Pneumatic Mechanic Certification

Manual
Including Study Guide, Solutions, & Pre-Tests

FLUID POWER SOCIETY

Manual # 403 - 08/01

FLUID POWER CERTIFICATION BOARD

FLUID POWER SOCIETY

The International Organization for Fluid Power and Motion Control Professionals

General Pneumatic Safety Guidelines

Compressed air can be dangerous unless precautions are taken. These precautions are mostly common sense, but are nonetheless worth listing in places where compressed air is used. Consideration should be given to placing these, or similar, guidelines in a prominent place.

- Only pressure vessels built to a national or international standard should be used for air receivers.
- It is essential that a check valve and shut-off valve are fitted in the delivery line when the compressor is to be coupled in parallel with another compressor or connected to an existing air supply system. In such cases, a safety valve must be provided upstream of the valves, unless one is already fitted on the compressor.
- Do not use frayed, damaged or deteriorated hoses. Always store hoses properly and away from heat sources or direct sunlight. A hose failure can cause serious injury.
- Use only the correct type and size of hose end fittings and connections. Use heavy duty clamps made especially for compressed air systems.
- Use eye protection. If using compressed air for cleaning down equipment, do so with extreme caution. Take care not to blow dirt at people or into machinery.
- When blowing through a hose or air line, ensure that the open end is held securely. A free end will whip and can cause injury. Open the supply air cock carefully and ensure that any ejected particles will be restrained. A blocked hose can become a compressed air gun.
- Never apply compressed air to the skin or direct it at a person. Even air at a pressure of 15 psi (1 bar) can cause serious injury. Never use a compressed air hose to clean dirt from your clothing.
- Do not use air directly from a compressor for breathing purposes, for example charging air cylinders, unless the system has been specifically designed for such purpose and suitable breathing air filters and regulators are in place.

Precautions during start-up:

- If an isolating or check valve is fitted in the compressor discharge, it is essential to check that an adequate safety valve is in place between this isolating valve and the compressor and that the isolating valve is open.
- Before starting any machinery, all protective guards should be in position and be secure.
- On the initial start-up, the direction of rotation of an compressor must be checked. Severe damage may be caused if the compressor is allowed to run in the wrong direction.
- Ensure that a machine can not be started inadvertently. Place a warning notice at the lock-out.
- Do not weld or in anyway modify any pressure vessel.
- Isolating valves should be of the self venting type and designed to be locking in the “off” position so that air pressure cannot be applied inadvertently while the machine is being worked on.
- Exposure to excessive noise can damage hearing. Wear ear protection.
- Noise reducing mufflers can be fitted to machines to lessen the noise health hazard.
- A concentration of oil mist in the air from system lubricators can be hazardous.
- Check hoses and couplings daily before use. Use only hoses designed to handle compressed air. Provide all hose couplings with a positive locking device. Secure Chicago-type fittings together with wire or clips.
- Never crimp, couple, or uncouple pressurized hose. Shut off valves and bleed down pressure.
- When using compressed air for cleaning purposes, ensure pressure does not exceed 30 psi. Use goggles or a face shield over approved safety glasses for this application. Do not use compressed air to clean dust or debris off your body.
- Make sure all hoses exceeding 1/2 inch ID have a safety device at the source of supply or branch line to reduce the pressure in case of hose failure.

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Pneumatic Mechanic Certification Study Guide

Foreword

This study guide has been written for candidates who wish to prepare for the Pneumatic Mechanic Certification exam. It contains numbered outcomes, from which test items on the exam were written, a discussion of the related subject matter with illustrations, references for additional study, and review questions. While the study guide covers the basics of the exam, additional reading of the references is recommended.

The outcomes and review questions are intended to focus attention on a representative sample of the subject matter addressed by the exam. This does not mean that the study guide will teach the test. Rather, the study guide is to be used as a self-study course, or an instructional course if a Review Training Seminar is available, to address representative subject matter covered by the exam. Both the exam questions and review questions have been written from the same outcomes. To this extent, if the candidate understands the subject matter given here and can answer the review questions correctly, he or she should be prepared to take the Pneumatic Mechanic Certification exam.

The U.S. Government Federal Occupational Code defines the special skills and knowledge required by Fluid Power Mechanics as follows:

“Fabricates, assembles, services, maintains, and tests fluid power equipment, specifically hydraulic and pneumatic force and motion control systems, and following blueprints, schematics, or drawings, using hand tools, power tools, and testing devices and applying knowledge of hydraulic, pneumatic, and electrical principles. Analyzes blueprints, schematics, diagrams, and drawings to determine fabrication specifications, using instruments, such as micrometers, verniers, and calipers. Assembles fluid power components such as pumps, cylinders, valves, reservoirs, motors, accumulators, filters, and controls, using hand tools and holding devices. Connects unit to test equipment, and records data such as fluid pressure, flow rate, and power loss due to friction and parts wear. Identifies the need for modification in maintenance procedures, test procedures, instrumentation, or setup, based upon test results and machine operational performance.”

Based upon this description, the Pneumatic Mechanic must demonstrate expertise in the skill areas, as well as knowledge, comprehension and application of various principles addressed in this study guide. The study guide follows a simple format that uses outcomes and review questions to focus attention on what is important. If a candidate can master the outcomes by understanding the technical information and answering the review questions correctly, he or she should be able to achieve a passing score on the examination, and the honor of becoming an Pneumatic Mechanic.

To achieve certification requires passing the three hour written exam and the three hour Job Performance (hands-on) exam.

Introduction

This Study Guide consists of approximately 100 questions written from 24 tasks and related statements that were used to structure the written portion of the Pneumatic Mechanic Test. Each question has been written from the outcomes for a particular task, and these same outcomes were used to construct the written test items. Thus, when the review questions can be answered correctly, one should be prepared to take the examination.

Seven job responsibilities have been used to classify Pneumatic Mechanic subject matter. The 24 tasks are organized under these headings, and review questions have been written for each task. A brief definition of each job responsibility is given here to focus attention on major areas covered by the examination.

Preventive maintenance - means to inspect and monitor the machine.

Assemble components - requires inspection and replacement of defective parts, including installation and adjustment of components.

Field repairs - involves the ability to fix inoperable machinery at the work site. Tasks include changing hoses and hard plumbing hoses that have failed, as well as compressors cylinders, motors, control valves, seals, and gauges.

Major repairs - consists of overhaul procedures on major components, usually installing a kit of replacement parts, and then bench testing the overhauled component.

Minor repairs - requires the ability to fix minor components and make simple adjustments to machinery.

Replace components - means to exchange one component for another using a change-out procedure. The essence of the job responsibility is to replace faulty components using change-out procedures.

Troubleshooting - means to find and fix the failure in a component or system. The steps used to isolate component and system malfunctions are followed.

Following the subject matter discussion for each task is a list of references. These references contain information related to the task. Use of the references is recommended for further study of the subject matter.

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FPS Pneumatic Mechanic Certification			
Equations	**Page #**	**Equation**	**Equation**
Eq. #1	15	$Torque_{lb\text{-}ft} = Force_{lb} \times Lever\ Arm_{ft}$ $Torque_{lb\text{-}in} = Force_{lb} \times Lever\ Arm_{in}$	$T = F \times L$
Eq. #2	22	$Torque_{lb\text{-}in} = (Pressure_{psig} \times Displacement_{cipr} \times Efficiency_{decimal}) / 2\pi$	$T = (PSI \times CIPR \times Eff) / 6.28$
Eq. #3	25	$Force_{lb} = Pressure_{psig} \times Area_{sq\text{-}in}$ $Pressure_{psig} = Force_{lb} / Area_{in}$ $Area_{sq\text{-}in} = Force_{lb} / Pressure_{psig}$	$F = P \times A$ $P = F / A$ $A = F / P$
Eq. #4	25	$Area_{sq\text{-}in} = Diameter^2 \times 0.7854 = \pi D^2 / 4$	$A = D^2 \times 0.7854$
Eq. #5	25	$Annular\ Area_{sq\text{-}in} = Piston\ Area_{sq\text{-}in} - Rod\ Area_{sq\text{-}in}$	$AA = PA - RA$
Eq. #6	25	$Absolute\ Pressure_{psia} = Gauge\ Pressure_{psig} + 14.7$ $Gauge\ Pressure_{psig} = Absolute\ Pressure_{psia} - 14.7$	$PSIA = PSIG + 14.7$ $PSIG = PSIA - 14.7$
Eq. #7	25	$Pressure_{psig} = Vacuum_{in\text{-}Hg} / 2.03$	$PSIG = in\text{-}Hg / 2.03$
Eq. #8	26	$Volume_{cu\text{-}in} = Area_{sq\text{-}in} \times Stroke_{in}$	$V = A \times S$
Eq. #9	30	$Initial\ Pressure_{psia} \times Initial\ Volume_{cu\text{-}in} =$ $Final\ Pressure_{psia} \times Final\ Volume_{cu\text{-}in}$	$P_1 \times V_1 = P_2 \times V_2$
Eq. #10	30	$Compression\ Ratio = Initial\ Volume_{cu\text{-}in} / Final\ Volume_{cu\text{-}in}$	$CR = IV / FV$ Or: $CR = V_1 / V_2$
Eq. #11	31	$Compression\ Ratio = (Pressure_{psig} + 14.7) / 14.7$	$CR = (PSIG + 14.7) / 14.7$
Eq. #12	31	$Compressed\ Air_{CFM} = Free\ Air_{SCFM} / Compression\ Ratio$	$CFM = SCFM / CR$
Eq. #13	31	$(Initial\ Pressure_{psia} \times Initial\ Volume_{cu\text{-}in}) / Initial\ Temperature_{°R} =$ $(Final\ Pressure_{psia} \times Final\ Volume_{cu\text{-}in}) / Final\ Temperature_{°R}$	$(P_1 \times V_1) / T_1 = (P_2 \times V_2) / T_2$
Eq. #14	31	$°Rankine = °Fahrenheit + 460$	$°R = °F + 460$

Preventive Maintenance

The purpose of "Preventive Maintenance" is to keep the system clean, cool, tight, quiet, and free of leaks and vibration.

Task 1.0	**Service a pneumatic filtration system.**
Outcome 1.1.	**Knows the contaminants which must be removed from the flow of compressed air.**
Outcome 1.2.	**Knows the location of filters in a pneumatic system.**
Outcome 1.3.	**Understands the relationship between pore size and pressure drop through the filter.**
Outcome 1.4.	**Knows how pneumatic filters are rated and what pore sizes are appropriate.**

Air filtration systems condition the air by first separating out water and then filtering the air. Both dynamic and static methods are used. Erratic and/or sluggish operation may indicate the filter is not operating properly. Periodic service is necessary for optimum performance of the pneumatic system.

Filtered air increases the service life and dependability of pneumatic components. Solid contaminant particles can reduce or plug orifices, wear out seals, and score moving parts. Likewise, condensed water can wash away lubricants and cause rust which flakes off and becomes a contaminant.

An air filter cleans the air through a combination of dynamic (swirling) and static (porous) media filtration. Dynamic filtration is accomplished by directing the incoming air through a deflector baffle that spins the air outward and downward in a whirling pattern. Centrifugal force hurls large particles and liquid water outward against the inner bowl walls. These contaminants flow past the quiet zone baffle and collect at the bottom of the bowl in the sump area. The air changes direction and flows through the porous filter media which strains out the smaller particles. The size of the particles removed from the air depends upon the pore size of the filter element.

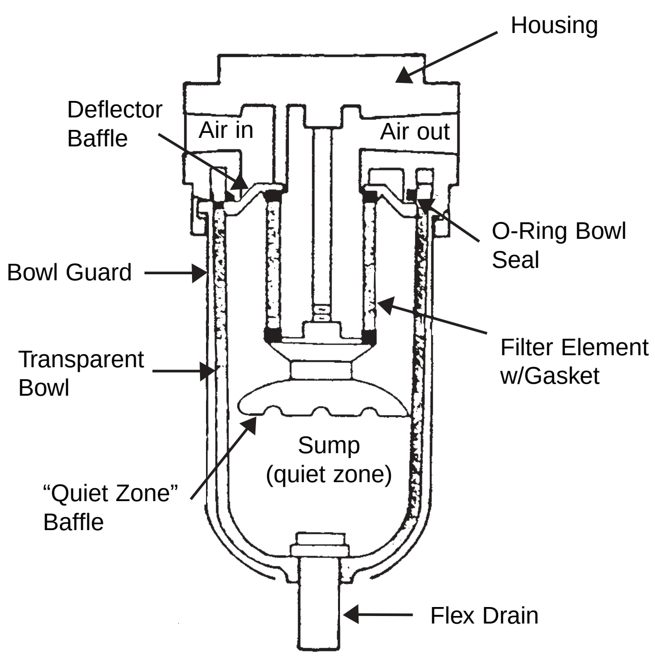


Fig. 1. Filter for Compressed Air

Most filter bowls are made from metal or a transparent polycarbonate plastic to permit visual inspection of the moisture and trapped particles in the sump. For applications where bowl cracking and potential failures are problems, a perforated metal guard is normally fitted over the bowl. Bowl guards are used to protect personnel from injury due to bowl failure.

Filter elements are available in a variety of materials including felt, paper, cellulose, metal, plastic screening, metal ribbon, sintered bronze, sintered plastic, glass fiber, and cloth. Filter elements are rated for the minimum particle size which they will remove from an air stream. Both NOMINAL and ABSOLUTE RATINGS are used, making comparisons difficult.

The main compressed air filters in a pneumatic system are located downstream of the compressor. In addition to the main filters, combination filter-regulator-lubricator units are installed with the bowl down on a horizontal line at each air drop to condition the air just before the air reaches the component it serves. Most compressors also make use of an inlet air filter (breather) to remove dirt before the air enters the compressor.

Filters are typically rated according to the size of particles they will remove. A micrometer, or micron, is the typical unit of measure for filters. A micron (micrometer) is equal to one millionth of a meter. For most industrial applications, filter elements rated at 40-60 microns (micrometers) are available, although filters down in the 3 to 20 micron (micrometer) range are preferred. As micrometer size decreases, the size of the filter must increase to provide the same air flow at the same pressure drop. This is because finer filtration results in a higher pressure drop for the same size filter at a given flow rate.

For proper air filter maintenance, it is important to be sure the filter/separator is removing the water. A filter separator that does not remove the water cannot filter the air effectively. The condition of the water trap and filter element is determined by visual inspection. Water must be drained periodically from the filter. The proper function of automatic drains should be checked periodically.

Many solvents commonly found in the workplace, as well as many synthetic compressor lubricants, will cause a failure of polycarbonate bowls. The use of metal bowls is urged in these applications.

Coalescing filters are used to remove oil vapor. They also remove particles in the range of 0.3 to 0.9 microns. Coalescing filters are generally protected by a standard 3 to 5 micron particulate filter. The air that would serve such an application would likely have been conditioned by an air dryer.

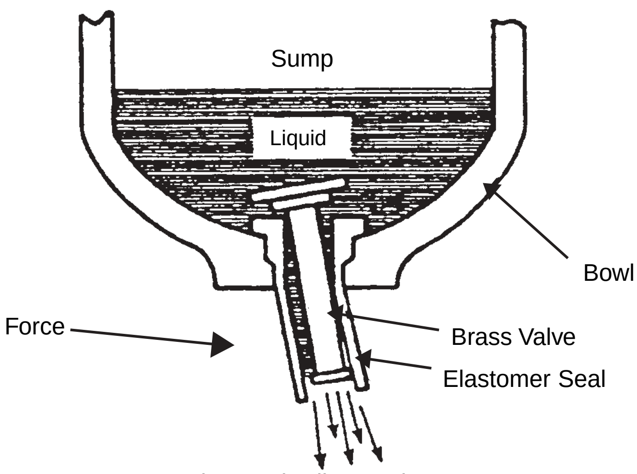


Fig. 3. Air Filter Drain

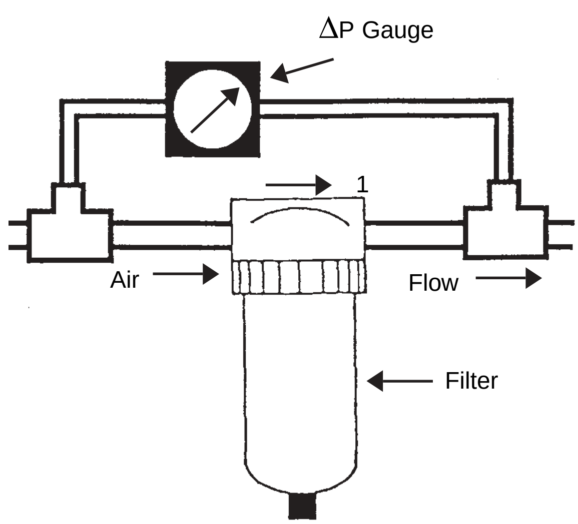


Fig. 2. Filter Pore Size Affects Pressure Drop

Review: 1.1.
Static filtration involves:

a. cooling the air to its dew point.
b. swirling the air.
c. passing the air through a porous media.
d. using a 10 micron filter element.
e. removing water from the air.

Review: 1.2.
For a given air flow rate, as the pore size of the filter decreases (the filter media gets finer), the pressure drop through the filter:

a. stays the same.
b. increases.
c. decreases.
d. increases only if the filter plugs.
e. decreases only if the filter plugs.

Review: 1.3.
In industrial applications, what is the preferred filter size range?

a. 0.1 - 1 micron
b. 3 - 20 microns
c. 40 - 60 microns
d. 60 - 100 microns
e. 100 - 400 microns

Review: 1.4.
The primary purpose of the filter at the compressor inlet is to:

a. remove moisture.
b. protect the compressor.
c. keep dust out of the receiver.
d. remove oil mist.
e. serve as a muffler for air noise.

Task 2.0	**Service a diaphragm type pneumatic regulator.**
Outcome 2.1.	**Knows the purpose of a pressure regulator.**
Outcome 2.2.	**Knows how to check a pressure regulator for proper operation.**

Air regulators keep the operating pressure (downstream pressure) constant regardless of fluctuations in either the upstream pressure or the air consumption. Some regulators, known as venting regulators, also bleed off excess air should the downstream pressure setting be reduced, or rise over the setpoint due to circuit action.

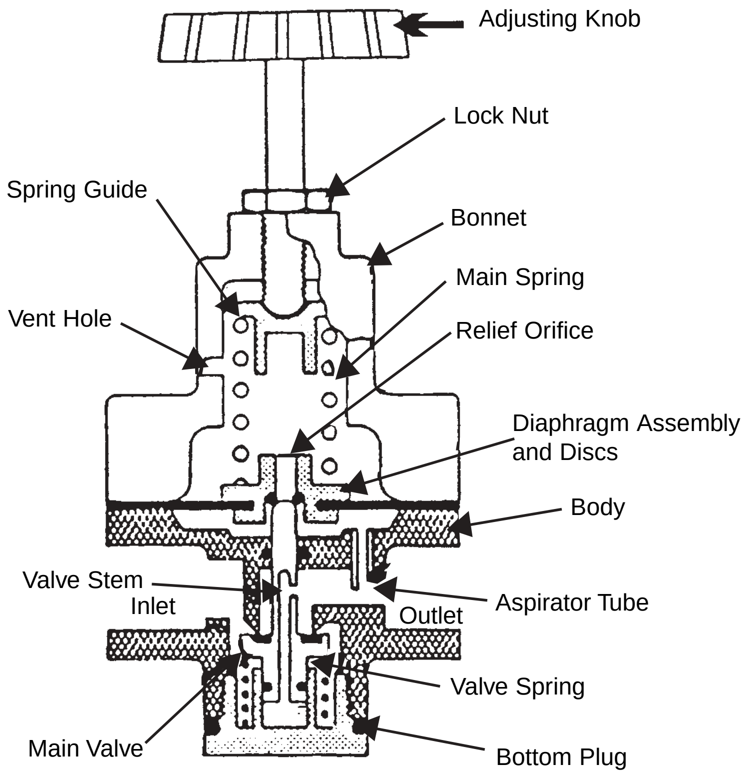


Fig. 4. Venting Air Regulator

To regulate the air pressure of an air supply, the upstream pressure must be higher than the downstream pressure. The diaphragm regulates pressure by opening and closing the main valve poppet. Outlet pressure acts on one side of the diaphragm, and the spring acts on the other. Spring force is adjusted by means of an adjusting screw, to vary the pressure setting of the regulator.

To check a pressure regulator for adjustment, release compression on the regulator spring and open the outlet valve. Adjust the pressure regulator to approximately 80% of inlet pressure showing on the receiver side of the shut-off valve. The regulated air pressure will show on the regulator pressure gauge. Fully open and close the outlet valve slowly to see whether the air regulator compensates for changes in flow while still maintaining the regulated pressure at 80% of inlet pressure.

Repeat the previous step at three other pressures: 20%, 40%, and 60% of supply pressure.

Finally, if you have a venting regulator, close the outlet valve to stop the flow of air from the regulator, back off the regulator from 60% to 30% of the upstream pressure. This will test the regulator when over-pressure at the outlet is reduced to the new pressure setting by bleeding off air in the outlet passage through the vent holes to atmosphere. Note: If the pressure regulator is not equipped with vent holes, the regulator will not compensate without bleeding off air at the outlet manually.

Relieving regulators are designed for non combustible gas service.

Any device used for oxygen service must be properly cleaned for that service.

Review: 2.1.

Air pressure regulators determine the maximum pressure:

a. at the compressor.
b. downstream of the regulator.
c. in the receiver.
d. in the aftercooler.
e. upstream of the regulator.

Review: 2.2.

In a system with sufficient upstream pressure, the pressure downstream of a properly sized regulator:

a. will increase to receiver pressure when air is not being used.
b. will decrease when air is not being used.
c. is dependent upon the temperature of the air.
d. should always be higher than the upstream pressure.
e. should be constant, regardless of the air flow rate through the regulator.

Task 3.0	**Service a pneumatic lubricator.**
Outcome 3.1.	**Understands how an air lubricator works.**
Outcome 3.2.	**Recognizes the symptoms and causes of air lubricator failure.**
Outcome 3.3.	**Knows how air lubricators are sized.**

The lubricator provides lubrication for the sliding parts in a pneumatic system. This reduces friction losses, wear, and provides a certain amount of corrosion protection. Servicing the lubricator requires checking the oil level, refilling, and adjusting the lubricator to provide the quantity of oil needed to suit the need of the actuator.

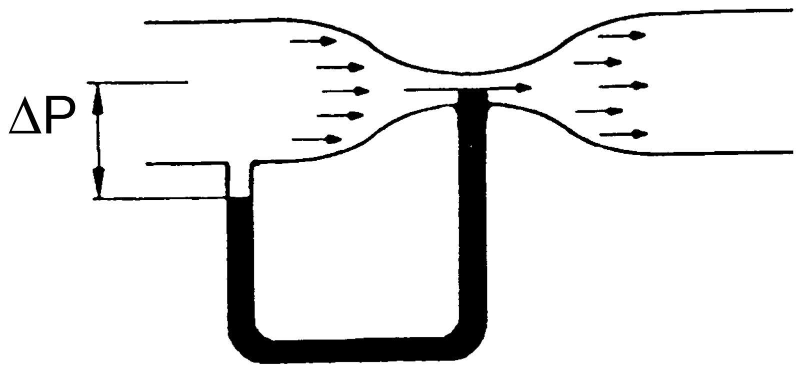


Fig. 5. A Venturi Causes A Pressure Imbalance

Lubricators utilize a venturi through which the air stream passes. The venturi causes the pressure to drop as air passes through the restrictor portion of the lubricator. When air pressure in the restrictor drops, oil flows up through the rise tube, rise tube check valve, drip dome, and enters the airstream through the flow tube as a fine mist.

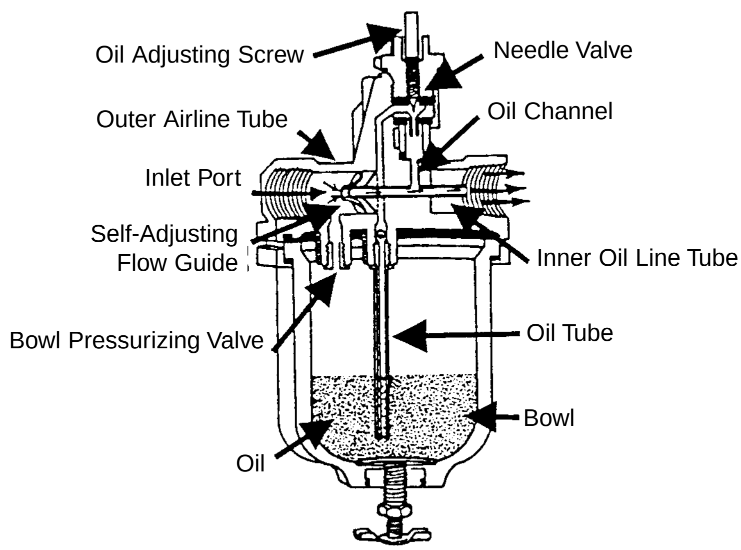
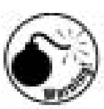


Fig. 6. Pneumatic Lubricator

Lubricators are sized for a range of air flows. They function best when they operate within this range. The quantity of oil per unit time is regulated with an adjusting screw that restricts an orifice.

Lubricators must be installed horizontally in the line and the direction of flow must be as marked on the lubricator. Use the proper viscosity oil for the lubricator. Usually, this is specified as ISO 22 oil.

When the lubricator has been filled, operate the system at rated air flow and check to see that oil droplets appear in the drip dome. If no oil passes through the drip tube, open the adjustment in 1/2 turn increments to clear the needle valve, and then reset the valve adjustment.



If a pre-lubricated component is installed in a lubricated system, the oil introduced to the airstream by the lubricator will wash the pre-lube grease out of the pre-lubed component. Therefore the component must continue to be lubricated in the future. “Once lubricated, always lubricated.”

Relieving / Venting regulators are designed for air service.

Non-venting regulators are designed for use with toxic, combustible, or oxygen-displacing gases.

Any device used for oxygen service must be properly cleaned for that service.

Review: 3.1.
Which part of the lubricator causes the pressure drop?

a. Oil tube
b. Needle valve
c. Flow guide
d. Venturi
e. Bowl pressurizing valve

Review: 3.2.
A lubricator will not function if the:

a. bowl is only half full of oil.
b. needle valve is open too far.
c. drain valve is stuck shut.
d. bowl pressurizing valve is open.
e. air flow rate is too low.

Review: 3.3.
The purpose of the venturi in the lubricator is to:

a. pressurize the oil.
b. separate the oil and air.
c. increase the air flow rate.
d. reduce air stream pressure to mix oil and air.
e. decrease the air flow rate.

Task 4.0	**Change the oil in an air compressor.**
Outcome 4.1.	**Understands fluid properties and how they affect the suitability of an oil for use in a compressor.**
Outcome 4.2.	**Recognizes the need to monitor compressor oil level and condition.**

The oil in a compressor is changed at periodic intervals, or when the temperature changes and the oil viscosity in the base of the compressor is unsuitable. Oil becomes contaminated with debris from wear and age. The additive package that improves the service related properties of the oil also breaks down. Changing the oil is a routine maintenance task. However, care must be exercised not to damage the compressor by using an improper oil, using an improper procedure, or through poor workmanship.

Extending oil change intervals may allow the oil to become loaded with contaminants and break down, and sludge to build up in the crankcase. Follow manufacturers specifications for the time interval between compressor oil changes (typically 1000 to 8000 hours, depending on conditions).

Oil viscosity is very important. The oil viscosity is selected for the ambient (surrounding) air temperature from the following chart:

Temperature range	ISO Viscosity Grade
-5º F to +140º F -22º C to +60º C	22
+5º F to +170º F -15º C to +77º C	32
+15º F to +190º F -9º C to +88º C	46
+30º F to +210ºF -1º C to +99º C	68

Fig. 7. Oil Viscosity Selection Chart

If the oil level is low, the compressor will not receive adequate lubrication, bearing friction and heat will increase, and bearings will fail. The rod bearing most commonly fails, causing a knock that can be heard when the clearance between the journal and bearing reaches about 0.050 in. When the rod knock is heard, both the bearing shell and journal have been damaged.

Contaminants will settle out of non-detergent oil, while detergent oil will hold contaminants in suspension. Full-flow filters are required with detergent oil so that contaminants dispersed by the action of the detergent can be trapped.

A rust inhibitor is used to prevent the metal parts from rusting. Heating and cooling can cause condensation which promotes rusting. Rusting generates scale material that can damage the bearings and cause oil breakdown.

An oxidation inhibitor is used to prevent the oil from oxidizing. Air is mixed with the oil as it splashes inside the crankcase. This action can cause the oil to break down unless it is fortified with an inhibitor.

Review: 4.1.
A detergent in the oil will:

a. force contaminants to settle out of the oil.
b. hold contaminants in suspension.
c. clean the oil filter.
d. cause the compressor to use more oil.
e. extend the oil change interval.

Review: 4.2.
A compressor which uses oil:

a. must be rebuilt.
b. is working fine.
c. should be equipped with an automatic filling mechanism.
d. will run too hot.
e. not enough information to make a decision.

Task 5.0	**Torque screws on a circular pattern.**
Outcome 5.1.	**Understands the concept of torque and solves basic mathematical problems related to torque.**
Outcome 5.2.	**Knows how bolt size and strength affect torque values.**

Proper torquing of screws is important, regardless of the component being serviced or repaired. Torquing is necessary to insure proper distribution of forces and loads, insure sealing between mating surfaces, and prevent failures of components and screws.

Torque is defined as a turning or twisting effort, sometimes called a rotary force. A torque wrench is necessary to actually measure the torque being exerted on a bolt. The proper torque is normally determined by the component manufacturer and will depend on the size of the bolt, thread pitch, and bolt hardness.

(Eq. 1) $Torque_{lb\text{-}ft} = Force_{lb} \times Lever\ Arm_{ft}$ $\quad T = F \times$

$Torque_{lb\text{-}in} = Force_{lb} \times Lever\ Arm_{in}$

Screws oriented on a circular pattern are torqued in a criss-cross pattern sequence to draw the parts together evenly. (See Figure 9) OVER TORQUING WILL DAMAGE THE COMPONENT because it will strip and break screws, as well as deform gaskets and mating surfaces. In severe cases, over torquing or uneven torquing may break the component.

The best way to tighten screws to a uniform torque is with a torque wrench using a cross pattern sequence that tightens all screws evenly. If a gasket or seal leaks, and the screws are tight, over-torquing will NOT stop the leak. Rather, it can result in damage to the screws or component.

Higher strength screws have higher torque values than softer screws. Grade 2 screws have no markings on the head. The grade of a bolt is two higher than the number of marks on the head. Grade 5 screws have a higher strength and approximately 50% higher torque values. They have three dash marks on the head. Grade 8 screws have six dash marks on the head and have approximately 100% higher torque values than grade 2 screws. Where higher strength screws are found, higher torque values may be used.

It is important that the torque wrench be calibrated before starting to torque screws. There are a number of ways to check the accuracy. One is to use another torque wrench to see if both wrenches yield the same value. Another is to use a force scale to pull on the handle one foot from the socket and to compare several values on the force gauge with the values on the torque wrench.

It is also important to use a wrench sized for the job. A wrench calibrated in inch pounds (in. lb.) is more appropriate for 1/4-in. and 5/16-in. screws than a torque wrench calibrated in foot pounds (ft. lb.) because the wrench is smaller and the torque value is more accurate. There also is less chance of over tightening the bolt. To convert ft. lb. torque values to in. lb. values, multiply by 12, the number of inches in a foot.

To tighten screws arranged in a circular pattern where several screws are used to attach the part or fasten two major components together, torque the screws in the proper sequence. This is done to prevent cocking the part by putting uneven pressure both on the seals and the part. Do not torque screws sequentially around the part. This will result in uneven pressure on the part and seal. Severe cases of uneven tightening will break machine parts, strip threads, and break screws. It is customary to snug the screws by hand, and then apply the final torque in one or two more passes.

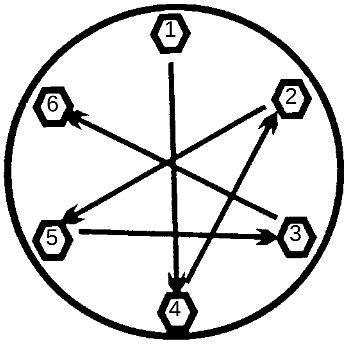


Fig. 9. Torque Circular Bolt Patterns
in a Criss-Cross Pattern

Review: 5.1.

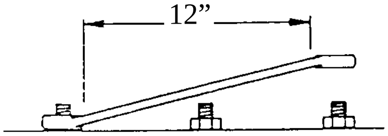
The "grade number" of a bolt:

a. indicates whether it has coarse or fine threads.
b. is an indication of hardness.
c. is the proper torque value in foot-pounds.
d. indicates whether or not it is plated.
e. predicts how many times the bolt may be reused without failure.

Review: 5.2.

If a torque of 60 lb-ft is needed on the bolt, how much force will be needed on the wrench?

a. 5 pounds
b. 10 pounds
c. 20 pounds
d. 40 pounds
e. 60 pounds



Assemble Components

Pneumatic circuits and systems consist of components that have been assembled, installed, and adjusted. Assembly drawings and illustrations are commonly used to show the positions of the respective parts in an assembly. Components such as valves are shown as assemblies for this purpose. New components must be assembled as well. Hoses and fittings, for example, are made to length. Proper assembly of components requires using assembly drawings, written procedures, hand and machine tools, and gauges. Craftsmanship and cleanliness are important to assure that the work meets safety specifications and workmanship standards.

Task 6.0	**Assemble an air regulator.**
Outcome 6.1.	**Understands the operation of venting and non-venting regulators.**
Outcome 6.2.	**Understands the operation of venting and non-venting regulators.**
Outcome 6.3.	**Recognizes the causes and symptoms of regulator failure.**

An air regulator maintains constant downstream pressure regardless of fluctuations upstream, saves compressed air by regulating pressure, and provides controlled pressure in systems where air pressure demand is variable.

Air regulators are manufactured in both venting and non-venting designs. Venting regulators release excess downstream pressure when the pressure is above the regulator setting. Non-venting regulators are not capable of releasing downstream air.

When readjusting a venting type regulator from a higher to lower pressure, the regulator will automatically bleed off excess downstream air. Air must be exhausted from the downstream side of a non-venting regulator when resetting to a lower pressure. Non-venting regulators are not equipped to exhaust excess downstream air.

Air pressure regulators are adjusted according to the requirements of the load being served. Regulators must be readjusted when the requirements of the actuator or load change.

Periodically, regulators require repair or rebuilding. An air regulator may be repaired without a rebuild kit if the faulty part is identified and repaired or replaced. Over time, however, the fabric diaphragm in the regulator will lose its resilience and leak. This lets air pass through the diaphragm and out the vent hole. A small leak is not likely to affect the operation of the regulator, but a larger leak could bleed off sufficient air to cause the regulator to malfunction. Any size leak at the regulator should be fixed.

Review Task 2.0 for further study.

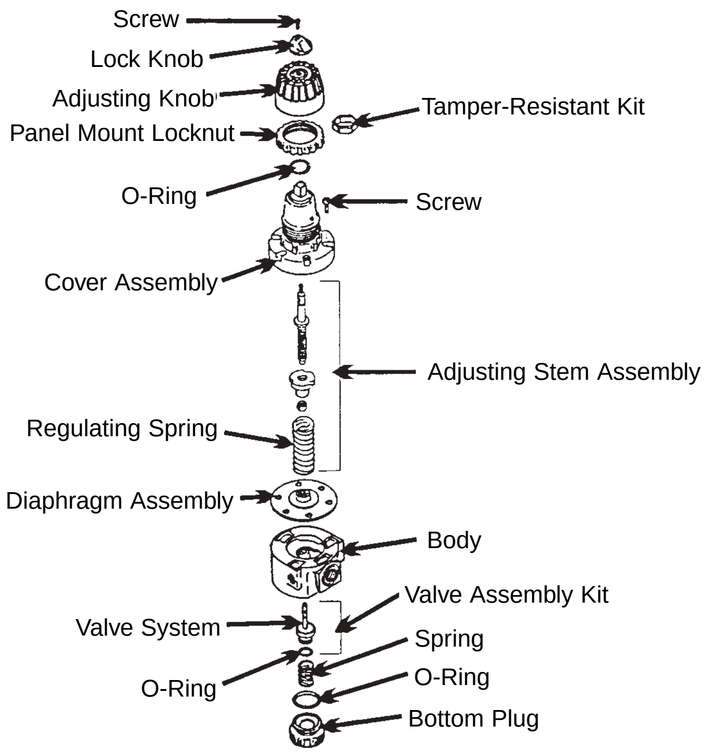


Fig. 10. Air Regulator Assembly

Review: 6.1.
The gauge on an air regulator indicates the pressure:
a. at the inlet.
b. at the outlet.
c. between the inlet and outlet.
d. in the spring chamber.
e. at the compressor.

Review: 6.2.
A leaking regulator diaphragm will cause:
a. excessive downstream pressure.
b. excessive upstream pressure.
c. leaking air out the vent hole.
d. no change in regulator performance.
e. the lubricator to malfunction.

Review: 6.3.
A non-venting regulator is to be reset from a higher pressure to a lower pressure. To properly set the regulator:
a. reduce the upstream pressure first.
b. it will be necessary to vent down stream air.
c. simply back the adjuster screw out.
d. turn the adjuster screw in.
e. shut off the air supply.

Assemble Components

Task 7.0	**Assemble a pneumatic directional control valve.**
Outcome 7.1.	**Distinguishes between packed bore and packed spool valves.**
Outcome 7.2.	**Correctly interprets information from a schematic symbol of a directional valve.**

Pneumatic directional control valves come in several construction styles. Poppet, metal spool and sleeve, and resilient seal spool valves are the most popular. Resilient seal valves can be either packed spool or packed body (or bore) designs depending on whether the seals are on the spool or in the body. Disassembly and assembly of pneumatic valves may be required when the seals leak to the point that the control valve will not allow the circuit to work. Replacement seal kits that contain a grease-like lubricant can be used to prevent damage to the seals during reassembly and operation. The method used to replace the seals and assemble the valve depends upon the construction style of the valve. Each manufacturer provides directions for cleaning, lubrication, and assembly. Care must be taken when solvents are used around synthetic rubber seals. Only approved greases should be used as a lubricant.

With pneumatic directional control valves, the application determines how the ports are connected to provide the proper flow paths. In a typical application, the supply port is connected to actuate a double-acting cylinder in one direction, while the return air from the other side of the cylinder is exhausted through the return air port(s) to the atmosphere.

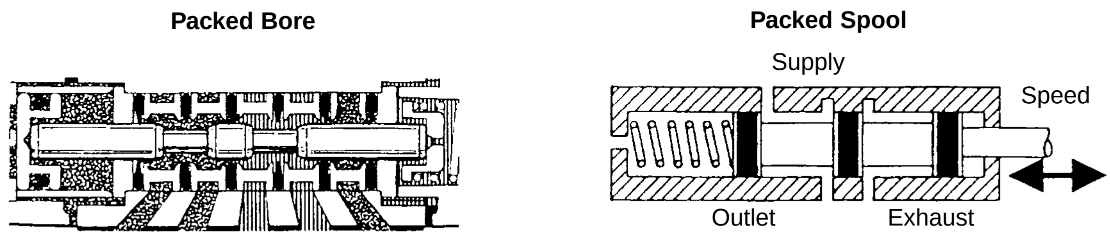
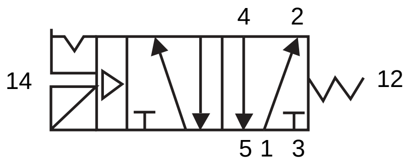


Fig. 11. Packed Bore and Packed Spool Valves (Courtesy of Parker Hannifin)

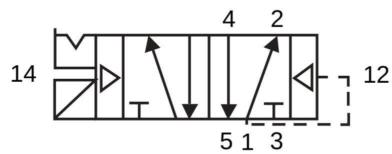
Pneumatic valves make extensive use of aluminum. Their construction is lighter than hydraulic valves that serve the same function. Because aluminum does not have the high strength properties of steel, care must be taken not to over-tighten tapered pipe (NPT) port connections. For example, the pipe or fitting torque for 1/4 inch NPT body ports should not exceed 15 ft. lb. (180 in. lb.).

If speed control is required on a component controlled by a four-way five port pneumatic valve, the speed control device should be installed in either the “ISO #2” (A) and “ISO #4” (B) (cylinder pressure) ports, or “ISO #3” (EA) and “ISO #5” (EB) (cylinder exhaust) ports or lines, but generally not in the "P" (pressure) port or line, especially if a pilot operated valve is used. Installing a speed control device in the “ISO #1” (P) port or line may cause a malfunction in pilot operated valves due to low control pressure at the "P" port. See Figure 12.

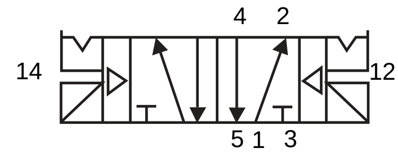
International Standards Organization (ISO) Standard 1219 describes the symbols which are used to graphically depict pneumatic directional control valves. See Task 20.0 for further study of these symbols.



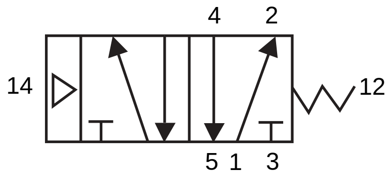
5 Port / 2 Position,
Single Solenoid,
Metal Spring Return



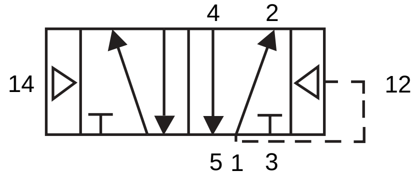
5 Port / 2 Position,
Single Solenoid,
Air Pilot Return



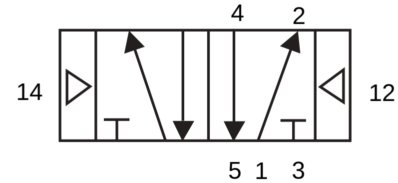
5 Port / 2 Position,
Double Solenoid



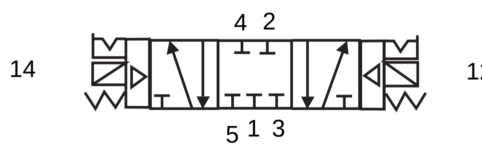
5 Port / 2 Position,
Single Air Pilot,
Metal Spring Return



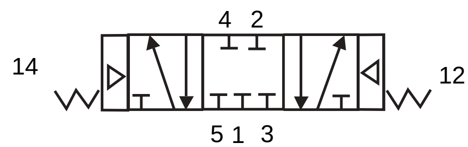
5 Port / 2 Position,
Single Air Pilot,
Air Pilot Return



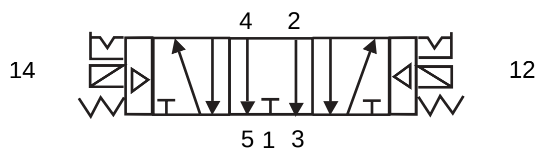
5 Port / 2 Position,
Double Air Pilot



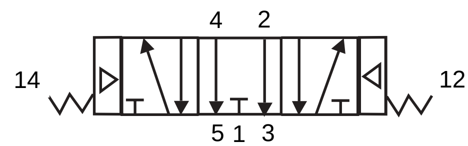
5 Port / 3 Position,
Closed Center,
Double Solenoid



5 Port / 3 Position,
Closed Center,
Double Air Pilot



5 Port / 3 Position,
Exhaust Open Center,
Double Solenoid



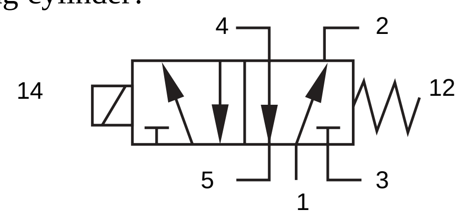
5 Port / 3 Position,
Exhaust Open Center

Fig. 12. Directional Control Valve Symbols

Review: 7.1.

In the direct-acting solenoid-operated valve shown, which port would be fitted with a restrictor to achieve meter-in flow control for both extension and retraction of a double acting cylinder?

a. Port 4
b. Port 2
c. Port 1
d. Port 5
e. Port 3



Review: 7.2.

A packed spool directional control valve has the seals:

a. at the armatures.
b. in the P port.
c. in the valve sleeve.
d. on the valve spool.
e. in the outlet port.

	Task 8.0	**Assemble a vane type air motor.**
	Outcome 8.1.	**Understands the reasons why air motors must operate on conditioned air.**
	Outcome 8.2.	**Recognizes the problems caused by operating an air motor on unconditioned air.**
	Outcome 8.3	**Solves basic equations involving motor torque, pressure, displacement, and efficiency.**

With pneumatic motors, the potential energy of compressed air is converted to mechanical energy. The air pressure at the motor inlet is greater than the pressure at the outlet. This differential pressure acts on the vanes, turning the motor rotor which turns the output shaft.

The construction principle of vane motors is similar to that of vane-type air compressors. A rotor is mounted eccentrically in a stationary body bore. The vanes slide in radial slots machined into the rotor. Vane motors can have from three to ten vanes.

With the rotor located off-center, inlet porting is arranged so that pressurized air exerts an unbalanced rotational force against the vanes, and the rotor turns about its center.

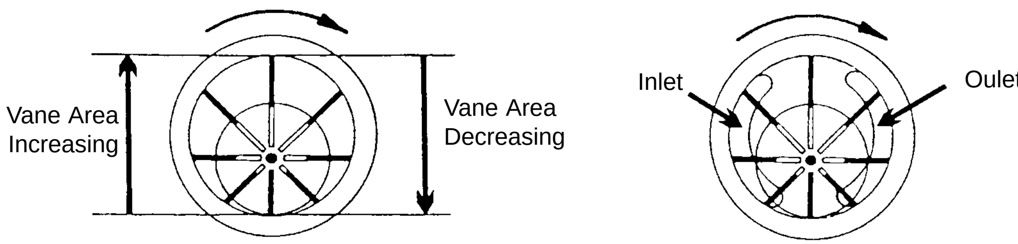


Fig. 13. Vane Type Air Motor Principle (Courtesy of Parker Hannifin)

Since the vanes are pushed radially against the bore by centrifugal force, lubricated compressed air is necessary to reduce friction, vane tip wear, and to help seal the sliding contact line between vane and bore. The typical lubricant recommended is SAE #10 detergent engine oil, feeding one drop for every 50-75 cfm of air flowing through the motor.

Vane motors operate at speeds from 100 to 25,000 revolutions per minute (rpm) and deliver more horsepower per pound than piston air motors. Adequate air preparation is important for extended motor operational life. Solid particulate contaminants can quickly cause internal damage at high air speeds through the motor, so proper filtration is essential. A filter should be installed in the air line upstream of the motor.

Due to the temperature drop in an air motor which can condense water vapor, dry air is desired. Condensation causes the motor to rust inside and, in extreme cases, impairs operation as ice forms in the muffler. To prevent this condition, a moisture trap should be installed in the air line upstream of the motor.

Careful alignment with the load during installation is critical for optimum service life. Excessive axial or radial thrust loads at the motor shaft will have a negative effect on performance and cause premature bearing failure.

Air motor exhaust noise often exceeds safe sound-level standards. Most motor manufacturers supply the appropriate muffler to lower the noise without generating excessive back pressure on the motor.

Air vane motors that are allowed to run free at high speed will generate excessive internal friction, increase internal clearances and damage the motor. The maximum speed ranges from 2000 rpm for a typical 8 HP unit to 3000 rpm for a typical 3-4 HP unit. Smaller units tend to have higher maximum speed ratings.

Vane type air motors must periodically be serviced and repaired. Typical service involves the replacement of the vanes and bearings. If the housing body is not rusted, pitted, or worn excessively, cleaning the unit and replacing the vanes and bearings will restore it to proper operation. Remember that NEGLECT is the cause of many problems with air motors, as is abuse, either by the mounting or by the application. For example, hitting the shaft with a hammer, misaligning the load, or subjecting the air motor to axial or radial bearing loads without proper support will damage the air motor.

Satisfactory operation of a vane air motor requires the proper internal clearances. Some housing wear is to be expected and is compensated for by the vanes as they extend farther from the slots. Clearance at the end housing should be checked to be sure the proper vanes are used, and that the rotor-to-housing clearance is not excessive. Typical clearance is approximately 0.002 inch per inch of width of the rotor. A two-inch wide rotor, for example, would have an end clearance of about 0.004 inch. End cover wear should be minimal unless the shaft has been subjected to axial loads, in which case one end housing may be ruined.

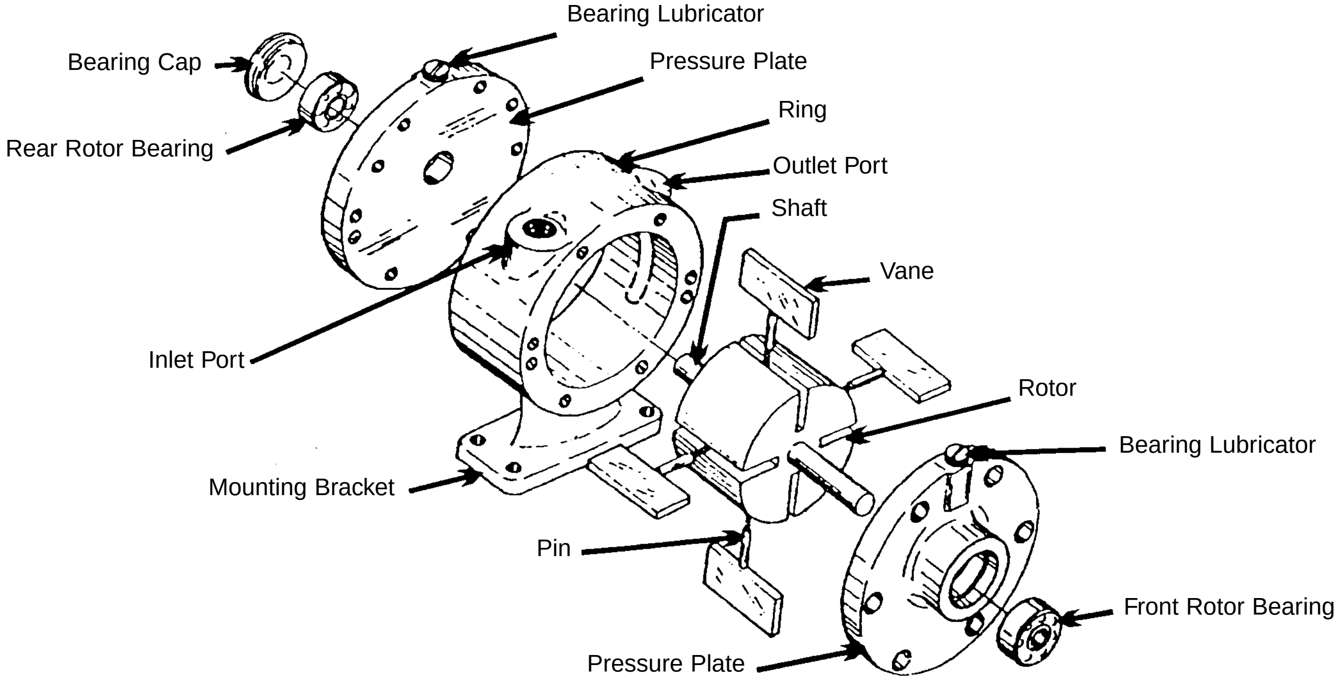


Fig. 14. Vane Type Air Motor Construction (Courtesy of Gast Manufacturing Corp.)

The output torque capability of an air motor must occasionally be determined. Equation 2 provides the relationship between motor Torque, Displacement, Pressure, and Efficiency.

(Eq. 2)

$$Torque_{lb\text{-}in} = (Pressure_{psig} \times Displacement_{cipr} \times Efficiency_{decimal}) / 2\pi$$

$$T = (PSI \times CIPR \times Eff) / 6.28$$

Displacement is in cubic inches per revolution (cipr)

Note: Efficiency is expressed as a decimal value. For example, if the efficiency of the motor is 88%, the value of “0.88” is used in the equation.

$2\pi = 6.28$

Equation 2 may also be used to find the pressure required for a given motor to drive a specified load (torque).

Review: 8.1.
An air motor which runs on unconditioned air will:

a. run too fast.
b. run too slow.
c. not run at all.
d. experience premature wear.
e. blow up.

Review: 8.2.
A 10 cipr air motor operating at 100 psi has an efficiency of 80 percent. The output torque is:

a. 1000 in.lb.
b. 800 in. lb.
c. 159 in. lb.
d. 127 in. lb.
e. 80 in. lb.

Field Repairs

"Field Repairs" take place at the worksite to fix machinery that is not operating properly or has become inoperable because of component failures or improper settings. Most of these problems do not require shop facilities. Where parts must be replaced, their identification must be known, and equipment such as gauges, hand tools, and supplies must be available.

Task 9.0	**Replace piston cup packing and rod seals in a pneumatic cylinder.**
Outcome 9.1.	**Solves equations involving cylinder force, pressure, area, and volume.**
Outcome 9.2.	**Solves equations involving vacuum, area, and force.**
Outcome 9.3.	**Knows how to test an air cylinder for leaks.**
Outcome 9.4.	**Understands how to install seals in a pneumatic cylinder.**
Outcome 9.5.	**Translates pressure values between the gauge, absolute pressure, and mercury vacuum scales.**

Pneumatic tie-rod cylinders must seal in five places. Static seals exist between the barrel and each end cap and where the piston attaches to the cylinder rod. Dynamic seals, which are more prone to leakage, exist between the piston and the barrel and at the rod bushing.

Common symptoms of failure include air escaping at the rod seal or through the exhaust port at the directional control valve, which indicates that air is by-passing the piston. Field repairs for these problems consist of removing the cylinder and replacing the faulty parts.

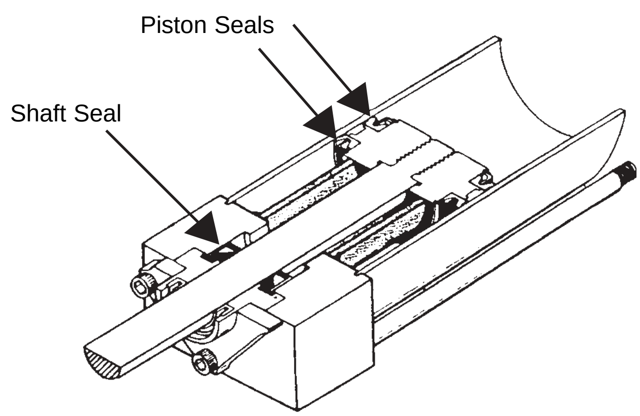


Fig. 15. Dynamic Cylinder Seal Design and Location
(Courtesy of Parker Hannifin)

Air escaping through the vent hole on a single acting cylinder when the cylinder is pressurized, but not moving, means the piston seal is leaking. Air escaping through the exhaust port in the control valve actuating double acting cylinders under the same circumstances may also mean the piston seal is leaking, either at the double cup piston packing or at the rod-to-piston O-ring seal. Leakage around the cylinder barrel indicates that one or both of the barrel seals are leaking. Leakage at the cylinder rod indicates the rod seal is leaking and that the rod bearing may be worn as well.

Premature wear of the double-cup (piston) packing or rod seal can be caused by:

a. misalignment - which puts side thrusts on the rod, wears the rod bushing, and cocks the cylinder.

b. higher than rated pressure or cycle rates - that subject seals to high stress and generate shock loads when the piston bottoms at the end of the stroke.

c. contamination - too much oil, water, or foreign material in the cylinder that reduces cylinder velocity and causes increased wear.

Check the rod bushing for wear if the rod seal is leaking. The rod seal and bushing are usually part of the same assembly. Some are removed from the outside, while others are removed from the piston side. The attachment can be by a threaded gland (as are some hydraulic cylinders), snap ring, or press-fit in the rod cap. Before reassembling the rod cap over the rod, lubricate the seal and bushing with lubricating oil. Care should be exercised not to damage the seal on the cylinder rod threads. (Use a cone installation tool, if one is available, to ease the seal over the end of the cylinder rod.

If the piston seals are to be replaced, it is important to install the new seals so that the lips are facing the cylinder ports on the piston (Note: seals are reversed on a vacuum cylinder). If the cylinder is single acting, the lip of the seal must face the pressure.

As with any seal repair, always lubricate the new seal prior to assembly. Exercise caution not to cut or damage new seals when installing them over threads, splines, or shoulders.

It may be necessary on occasion to calculate air cylinder force capabilities using Equations 3, 4, and 5.

(Eq. 3) $Force_{lb} = Pressure_{psig} \times Area_{sq\text{-}in}$ $F = P \times A$

$Pressure_{psig} = Force_{lb} / Area_{in}$ $P = F / A$

$Area_{sq\text{-}in} = Force_{lb} / Pressure_{psig}$ $A = F / P$

(Eq. 4) $Area_{sq\text{-}in} = Diameter^2 \times 0.7854$ $A = D^2 \times 0.7854$

(Eq. 5) $Annular\ Area_{sq\text{-}in} = Piston\ Area_{sq\text{-}in} - Rod\ Area_{sq\text{-}in}$ $AA = PA - RA$

Before solving equation 5, the rod area must be found from equation 4 using the rod diameter instead of the cylinder bore.

When working with vacuum cylinders and vacuum applications, it is necessary to convert vacuum values (in inches of mercury) to pressure values in psi. It must first be recognized that pressure values are normally given in the gauge readings above atmosphere pressure. The pressure of the atmosphere is not accounted for in gauge pressure readings. The pressure of the atmosphere is approximately 14.7 psi above a perfect vacuum. Absolute pressure readings are taken from a perfect vacuum. Equation 6 indicates the conversion from gauge to absolute pressure.

(Eq. 6) $Absolute\ Pressure_{psia} = Gauge\ Pressure_{psig} + 14.7$ $PSIA = PSIG + 14.7$

$Gauge\ Pressure_{psig} = Absolute\ Pressure_{psia} - 14.7$ $PSIG = PSIA - 14.7$

Vacuum is measured in inches of mercury (in. Hg.) from atmospheric pressure. Equation 7 describes the relationship between the vacuum and atmospheric pressure in psi and in inches of mercury.

(Eq. 7) $Pressure_{PSIG} = Vacuum_{in\text{-}Hg} / 2.03$ $PSIG = in\text{-}Hg / 2.03$

Vacuum cylinders and suction cups operate by virtue of the pressure differential between the vacuum and atmospheric pressure. Accordingly, the vacuum reading must first be converted to psi. This value is multiplied by the area against which the vacuum is applied to determine force.

It may also be necessary to calculate air consumption rates of a cylinder. Since air is compressible, the volume of air needed at the operating pressure of the cylinder is the most straight forward calculation.

(Eq. 8) $Volume_{cu\text{-}in} = Area_{sq\text{-}in} \times Stroke_{in}$ $V = A \times S$

The area used is either piston or rod end area, depending upon whether the volume is to be calculated for extension (piston area) or retraction (rod end area).

Examples of pressure and vacuum applied to cylinders follow:

A.) A 4" cylinder with a 1" rod is used with 100 psig air. Calculate the cylinder extension and retraction forces.

From equation 4:

$Area_{piston} = (4")^2 \times 0.7854 =$ <u>12.57 sq-in</u>
$Area_{rod} = (1")^2 =$ <u>0.78 sq-in</u>

From Equation 5:

Annular Area = 12.57 sq-in - 0.78 sq-in = <u>11.79 sq-in</u>

Using Equation 3:

$Force_{extention}$ = 12.57 sq-in x 100 psig = <u>1257 lb.</u>

$Force_{retraction}$ = 11.79 sq-in x 100 psig = <u>1179 lb.</u>

B.) A vacuum of 20 in. Hg. is applied to the piston (cap) end of the previous 4" cylinder. Calculate the retraction force developed if the rod end is vented.

$Area_{piston}$ = <u>12.57</u>

From Equation 7:

PSIG = 20 in-Hg / 2.03 = <u>9.85 psid = 9.85 psig</u>

From Equation 3:

$Force_{retraction}$ = 9.85 psig x 12.57 sq-in = <u>123.8 lb.</u>

In vacuum cylinder applications, the rod area becomes of some interest. Since the rod area is exposed externally to the cylinder, atmospheric pressure is typically acting on the rod area. However, since forces and rod sizes are normally very small, a reasonable approximation is to utilize the full (piston) area for calculations involving cylinder forces due to vacuum in both extension and retraction.

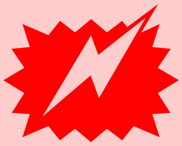
Review: 9.1.
Calculate the pressure needed to extend a 2 inch bore cylinder raising a 200 pound load.
a. 200 psig
b. 100 psig
c. 64 psig
d. 32 psig
e. 20 psig

Review: 9.2.
The volume of air needed to cycle a double acting cylinder with a 2 inch bore and a 1 inch rod and 8 inches stroke is:
a. 44.0 cu-in.
b. 32.0 cu-in.
c. 31.4 cu-in.
d. 28.3 cu-in.
e. 25.1 cu-in.

Review: 9.3.
Piston cup seals and rod seals are examples of what type of seal?
a. static
b. dynamic
c. rolling
d. leather
e. low pressure

Review: 9.4.
A pressure reading of 20 psig equates to:
a. 5.3 psia
b. 9.8 psia
c. 20.0 psia
d. 34.7 psia
e. 40.6 psia

Review: 9.5.
A vacuum of 10 in-Hg. is applied to a 3 inch vacuum cup. This cup will be able to lift:
a. 3.0 pounds.
b. 7.1 pounds.
c. 10.0 pounds.
d. 30.0 pounds.
e. 34.8 pounds.



Task 10.0	**Replace and adjust the drive belts on an air compressor.**
Outcome 10.1.	**Knows how to check and adjust compressor drive belts.**
Outcome 10.2	**Understands drive belt terminology.**

Compressor drive belts wear with use. Periodic adjustment will extend their useful life. When they become frayed, cracked, dried out, or slip, making a shrieking noise, even when tightened properly, replacement is necessary. Motor pulley-to-compressor belt wheel alignment and proper belt tension are the two important adjustments to make.

Pulley alignment is easy to check. A straight edge or a cord pulled taut across the edge of the pulleys provides an accurate check of alignment. Pulleys must be aligned to insure optimum belt life and performance.

Belt tension should also be checked on existing or new belts. Belt tension is checked by deflecting the belts with a known force midway between the pulleys and measuring the amount of deflection. The force to be applied should be between 20 and 30 ounces of push or pull (1-1/4 to almost 2 pounds). 1-1/2 pounds is a good value to use. The belt should deflect by a value of "t" / 64 inches under this force where "t" is the distance between the two shafts in inches. Therefore, if the pulleys are 32 inches apart, the belt should deflect 32/64" (1/2)" when a force of 1-1/2 pounds is applied to the back of the belt. The most serious consequence of V-belts that have been adjusted too tightly is that the compressor and motor bearings will be overloaded.

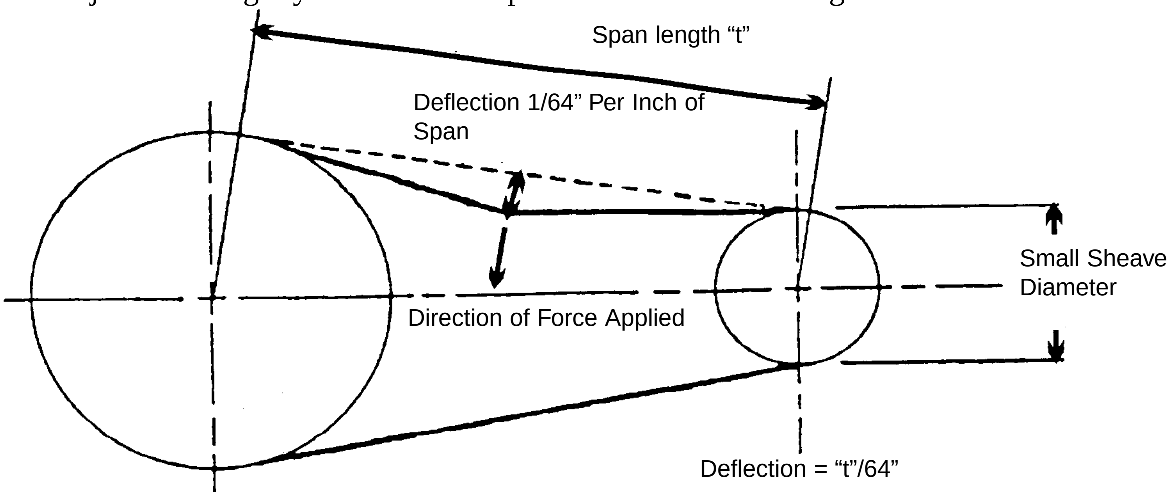


Fig. 16. Checking Air Compressor Belt Tension

When replacing belts in a multiple belt drive, all belts should be renewed at the same time. This ensures that the load is shared evenly by all of the belts in the set. Check the pulleys for wear. V-belts drive from the sides and will not drive properly if the bottom of the belt rides on the bottom of the pulley.

Review: 10.1.
V-Belts transmit power to/from pulleys:
a. at the larger pulley only.
b. along the sides of the belt.
c. at the top edge of the belt.
d. at the bottom of the belt.
e. along the small pulley only.

Review: 10.2.
A V-belt drive measures 20 inches between the motor shaft and compressor shaft. When pulling on the belt with a force of 1-1/2 pounds mid-way between the pulleys, the belt should deflect:
a. 0.2".
b. 1-1/2".
c. 20/100".
d. 5/16".
e. 5/64".

Task 11.0	**Adjust the pressure settings on an air compressor.**
Outcome 11.1.	**Understands the various compressor controls and their applications.**
Outcome 11.2.	**Knows the procedure to check and adjust compressor controls.**
Outcome 11.3.	**Calculates air flow requirements in standard cubic feet/minute (SCFM) and compressor delivery in cubic feet/minute (CFM).**
Outcome 11.4.	**Converts air flow requirements from compressed conditions to atmospheric conditions.**
Outcome 11.5.	**Solves equations involving Compression Ratio (CR).**

On piston type compressors of less than about 25 HP, operating less than 50% of the time, the automatic stop-start control is the most common. The control consists of a pressure sensitive switch wired to the drive motor control circuit. When air is used from the receiver and pressure drops below the low pressure setting, for example 90 psi, the motor control pressure switch switch closes and the compressor kicks on. When the pressure reaches the high pressure setting, for example 125 psi, the motor control pressure switch opens and the compressor stops. Automatic start-stop control is appropriate when the compressor cycles not more than five to seven times per hour, which is about once every 10 minutes.

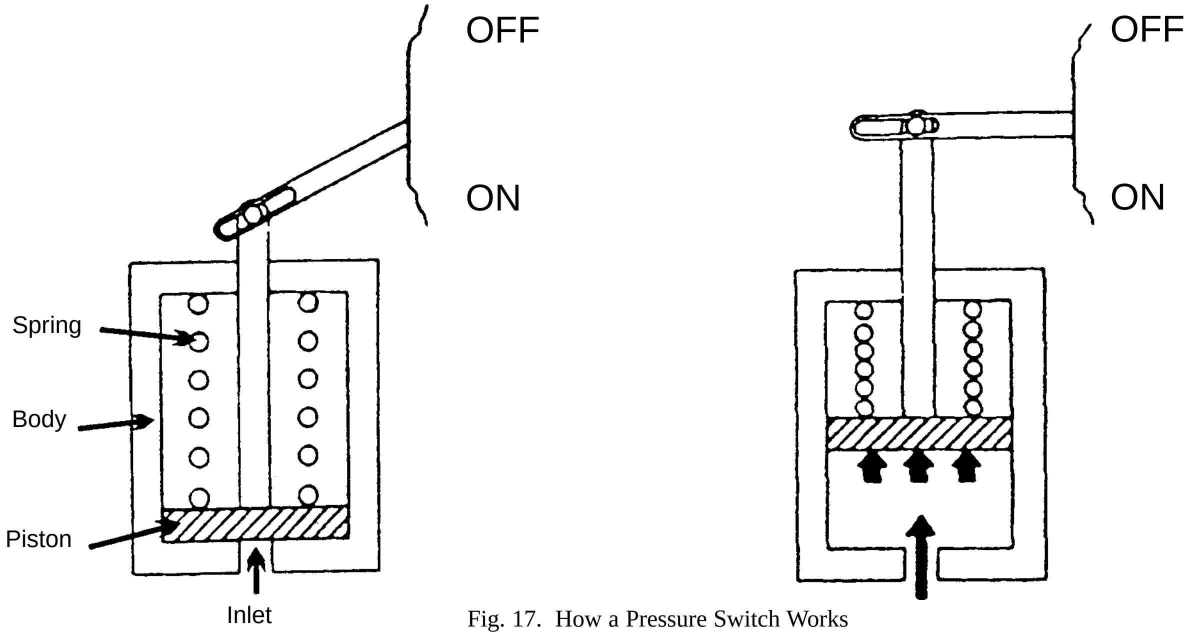


Fig. 17. How a Pressure Switch Works

If the compressor operates more than 50% of the time, and the pressure control cycles more than five to seven times per hour, a constant speed control is typically used. This allows the motor to run continuously, but the compressor is regulated by one of several types of controls including inlet valve unloaders and inlet air throttling.

Constant speed control regulation is a method of maintaining receiver pressure without starting and stopping the motor. This is accomplished by equipping the compressor with a discharge unloader, an intake valve unloader, or an inlet air throttle. A discharge unloader opens a valve at the compressor outlet and redirects air from the outlet to the atmosphere. Intake valve unloaders hold the intake valve open, thus preventing air pressurization. Unloaders are discussed in Task 16.0.

Some compressors are equipped with dual controls. When dual controls are used, the stop-start control pressure settings are higher than the constant speed control pressure settings, and the two sets of pressure settings are separated by a dead band of at least 10 psi.

The difference between the cut-in and cut-out (differential) pressure of a constant speed and start-stop controls is usually at least 10% of operating pressure. Electrical codes require that the compressor motor have overload protection to keep the motor from overheating, which could cause a fire. The motor should be protected by thermal contacts that will open at approximately 115% of its normal load after a short period of time.

There is interaction between the range (cut-out pressure) adjustment and differential adjustment. When the pressure range is increased, the differential pressure should be increased. Also, if differential pressure is decreased, the range (cut-out pressure) should be decreased.

Compressor controls, like the compressor size, must be selected based on the type of compressor, the air flow requirements, and frequency of the air use needs. Compressors are typically rated in Standard Cubic Feet per Minute (SCFM). CFM refers to a volume of air compressed to some given pressure.

"Standard" air is uncompressed air at sea level (14.7 psia) at 68 degrees Fahrenheit and 36% relative humidity. Since air is compressible, it is necessary to define standard air conditions to enable comparisons of compressors and evaluations of air flow needs. "Free" air is air at local atmospheric conditions. Since the environmental factors of temperature and relative humidity change, free air is not well defined. Free air is usually called scfm, even though that is not technically correct.

The compression ratio of the compressor dictates the pressure capability of the compressor. The compression ratio is a comparison of the volume of the compression cylinder at its maximum volume (bottom dead center for piston compressors) to its minimum volume (top dead center). If the temperature is assumed to be constant, the compression ratio dictates the pressure ratio directly. When the temperature is constant, equation 9 provides this relationship.

(Eq. 9) $\text{Initial Pressure}_{psia} \times \text{Initial Volume}_{cu\text{-}in} = \text{Final Pressure}_{psia} \times \text{Final Volume}_{cu\text{-}in}$

$$P_1 \times V_1 = P_2 \times V_2$$

P_1 is the pressure at the beginning of compression. Since Equation 9 works with absolute pressures only, Equation 6 must be used to convert atmospheric pressure (0 psi) to absolute pressure (14.7 psia).

V_1 is the volume at the beginning of compression. V_2 is the volume at the end of the compression process. This dictates Equation 10:

(Eq. 10) $\text{Compression Ratio} = \text{Initial Volume}_{cu\text{-}in} / \text{Final Volume}_{cu\text{-}in}$ $CR = IV / FV$

or $CR = V_1 / V_2$

If air at atmospheric pressure is compressed in a compressor with a 4:1 compression ratio, Equation 9 dictates that $P_2 = 14.7 \times 4 / 1 = 58.8$ psia. P_2 must now be converted back to gauge pressure by subtracting 14.7 psi. So the final (gauge) pressure is 44.1 psi, assuming a constant temperature.

An alternative formula for compression ratio is:

(Eq. 11) Compression Ratio = $(Pressure_{psig} + 14.7) / 14.7$ CR = (PSIG + 14.7) / 14.7

For example, the compression ratio of a compressor at 100 psig is 7.8.

CR = (PSIG + 14.7) / 14.7 = (100 psig + 14.7) / 14.7 = 7.80

To calculate CFM:

(Eq. 12) Compressed Air_{CFM} = Free Air_{SCFM} / Compression Ratio CFM = SCFM / CR

Therefore, if a compressor pumps 115 SCFM of air, it will deliver 14.74 CFM of air at 100-psig:
CFM = 115 SCFM / 7.80 = 14.74 CFM

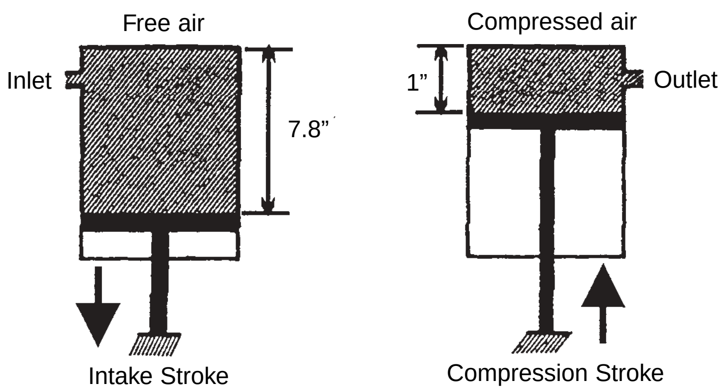


Fig. 18. Compression Ratio

Temperature is not always constant. When this is the case, the temperature change must be accounted for. The Universal Gas Law explains this relationship:

(Eq. 13)

(Initial $Pressure_{psia}$ x Initial $Volume_{cu\text{-}in}$) / Initial $Temperature_{°R}$ = (Final $Pressure_{psia}$ x Final $Volume_{cu\text{-}in}$) / Final $Temperature_{°R}$

$$(P_1 \times V_1) / T_1 = (P_2 \times V_2) / T_2$$

In this equation, "T" is temperature in absolute units. Absolute temperature is measured from absolute zero, the temperature at which all molecular activity is thought to stop. Absolute zero occurs at -460 degrees Fahrenheit.

(Eq. 14) ˚Rankine = ˚Fahrenheit + 460 ˚R = ˚F + 460

Obviously the outlet (system) pressure of a pneumatic system affects the compressor delivery since it dictates the pressure to which the compressor must compress the air. As the pressure increases, the delivery for a given compressor decreases. Two-stage compressors are more efficient at higher pressures.

Compressor design, compressor capacity, air flow requirements, system pressure, and the frequency of air requirements should all be considered when setting and resetting compressor controls to insure optimum efficiency and compressor life.

There are several types of compressors. Examples of positive displacement compressor construction are: piston, rotary vane, rotary screw, and diaphragm. Centrifugal compressors, which contain a turbine fan, are not positive displacement compressors.

Review: 11.1.
A start-stop control is typically used when the compressor has a duty cycle below:

a. 10%.
b. 30%.
c. 50%.
d. 70%.
e. 90%.

Review: 11.2.
A compressor has a compression ratio of 8 to 1. What is the pressure limit of the compressor (constant temperature)?

a. 8 psig
b. 80 psig
c. 95 psig
d. 103 psig
e. 118 psig

Review: 11.3.
A pneumatic system requires 10 cfm at 100 psig. How much free air is required?

a. 10 cfm
b. 78 cfm
c. 100 cfm
d. 780 cfm
e. 1000cfm

Review: 11.4.
A control which holds the intake valve of a piston compressor open is an example of which control?

a. On/off
b. Start/stop
c. Constant speed
d. Intake valve
e. Dual

Review: 11.5.
Which of the following is not a positive displacement compressor?

a. Centrifugal
b. Screw
c. Vane
d. Piston
e. Diaphragm

Task 12.0 — **Replace a compressor head gasket and service the valve plate.**
Outcome 12.1. — **Recognizes the causes of compressor head air leaks.**
Outcome 12.2. — **Knows the proper procedures to repair, service, and replace a compressor head, including torquing of the head screws.**

Compressor head gaskets may leak for a variety of reasons. These include loose head screws, a warped head, or a cracked head gasket. To replace a leaking head gasket, or to inspect and service the finger valve plate, the head must be removed, the parts cleaned, and the new gasket installed following the proper procedure. Of major importance are the cleaning operation, installation of the gasket, and torquing the air head cap screws. Improper service is a major source of damage to finger valves. Over-tightening screws does not improve the gasket seal. Rather, it can result in damage to the gasket, cap screws, and air head.

When servicing a valve plate and cylinder head, one must remember that the valve plate must be treated with special care. The finger valves are precision reed valves that function as check valves and can be easily damaged. Once damaged, they will not operate properly and must be replaced.

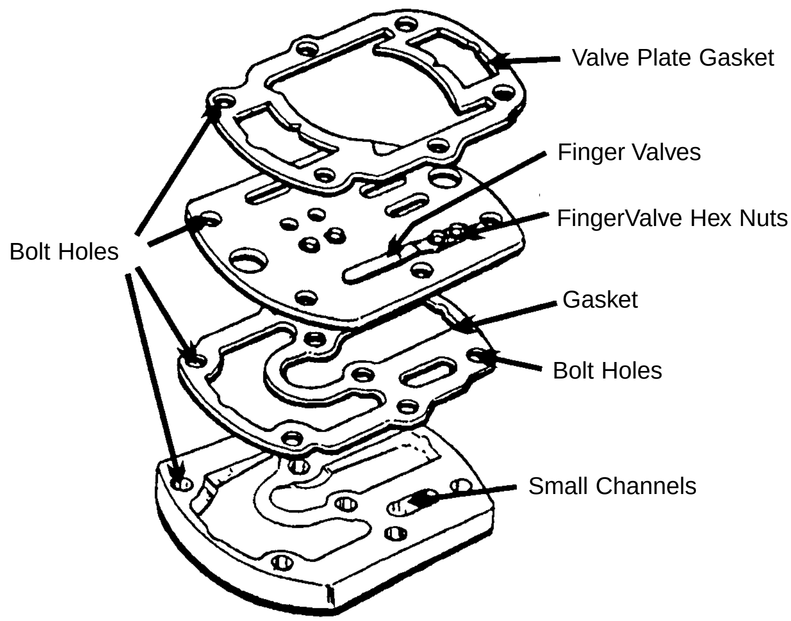


Fig. 19. Compressor Head Components

The head is cleaned by scraping off the head gasket material and other foreign matter that might include carbon. Use a square ground putty knife, not a sharpened one that can scratch and nick the head. Then blow and wipe the head clean.

The valve plate should be washed in solvent with a stiff non-wire bristled brush. Do not get the bristles in the valves. If solvent does not clean the valve plate, the finger valves must be removed to prevent damage when the valve plate is scraped with a square ground putty knife. Do not scrape where the finger valves seal. This will damage the surface.

Tighten the cap screws with a torque wrench using a criss-cross pattern sequence. Start by tightening each bolt partially so the head will be pulled down evenly. Torque values for different size cap screws are given in Task 5.0.

Review: 12.1.
Over torquing a compressor cylinder head will:
a. help the gasket seal better.
b. improve compressor performance.
c. possibly break a stud.
d. improve heat dissipation.
e. allow the compressor to operate faster.

Review: 12.2.
Screws arranged in a circular pattern:
a. don't have to be torqued.
b. should be torqued in a criss-cross pattern.
c. should be torqued around in a circular pattern.
d. should be fully torqued on the first pass.
e. should be grade 8.

Major Repairs

As explained in Task 5.0, screws oriented in a circular pattern are torqued in a criss-cross manner. Never tighten two adjacent screws.

"Major Repairs" consists of bench work that requires inspection and replacement of defective parts when a used unit is overhauled. It also includes adjustment, installation, and testing to ensure that the unit operates properly. In a typical application, a rebuild kit is installed to replace the worn parts in the unit, eliminating the need for machine work. A number of components are overhauled including air compressors, transmissions, and even air tools. Cylinders are overhauled as long as the barrel does not require resizing. This would make the job a rebuild operation, which is considered beyond the scope of a first level mechanic.

Task 13.0	**Install an overhaul kit in an air impact wrench.**
Outcome 13.1.	**Understands the effects of unconditioned air on pneumatic tools.**
Outcome 13.2.	**Recognizes the effect of air pressure on wrench torque and air flow on wrench speed.**

The pneumatic vane motor in an air impact wrench converts compressed air to rotary power. An air impact wrench is a combination of a vane-type motor coupled to an impact mechanism that converts the motor torque into a series of powerful rotary blows. This in turn exerts torque on the load connected to an external shaft. When the pressure-generated torque exceeds the load torque, the pneumatic motor converts the energy of compressed air into continuous rotary mechanical energy and turns the load.

The torque of an air impact wrench can be limited by regulating the supply pressure. Some air impact wrenches are also equipped with torque controls that limit the output torque to a set value by shutting off the air supply.

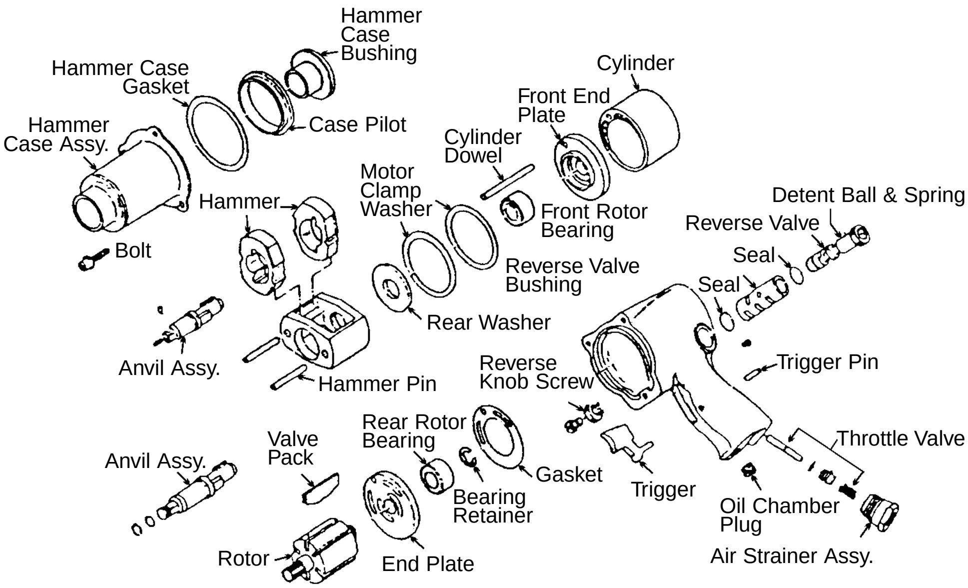


Fig. 20. Air Impact Wrench (Courtesy of Ingersoll-Rand)

Over time, internal wear reduces the efficiency of the air wrench. To restore the tool to its original performance, the internal moving parts that wear and the seals are replaced as a kit. A typical air impact wrench rebuild kit consists of valve bushings, front and rear rotor bearings, motor vanes, gaskets, and springs.

Adequate air preparation is important to extended motor operational life. Solid particulate contaminants can quickly cause internal damage at high air speeds through the motor, so proper filtration is essential.

As with any major repair, cleanliness, thoroughness, and attention to detail are important. New components, including seals, should be lubricated prior to assembly. Contaminants should not be allowed to remain in the component. Torque all covers and assemblies carefully.

Review: 13.1.
Impact wrench speed is controlled by the:
a. pressure at inlet.
b. size of air line.
c. inlet pressure at the regulator.
d. air flow rate.
e. reversing valve.

Review: 13.2.
Unconditioned air supplied to an impact wrench will:
a. cause premature wear.
b. cause over-speeding.
c. have no effect.
d. make the wrench turn faster.
e. create excessive exhaust noise.

Minor Repairs

"Minor Repairs" include simple tasks that return the machinery to proper working order with a minimum of downtime. The tasks are more complex than routine maintenance but less complicated than major repairs or replacing components. Stopping leaks, resealing fittings, calibrating gauges, cleaning air compressor intercooler tubes, and such manual skills as removing a broken cap screw from an air compressor head are typical of the work performed under this job responsibility.

Task 14.0	**Clear the drain cock on an air receiver.**
Outcome 14.1.	**Understands the relationships between gauge and absolute pressures and standard, free, and compressed air.**
Outcome 14.2.	**Calculates the volume of an air receiver.**
Outcome 14.3.	**Knows the purpose of an air receiver and additional components located at the receiver.**

The main purpose for the air receiver is to store pressurized air for future use. The air receiver ensures that a steady supply of pressurized air is available. It also dampens piston compressor pulsations caused by the pumping action of compressor pistons.

The air receiver minimizes the frequency of loading (on) and unloading (off) of the compressor motor. The air receiver serves as a place for contaminants such as water, oil, and dust particles to collect and settle out. Scheduled maintenance of the air receiver includes draining the water, oil, and contaminants from the bottom of the receiver. This prevents condensate and oil from migrating out of the receiver with the air stream. Up to a gallon of condensate per hour may be produced during humid summer conditions. Usually the procedure is repeated daily without incident, but once in a while the draincock becomes clogged and must be removed to clear the obstruction.

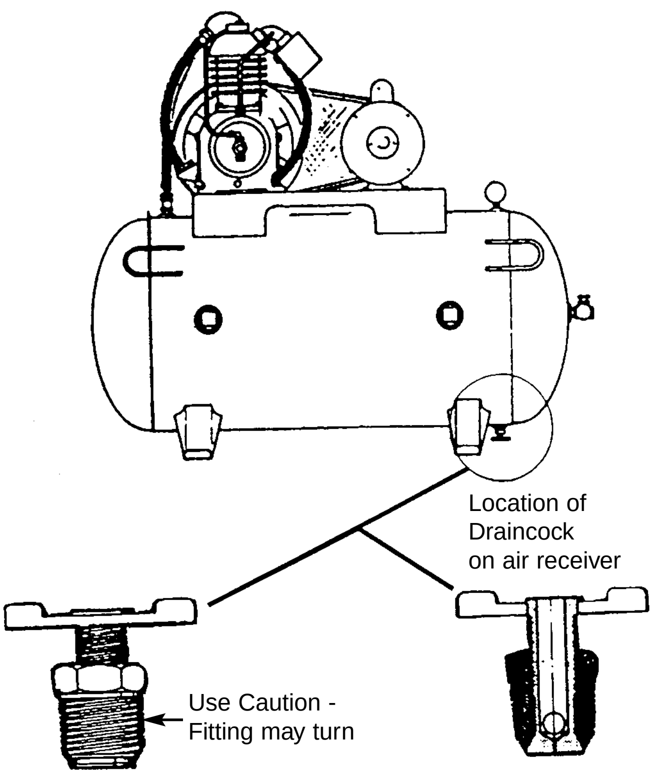


Fig. 21. Air Compressor Draincock

Caution: Before removing the draincock to service it, lock out the electricity and then vent all pressurized air.

Several important conversions relate to air receivers. These relationships (conversions) pertain primarily to pressures and volumes. Since each conversion affects one variable only, they are not listed as equations.

A. 1 cubic foot (cu-ft) = 7.48 gallons (volume)
B. 1 Bar = 14.5 psig (pressure)
C. 1 foot = 12 inches (distance)
D. 1 cubic foot = 1728 cubic inches (cu-in), (volume)

Equation 8 works to calculate receiver volume with the provision that the receiver length is substituted for cylinder stroke.

The American Society of Mechanical Engineers (ASME) sets standards for air receivers and air safety valves. Items required by the ASME include a draincock, pressure gauge, and safety valve. These safety (pressure) valves should be checked periodically by manually overriding the valve to vent air pressure from the receiver. This ensures the valve is free and unobstructed. Review Tasks 9.0 and 11.0 for further study.

Review: 14.1.
A pressure of 100 psia converts to a gauge pressure of:
a. 114.7 psig.
b. 100.0 psig.
c. 85.3 psig.
d. 14.7 psig.
e. 0 psig.

Review: 14.2.
An air receiver is 18 inches in diameter by 48 inches long. It's volume is:
a. 864 cubic inches.
b. 7.07 cubic feet.
c. 52.8 cubic feet.
d. 864 gallons.
e. 7.07 gallons.

Review: 14.3.
What components might be found at an air receiver?
a. Draincock, safety valve, and lubricator
b. Draincock, safety valve, and pressure guage
c. Regulator, safety valve, and pressure switch
d. Regulator, lubricator, and check valve
e. Compressor, filter, and lubricator

	Task 15.0	**Inspect and service a concentric ring valve airhead with an unloader.**
	Outcome 15.1.	**Understands the operation of a concentric ring valve airhead.**
	Outcome 15.2.	**Knows the proper tools to use and procedures to follow to clean an airhead.**

A concentric ring valve airhead serves the same purpose as an airhead with finger (reed) valves. Downward movement of the piston pulls the intake ring valve off the air slots, permitting air to rush into the cylinder, while upward movement of the piston lifts the discharge ring valve off a second set of air holes, pushing air into the receiver.

Some concentric ring valve compressors are equipped with an unloader. The unloader mechanism consists of a controller piston that forces the inlet valve off its seat, preventing the cylinder from compressing air.

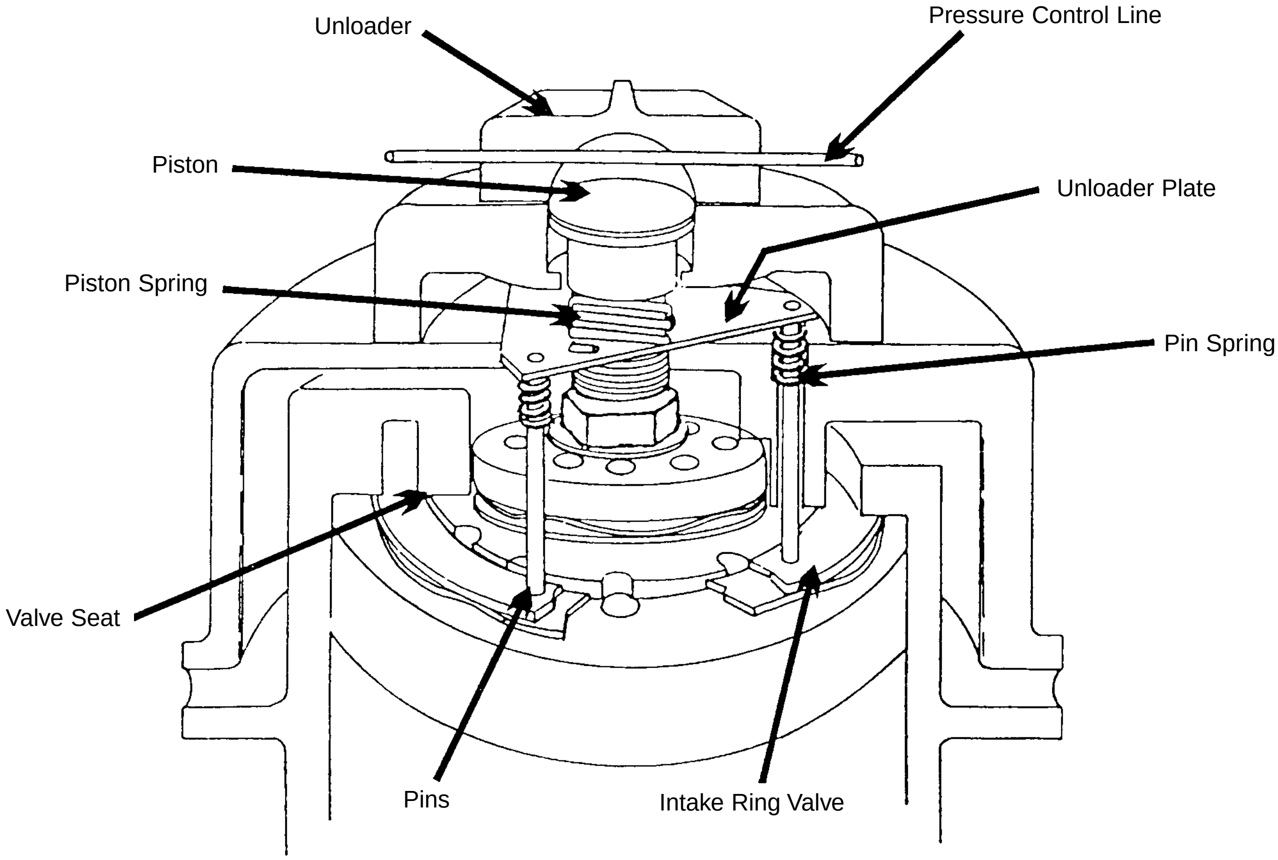


Fig. 22. Concentric Valve Airhead Cutaway (Courtesy of Ingersoll-Rand)

Periodic maintenance of the concentric ring valve airhead consists of removing the valve mechanism and airhead, inspecting the valve parts for wear and grooves, removing carbon deposits, and then following the proper cleaning and assembly procedure. The parts of the concentric ring valve are precision ground, which requires that solvent and a stiff non-wire brush be used to remove carbon and residue. The ring valve and seat should be smooth and flat. Parts that are warped, worn, or grooved must be replaced.

Care must be exercised to thoroughly clean all parts without damage to precision surfaces. Reassembly involves proper lubrication and torquing of screws. Review Tasks 5.0 and 12.0 for further study.

Review: 15.1.

An unloader:

a. holds the exhaust valve open.
b. holds the intake valve open.
c. holds both valves open.
d. blocks off the compressor outlet.
e. shuts off the motor.

Review: 15.2.

A compressor valve assembly may be serviced and reinstalled if:

a. cracked.
b. warped.
c. carboned.
d. pitted.
e. none of the above.

Minor Repairs

Task 16.0	**Remove a broken airhead cap screw.**
Outcome 16.1.	**Knows the procedure for using an E-Z out.**
Outcome 16.2.	**Recognizes the limitations of E-Z outs.**

Removing a broken cap screw is a basic skill that requires center punching, drilling, soaking the cap screw with penetrating oil, using the E-Z Out, and chasing the threads with a plug or bottoming tap. Skill and craftsmanship are required to restore the thread to original condition.

As basic as the skill is, careless work or poor craftsmanship can result in broken tools and a damaged component. For example, center punching the broken cap screw off-center can cause the drill to run out and remove thread material. If the drill bit or E-Z Out breaks, the job becomes more difficult because the tool steel remaining in the bolt cannot be drilled. In both cases the damage is usually irreversible, sometimes requiring drilling and tapping a larger hole or installation of a helical thread replacement.

To remove the broken bolt using an E-Z Out, center punch the bolt to start the drill. It is important that the punch mark be in the center of the bolt to prevent the drill from running out and damaging the threads. Remember, the bolt can be replaced, but the threads in the cylinder cannot.

Soak the bolt with penetrating oil and, if the bolt protrudes enough, tap it several times with a ball peen hammer. This will speed the action of the penetrating oil. Do not strike the cylinder. This can ruin the compressor.

First drill a pilot hole, then a finish hole. The pilot hole allows for some margin of error should the bit break or run off center. The finish hole should be half the size of the bolt, and the pilot drill should be half the size of the finish bit. Hold the drill firmly and square so that the drill follows the center line of the bolt. Drill completely through the bolt but not into the cylinder casting. This will prevent the E-Z Out from bottoming in the hole.

To set the E-Z Out, drive the proper size E-Z Out into the finish hole with a ball peen hammer. It should be tight enough that the sharp edges cut into the bolt but not into the threads. It also has to be tight enough to lead into the bolt when it is turned, and not turn inside the bolt when it is turned counterclockwise to remove the bolt.

To remove the bolt, turn the E-Z Out with a tap wrench or socket and T-handle counterclockwise. The object is to apply an even and controlled torque to remove the bolt. Also know that E-Z Outs break, and when they do, their removal is difficult. If the E-Z Out begins to turn and has not bottomed, drive it farther into the broken cap screw with a ball peen hammer. If the E-Z Out does not turn in the bolt but will not remove the bolt, remove it by turning it clockwise and redrill the hole the next size over to thin the bolt at the threads. Be careful not to drill into the threads.

Review: 16.1.

The purpose for center-punching a broken bolt before drilling is to:

a. loosen the threads.
b. lock the bolt in place.
c. prevent the drill from slipping to one side.
d. make the bolt easier to drill.
e. crack the bolt.

Review: 16.2.

An E-Z Out:

a. is turned counterclockwise.
b. is larger than the bolt to be removed.
c. is made of soft steel.
d. can't slip.
e. will always remove the broken bolt.

Task 17.0	**Remove and clean air compressor intercooler tubes.**
Outcome 17.1.	**Understands the function of intercoolers and aftercoolers.**
Outcome 17.2.	**Knows how to remove and reinstall intercooler tubes to minimize the risk of tube damage.**

The three main types of air coolers are: precoolers, intercoolers, and aftercoolers. Precoolers are heat exchangers that cool the air before it is compressed. Intercoolers are heat exchangers that cool the air between the compressive stages of a multi-staged compressor. Aftercoolers are heat exchangers that cool the air after it has been compressed.

Precoolers and aftercoolers commonly employ water as a medium for heat dissipation, whereas intercoolers commonly use air as the cooling medium. A typical intercooler is composed of three different parts: a fan, fins, and core tube. The fan directs cool air past the heat conduction fins. The fins are metal plates through which the core tube runs and the tubes connect between the compressive stages of a multi-staged compressor.

The intercooler tubes improve the volumetric efficiency of a 2 stage compressor by cooling the air between the first and second stages of air compression. Part of the energy to drive the compressor is used to drive the fan in the compressor wheel, which cools the compressor case and head, and the cooling fins of the intercooler.

The heat of compression is transferred from the hot air to the core tubes, fins, and then to atmosphere. The fan helps by directing a continuous flow of air between the fins and across the tubes. Over time, the air tubes pick up dust which clogs the fins. This cuts down the air flow between the fins and reduces the cooling action. Cleaning involves removing the tubes and taking them to a bench for cleaning.

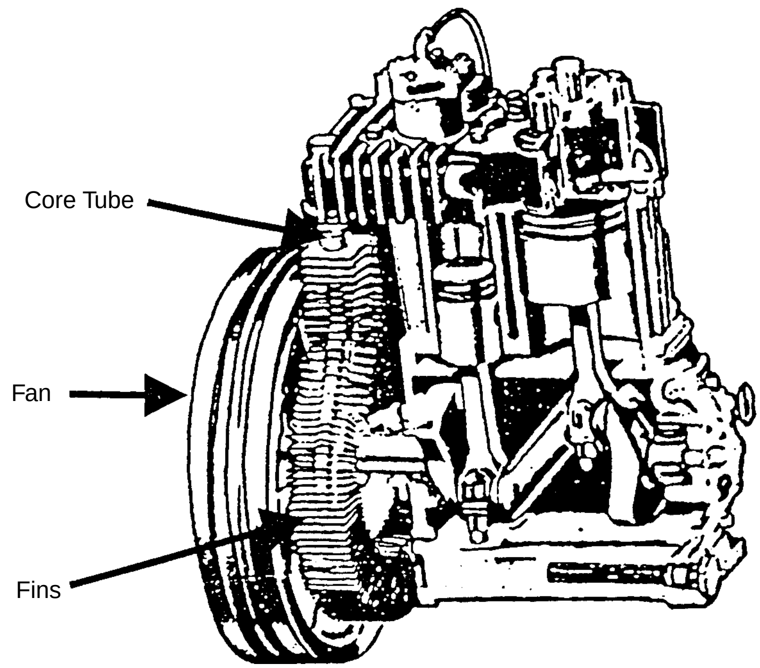


Fig. 23. Air Compressor Intercooler Tubes

WARNING: The first step in starting any compressor maintenance is to lock out the electrical power. Next, ensure that the system is isolated and that all sources of pressure have been completely bled down. Whenever working around compressed fluids, including compressed air, wear safety glasses, even if you believe all of the pressure has been relieved.

When removing the intercooler tubes, care must be taken not to bend or damage the fins. Place the intercooler tubes on a clean workbench. To prevent debris from entering the compressor through the adapter fittings, cap the ports.

Clean the intercooler tubes using compressed air to blow out loose dust that has accumulated between the fins. Dirt that does not blow free can be loosened with a firm non-wire brush. Blow the inside of the tube clear last, and wipe the flare ends clean with a lint free shop towel. Lay out the clean intercooler tubes on the bench for assembly.

Remount the intercooler tubes by installing the innermost tube first. Remove the caps from the ports just before assembling each tube. Coat the outside of each flare with oil. This will reduce the tendency for the flare nuts to twist the flare when the connection is tightened. Hand tighten the flare nuts, and then tighten the flare nut with a flare nut wrench while holding the adapter with an end wrench.

Review: 17.1.
The difference between an intercooler and an aftercooler is:

a. aftercoolers can't be used on two stage compressors.
b. intercoolers use water.
c. the intercooler has less cooling capacity.
d. intercoolers are installed between the compression stages.
e. aftercoolers are smaller.

Review: 17.2.
What will become of dirt which is allowed to enter the intercooler tubes while they are being cleaned? It will:

a. stay there
b. vent to atmosphere
c. be drawn into the first stage
d. be drawn into the second stage
e. go directly into the receiver

Review: 17.3.
Flare fitting assemblies which are not lubricated prior to assembly may:

a. twist and damage the tube when tightened.
b. be overtorqued.
c. not go together.
d. work loose after a few hours.
e. not dissipate heat efficiently.

Task 18.0 **Replace an air hose clamp type fitting.**
Outcome 18.1. **Knows the procedure to correctly assemble a clamp-type fitting on a hose.**

Reusable clamp type fittings are available for both hydraulic and pneumatic hoses. Air hoses make common use of these fittings because they simplify assembly and repair operations in the field. The nipple can be inserted without a vise such as is required with reusable screw type fittings.

Clamp type fittings use a barbed hose end nipple inserted into the hose. Then the clamp is bolted over the hose to grip the nipple. As an added safety feature, the clamp hooks over a retaining groove on the nipple. This position keeps the clamp and nipple together.

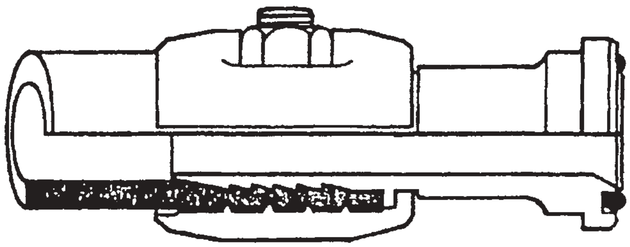


Fig. 24. Clamp Type Hose Fitting

To install the clamp type fitting, first lubricate the nipple with heavy oil. This will allow the nipple to seat without distorting the hose tube. Push the insert into the hose until it bottoms squarely against the end of the hose.

Hook the socket halves into the nipple retaining groove. This helps to retain the hose on the nipple. Line up the bolt shoulders with the socket, and attach nuts and screws uniformly. Align both bolt hexes so that the flats are parallel to the vise jaws, and clamp firmly in a vise. Tighten screws uniformly until socket halves "bottom" on the stop pads. Clean and inspect the assembly.

Review: 18.1.
Lubricating the nipple of a clamp type fitting:

a. is not necessary.
b. is only done when large hose is used.
c. will damage the hose.
d. permits assembly without damaging the hose.
e. is best done with gasket sealer.

Replace Components

"Replace Components" means to exchange one component for another, including scheduled and unscheduled exchange of components on a pneumatic system using approved procedures and without damaging the machine. The essence of the job responsibility is to replace faulty components using change-out procedures. For example, identify the specifications for a faulty air valve and replace the valve with an equivalent replacement valve.

Task 19.0	**Determine specifications from a component code break down.**
Outcome 19.1.	**Understands the specifications available from a component model number.**

Components are ordered from manufacturers using code specifications. This means that to order the component, certain information about its size and operational characteristics is necessary. These same code specifications are given both in the manufacturer's catalog and on the identification tags of respective components. If a component of unknown specifications is encountered, along with the manufacturer's name, the mechanic can determine the specifications of the component by breaking down the code using the manufacturer's catalog literature. Each manufacturer has its own way of assembling model codes. To become proficient in ordering new or replacement components and identifying existing components on a machine, some familiarity with literature from various manufacturers is necessary.

10 - SR - A - AR*- 72 - B - 2 - N - 4 - 8 - 1 -125 - DA

10	Quantity
SR	SR= Single Rod End; DR= Double Rod End
A	Series A
AR*	AR= Air Service; SF= Spring Loaded Teflon "U" Cups
72	Mounting Style
B	B= Bolted Bushing; R= Retainer; K= Key Retainer (Models 72, 74, 77)
2	Rod End Style #1, #2 Std., #4, #6
N	Cushions: R= Rod End Cushioned; C= Cap End Cushioned; B= Both Ends Cushioned; N= Non-Cushioned
4	Bore Dia.
8	Stroke
1	Rod. Dia.
125	Operating Pressure
DA	Action: DA= Double Acting; SAR= Single Acting Pressure on Rod End; SAC= Single Acting Pressure on Cap End

* Temperature limitations for Buna cups 180° F; for spring loaded Teflon cups -50° F to +450 F.

* 1-1/2" bore, 1" rod; 2" bore, 1-3/8" rod; 2-1/2" bore, 1-3/4" rod models are not available with piston "U" cup design. Seal ring construction is furnished in these bore and rod combinations.

Fig. 25. Typical Air Cylinder Model Code Breakdown

Of particular importance to pneumatic components is the C_v (flow) rating. The coefficient of velocity (C_v) is a constant for each flow path through a component. Because of the compressibility of air, the flow rate and pressure drop across a component is in direct proportion to the C_v value. Therefore, the higher the C_v, the more air the component will pass.

The C_v rating of a valve is not readily apparent by visual examination. C_v ratings for valves are tested and published by manufacturers. When selecting replacement components, be careful to correctly identify the existing component's C_v, so that the replacement will match the current valve.

Review: 19.1.

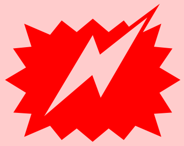
Air valves with 1/2 inch ports:

a. all have the same air flow rating.
b. have a higher pressure drop than 3/8 inch valves.
c. could have C_V's falling over a wide range.
d. are too small for cylinders with 3/4 inch ports.
e. are usually made of steel.

Review: 19.2.

The C_V rating of a valve indicates:

a. the valve port size.
b. the air flow rating.
c. the material used in the valve.
d. how rapidly the valve shifts.
e. the quality of the valve.



Task 20.0 **Identify components from a circuit schematic.**
Outcome 20.1. **Distinguishes between graphic, pictorial and cutaway drawings.**
Outcome 20.2. **Identifies components from a graphic circuit schematic.**

There are three types of fluid power drawings: pictorial, cutaway, and graphic symbol diagrams. These three types of representations for components and circuits are used to communicate how the fluid power circuit is constructed and operates. The most common symbols are the standard graphic symbols.

Graphic symbols show connections, flow paths, and functions of components represented. They can indicate conditions occurring during transition from one flow path arrangement to another. Symbols do not indicate construction, nor do they indicate values, such as pressure, flow rate, and other component settings.

Pictorial diagrams show the general location, function and appearance of parts and assemblies through component drawings.

Cutaway diagrams show the positions of parts and assemblies for components in more detail and how they operate in a circuit. Their use is limited to individual components.

To identify components in a circuit diagram, each basic symbol must be recognized. This requires some memorization of the symbols. Once understood, however, the symbols lead to an understanding about how each component functions, how the fluid power system operates, and how components interact with each other.

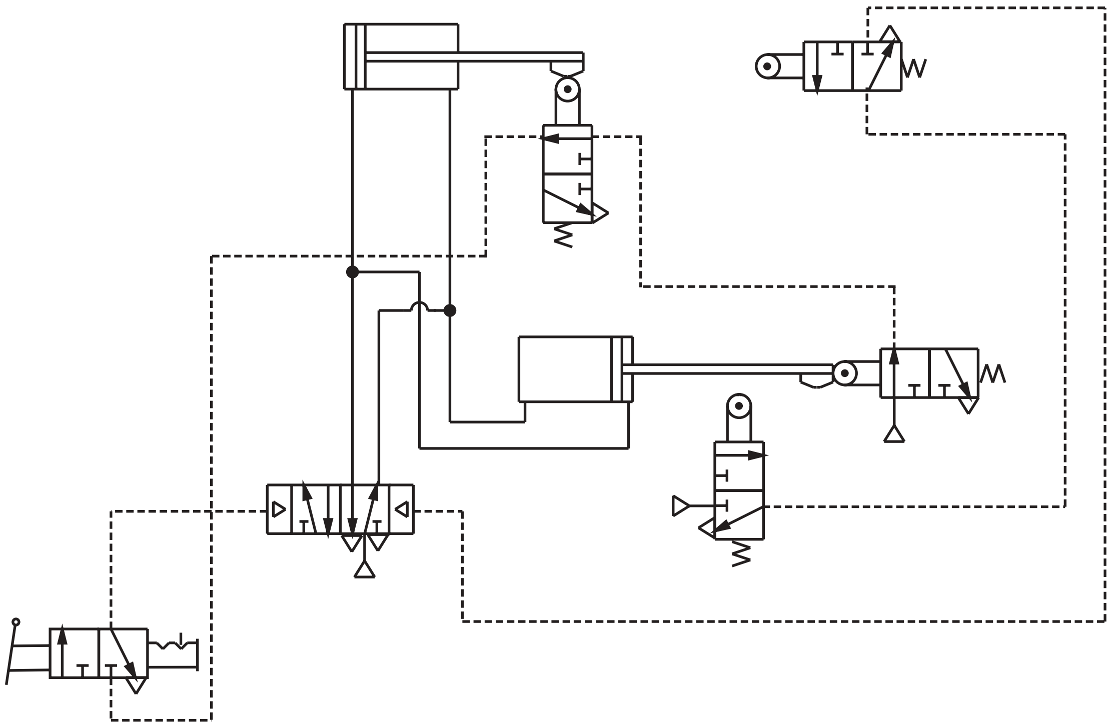


Fig. 26. Sample Pneumatic Circuit Schematic

Review: 20.1.

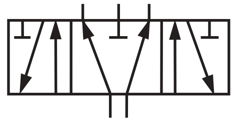
Which is the most common symbol system used to show information regarding component and circuit operation?

a. Pictorial drawings
b. Cutaway
c. Graphic symbols
d. Manufacturing prints
e. Isometric diagram

Review: 20.2.

This symbol is a:

a. directional valve.
b. compressor.
c. air motor.
d. pressure regulator.
e. air receiver.



Replace Coponents

Task 21.0	**Make up and install an air piping system with four elbows and a union.**
Outcome 21.1.	**Knows the advantages and disadvantages of using steel pipe, plastic pipe, copper tube, hose, or manifolds for conveyance of compressed air.**
Outcome 21.2.	**Knows the proper procedure for measuring tapered thread pipe lengths to fit an existing assembly.**
Outcome 21.3.	**Understands how to size and install air lines.**

Installing an air piping system requires basic plumbing skills. These include laying out a piping system, taking measurements, figuring the lengths of pipe runs, and assembling the piping system using approved methods of sealing and mounting the pipe. As straightforward as this task seems to be, it requires considerable skill to assemble a piping system that is both functional as well as correct in layout, alignment, and craftsmanship. Also, there are a number of inherent problems with piping systems that must be avoided.

Several important terms used in pipe measurement are defined here:

<u>Center-to-center length (C-C)</u> - the distance between the centers of two pipes to be joined at an angle, for example by an elbow, tee, or 45 degree fitting.

<u>Face-to-face length (F-F)</u> - the distance between the two fittings that are to be joined by a length of pipe. The face-to-face length must be added to the lengths at each end that are necessary to join the pipe inside the fittings.

<u>Make-up length (M.U.L.)</u> - the length necessary to join the pipe to the fittings. Add the make-up length at each end of the pipe to the face-to-face length to arrive at the length of pipe needed for assembly.

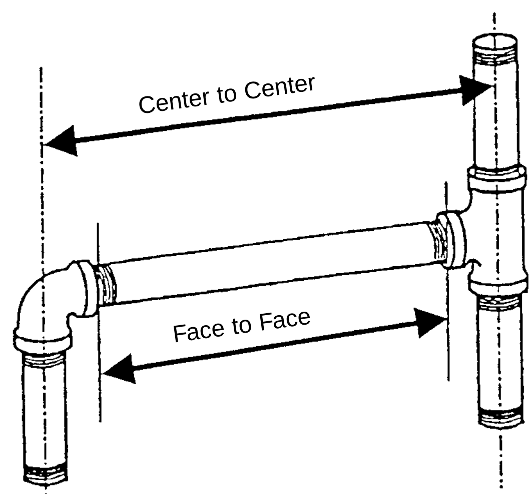


Fig. 27. Pipe Measurements

Pneumatic systems may utilize ABS plastic pipe, steel pipe, copper tubing or hose for conveyance lines. Plastic pipe is lightweight and easy to install. It does not require threading since the ends are glued together. The installations are, however, permanent and cannot be reused.

Iron pipe must be threaded. It may be disassembled and reused but is heavy and difficult to assemble. Fabrication of threaded pipe systems is slower and requires far more fittings than a tubing assembly. Galvanizing may flake off the inside of galvanized pipe thereby contamination components located downstream.

Copper tubing may be bent to fit the machine or structure involved. Several sections of copper tubing can be connected to each other by soldering (sweating) them together with unions, tees, and crosses. Threaded unions may also be used to assemble copper tube systems. One disadvantage to copper tubing is that the line is subject to external damage and must be protected. In order to connect copper tubing to a component, the ends may be flared for use with a flare type fitting, or a compression fitting may be used. An advantage of copper tubing is that is will not rust.

Replace Coponents

Warning: PVC piping should not be used in pneumatic systems. When PVC pipe fails it shatters into pieces, creating a safety hazard. ABS piping is acceptable for use in pneumatic systems.

Hose is used where relative movement between components is required. Hose should be avoided if possible for permanent, non-moving applications.

Regardless of the type of material used, the proper size conductor must be selected to carry the required air flow without excessive pressure losses. Tables are available for sizing air lines. Pipelines should be installed with a downward slope of 1/8 inch to 1/4 inch (1% to 2%) per foot of run in the direction of flow. This drains condensation away from the receiver. Drain legs must be installed to capture this moisture.

The greatest source of damage when using pipe is over-tightening. A second source of problems is the improper use of sealants that migrate through the system and terminate in air valves and other components. Caution should be used when connecting pipe. Since the pipe threads are tapered, over-tightening may cause the component housing or fitting with the internal thread to rupture. The use of Teflon paste as a sealant, rather than Teflon tape, is encouraged.

Threaded pipe is always installed using two pipe wrenches, one to hold the stationary pipe fitting and the other to turn the pipe run. The only exception is when a pipe run is threaded into a stationary machine member or rigidly mounted component. The installation of pipe unions allow disassembly of sections of piping systems without having to disassemble each fitting and piece of pipe.

Review: 21.1.
Air distribution lines should:

a. be horizontal.
b. slope away from the compressor.
c. slope towards the compressor.
d. have valleys and water traps.
e. be run on a 45 degree angle.

Review: 21.2.
If a pipe to be installed between two fittings is cut to the same dimension as the face-to-face measurement between the fittings, the pipe will:

a. be too long.
b. be the right length.
c. fit after being threaded.
d. work if a union is installed.
e. be too short.

Review: 21.3.
Copper tubing:

a. is not suitable for air lines.
b. corrodes if water is present in the air.
c. can be bent to fit the machine.
d. is threaded using a straight (parallel) thread.
e. won't seal above 50 psi.

Troubleshooting

The purpose of this job responsibility is to find and fix the failure. What the troubleshooter does is focus attention on the symptoms, formulate problem statements that account for these symptoms, and then follow a procedure to identify the component or condition that is causing the problem.

Task 22.0	**Determine why an air cylinder "fails to move the load" or "moves the load too slowly."**
Outcome 22.1.	**Calculates cylinder area and force capability.**
Outcome 22.2.	**Identifies symptoms of leaking seals in an air cylinder.**

Air cylinders are sized to move static loads, overcome friction loads, make up for the drop in air pressure between the air line and the cylinder, make up for the pressure drop within the cylinder as it extends and retracts, and generate additional force to overcome back pressure loads (on the opposite side of the piston).

A common practice in sizing an air cylinder is to estimate the air pressure at the cylinder ports to be 90% to 95% of the line pressure.

The bore of air cylinders is typically oversized 25% to 30% to account for seal friction, mechanical friction, and pressure drop within the cylinder as it extends and retracts. This has the effect of increasing the force available from the cylinder by 50% to 70%. For example, increasing a 4 inch diameter cylinder to 5 inches increases the area from 12.6 to 19.6 square inches, which represents an increase in area of 56%.

Back pressure loads are figured separately. (For example, some meter-out circuits and mufflers induce back pressure loads as the cylinder extends). If the cylinder is not oversized to account for this resistance, the supply pressure will have to be increased for the cylinder to have the required velocity and force.

If an air cylinder "fails to move the load", the following problems could be present:

1. The load is too great - Compute the force available from the cylinder and match it against the force required to move the load resistance. Here the force available from the cylinder is computed from the line pressure and effective area of the cylinder (extending or retracting).

2. The load resistance is binding - This increases the force required to move the load.

3. The cylinder is undersized - This could also be the case if the load moves too slowly because the pressure typically drops when the load extends at rated speed.

4. The cylinder rod is over-extended - This cocks the cylinder and would occur on the return stroke. Check to see if the cylinder has a shock pad on the rod side to limit the stroke.

5. The cylinder barrel is bent or dented, binding the piston - check the barrel for external damage. The piston can bind if the load exerts a side thrust, causing the piston to gall the cylinder barrel. The rod bushing usually will be worn if this condition has been present for some time.

6. The piston seal is blown - on a single acting cylinder, air will be heard escaping through the vent on the rod side of the cylinder. On double acting cylinders, remove one of the connections to the cylinder, and test for escaping air. Feeling or listening for air leaks can be hazardous. It is safer to test for air leaks by using a

brush to apply a soapy water solution. The formation of bubbles will indicate a leak. Be sure to actuate the directional control valve in the proper direction.

7. There are several internal parts that could be malfunctioning, either because they are worn out, or because they were installed incorrectly. These include:

   a.) The compression spring is damaged (on single-acting cylinders).
   b.) The cup seal worn, not tight on the piston, or mounted on the piston facing the wrong way.
   c.) The bearing bushing is worn allowing air to leak past the seal.
   d.) The air vent clogged (on single acting cylinders).

"Slow movement" is more difficult to pinpoint. The cylinder moves the load but at a rate slower than specified. Remember that a pressure drop occurs within the cylinder as it extends and retracts, and the extent of this drop may be difficult to measure. The following procedure is recommended to determine the cause of slow pneumatic cylinder operation:

1. First, check those items that relate to the cylinder in #6 and #7 above.

2. If the load moves, but moves slowly, the solution could be to adjust the air flow. The air lines could be undersized, failing to deliver the required flow. Line volume must be considered since the lines must fill and evacuate each time the cylinder cycles.

3. Check the cylinder being used against charts that estimate the cycle rate for the economical range of operation. This takes into account the size of the control valve, pressure range, and load.

4. Check to see if the cylinder is subjected to side thrusts that could cause partial binding. Disconnect the cylinder, and check the rod bushing. See if the cylinder is cocking.

5. Determine if, over time, additional load or friction has been added to the load that the cylinder was not originally sized to move. Disconnect the cylinder, and verify that the load is not binding. The load may be too heavy to move by hand.

6. If a meter-out circuit is used, determine that the adjustment is correct. If a muffler is used, be sure it is not clogged or obstructed.

7. Check for restrictions in the inlet line. Pressure could be correct at the inlet, but restrictions could lower the pressure below specifications by the time air reaches the cylinder ports.

8. Make sure the directional control valve is shifting completely. If it is not, the air supply will be reduced.

9. See if the circuit matches the original design. Occasionally, changes are made without amending original circuit diagrams.

10. Finally, check to see that the cylinder is sized to do the job. It could have been downsized during a changeover. Use the following rule of thumb procedure:

    a.) Figure the pressure at the cylinder ports at 90% of supply pressure.
    b.) Determine the force load, and add 20% for friction.
    c.) If there are back-pressure loads, these are added to the force and friction loads.
    d.) Compute the bore size based on 150% of the total force consisting of force load, friction load, and back pressure load.
    e.) From the cycle rate, compute the required delivery in free air, and then be sure the compressor and lines are sized to deliver this flow rate.
    f.) Finally, check the cylinder bore and required flow against the specifications of the existing cylinder.

Review Task 9.0 for further study and to review the equations used to calculate cylinder areas and forces.

Review: 22.1.
An air cylinder has a 2 inch bore and 1 inch rod. Air is available at 100 psig. What is the maximum extension and retraction force available from the cylinder?

a. 200 lb., 100 lb.
b. 314 lb., 100 lb.
c. 400 lb., 78 lb.
d. 200 lb., 78 lb.
e. 314 lb., 235 lb.

Review: 22.2.
A leaking rod seal will:

a. reduce cylinder extension force.
b. reduce cylinder retraction speed.
c. reduce both extension and retraction forces.
d. be detectable during cylinder extension.
e. cause rod bushing failure.

Review: 22.3.
With no flow controls and ignoring friction, an air cylinder with a 3 inch bore and 1 inch rod which must move 353 pounds on extension and 314 pounds on retraction will:

a. extend and retract at the same speed.
b. extend faster than it will retract.
c. retract faster than it will extend.
d. extend but never retract.
e. retract but never extend.

Task 23.0	**Determines why a solenoid operated directional control valve fails to operate.**
Outcome 23.1.	**Recognizes symptoms of air valve failures and their causes.**
Outcome 23.2.	**Understands the operation of pilot operated directional valves.**

Some pneumatic valves utilize seals in the spool or in the bore to prevent leakage. These lightweight valves may be either directly actuated by solenoids, pilot operated, or mechanically actuated. Solenoids are used on pilot valves to shift larger directional valves.

Valve seals may deteriorate, causing binding. Solenoid failures and contamination may also render a valve inoperable. A general trouble-shooting procedure will lead to identification of the problem. To determine the reason an air solenoid valve fails to shift, use the following procedure:

- Check the voltage to the solenoids when the valve is actuated. Be sure both solenoids are not operated at the same time. Attach pilot lights to the solenoids. The lights should not illuminate simultaneously.

- Check that the manual override will shift the valve. If it will not, the valve is stuck, either from binding, or from obstructions to the spool.

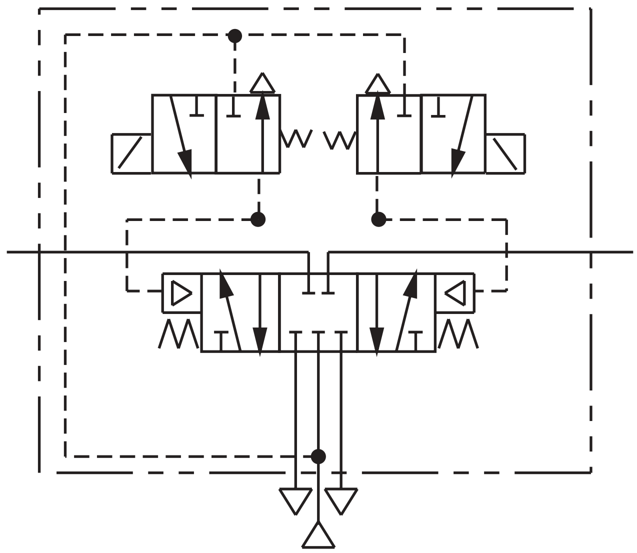


Fig. 28. Pilot Operated Pneumatic Directional Control Valve

- Loosen the mounting screws to see if this releases a stuck valve. Uneven mounting surfaces will twist the housing and can cause the valve to bind.

- If the solenoid valve operates the pilot stage, the pilot passages to the main spool could be plugged. First determine that the main valve shifts without obstruction, then shift the pilot valve. If the pilot valve shifts but the main power valve does not, check the pilot ports. Shop air can be used to shift the main valve to check for pilot port obstructions, but this may not clear the ports.

- Check the ambient temperature. Occasionally solenoid valves are placed in an environment that is too hot or too cold. Heat breaks down the insulation. Cold causes valve parts to shrink; lubrication becomes too viscous; and the solenoid cannot shift the valve.

- Check the incoming air line to be sure that pilot pressure is at the rated setting. Low air pressures will not shift some pilot operated main valves. Another way to solve this problem is to switch to external pilots.

- Sometimes failure of the valve seals will allow sufficient bypass leakage that the cylinder or motor will not operate. This may be blamed on a stuck valve, when actually the problem is a blown valve seal. To check for leaking valve seals, disconnect the pressure ports to the cylinder and plug the lines. Then shift the valve through both positions. Leaks to the exhaust port are caused by air flowing across the seals on the valve spool.

- Solenoid operated pneumatic directional valves may be fitted with either AC or DC solenoids. Both high and low voltage will overheat an AC coil. Voltage levels of plus or minus 10% are considered high and low, respectively. Over voltage increases the shifting force exerted by the solenoid, but shortens its life. Low voltage decreases the solenoid force. Thus, it may not complete its full travel distance. When an AC solenoid is energized, high inrush current exists until the armature usage shifts completely. Once the armature has completely shifted, the current drops to a much lower holding current. If the armature cannot shift completely, due to a low voltage condition or an obstructed valve spool, a humm or buzz may be heard. The coil will soon burn out due to the high current draw. DC coils are not subject to high inrush conditions, but DC coils may still burn out if they are subjected to overvoltage.

Review Task 7.0 for further study and discussion of pneumatic directional valves.

Review: 23.1.
If the air supply is shut off to a directly actuated solenoid air valve, the valve should:
a. not shift.
b. shift normally.
c. shift slowly.
d. shift rapidly.
e. work with manual overrides only.

Review: 23.2.
If the air supply is shut off to a pilot operated solenoid air valve, the valve should:
a. not shift.
b. shift normally.
c. shift slowly.
d. shift rapidly.
e. work with manual overrides only.

Review: 23.3.
A "humming" AC solenoid may indicate that the:
a. solenoid is shorted.
b. solenoid is open.
c. valve has not shifted completely.
d. DC power is being sent to an AC solenoid.
e. valve is being shifted too rapidly.

Task 24.0 **Determines why an air motor has a low stall torque or fails to reach its rated speed.**

Outcome 24.1. **Knows the causes of air motor failure.**

Outcome 24.2. **Understands the importance of conditioned air for proper air motor operation.**

Air motors provide smooth, clean, safe, explosion-proof, vibration free power. They can be stopped, started, stalled, and reversed many times without damage. Air motors do not burn out, and their power-to-weight ratio is higher than their electric motor counterparts. Compressed air is available in most plants, providing a ready source to convert pressurized air to mechanical power by simply connecting and conditioning the air to the motor.

Most problems with air motors can be traced to abuse or lack of maintenance. These would include:

a. Foreign materials in the motor
b. Misalignment
c. Corrosion
d. Improper lubrication

The motor must be supplied with clean and relatively moisture-free air. The motor also must be lubricated. When the motor has not been used for an extended period of time, internal parts may corrode, stick, and generate rust, seizing the unit.

Symptoms of malfunctioning include:

a. Slow operation
b. Low torque
c. Both slow operation and low torque

Air motors which operate slowly or at low torque should be checked. The following list represents items that should be checked:

- Air pressure to motor
- Obstructed outlet
- Damaged lines
- Restricted filter or water in filter
- Choked flow controls
- Load binding or misalignment

Refer to Task 8.0 for further study.

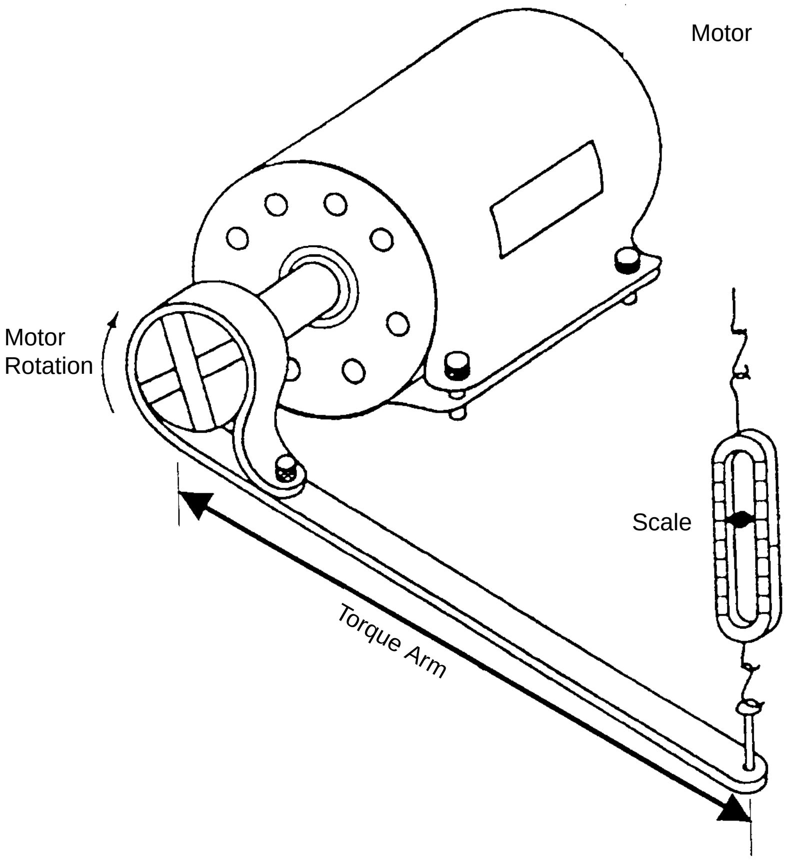


Fig. 29. Motor Torque

Review: 24.1.
Air motors may run too slowly if:

a. the filter is plugged.
b. the muffler frosts over.
c. the air line is damaged.
d. the vanes are stuck in their slots.
e. all of the above.

Review: 24.2.
Air motors should be supplied with air which is:

a. dry
b. cool
c. lubricated
d. filtered
e. all of the above

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Solutions to Review Questions and Problems

Review #

1.1. c.

1.2. b.

1.3. b.

1.4. b.

2.1. b.

2.2. e.

3.1. d.

3.2. e.

3.3. d.

4.1. b.

4.2. e.

5.1. b.

5.2. e.

Equation 1 must be solved for force.

(Eq. 1) **T = F x L**

The lever arm involved here is 1 ft. (12"). Since a torque of 60 lb-ft is needed, we solve for force: Force = Torque / Lever Arm.

Force = 60 lb-ft / 1 ft. = 60 pounds.

6.1. b.

6.2. c.

6.3. b.

7.1. c.

7.2. d.

8.1. d.

8.2. d.

Equation 2 must be solved.

(Eq. 2) **T = (PSI x CIPR x Eff) / 6.28**

Torque = 100 psig x 10 CIPR x 0.8 / 6.28 = 127 lb-in

9.1. c.

Equations 3 and 4 apply.

(Eq. 3) **F = P x A**

(Eq. 4) **A = D^2 x 0.7854**

The piston area is found from Equation 4 to be (2") = 3.14 sq-in. Then Equation 3 is written such that P = F / A, so Pressure = 200 lb. / 3.14 sq-in = 64 psig.

9.2. a.

Equations 4, 5, and 8 apply.

(Eq. 4) **A = D^2 x 0.7854**

$Area_{piston}$ = 3.14 sq-in

$Area_{rod}$ = 0.79 sq-in

(Eq. 5) **AA = PA - RA**

= 3.14 sq-in - 0.79 sq-in
= 2.35 sq-in

(Eq. 8) **V = A x S**

$Volume_{extending}$ 3.14 sq-in x 8” = 25.1 cu-in

$Volume_{retracting}$: = 2.35 sq-in x 8” = 18.8 cu-in

The volume to cycle is the sum of these values, 43.9 cu-in of air.

9.3. b.

9.4. d.

Equation 6 is used to convert between gauge and absolute pressure.

(Eq. 6) **PSIA = PSIG + 14.7**

20 psig + 14.7 = 34.7 psia.

9.5. e.

Equation 7 is solved for pressure.

(Eq. 7) **PSID = in-Hg / 2.03**

10 in-Hg / 2.03 = 4.93 psid = 4.93 psig.

This represents the difference between atmospheric and suction cup pressure and determines how much can be lifted.

Equation 4 is used to find cup area.

(Eq. 4) **D^2 x 0.7854**

$(3”)^2$ x 0.7854 = Area = 7.07 sq-in

Equation 3 is used to calculate the force.

(Eq. 3) **F = P x A**

4.93 psig x 7.07 sq-in = 34.8 lb.

10.1. b.

10.2. d.

11.1. c.

11.2. b

Equation 10 is used to solve for compression ratio.

(Eq. 10) **CR = IV / FV**

CR = 8 cu-in / 1 cu-in = 8:1

Equation 6 must be used to convert the inlet air to absolute pressure.

(Eq. 6) **PSIA = PSIG + 14.7**

P_1 (inlet air) = 0 psig + 14.7 = 14.7 psia

Equation 9 is solved for final pressure (psia).

(Eq. 9) $P_1 \times V_1 = P_2 \times V_2$

Rewritten: $P_2 = \frac{P_1 \times V_1}{V_2}$

Uncompressed air is assigned as "initial" air designated by the "1" subscript. Compressed air is the "final" or "2" air.

P_2 = 14.7 psia x 8 = 117.6 psia

Now equation 6 is used to convert 117.6 psia back to gauge pressure by subtracting 14.7.

PSIA = PSIG + 14.7

Rewritten: PSIG = PSIA - 14.7 =
117.6 psig - 14.7 = 102.9 psia

11.3. b.

Equation 9 rewritten as below is solved for the initial volume.

(Eq. 9) $V_1 = P_2 \times V_2 / P_1$

If P_1 is uncompressed air (14.7 psia), then V_1 is the uncompressed volume being sought. P_2 = 100 psig + 14.7 = 114.7 psia and V_2 = 10 cfm.

$V_1 = P_2 \times V_2 / P_1$ =114.7 psia x 10 cfm / 14.7 psia = 78 scfm.

11.4. c.

11.5. a.

12.1. c.

12.2. b.

13.1. d.

13.2. a.

14.1. c.

Equation 6 must be rewritten to solve for gauge pressure.

(Eq. 6) **PSIG = PSIA - 14.7**

100 psia - 14.7 = 85.3 psig.

14.2. b.

Working in inches, the area of the receiver is found using Equation 4.

(Eq. 4) Area = $(18")^2$ x 0.7854 = 254.5 sq-in

Volume is found from Equation 8.

In this case stroke and length are equivalent, so volume **V = A x S**

254.5 sq-in x 48" = 12,215 cu-in

Since this isn't an answer choice, divide by 1728 (the number of cubic inches in a cubic foot) to translate 12,215 cu-in to 7.07 cu-ft.

14.3. b.

15.1. b.

15.2. c.

16.1. c.

16.2. a.

17.1. d.

17.2. d.

17.3. a.

18.1. d.

19.1. c.

19.2. b.

20.1. c.

20.2. a.

21.1. b.

21.2. e.

21.3. c.

22.1. e.

Equation 4 is solved for piston and rod area.

(Eq. 4) $A_{piston} = D^2 \times 0.7854$ = $(2")^2$ x 0.7854 = 3.14 sq-in

A_{rod} = $(1")^2$ x 0.7854 = 0.79 sq-in

Equation 5 is used to find rod end area.

(Eq. 5) **AA = PA - RA** = 3.14 sq-in -0.79 sq-in = 2.35 sq-in

Equation 3 is solved for extension and retraction forces.

(Eq. 3) **F = P x A**

$F_{extention}$ = 3.14 sq-in x 100 psig = 314 lb.

$F_{retraction}$ = 2.35 sq-in x 100 psig = 235 lb.

22.2. b.

22.3. c.

The same pressure is required to extend and retract. As in Problem 22.1, the areas must be calculated from Equations 4 and 5.

Equation 4 is solved for piston and rod area.

(Eq. 4) **A = D^2 x 0.7854**

A_{piston} = 7.07 sq-in.
A_{rod} = 0.79 sq-in.

Equation 5 is used to find rod end area.

(Eq. 5) **AA = PA - RA**

7.07 sq-in - 0.79 sq = in = 6.28 sq-in

From Equation 3, the pressure to extend and retract is calculated.

Equation 3 is solved for extension and retraction forces.

(Eq. 3) **F = P x A**
Rewritten: P = F / A

$P_{extention}$ = $F_{extending}$ / $A_{piston\ area}$ = 353 lb. / 7.07 sq-in = 50 psig.

$P_{retraction}$ = $F_{retracting}$/ AA =314 lb. / 6.28 sq-in = 50 psig

Since the cylinder requires the same pressure in both directions, the air flow rate will be the same in both directions. The cylinder has a smaller area on the rod end and hence a smaller volume. This means that the rod side of the cylinder will fill faster, hence the cylinder retracts faster.

23.1. b.

23.2. a.

23.3. c.

24.1. e.

24.2. e.

Introduction

Pre-tests are used to evaluate candidate preparedness for certification tests. Pre-tests may be either taken individually or in a group setting such as during a Review Training Session (RTS). As a part of an RTS, Pre-tests are used to allow the instructor to tailor the subject matter coverage to the needs of the audience. When a candidate is studying individually or in a small group, pre-tests provide insight into which areas require further study and whether the candidate should consider other study options, such as an RTS.

Included in this manual are three separate pre-tests for the Pneumatic Mechanic certification test. Each pre-test has its own separate answer sheet which appears at the end of the pre-tests. Individual pre-tests are numbered PS-1, PS-2, and PS-3. The answer key for all three pre-tests appears at the end of the manual.

Candidates are encouraged to take a pre-test early in the study process. Pre-tests should be taken under timed conditions. A maximum of forty-five minutes should be allotted for each pre-test. This should be sufficient time to answer all twenty-five questions on the pre-test. The results of the pre-test will guide the candidate to one of four possible courses of action regarding tests preparation.

1. Take the test: Preparation is sufficient.
2. Study the material using the Study Manual.
3. Attend a Review Training Session (RTS): Preparation is good, but not sufficient to pass the test.
4. Participate in a formal (general) course: A Review Training Session would not provide adequate preparation to pass the test.

Additional pre-tests should be taken after individual study or attendance at an RTS to further evaluate test readiness. In some instances, it may be desirable to take all three pre-tests at different times during the study process to better access preparedness and effectiveness of study.

The answer sheets provided have been developed such that each question is referenced to a particular subject matter area of the study manual and of the test. The candidate is encouraged to fold the answer sheet vertically along the dotted line before taking the pre-test. This will eliminate any bias that may occur by having the appropriate outcome statement appear with the answers and more closely mimics actual test conditions. After checking the answers, the answer sheet may be opened to reveal the areas where further study is needed. This should enable directed study in the areas where a deficiency exists.

Candidates should be advised that each pre-test covers only a representative sample of the types of questions found on the test. Due to the need to keep the pre-test brief, not all subject matter is covered on every pre-test. Thorough preparation for the certification test is strongly encouraged.

The experience of taking pre-tests under timed conditions should reduce test anxiety associated with the actual certification test. If necessary, candidates may wish to retake the pre-tests after some period of time has elapsed to recheck their knowledge.

Suggestions or comments for improvements of these pretests and other certification materials should be sent to:

Fluid Power Certification Board
c/o FPS
3245 Freemansburg Avenue
Palmer, PA18045-7118
Tel: 610-923-0386,
Fax: 610-923-0389 E-mail: FPS@IFPS.ORG

Pneumatic Mechanic Certification Pre-Test - 1

1. Static filtration involves:

   a. cooling the air to its dew point.
   b. swirling the air.
   c. passing the air through a porous media.
   d. using a 10 micron filter element.
   e. removing water from the air.

2. Air pressure regulators determine the maximum pressure:

   a. at the compressor.
   b. downstream of the regulator.
   c. in the receiver
   d. in the aftercooler.
   e. upstream of the regulator.

3. Which part of the lubricator causes the pressure drop?

   a. Oil tube
   b. Needle Valve
   c. Flow guide
   d. Venturi
   e. bowl pressurizing valve

4. A lubricator will not function if the:

   a. bowl is only half full of oil.
   b. needle valve is open too far.
   c. drain valve is stuck shut.
   d. bowl pressurizing valve is open.
   e. air flow rate is too low.

5. A detergent in the oil will:

   a. force contaminants to settle out of the oil.
   b. hold contaminants in suspension.
   c. clean the oil filter.
   d. cause the compressor to use more oil.
   e. extend the oil change interval.

6. The "grade number" of a bolt:

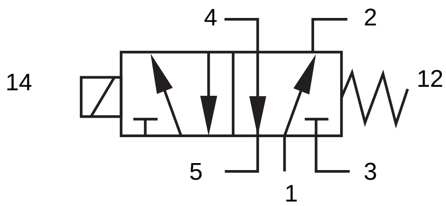
   a. indicates whether it has coarse or fine threads.
   b. is an indication of hardness.
   c. is the proper torque value in foot-pounds.
   d. indicates whether or not it is plated.
   e. predicts how many times the bolt may be reused without failure.

7. The gauge on an air regulator indicates the pressure:

   a. at the inlet.
   b. at the outlet.
   c. between the inlet and outlet.
   d. in the spring chamber.
   e. at the compressor.

8. Which port would be fitted with a restrictor to achieve meter-in flow control for both extension and retraction of a double acting cylinder?

   a. Port 2
   b. Port 4
   c. Port 1
   d. Port 3
   e. Port 5



9. An air motor which runs on unconditioned air will:

   a. run too fast.
   b. run too slow.
   c. not run at all.
   d. experience premature wear.
   e. blow up.

10. Calculate the pressure needed to extend a 2 inch bore cylinder raising a 200 pound load.

    a. 200 psig.
    b. 100 psig.
    c. 64 psig.
    d. 32 psig.
    e. 20 psig.

11. V-Belts transmit power to/from pulleys:

a. at the larger pulley only.
b. along the sides of the belt.
c. at the top edge of the belt.
d. at the bottom of the belt.
e. along the small pulley only.

12. A start-stop control is typically used when the compressor has a duty cycle below:

a. 10%.
b. 30%.
c. 50%.
d. 70%.
e. 90%.

13. Over torquing a compressor cylinder head will:

a. help the gasket seal better.
b. improve compressor performance.
c. possibly break a stud.
d. improve heat dissipation.
e. allow the compressor to operate faster.

14. Impact wrench speed is controlled by the:

a. pressure at inlet.
b. size of air line.
c. inlet pressure at the regulator.
d. air flow rate.
e. reversing valve.

15. A pressure of 100 psia converts to a gauge pressure of:

a. 114.7 psig.
b. 100.0 psig.
c. 85.3 psig.
d. 14.7 psig.
e. 0 psig.

16. An unloader:

a. holds the exhaust valve open.
b. holds the intake valve open.
c. holds both valves open.
d. blocks off the compressor outlet.
e. shuts off the motor.

17. The purpose for center-punching a broken bolt before drilling is to:

a. loosen the threads.
b. lock the bolt in place.
c. prevent the drill from slipping to one side.
d. make the bolt easier to drill.
e. crack the bolt.

18. The difference between an intercooler and an aftercooler is:

a. aftercoolers can't be used on two stage compressors.
b. intercoolers use water.
c. the intercooler has less cooling capacity.
d. intercoolers are installed between the compression stages.
e. aftercoolers are smaller.

19. Lubricating the nipple of a clamp type fitting:

a. is not necessary.
b. is only done when large hose is used.
c. will damage the hose.
d. permits assembly without damaging the hose.
e. is best done with gasket sealer.

20. Air valves with 1/2 inch ports:

a. all have the same air flow rating.
b. have a higher pressure drop than 3/8 inch valves.
c. could have C_V's falling over a wide range.
d. are too small for cylinders with 3/4 inch ports.
e. are usually made of steel.

21. Which is the most common symbol system used to show information regarding component and circuit operation?

    a. Pictorial drawings
    b. Cutaway
    c. Graphic symbols
    d. Manufacturing prints
    e. Isometric diagram

22. Air distribution lines should:

    a. be horizontal.
    b. slope away from the compressor.
    c. slope towards the compressor.
    d. have valleys and water traps.
    e. be run on a 45 degree angle.

23. An air cylinder has a 2 inch bore and 1 inch rod. Air is available at 100 psig. What is the maximum extension and retraction force available from the cylinder?

    a. 200 lb., 100 lb.
    b. 314 lb., 100 lb.
    c. 400 lb., 78 lb.
    d. 200 lb., 78 lb.
    e. 314 lb., 235 lb.

24. If the air supply is shut off to a directly actuated solenoid air valve, the valve should:

    a. not shift.
    b. shift normally.
    c. shift slowly.
    d. shift rapidly.
    e. work with manual overrides only.

25. Air motors may run too slowly if:

    a. the filter is plugged.
    b. the muffler frosts over.
    c. the air line is damaged.
    d. the vanes are stuck in their slots.
    e. all of the above.

Pneumatic Mechanic Pre-Test - 1 Answer Sheet

Preventive Maintenance

Outcome:		Page	Answers
1.1	Knows the contaminants which must be removed from the flow of compressed air.	6	1. A B C D E
2.1	Knows the purpose of a pressure regulator.	9	2. A B C D E
3.1	Understands how an air lubricator works.	11	3. A B C D E
3.2	Knows how air lubricators are sized.	11	4. A B C D E
4.1	Understands fluid properties and how they affect the suitability of an oil for use in a compressor.	13	5. A B C D E
5.2	Knows how bolt size and strength affect torque values.	15	6. A B C D E

Assemble Components

6.2	Understands the operation of venting and non-venting regulators.	17	7. A B C D E
7.2	Correctly interprets information from a schematic symbol for a directional valve.	19	8. A B C D E
8.1	Understands the reasons why air motors must operate on conditioned air.	21	9. A B C D E

Field Repairs

9.1	Solves equations involving cylinder force, pressure, area, and volume.	24	10. A B C D E
10.1	Knows how to check and adjust compressor drive belts.	28	11. A B C D E
11.1	Understands the various compressor controls and their applications.	29	12. A B C D E
12.1	Recognizes the causes of compressor head air leaks.	33	13. A B C D E

Major Repairs

13.2	Recognizes the effects of air pressure on wrench torque and air flow on wrench speed.	34	14. A B C D E

Minor Repairs

14.1	Understands the relationships between gauge and absolute pressures and standard, free, and compressed air.	36	15. A B C D E
15.1	Understands the operation of a concentric ring valve airhead.	38	16. A B C D E
16.1	Knows the procedure for using an E-Z out.	40	17. A B C D E
17.1	Understands the function of intercoolers and aftercoolers.	41	18. A B C D E
18.1	Knows the procedure to correctly assemble a clamp-type fitting on a hose.	43	19. A B C D E

Pneumatic Mechanic Pre-Test - 1 Answer Sheet

Replace Components

19.1	Understands the specifications available from a component model number.	44	20. A B C D E
20.1	Distinguishes between graphic, pictorial, and cutaway drawings.	46	21. A B C D E
21.3	Understands how to size and install air lines.	48	22. A B C D E

Troubleshooting

22.1	Calculates cylinder area and force capability.	50	23. A B C D E
23.1	Recognizes symptoms of air valve failures and their causes.	53	24. A B C D E
24.1	Knows the causes of air motor failure.	55	25. A B C D E

1. For a given air flow rate, as the pore size of the filter decreases (the filter media gets finer), the pressure drop through the filter:

   a stays the same.
   b. increases.
   c decreases.
   d. increases only if the filter plugs.
   e. decreases only if the filter plugs.

2. The primary purpose of the compressor inlet filter is to:

   a. remove moisture.
   b. protect the compressor.
   c. keep dust out of the receiver.
   d. remove oil mist.
   e. serve as a muffler for air noise.

3. The pressure downstream of a properly sized regulator:

   a. will increase to receiver pressure when air is not being used.
   b. will decrease when air is not being used.
   c. is dependent upon the temperature of the air.
   d. should always be higher than the upstream pressure.
   e. should be constant, regardless of the air flow rate through the regulator.

4. Which part of the lubricator causes the pressure drop?

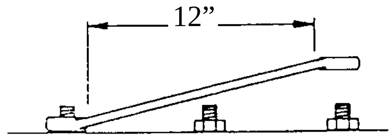
   a. Oil tube
   b. Needle valve
   c. Flow guide
   d. Venturi
   e. Bowl pressurizing valve

5. A compressor which uses oil:

   a. must be rebuilt.
   b. is working fine.
   c. should be equipped with an automatic filling mechanism.
   d. will run too hot.
   e. not enough information to make a decision.

6. If a torque of 60 foot pounds is needed on the bolt, how much force will be needed on the wrench?

   a. 5 pounds
   b. 10 pounds
   c. 20 pounds
   d. 40 pounds
   e. 60 pounds



7. A leaking regulator diaphragm will cause:

   a. excessive downstream pressure.
   b. excessive upstream pressure.
   c. leaking air out the vent hole.
   d. no change in regulator performance.
   e. the lubricator to malfunction.

8. A packed spool directional control valve has the seals:

   a. at the armatures.
   b. in the P port.
   c. in the valve sleeve.
   d. on the valve spool.
   e. in the outlet port.

9. A 10 CID air motor operating at 100 psig has an efficiency of 80 percent. The output torque is:

   a. 1000 lb-in.
   b. 800 lb-in.
   c. 159 lb-in.
   d. 127 lb-in.
   e. 80 lb-in.

10. The volume of air needed to cycle a double acting cylinder with a 2 inch bore and a 1 inch rod and 8 inch stroke is:

    a. 44.0 cu-in.
    b. 32.0 cu-in.
    c. 31.4 cu-in.
    d. 28.3 cu-in.
    e. 25.1 cu-in.

11. A V-belt drive measures 20 inches between the motor shaft and compressor shaft. When pulling on the belt with a force of 1-½ pounds mid-way between the pulleys, the belt should deflect:

a. 0.2 inches
b. 1-½ inches
c. 20/100 inches
d. 5/16 inches
e. 5/64 inches

12. A compressor has a compression ratio of 8 to 1. What is the pressure limit of the compressor (constant temperature)?

a. 8 psig
b. 80 psig
c. 95 psig
d. 103 psig
e. 118 psig

13. Screws arranged in a circular pattern:

a. don't have to be torqued.
b. should be torqued in a criss-cross pattern.
c. should be torqued around in a circular pattern.
d. should be fully torqued on the first pass.
e. should be grade 8.

14. Unconditioned air supplied to an impact wrench will:

a. cause premature wear.
b. cause over-speeding.
c. have no effect.
d. make the wrench turn faster.
e. create excessive exhaust noise.

15. What components might be found at an air receiver?

a. Draincock, safety valve, and lubricator
b. Draincock, safety valve, and pressure guage
c. Regulator, safety valve, and pressure switch
d. Regulator, lubricator, and check valve
e. Compressor, filter, and lubricator

16. A compressor valve assembly may be serviced and reinstalled if:

a. cracked.
b. warped.
c. carboned.
d. pitted.
e. none of the above.

17. An E-Z Out:

a. is turned counterclockwise.
b. is larger than the bolt to be removed.
c. is made of soft steel.
d. can't slip.
e. will always remove the broken bolt.

18. The difference between an intercooler and an aftercooler is:

a. aftercoolers can't be used on two stage compressors.
b. intercoolers use water.
c. the intercooler has less cooling capacity.
d. intercoolers are installed between compression stages.
e. aftercoolers are smaller.

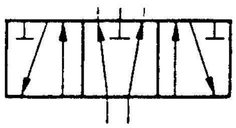
19. What will become of dirt which is allowed to enter the intercooler tubes while they are being cleaned? It will:

a. stay there
b. vent to atmosphere
c. be drawn into the first stage
d. be drawn into the second stage
e. go directly into the receiver

20. The C_V rating of a valve indicates:

a. the valve port size.
b. the air flow rating.
c. the material used in the valve.
d. how rapidly the valve shifts.
e. the quality of the valve.

21. This symbol is a:



a. directional valve.
b. compressor.
c. air motor.
d. pressure regulator valve.
e. air receiver.

22. If a pipe to be installed between two fittings is cut to the same dimension as the face-to-face measurement between the fittings, the pipe will:

a. be too long.
b. be the right length.
c. fit after being threaded.
d. work if a union is installed.
e. be too short.

23. A leaking rod seal will:

a. reduce cylinder extension force.
b. reduce cylinder retraction speed.
c. reduce both extension and retraction forces.
d. be detectable during cylinder extension.
e. cause rod bushing failure.

24. If the air supply is shut off to a pilot operated solenoid air valve, the valve should:

a. not shift.
b. shift normally.
c. shift slowly.
d. shift rapidly
e. work with manual overrides only.

25. Air motors should be supplied with air which is:

a. dry
b. cool
c. lubricated
d. filtered
e. all of the above

Pneumatic Mechanic Pre-Test - 2 Answer Sheet

Preventive Maintenance

Outcome:		Page	Answers
1.3	Understands the relationship between pore size and pressure drop through the filter.	6	1. A B C D E
1.2	Knows the location of filters in a pneumatic system.	6	2.A B C D E
2.2	Knows how to check a pressure regulator for proper operation.	9	3.A B C D E
3.1	Understands how an air lubricator works.	11	4. A B C D E
4.2	Recognizes the need to monitor compressor oil level and condition.	13	5.A B C D E
5.1	Understands the concept of torque and solves basic mathematical problems related to torque.	15	6. A B C D E

Assemble Components

6.3	Recognizes the causes and symptoms of regulator failure.	17	7. A B C D E
7.1	Distinguishes between packed bore and packed sleeve valves.	19	8.A B C D E
8.3	Solves basic equations involving motor torque, pressure, displacement, and efficiency.	21	9.A B C D E

Field Repairs

9.1	Solves equations involving cylinder pressure, area, and volume.	24	10. A B C D E
10.1	Knows how to check and adjust compressor drive belts.	28	11. A B C D E
11.5	Solves equations involving Compression Ratio (CR).	29	12. A B C D E
12.2	Knows the proper procedures to repair, service, and replace a compressor head, including torquing of the head screws.	33	13. A B C D E

Major Repairs

13.1	Understands the effect of unconditioned air on pneumatic tools.	34	14. A B C D E

Minor Repairs

14.3	Knows the purpose of an air receiver and additional components located at the reservoir.	36	15. A B C D E
15.2	Knows the proper tools to use and procedures to follow to clean an airhead.	38	16. A B C D E
16.1	Knows the procedure for using an "Easy Out."	40	17. A B C D E
17.1	Understands the function of intercoolers and aftercoolers.	41	18. A B C D E
17.2	Knows how to remove and reinstall intercooler tubes to minimize the risk of tube damage.	41	19. A B C D E

Replace Components

19.1	Understands the specifications available from a component model number.	44	20. A B C D E

20.2	Identifies components from a graphic circuit schematic.	46	21. A B C D E
21.2	Knows the proper procedure for measuring tapered thread pipe lengths to fit an existing assembly.	48	22. A B C D E
	Troubleshooting		
22.2	Identifies symptoms of leaking seals in an air cylinder.	50	23. A B C D E
23.2	Understands the operation of pilot operated directional valves.	53	24. A B C D E
24.2	Understands the importance of conditioned air for proper air motor operation.	55	25. A B C D E

Pneumatic Mechanic Certification Pre-Test - 3

1. In industrial applications, what is the perferred normal filter size range?

   a. 0.1 – 1 micron
   b. 3 – 20 microns
   c. 40 – 60 microns
   d. 60 – 100 microns
   e. 100 – 400 microns

2. Air pressure regulators determine the maximum pressure:

   a. at the compressor.
   b. downstream of the regulator.
   c. in the receiver.
   d. in the aftercooler.
   e. upstream of the regulator.

3. Which part of the lubricator causes the pressure drop?

   a. Oil tube
   b. Needle valve
   c. Flow guide
   d. Venturi
   e. Bowl pressurizing valve

4. A detergent in the oil will:

   a. force contaminants to settle out of the oil.
   b. hold contaminants in suspension.
   c. clean the oil filter.
   d. cause the compressor to use more oil.
   e. extend the oil change interval.

5. The "grade number" of a bolt:

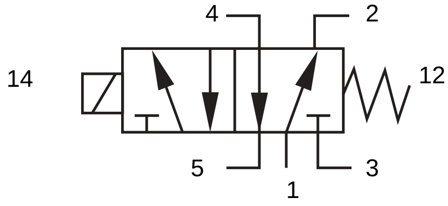
   a. indicates whether it has coarse or fine threads.
   b. is an indication of hardness.
   c. is the proper torque value in foot-pounds.
   d. indicates whether or not it is plated.
   e. predicts how many times the bolt may be reused without failure.

6. A non-venting regulator is to be reset from a higher pressure to a lower pressure. To properly set the regulator:

   a. reduce the upstream pressure first.
   b. it will be necessary to vent down stream air.
   c. simply back the adjuster screw out.
   d. turn the adjuster screw in.
   e. shut off the air supply.

7. Which port would be fitted with a restrictor to achieve meter-in flow control for both extension and retraction of a double acting cylinder?

   a. Port 2
   b. Port 4
   c. Port 1
   d. Port 3
   e. Port 5



8. An air motor which runs on unconditioned air will:

   a. run too fast.
   b. run too slow.
   c. not run at all.
   d. experience premature wear.
   e. blow up.

9. Piston cup seals and rod seals are examples of what type of seal?

   a. static
   b. dynamic
   c. rolling
   d. leather
   e. low pressure

10. A vacuum of 10 in-Hg is applied to a 3 inch vacuum cup. This cup will be able to lift:

    a. 3.0 pounds.
    b. 7.1 pounds.
    c. 10.0 pounds.
    d. 30.0 pounds.
    e. 34.8 pounds.

11. V-Belts transmit power to/from pulleys:

a. at the larger pulley only.
b. along the sides of the belt.
c. at the top edge of the belt.
d. at the bottom of the belt.
e. along the small pulley only.

12. A pneumatic system requires 10 cfm compressed at 100 psig. How much free air is required?

a. 10 scfm
b. 78 scfm
c. 100 scfm
d. 780 scfm
e. 1000 scfm

13. A control which holds the intake valve of a piston compressor open is an example of which control?

a. on/off
b. start/stop
c. constant speed
d. intake valve
e. dual

14. Impact wrench speed is controlled by the:

a. pressure at inlet.
b. size of air line.
c. inlet pressure at the regulator.
d. air flow rate.
e. reversing valve.

15. An air receiver is 18 inches in diameter by 48 inches long. Its volume is:

a. 864 cubic inches
b. 7.07 cubic feet
c. 52.8 cubic feet
d. 864 gallons
e. 7.07 gallons

16. An unloader:

a. holds the exhaust valve open.
b. holds the intake valve open.
c. holds both valves open.
d. blocks off the compressor outlet.
e. shuts off the motor.

17. The purpose for center-punching a broken bolt before drilling is to:

a. loosen the threads before drilling.
b. lock the bolt in place.
c. prevent the drill from slipping to one side.
d. make the bolt easier to drill.
e. crack the bolt.

18. Flare fitting assemblies which are not lubricated prior to assembly may:

a. twist and damage the tube when tightened.
b. be overtorqued.
c. not go together.
d. work loose after a few hours.
e. not dissipate heat efficiently.

19. Lubricating the nipple of a clamp type fitting:

a. is not necessary.
b. is only done when large hose is used.
c. will damage the hose.
d. permits assembly without damaging the hose.
e. is best done with gasket sealer.

20. Air valves with 1/2 inch ports:

a. all have the same air flow rating.
b. have a higher pressure drop than 3/8 inch valves.
c. could have C_V's falling over a wide range.
d. are too small for cylinders with 3/4 inch ports.
e. are usually made of steel.

21. Which is the most common symbol system used to show information regarding component and circuit operation?

a. Pictorial drawings
b. Cutaway and drawings
c. Graphic symbols
d. Manufacturing prints
e. Isometric diagram

22. Copper tubing:

a. is not suitable for air lines.
b. corrodes if water is present in the air.
c. can be bent to fit the machine.
d. is threaded using a straight (parallel) thread.
e. won't seal above 50 psi.

23. With no flow controls and ignoring friction, an air cylinder with a 3 inch bore and 1 inch rod which must move 353 pounds on extension and 314 pounds on retraction will:

a. extend and retract at the same speed.
b. extend faster than it will retract.
c. retract faster than it will extend.
d. extend but never retract.
e. retract but never extend.

24. A "humming" AC solenoid may indicate that the:

a. solenoid is shorted.
b. solenoid is open.
c. valve has not shifted completely.
d. DC power is being sent to an AC solenoid.
e. valve is being shifted too rapidly.

25 Air motors may run too slowly if:

a. the filter is plugged.
b. the muffler frosts over.
c. the air line is damaged.
d. the vanes are stuck in their slots.
e. all of the above.

Pneumatic Mechanic Pre-Test - 3 Answer Sheet

Preventive Maintenance

Outcome:

		Page	Answers
1.4	Knows how pneumatic filters are rated and what pore sizes are appropriate.	6	1. A B C D E
2.1	Knows the purpose of a pressure regulator.	9	2. A B C D E
3.1	Understands how an air lubricator works.	11	3. A B C D E
4.1	Understands fluid properties and how they affect the suitability of an oil for use in a compressor.	13	4. A B C D E
5.1	Understands the concept of torque and solves basic mathematical problems related to torque.	15	5. A B C D E

Assemble Components

6.2	Understands the operation of venting and non-venting regulators.	17	6. A B C D E
7.2	Correctly interprets information from a schematic symbol of a directional control valve.	19	7. A B C D E
8.1	Understands the reasons why air motors must operate on conditioned air.	21	8. A B C D E

Field Repairs

9.4	Understands how to install seals in a pneumatic cylinder.	24	9. A B C D E
9.2	Solves equations involving vacuum, area, and force.	24	10. A B C D E
10.1	Knows how to check and adjust compressor drive belts.	28	11. A B C D E
11.4	Understands the various compressor controls and their application.	29	12. A B C D E
11.1	Converts air flow requirements from compressed conditions to atmospheric conditions.	29	13. A B C D E

Major Repairs

13.2	Recognizes the effects of air pressure on wrench torque and air flow on wrench speed.	34	14. A B C D E

Minor Repairs

14.2	Calculates the volume of an air receiver.	36	15. A B C D E
15.1	Understands the operation of a concentric ring valve airhead.	38	16. A B C D E
16.1	Knows the procedure for using an EZ out.	40	17. A B C D E
17.2	Knows how to remove and reinstall intercooler tubes to minimize the risk of tube damage.	41	18. A B C D E
18.1	Knows the procedure to correctly assemble a clamp-type fitting on a hose.	43	19. A B C D E

Pneumatic Mechanic Pre-Test - 3 Answer Sheet

Replace Components

19.1	Understands the specifications available from a component model number.	44	20. A B C D E
20.1	Distinguishes between graphic, pictorial, and cutaway drawings.	46	21. A B C D E
21.1	Knows the advantages and disadvantages of using steel pipe, plastic pipe, copper tubing, hose, or manifolds for conveyance of compressed air.	48	22. A B C D E

Troubleshooting

22.1	Calculates cylinder area and force capability.	50	23. A B C D E
23.1	Recognizes symptoms of air valve failures and their causes.	53	24. A B C D E
24.1	Knows the causes of air motor failure.	55	25. A B C D E

Pneumatic Mechanic Pre-Test Answer Key

PM-1	PM-2	PM-3
1. C	1. B	1. C
2. B	2. B	2. B
3. D	3. E	3. D
4. E	4. D	4. B
5. B	5. E	5. B
6. B	6. E	6. B
7. B	7. C	7. C
8. C	8. D	8. D
9. D.	9. D	9. B
10. C	10. A	10. E
11. B	11. D	11. B
12. C	12. D	12. B
13. C	13. B	13. C
14. D	14. A	14. D
15. C	15. B	15. B
16. B	16. C	16. B
17. C	17. A	17. C
18. D	18. D	18. A
19. D	19. D	19. D
20. C	20. B	20. C
21. C	21. A	21. C
22. B	22. E	22. C
23. E	23. B	23. C
24. B	24. A	24. C
25. E	25. E	25. E

Help Improve This Guide

Updates, corrections and revisions to this Manual are requested and encouraged. This Manual is an on-going attempt at developing support materials for Certified Fluid Power candidates. It will undoubtedly require improvement. It is up to Certified Fluid Power candidates and Accredited Instructors to provide input and suggestions for improvement. The Fluid Power Certification Board, composed of industry volunteers, is responsible for determining what revisions and improvements are made to this Manual. The Manuals are updated on a regular basis and date stamped on each page.

Please send your suggestions for improvement to the executive director who is coordinating input on behalf of the Fluid Power Certification Board.

Thank you very much for helping us improve these materials for future candidates.

ATTN: Executive Director
Fluid Power Society
3245 Freemansburg Avenue, Palmer, PA 18045-7118
Phone: 610-923-0386 • Fax: 610-923-0389
PaulPrass@ifps.org

Comments

FLUID POWER CERTIFICATION

Setting competitive standards for Fluid Power Professionals

Fluid Power Certification ... How Can I Benefit?

Fluid Power Certification is a fast-growing educational movement in the industry today - and it's not surprising why.

Much of the traditional training from manufacturers, technical schools, and universities has been of high quality, but limited in its availability. Consequently, few of the 350,000 people working in the industry have been able to take full advantage of Fluid Power training. Many of today's fluid power professionals learned about the technology on the job and often did not receive the recognition they deserved for their educational accomplishments.

If the majority of your professional training was on-the-job or limited to short courses and workshops, then fluid power certification may be just what you need to stay competitive in today's marketplace. Fluid power certification gives you an opportunity to demonstrate your extraordinary effort to enhance your professionalism through education, training, and peer review. It may provide you with the credential you need to open the door for career advancement. For fluid power distributors, manufacturers and end-users, certification offers a multitude of benefits:

- Provides another measure with which to assess new employees.
- Establishes a minimal level of Fluid Power knowledge and skills.
- Educates your customers - so you don't have to.
- Helps satisfy requirements for employee qualifications.
- Demonstrates an individual's efforts to achieve and maintain the highest professional proficiency available in the industry.

What's Involved in Certification?

Fluid power certification consists of an optional review session, followed by a three-hour written test and recognition upon successful completion. For Mechanics' and Technicians' certification, an additional three-hour job performance test is also required.

How Many Kinds of Tests Are Offered?

The Fluid Power Certification Board currently offers nine Certification Tests at four levels:

- **Mechanic:** fabricates, assembles, tests, maintains and repairs systems and components, etc.
  - ***Master Mechanic***
    - Mobile Hydraulic Mechanic
    - Industrial Hydraulic Mechanic
    - Pneumatic Mechanic
- **Technician:** troubleshoots systems, tests and modifies systems, prepares reports, etc.
  - ***Master Technician***
    - Mobile Hydraulic Technician
    - Industrial Hydraulic Technician
    - Pneumatic Technician
- **Specialist:** analyzes and designs systems, selects components, instructs others in operations and maintenance, etc.
  - ***Fluid Power Specialist***
    - Hydraulic Specialist
    - Pneumatic Specialist
- **Engineer:** has a technology or engineering degree or is a current Professional Engineer, has eight years of work experience and has passed the Hydraulic & Pneumatic Specialist exams.

What Technologies are Covered by the Tests?

Fluid power and motion control technologies include questions on hydraulics, pneumatics, electronic control, and vacuum.

Who May Organize a Review Training Session?

Educational institutions, end-user companies, fluid power distributors, fluid power component manufacturers, for-profit educational organizations and the Fluid Power Society (local chapters or the national Headquarters), can organize review training sessions.

Who Administers the Tests?

Written testing is conducted under the supervision of local proctors retained by the Fluid Power Certification Board. Job performance testing may only be administered by an FPS Accredited Instructor. Tests are scheduled throughout the world in over 138 cities throughout the year.

How Will My Accomplishments be Recognized?

Certified fluid power professionals are encouraged to include their certification on their business cards and letterhead - even on work vehicle signage. Certification patches are also available for use on uniforms, as well as other promotional items. All Certified Professionals receive a certificate suitable for framing, wallet card, are recognized in the Fluid Power Journal, are listed in the annual Certification Directory, and on the Fluid Power Society's web site.

Will I Have to Renew My Certification?

Yes - Certifications are valid for five years. After that time, you must apply for re-certification based on a point system. On the re-certification form, you will be asked to list job responsibilities, additional educational courses you have taken or taught, and professional involvement in Fluid Power or allied organizations.

What Will This Cost Me?

The Fluid Power Certification Board has made every effort to keep costs low and make Certification available to as many fluid power professionals as possible. Many manufacturers and distributors subsidize or even reward this program because it provides a great return on investment. A contribution to the fluid power certification program helps upgrade the skills of those professionals committed to the industry and elevates the level of professionalism throughout the entire Fluid Power Industry.

How Can I Receive More Information?

For fee schedules, review sessions, manuals and other information, please visit our web site at www.IFPS.org, at 1-800-214-2958, contact Headquarters at 1-800-330-8520 or write to:

Fluid Power Certification Board
3245 Freemansburg Avenue
Palmer, PA 18046-7118
Phone: 800-330-8520, 610-923-0386;
Fax: 610-923-0389 E-mail:
FPS@IFPS.org;
Web: http://www.IFPS.org;

Fluid Power Certification Board

Certification Coordinator c/o FPS, 3245 Freemansburg Ave., Palmer, PA 18045-7118. Phone: 610-923-0386. Fax: 610-923-0389

Certification Test Application

You have three years from date of application to take the test, after which fees are forfeited.

Please fully complete form.

Name ______________________

Home Address ______________________

____

City ________ State ________ Zip ________

Phone ________ Fax ________

E-mail address ______________________

FPS Member I.D. # ______________________

Social Security Number **(Serves as your Test ID Number)** ______________________

Preferred mailing address: ❑ Home ❑ Work

Employer ______________________

Work Address ______________________

____

City ________ State ________ Zip ________

Phone ________ Fax ________

E-mail address ______________________

Present Job/Title ______________________

❑ **Full Time Student**
(Send proof of Full Time status with application - 12 Credits)

Education Information: (Check highest level attained)

Grade School Years ________

High School Years ________ Diploma ________

Technical Institute Years ________ Degree ________

College Years ________ Degree ________

NOTE
Payment Required
with Application
for application to be processed

Which test do you intend to take? (Check one)

❑ Mobile Hydraulic Mechanic* ❑ Mobile Hydraulic Technician* ❑ Hydraulic Specialist

❑ Industrial Hydraulic Mechanic* ❑ Industrial Hydraulic Technician* ❑ Pneumatic Specialist

❑ Pneumatic Mechanic* ❑ Pneumatic Technician* ❑ Engineer (separate application required)

❑ Job Performance Only – Hydraulic or Pneumatic (Circle One)

***Requires the Job Performance Test**

Test Date: ______________________ Test Site: ______________________

Item	Amount
Test Fee	
Full Time Student Test Fee	
Retake Fee — Written Test	
Retake Fee — Job Performance Test	
Certification Manual #	
Test Reschedule Fee (Refer to Policies)	
TOTAL DUE	

For Office Use Only
Member #:
Prior Tests:
Fee Received:

Payment Required with Application for application to be processed.
Payment Type:

❑ Check or Money Order Enclosed (in U.S. funds only)

❑ Credit Card (MasterCard or Visa Only) (Required)

Type of Card: ❑ MC ❑ VISA Credit Card Number ______________________ Exp. Date ________

Signature ______________________

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