Air Compressors

Two Types

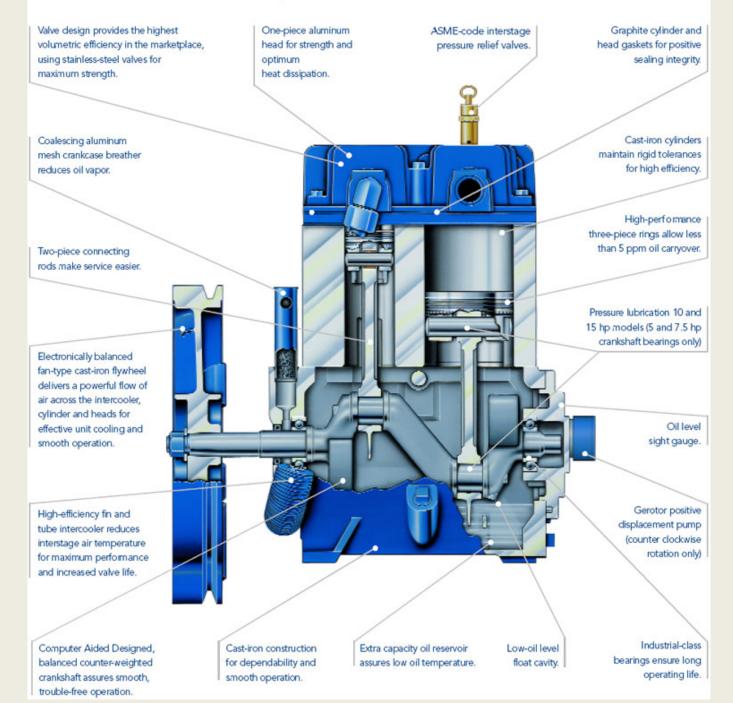
- Positive Displacement
 - Reciprocating
 - Rotary Screw
- Dynamic
 - Centrifugal
 - Axial flow







QUINCY PLT - TWO-CYLINDER, TWO-STAGE CUTAWAY



Intake unloaders allow for loadless starting, system flexibility, energy savings, and less wear on the motor. Cast-iron valve seats are lapped for a total seal, eliminating the need for a discharge line check valve.

> Steel valve discs use a unique low lift design and cast-iron bumpers for increased efficiency and less downtime.

> > Aluminum connecting rods with oil passage for full flow lubrication to piston pins to extend compressor life.

Hydraulic unloader and Safe-Q-Lube protects compressor if oil pressure drops below normal (when loadless starting or dual control is specified).

Pressure lubrication with positive displacement oil pump to assure constant lubrication of all critical wear areas.

Spin-on oil filter for convenient, clean lubrication.

Individual valve pockets allow easy access for routine maintenance.

High-pressure pistons are cast-iron for strength and long life.

Cast-iron cylinders maintain rigid tolerances for high efficiency.

Intercooler has large circular fins for maximum heat dissipation and longer life.

Rifle-drilled, counter-weighted, one-piece crankshaft reduces vibration, extends life of bearings and wrist pins.

Tapered roller bearings are oversized and easily adjusted for trouble-free operation.

Cast-iron crankcase and flywheel for strength and durability.

Rotary Screw Compressors



Rotary Screw Compressors

- "Direct Injection", "Oil-injected", "Directcooled", "Flooded"
 - Various names are suggestive of the direct contact of lubricating/cooling oil onto the rotating screw parts
 - Requires a separator just after compression to remove oil from the compressed air
- "Oil-free", "Oil-less", "Dry" compressors also available (food industry, hospitals, etc.)





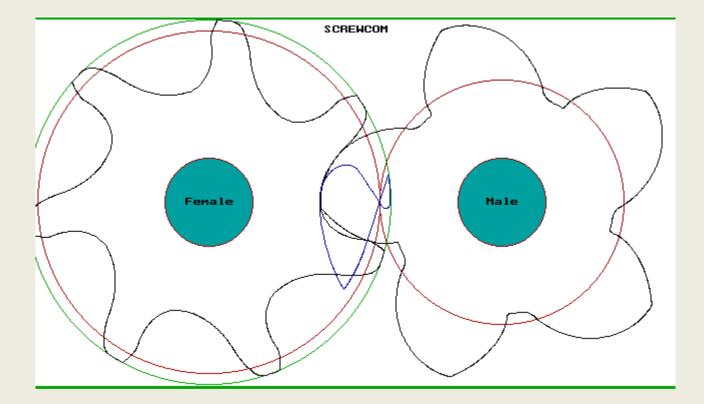






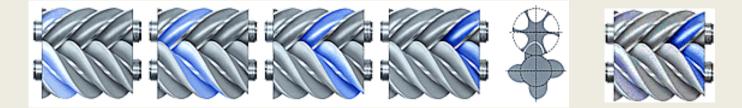






Animations

- <u>http://www.youtube.com/watch?v=g8VpnTR</u>
 <u>WESQ</u>
- <u>http://www.youtube.com/watch?v=WFZ1bhF</u>
 <u>Eh2U</u>
- <u>http://www.youtube.com/watch?v=zQd-</u> <u>BTxNQHU</u>



Due to overlapping and continuous compression cycles, the rotary screw design generates virtually no vibration. Disturbing noise is minimized, providing a wider choice for the unit's location on the vehicle.

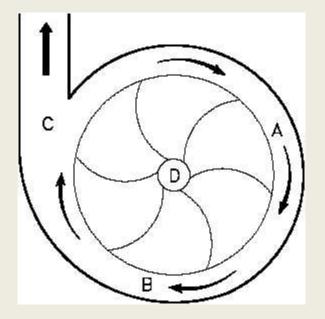
The ends of the rotors uncover the inlet: air enters the compression chamber.

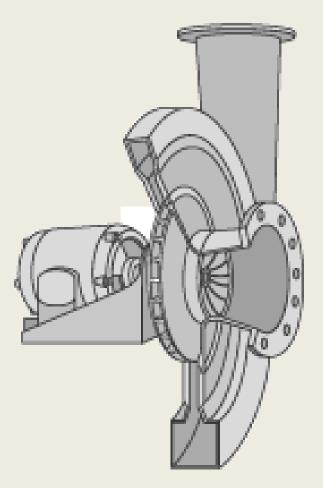
The air is 'compartment' flute.

As the rotors turn, entrapped in the the compartment becomes formed by a male progressively smaller, lobe and a female thereby compressing the entrapped air.

Compressed air leaves through the outlet port

Centrifugal Compressors





Centrifugal Compressors

 <u>https://www.youtube.com/watch?v=rtlF1LdZT</u> <u>ak</u>

Improving Compressed Air System Performance

a sourcebook for industry



U.S. Department of Energy Energy Efficiency and Renewable Energy Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable



http://www1.eere.energy.gov/industry/bestpractices/pdfs/compressed_air_sourcebook.pdf

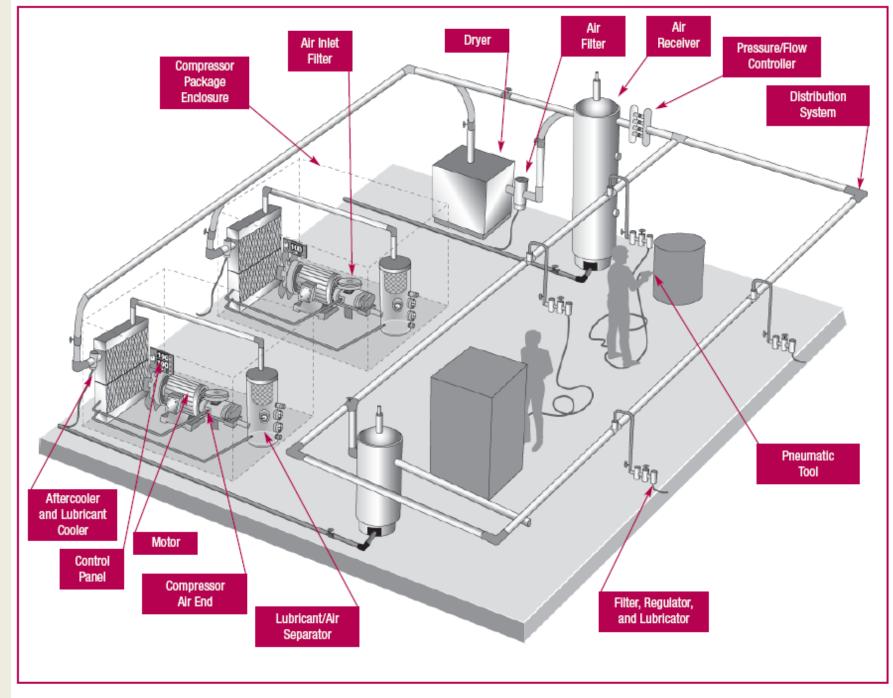


Figure 1.1 Components of a Typical Industrial Compressed Air System.

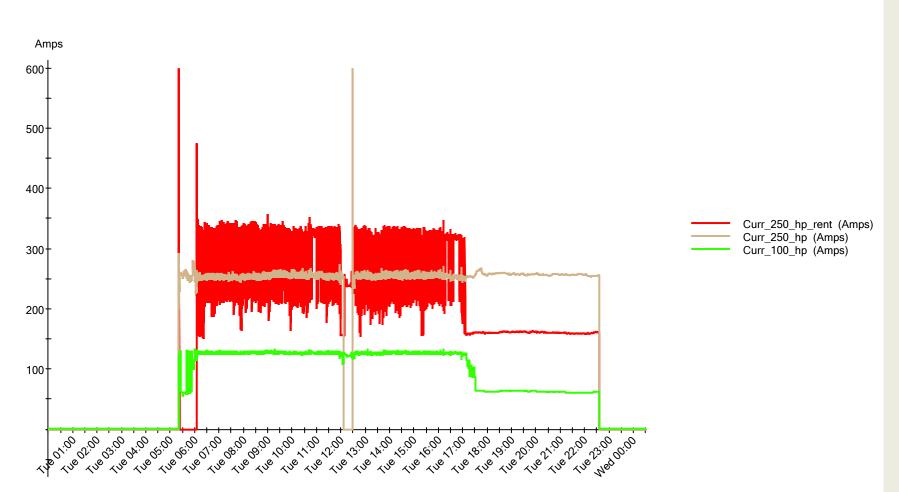
Compressor Controls

- On/Off (Start/Stop)
- Modulated
- Load/Unload
- Variable Displacement
- Variable Speed Drive (VSD)

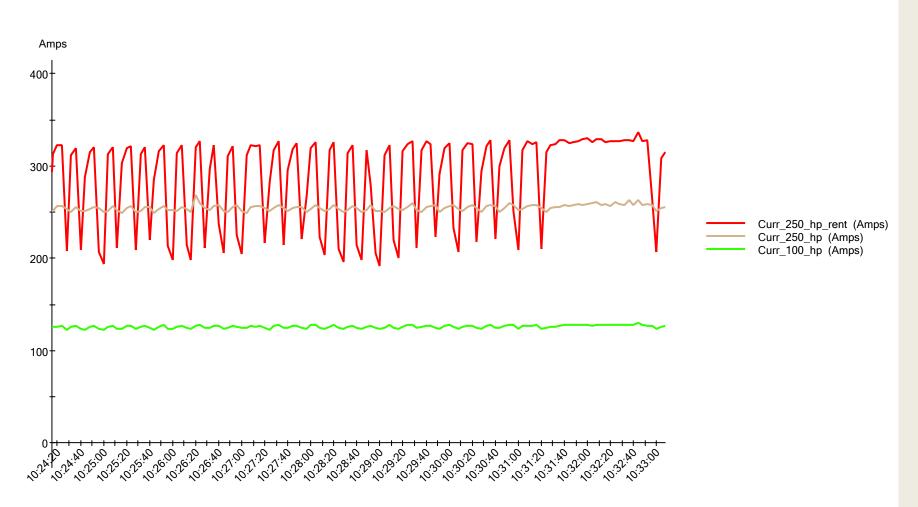
115 2200 2000 114 113 1800 Pressure 1600 112 1400 111 Flow to System (SCFM) Pressure (psig) 110 1200 109 1000 800 108 107 . 600 106 400 Air Flow from Plant Air Compressor 200 105 15:30 15:35 15:40 15:45 15:50 15:55 16:00 Copyright 2003 by Compressed Air Challenge®

Plant Air Consumption Plant Compressed Air Flow Rate and System Pressure

Figure 2.4 Pressure Profile Over a Defined Time Period.

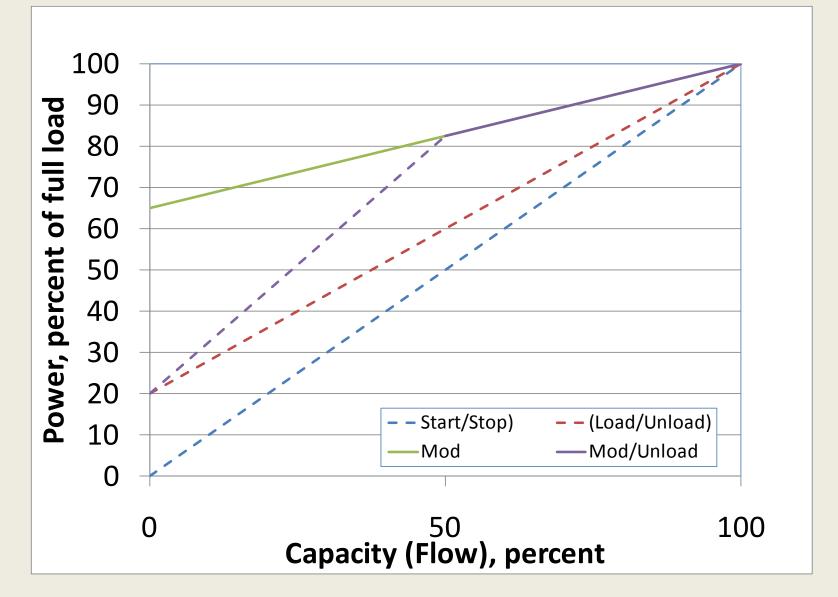


Interval data (4 seconds) for System (Not Assigned) and Periods (Not Assigned) 12/15/2008 11:54:06 PM to 12/17/2008 12:32:05 AM



Interval data (4 seconds) for System (Not Assigned) and Periods (Not Assigned) 12/16/2008 10:24:15 AM to 12/16/2008 10:33:08 AM

Typical Compressor Controls/Characteristics



Compressors - Saving Energy

- Reduce run time turn off when not needed
- Lower system pressure to lowest possible level
- Repair leaks
- Recover waste heat
- Additional system volume (load/unload only)
- Reduce use of pneumatic tools

Lower Pressure

• Rule of thumb:

For systems in the 100 psig range, every 2 psi decrease in discharge pressure results in approximately 1 percent power decrease at full output flow

Lower Pressure – Unregulated Usage

• Rule of thumb:

For systems with 30 to 50 percent unregulated usage, a 2 psi decrease in header pressure will decrease energy consumption by about 0.6 to 1.0 percent because of unregulated air

 Total is 1.6% to 2% power decrease for every 2 psi drop

Lower Pressure

Calculations

 Estimate annual energy usage (assume compressor runs fully loaded unless you know otherwise)

KWh = HP/ η_m x 0.746 x LF x H

- Compute reductions: every 2psi reduction is a 1.6% to 2.0% reduction in power, so each 2psi reduction gives 0.984 to 0.98 of the previous value $kWh_{new}=kWh_{old} \times (1 - PCT)^{\Delta P/2}$ $\approx kWh_{old} \times (1 - PCTx\Delta P/2)$

Example – Reduce Pressure

- A 150hp compressor runs 90% loaded 12 hours per day 5 days per week at a delivery pressure of 110psi. Estimate the energy and cost savings if the pressure is reduced to 90psi. Assume \$0.05/kWh for electricity and the motor is 95% efficient
- Solution:

Assume a 1.8% reduction for every 2psi to account for unregulated usage. First estimate the annual energy usage:

Example/Solution – Reduce Pressure

kWh= HP $/\eta_m x 0.746 x LF x H$ = 150hp/0.95 x 0.746kW/hp x 0.9 x 3120 hrs = 330,753 kWh/yr **Compute reductions** $kWh_{new} = 330,753 kWh x (1 - 0.018)^{20/2}$ = 275,816 kWh Energy Savings are 54,937 kWh/yr Net reduction is 16.6% At \$0.05/kWh, this amounts to \$2,747 / yr

Reduce Air Leaks

- A typical plant that has not been well maintained will likely have a leak rate equal to 20 percent of total compressed air production capacity.
- Proactive leak detection and repair can reduce leaks to less than 10 percent of compressor output



Costs calculated using electricity rate of \$0.05 per kilowatt-hour, assuming constant operation and an efficient compressor.

Reduce Air Leaks

- Calculations
 - Savings realized depend on the type of compressor controls
 - Input power decreases linearly with decrease in airflow

Control	Start/Stop	Mod	Unload
Slope (∆kW%/∆cfm%)	100/100	35/100	80/100

So for a 10% reduction in flow by repairing leaks

Control	Start/Stop	Mod	Unload
∆kW%	10%	3.5%	8%

Example - Reduce Leaks

- The compressor from the previous example uses modulating controls. The system reduces flow by 10% through a leaks program. Estimate energy and monetary savings at \$0.05 per kWh.
- Solution:

For a 10% reduction in flow, a 3.0% reduction in power results:

Example - Reduce Leaks

Savings = 275,816 kWh/yr x 0.035 = 9,654 kWh/yr At \$0.05/kWh, this comes to Cost Savings = 9,654 kWh/yr x \$0.05/kWh = \$ 83

Recover Waste Heat

- As much as 80 to 93 percent of the electrical energy used by an industrial air compressor is converted into heat.
- In many cases, a properly designed heat recovery unit can recover anywhere from 50 to 90 percent of this available thermal energy and put it to useful work heating air or water.
- Net potential is 40% to 84% recovery

Example - Recover Waste Heat

- The compressor from the previous example is air cooled. Estimate the amount of natural gas heating that could be displaced during twelve weeks of winter operation, and the cost savings at 85% combustion efficiency and \$4.00 /MMBtu fuel cost.
- Solution:

Assume 50% of the input power can be recovered:

Example - Recover Waste Heat

Savings = HP x LF x 2545Btu/hp-hr x 50% x H = 150hp x 0.90 x 2545Btu/hp-hr x 0.50 x (12wks x 5days/wk x 12hrs/day) x 1 MMBtu / 1E6Btu = 123.7 MMBtu Cost Savings = Savings / EFF x FuelCost = 123.7 / 0.85 x \$4.00 = \$ 582

Examples - Summary

Measure	Energy	Cost/Savings	
Baseline operation	330,753 kWh/yr	\$16,538 /yr	
Reduce Pressure	54,937 kWh/yr	\$ 2,747 /yr	16.6%
Repair Leaks	9,654 kWh/yr	\$ 483 /yr	2.9%
Recover Waste Heat*	36,254 kWh/yr (123.7 MMBtu/yr)	\$ 582 /yr	11.0%
TOTAL SAVINGS - Energy	100,845 kWh/yr		30.5%
TOTAL SAVINGS - Cost		\$ 3,812	23.0%

*Assumes plant can use all available heat over a 12-week period

Additional Volume

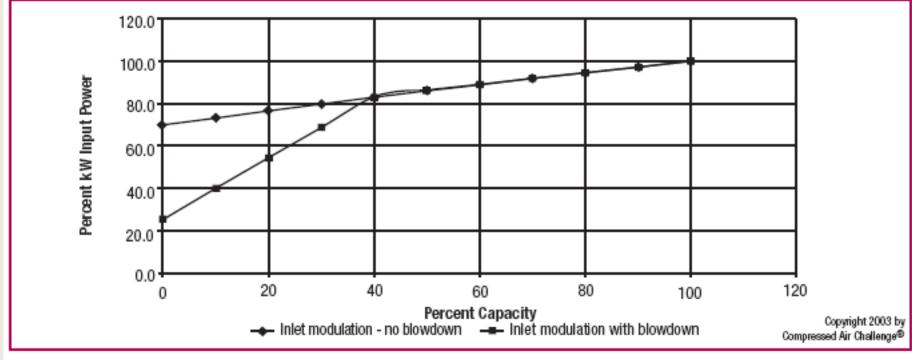


Figure 2.6 Lubricant-Injected Rotary Compressor with Inlet Valve Modulation.

Additional Volume

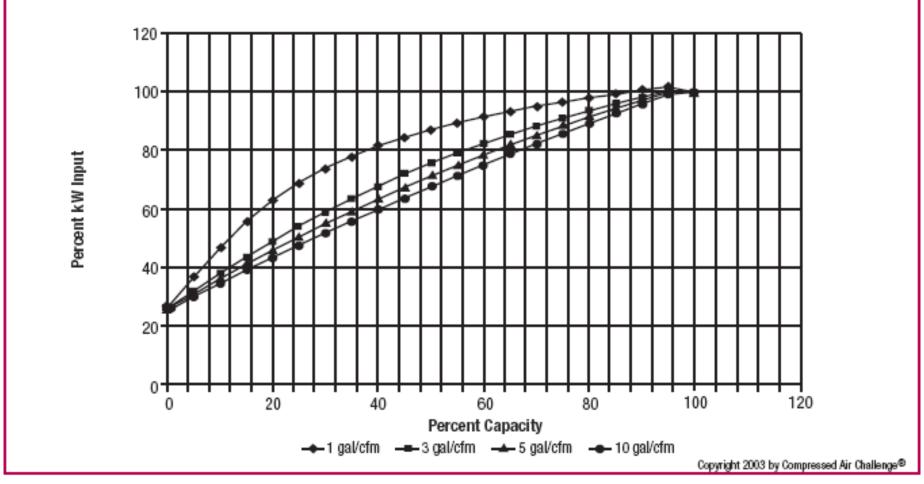


Figure 2.5 Effect of Receiver Capacity on Lubricant-Injected, Rotary Compressor with Load/Unload Capacity Control.