
CP2	90		
CP3	100		
CP4	105		
CP5	95		

Operation of Compressors

No	kW	FAD	
CP1	110	660	
CP2	90	500	
CP3	100	600	
CP4	105	645	
CP5	95	625	

Operation of Compressors

No	kW	FAD	kW / CFM
CP1	110	660	0.17
CP2	90	500	0.18
CP3	100	600	0.17
CP4	105	645	0.16
CP5	95	470	0.20

Comparison of Specific Power Consumption

	Reciprocating	Centrifugal	Screw
FAD	112 m^3/min (3950 cfm)		
KW	549	521	650
Specific Power ($kW/m^3/min$)	4.9	4.65	5.8

Replacement of Inefficient Compressors

- Compressor – Pneumatic Conveying
- Design Specifications
  - Capacity (FAD) = 20 m3/min
  - Pressure = 7.0 kg/cm2
  - Motor = 120 kW
- 10 year Old Compressor
  - Re-boring carried out
  - Overhauling done

Replacement of Inefficient Compressors

- Capacity Test Conducted
  - Actual volume (FAD) = 14.6 m3/min
  - Volumetric Efficiency = 73%
  - Operating Pressure = 7.0 ksc
  - Specific Power = 6.56 kW per m3/min
- Specific Power Norm - 4.9 kW/m^3/min for 7.0 ksc

Replacement of Inefficient Compressors

- Energy Saving potential : 25%
- Replaced with New Reciprocating Compressor

Annual savings	= Rs. 4.03 Lakhs
Investment	= Rs.8.00 Lakhs
Payback period	= 24 months

Segregate High-Pressure & Low-Pressure Compressed Air Users

- Reciprocating Compressors
  - 2700 m3/h x 5 nos.
- Compressed Air Generation
  - 7000 m3/h @ 7.4 ksc at generation
  - Pressure at Receiver – 6.0 ksc
- Major users – Interlacers & Instrumentation
- Requirement
  - 4400 m3/h @ 4.5 ksc for interlacer
  - 2600 m3/h @ 6.5 ksc for instrumentation

Segregate High-Pressure & Low-Pressure Compressed Air Users

- At interlacers – PRV's installed
  - After PRV pressure 2.2 ksc
- Higher volume required at lower pressure
  - Total volume at higher pressure
- Energy Inefficient Method - loss due to PRV's
- Power Consumption α Operating Pressure
- Excellent Potential to Segregate Generation

Segregate High-Pressure & Low-Pressure Compressed Air Users

- Dedicate 2 compressors for interlacer reqmt.
  - Operate at 4.5 ksc
  - About 34% pressure reduction
- Dedicate 1 compressor for instrumentation
  - Operate at the same existing pressure
- Separate lines laid with PLC control system

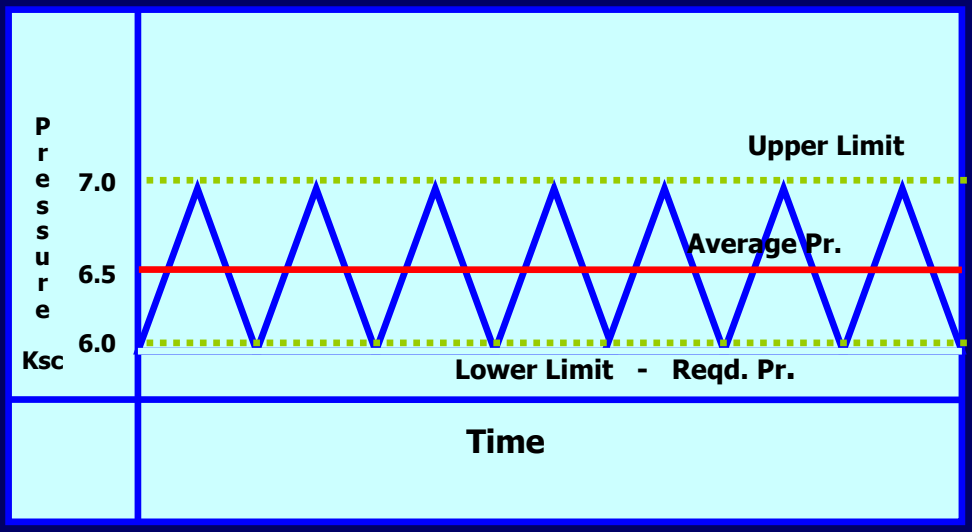
Annual Savings	: Rs.31.86 lakhs
Investment	: Rs.8.25 lakhs
Payback period	: 4 months

VFD - A New Concept

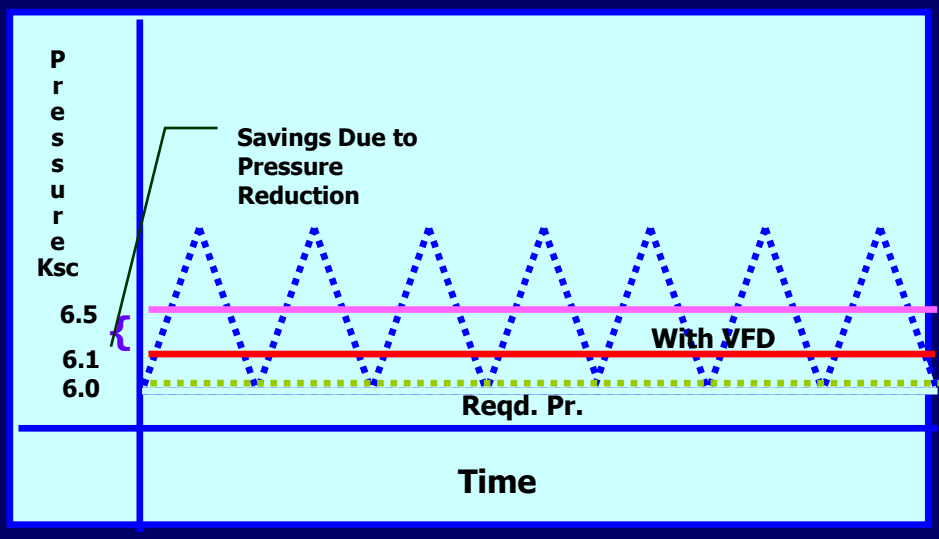
Advantages

- ❖ Operates at Lower Avg. Pressure
  - ➢ Proportional Savings
- ❖ No Unloading
- ❖ Less Leakages
  - ➢ Lower Pressure
- ❖ Better Motor Efficiency

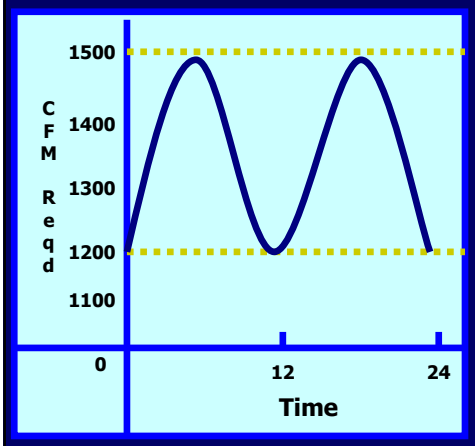
Concept - Conventional Control



Concept - VFD Control

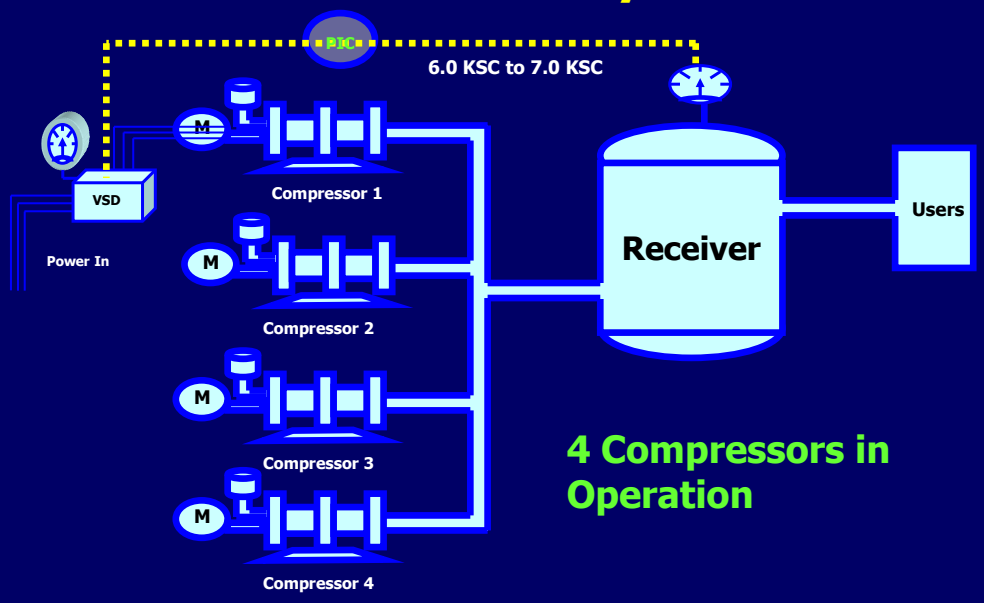


Savings in Unload Power



- Compressors Designed to meet Fluctuating Load
- Fluctuating Load Leads to Load / Unload
- Lean Time - Unload
- Unload power 15 - 40%
- No useful work
- VSD Avoids Unloading of Compressors

Case Study



4 Compressors in Operation

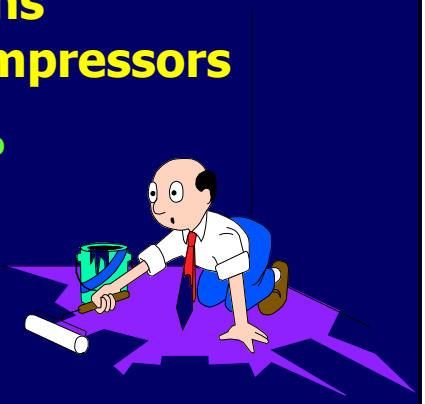
Install VFD for One Compressor

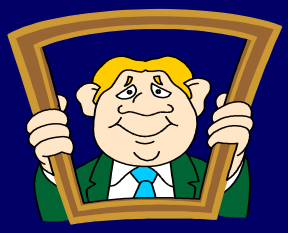
- VFD For One Compressor
- Constant Pressure of 6.0 ksc
- 4% Savings in all compressors

Annual Savings	= Rs.12.00 Lakhs
Investment	= Rs. 12.00 Lakhs
Payback period	= 12 Months

Precautions Reciprocating Compressors

- Lubrication Oil Pump Connected to the same shaft
- Lubrication Pump Output Depends on the Speed
- More than 30% Speed Reduction Leads to Mechanical Problems

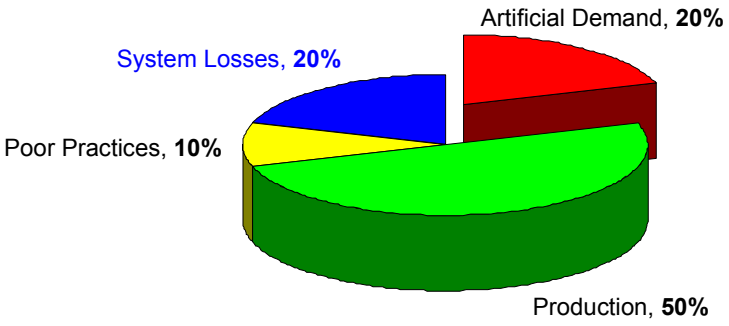




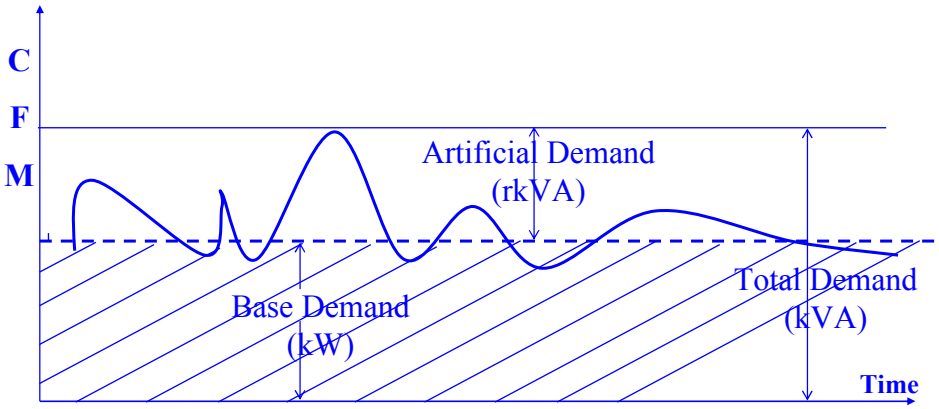
Alternative

- Install Separate Lubrication Pump
- Complicated
- Details to be Studied

Compressed Air Utilisation in a Conventional System

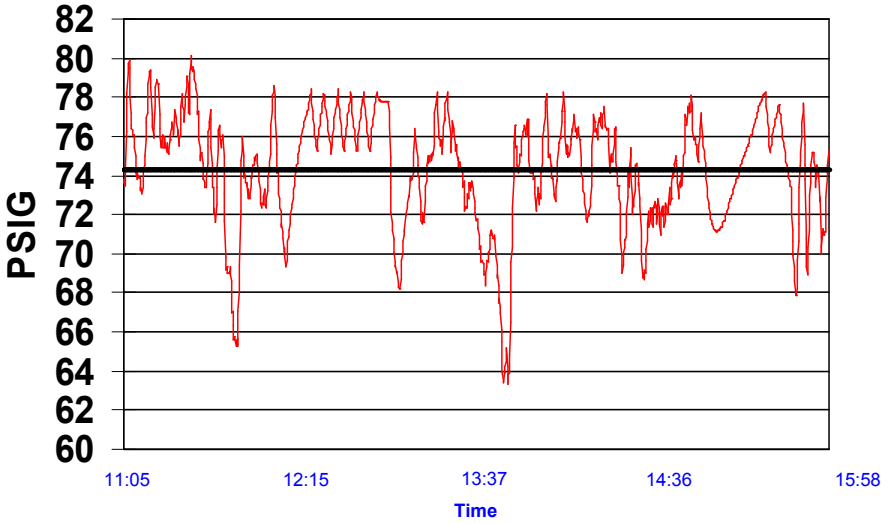


Compressed Air System



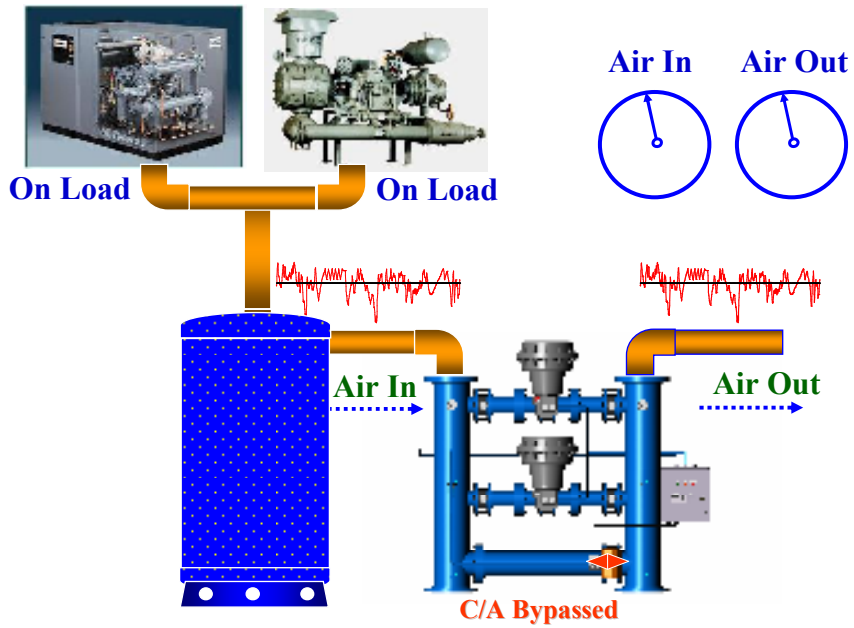
Reduce Artificial Demand to reduce Total Demand

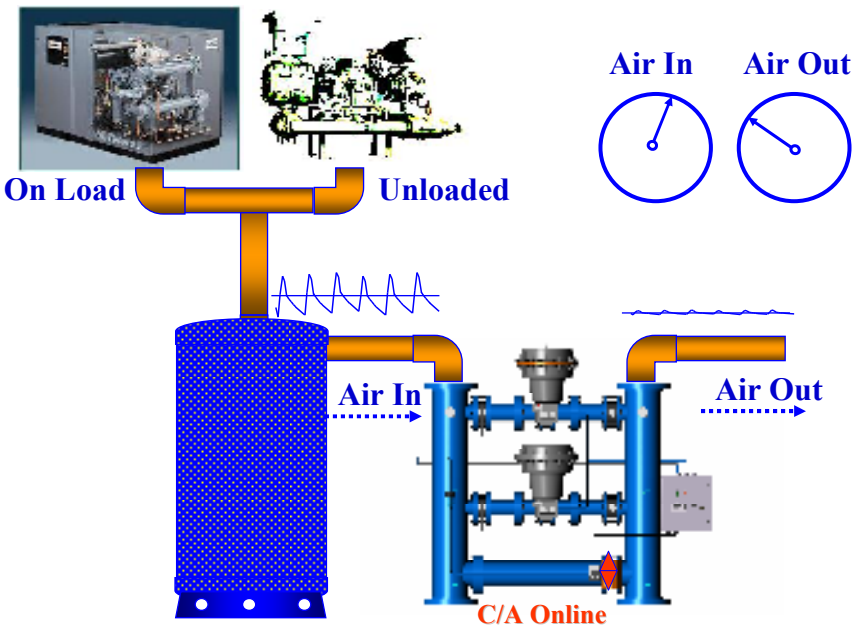
Compressed Air Pressure Real Time Data



The problem with fluctuating Air Pressure

- Higher Energy Consumption
- Increased maintenance costs
- Higher operating costs
- Interruptions in production schedules





Case Study: Manufacturing Industry

Before Control System

- Energy Consumed = 11,760 kWh/day
- Main Header Pressure Variances = +/- 13 psig

After Control System

- Energy Consumed = 10,329 kWh/day
- Main Header Pressure Variances = +/- 1.5 psig

Total Project Cost	**= 20 Lakhs**
Energy Cost Savings	**= Rs. 29 Lakhs per annum.**
Energy Savings	**= 2392 kWh/day (~ 19 %)**
Simple Payback period	**= Less than 9 months**

Minimise Leakages

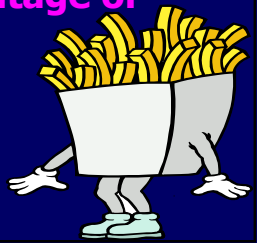
- Common in all industries
- Tricky
- Quantification

God has given abundant air, which is free!!

But … compressed air is not free!!

Quantification

- Allow compressor to run normally
- Allow compressed air to flow in the system
- Close all the user points
- Measure the loading and unloading time
- Percentage of loading time is percentage of leakages



Leakage Test

- Close all user points
- Charge the lines
- Note: On-load time of compressor (T)
  Off-load time of compressor (t)
- Q : Capacity of compressor

$$\text{Air leakage : } L = \left(\frac{T}{T + t}\right) . Q$$

$$\text{\% air leakage} = \frac{\text{Air leakage}}{\text{Compressor capacity}} \times 100$$

Cost Of Leakage At 7kg/cm^2

Orifice dia (mm)	Air Leakage (cfm)	Power Wasted (kW)	Annual Savings @ Rs.3.50/kWh.
1.6	6.5	1.26	Rs.35,000
3.2	26.0	5.04	Rs.1,40,000
6.4	104.0	20.19	Rs.4,25,000

List Of Energy Saving Ideas In Compressed Air System

- Select correct size air compressor
- Operate compressor at required pressure
- Install VFD
- Minimise system losses - Proper line sizing
- Replace compressed air with blower air for agitation
- Replace pneumatic tools with electric tools

List Of Energy Saving Ideas In Compressed Air System

- Provide ball valves at the user point to avoid compressed air wastage
- Use transvector nozzles in air hoses
- Cool inlet air to the compressor
- Provide sensors to sense unloading and switch off
- Replace inefficient compressors
- Install high efficiency dryers


Thank You
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Confederation Of Indian Industry
Energy Management Cell
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