

Pneumatic Tools

Introduction

Pneumatics refers to technology dealing with the application of pressurized gas (potential energy) to produce mechanical motion (kinetic energy). Pneumatic systems used in the fire/rescue service primarily use compressed gas as the source of power.

There is a variety of pneumatic tools used in the fire/rescue service, each with a specific function. While some of these tools were developed specifically for rescue, many are simply borrowed from other industries, such as the automotive repair industry.

All of the components of a pneumatic tool setup will be discussed in this module, starting with the air source and working downstream to the actual tool.

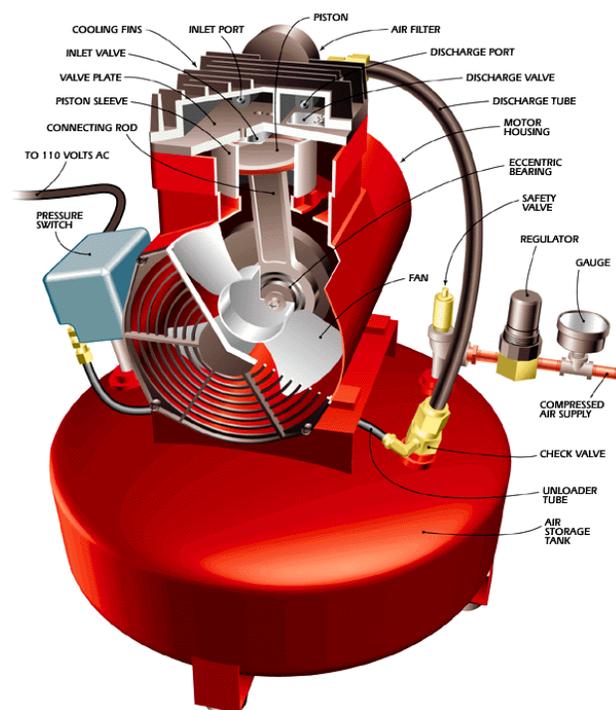
Air Sources

The key component to any pneumatic tool or airbag operation is compressed air. Compressed air can be obtained from a variety of sources on a rescue incident:

Air Compressors

Air compressors provide an unlimited supply of air. The most common type is the positive-displacement compressor that uses a reciprocating piston. (Other types that utilize impellers or rotary screws do exist.) The piston air compressor has components similar to an internal combustion engine: a crankshaft, connecting rod and piston, cylinder and a valve head. Typical compressors come in 1- or 2-cylinder versions and can be single- or two-stage.

The compressor supplies a storage tank. When needed, air is drawn from the tank and the compressor replenishes it. Air compressors stop supplying the storage tank when pressure inside the tank reaches a specified limit. When air is consumed and the pressure in the storage tank drops below a certain level, the compressor starts up again.



Air Compressors (continued)

Air compressors can be permanently mounted in a structure or on apparatus or they can be portable. They can be driven by an electric motor or an internal combustion engine, either directly or via a PTO.



The source of the compressor's power isn't as important as the compressor's capacities for air production. Two important specs to know about a compressor are its ratings for volume and pressure output. Volume output for air compressors is expressed in cubic feet per minute (cfm). The cfm rating of the compressor will dictate the quantity and type of pneumatic tools it can adequately supply. The pressure rating of the compressor is also a factor to consider. A higher pressure in the storage tank means a larger quantity of air. Larger quantities of air can support tools with higher air consumption rates.



The quality of the air coming out of an air compressor is vital to tool and equipment performance and service life. Ambient air contains moisture. When air is compressed, its temperature increases as well as its ability to hold water vapor. When air travels away from the compressor to the storage tank, its temperature decreases. When the temperature decreases, the water vapor condenses and builds up in the storage tank, air lines, and tools. The water can corrode air tanks and damage internal components of air tools and equipment. Some air compressors use oil to cool and lubricate internal components. Some of this oil can leave the compressor with the air and make its way to tools and equipment. Incorporating air treatment devices like air dryers and filters are a necessity for prolonging the service life of a pneumatic system.

Cascade Systems

Another air source is a cascade system. A cascade system is a group of high-pressure cylinders (two or more) connected together and fed by an air compressor. The cascade systems on apparatus are usually filled from an external compressor at a fire station. Air in a cascade system moves from the point of higher air concentration to the point of lower concentration. The cylinder with the higher air pressure will force air into the cylinder with the lower pressure until the pressures in both cylinders equalize. Since all cylinders in a cascade system are interconnected, air can be drawn from only one cylinder or a combination of any or all cylinders. However, pulling from only one cylinder at a time will help maintain higher pressures in the



remaining cylinders.

Cascade System (continued)



Cascade systems are most often used in the fire service to fill SCBA cylinders. These systems are filled with air compressors that meet OSHA and NFPA respiratory standards for breathing air. Therefore, air supplied with a SCBA cascade system will not contain the level of moisture and contaminants found in industrial air sources.

Self-Contained Breathing Apparatus (SCBA) Cylinders



Self-Contained Breathing Apparatus cylinders (SCBA) are a good portable air source when operating pneumatic tools and air bags. The caveat to their portability is the limitations on air volume. It is important to know cylinder capacities and quantities available during a rescue operation.

Scott SCBA Cylinder Capacities	
30-Minute	45 SCF
45-Minute	65 SCF
60-Minute	87 SCF

Mobile Air Carts



The air cart is a commercially made device that holds high-pressure cylinders. Two of the manufacturers of fire/rescue specific air carts are Scott and Air Systems International. Both of these variations contain two SCBA cylinders. They are connected to a manifold and provide a number of air outlets. The air cart is designed to operate off of one cylinder at a time. It will provide an audible alarm when the pressure in the cylinder being used reaches a level of approximately 500 psi. At that point, the remaining cylinder can be opened, and the air cart will transition to the higher pressure. The cylinders are set up in an arrangement that allows for the replacement of one cylinder while using the other. This arrangement allows for an uninterrupted air supply. They also contain a high-pressure inlet that allows hookup to an external air source such as a Mobile Air Unit.



Air Brake Systems

The air brake system on commercial trucks can be used to supply air for pneumatic tools. The engine air compressor produces air for the air brakes and other components. These air systems generally operate around 120 psi.

Tractor trailers have an air connection between the tractor and the trailer in order to provide an air supply for the rear brakes. There will be two hoses, one red and the other blue. The hoses are connected via a glad hands coupling. The blue hose is used for normal braking operation and it is referred to as service airline. The red hose is the emergency airline. In the event that the red airline becomes disconnected (such as when the trailer disconnects from the tractor), the trailer brakes are automatically applied. On some trailers, the same type of connection can be found at the rear end of the trailer.



The service and emergency airlines are supplied by the engine air compressor on the tractor. An adapter can be used to make the connection to the glad hands coupling on the rear of the tractor, providing an air supply for pneumatic tools and equipment.



Fire Apparatus Auxiliary Air

Fire apparatus will typically have air connection(s) for auxiliary air hookup. These connections are supplied by the air reservoirs that are part of the vehicles air system. Just like the commercial air brake systems previously discussed, fire apparatus air systems can provide approximately 120 psi of useable air.

Tire Fill Adapter



air source.

With the correct type of adapters, we can get air from the tires of vehicles on the scene. Generally, fire apparatus tires have an inflation pressure ranging from 110 to 120 psi while passenger cars may only have 25 to 35 psi to offer. Consideration should be given to the volume of air necessary to accomplish a task when utilizing this

Air Regulators

Air sources such as SCBA cylinders, air carts, cascade systems and some air compressors produce high pressure air (pressures in SCBA cylinders can be as high as 5500 psi). However, the majority of the pneumatic tools and airbags (even “high pressure” airbags) used in the fire/rescue service operate below 150 psi. Exceeding the normal operating pressures of pneumatic equipment can not only be a waste of valuable air supply, but also potentially damaging to the equipment. Therefore, a pressure-reducing device (pressure regulator) is needed to provide useable low pressure air.

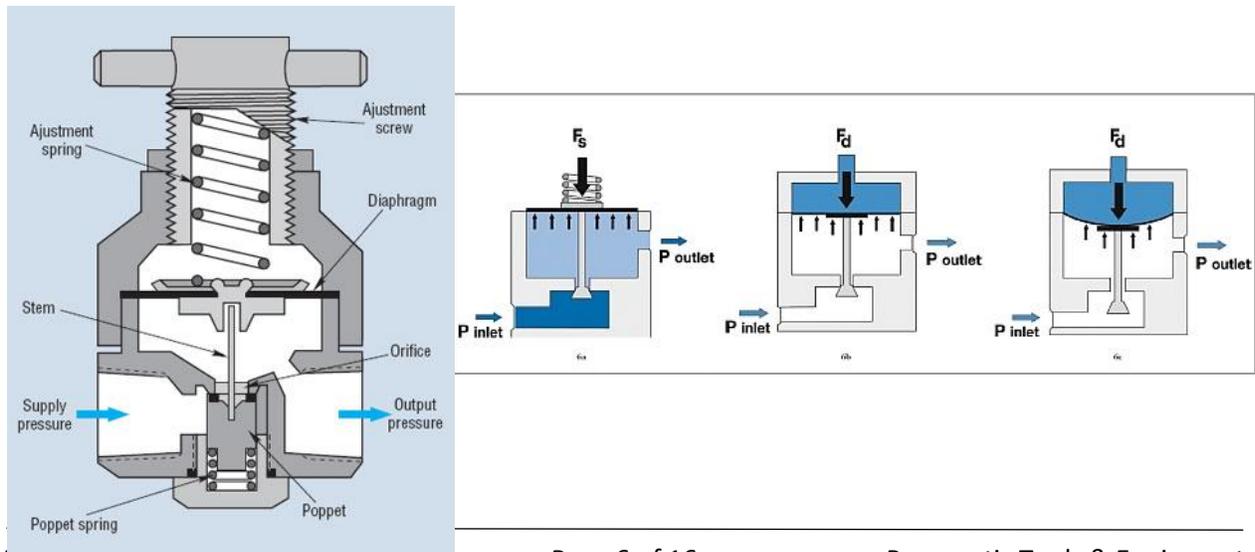
Components and Operation

Pressure regulators are comprised of three functional elements:

- A pressure reducing or restrictive element (generally a poppet valve)
- A sensing element (generally a diaphragm or piston)
- A reference force element (generally a spring)

At a basic level, an air regulators work like this:

1. High pressure air flows into the high pressure chamber of the regulator
2. The adjustment screw is tightened, which compresses the spring
3. The spring compression produces force that pushes down on the diaphragm/piston
4. The force on diaphragm/piston pushes down on the valve stem, opening the poppet valve
5. Air is able to enter the low pressure chamber of the regulator
6. The regulated air creates a force that opposes the diaphragm/piston and closes the poppet valve.
7. Increasing the force in the spring will result in an increase in opposing force from the air in the low pressure chamber and thus an increase in outlet air pressure. Decreasing the force in the spring will have the opposite effect



Diaphragm regulators are generally more sensitive to pressure changes and react more quickly. They are used for increased accuracy and low pressure applications. Piston regulators are more rugged and used when higher outlet pressures are required and are not held to as tight a tolerance. Both types are typically equipped with gauges to read both inlet and outlet pressures.



Diaphragm Regulator



Piston Regulator



Hurst PermaSet Regulator

A third type of regulator that is sometimes used in the fire/rescue service is the permanently-set or preset regulator. This regulator has a sensing element that is already set and is not adjusted during use. The outlet pressure on this style of regulator is set at the factory, generally at maximum of 175 psi. Hurst and Paratech utilize this style of regulator with some of their airbag controller setups.

Maintenance and Use

General operating practices are outlined in this section. Manufacturer's recommended operating procedures should always be followed when using a regulator.

Prior to connecting a regulator to an air source, perform the following:

- Check the regulator for any damage
- Ensure that inlet and outlet pressure gauges are reading "zero"; the regulator will still function with incorrect gauge readings, but a faulty outlet pressure gauge prevents accurate outlet pressure settings which could damage the equipment connected to the regulator
- Check the high pressure connection for the presence of an O-ring; replace if necessary
- If adjustable, ensure that the adjustment knob/handle is turned fully counterclockwise to lower outlet pressure and close the poppet valve, preventing the flow of air through the regulator. If the poppet valve is not closed when the high pressure source is opened, air can flow through the regulator, possibly at pressures too high for downstream equipment

Maintenance and Use (continued)

Once the regulator is connected to the air source, the operator should:

- Check for air leaks at the inlet (high pressure) coupling; if leaks exist, shut down the air source, check for O-ring issues and attempt to reconnect
- Connect the outlet (low pressure) coupling to an appropriate air hose
- If equipped, open the delivery shutoff valve on the regulator – this will allow air to flow through the regulator outlet downstream to the equipment
- Slowly turn the adjustment knob/handle clockwise to increase the outlet pressure to the correct setting; it may be necessary to fine tune the pressure adjustment once air tool operation begins and air is flowing through the regulator (Permanently set or preset regulators will automatically provide the set working pressure.)

Upon completion of the air tool/equipment operation, shut down the regulator as follows:

- Turn off the air supply
- If adjustable, reduce the regulator outlet pressure to “zero” by turning the adjustment knob/handle fully counterclockwise
- Disconnect the air hose from the outlet coupling
- Turn the adjustment knob/handle clockwise to bleed the pressure from the inlet side of the regulator
- Once both pressure gauges are at “zero”, return the adjustment knob/handle back to the fully counterclockwise position and disconnect the air source

Regulators should be stored in a clean, dry environment. Gauges are susceptible to damage so appropriate precautions should be taken to protect them. Any damage to the regulator or gauges and/or faulty operation should place the regulator out of service for repairs or replacement.

Air Hoses

Air hoses are a critical component of any pneumatic tool and airbag setup. They are the connecting medium between the equipment and can have a direct effect on air volume and pressure. Air hoses can be constructed of various types of rubber or plastic and may contain a form of fabric reinforcement. The hose should be marked with a service or working pressure; never exceed the manufacturer's recommended operating pressures.

Hose lengths can be short (around 16 feet for many airbag systems) or as long as 200 feet (common length for apparatus hose reels). Much like fire hose, air hose creates friction losses. The magnitude of these losses depend on hose diameter and length as well as air flow.

The Association for Rubber Products Manufacturers (ARPM) provides some tabulated data in their "Hose Handbook" referencing friction loss in air hose. Some of this data is shown in the tables below:

Friction Loss in Air Hose (psi) per 100-foot length

Hose I.D. (inch)	Gauge Pressure at Line (psi)	Cubic Feet Free Air Per Minute (SCFM)		
		3.0	5.0	10.0
1/4	100	3.73	10.36	-
	150	2.60	7.21	-
	200	1.99	5.53	22.14
3/8	100	0.44	1.23	4.92
	150	0.31	0.86	3.42
	200	0.24	0.66	2.63

From ARPM Hose Handbook, 8th Edition – Table 11-4A

Friction Loss for Pulsating Air through Hose (psi) per 100-foot length

Hose I.D. (inch)	Gauge Pressure at Line (psi)	Flow of Free Air (SCFM)		
		30	40	50
1/2	50	10.0	20.2	36.2
	80	5.6	12.0	21.6
	100	4.6	9.6	16.8

From ARPM Hose Handbook, 8th Edition – Table 11-4B

**The above tables refer to "Free Air" at atmospheric pressure (14.7 psi) and 80°F

**The pressure drops listed assume hose with smooth I.D. tubing and full-flow couplings. Greater pressure drops will occur in hose with rough I.D. tubing or restrictions at couplings/fittings.

The majority of pneumatic tools and equipment used in the fire service will require a minimum air hose diameter of $\frac{3}{8}$ ". Smaller $\frac{1}{4}$ " air hoses (commonly found on small home air compressors) will not meet volume requirements and can result in inefficient tool operation or even damage.



1/4" Recoil Air Hose

3/8" Air Hose

Pneumatic Tools

As mentioned at the beginning of the module, the majority of pneumatic tools used in rescue are actually designed for the automotive repair industry. However, there are some tools designed specifically for fire/rescue applications.

Types of Pneumatic Tools

Impact Wrench



Pneumatic impact wrenches provide high torque output. In addition to rotation, impact wrenches apply a hammering force. They are commonly used in automotive, construction, and assembly industries.

Impact wrenches come in drive sizes similar to ratchet sets. Common automotive drive sizes are 1/4", 3/8", 1/2", 3/4" and 1". For industrial applications, drive sizes can be as large as 1 1/2" and 2 1/2". Due to the high torque of an impact wrench, regular sockets should NOT be used. Standard chrome sockets are fairly brittle and can shatter from too much vibration. Impact sockets are made from chromolybdenum, which is a softer more malleable material. These sockets are designed to absorb the high impact forces from an impact wrench instead of shattering like standard sockets.

Torque ratings can range considerably depending on the size of the impact wrench and its application. Working torque ranges can be anywhere from 25 to 350 lb-ft. Maximum torques can exceed 1000 lb-ft.

Air consumption also varies with size and application. For automotive applications, average consumption rates can be 5-10 cfm. Under load, these torque wrenches may use in excess of 20 cfm. For industrial and manufacturing applications, air consumption rates can dramatically increase – some as high as 40 cfm.



Air Ratchet

Air ratchets apply far less torque and operate at lower RPMs than impact wrenches. They are designed to increase efficiency and save time in applications where standard ratchets would be used.



Air Ratchet (continued)

Standard drive sizes for air ratchets are 1/4", 3/8" and 1/2". Due to the lower torque ratings, impact sockets are not required. Torque ratings can range from 5 to 75 lb-ft.

Average air consumption rates for air ratchets are around 4-5 cfm.

Air Hammers

The air hammer (or "air chisel" as it's sometimes called) is one of the more commonly used pneumatic tools in rescue. In fact, a larger version of an air hammer, which will be discussed later in this module, was developed specifically for fire/rescue applications. As the name suggests, air hammers create a hammering action through the use of a piston.

The working end of the air hammer is the chisel. Chisels are used to pierce and cut metal. There are numerous types of chisel designs, each with different specialties.



Some Common Types of Chisels (from left to right)

- Tailpipe/muffler cutter
- Straight/flat chisel
- Cutting chisel
- Edging tool
- Tapered punch

Chisels are held in the air hammer with a retainer. There are two types of retainers: coil spring

and quick change. Most air hammers can be fitted with either type, but the quick change retainer is preferred for fire/rescue work. Quick change retainers are faster and easier to use and also minimize the risk of a chisel dislodging from the hammer during use associated with coil spring retainers.



Quick Change Retainer

Air consumption rates for air hammers are around 2-3 cfm, with some peaking between 10-15 cfm under load.



Coil Spring Retainer

Cut-off Tool

The pneumatic cut-off tool is simply a small version of the gasoline-powered Partner and Husqvarna cut-off saws carried on almost all truck companies and rescue squads. An abrasive cutting disc is attached to an arbor rotating at high speed (20,000+ RPMs). Most pneumatic cut-off tools use a 2⁷/₈" cutting wheel.



It is important to only use appropriately-sized cutting wheels and ensure that they are securely fastened to the arbor. Blade guards are standard on cut-off tools and they should be used. If cutting wheels are damaged in any way or worn to the point where they will no longer effectively cut, they should be replaced.

Air consumption rates are around 5-10 cfm, depending on the specific cutter.

Air Shear

Air shears are another type of pneumatic cutting tool. They are capable of cutting plastics and all types of aluminum, tin and up to 18-20 gauge steel. Unlike the cut-off tool's consumable cutting wheels, the air shear's blades are part of the tool and should not need replaced under normal use.



Air shears consume 4-5 cfm.

Air Reciprocating Saw

The air reciprocating saw is a smaller version of electric and battery-powered reciprocating saws found on almost all fire apparatus. The bi-metal blades can cut a variety of plastics and thin metals.



Standard 1/2" shank air reciprocating saw blades come in 14-tooth up to 32-tooth construction for coarse to fine cutting.

Common air consumption rates are 1-2 cfm during normal use.



Maintenance and Use

Air pressure is an important component of proper tool operation. The pneumatic tools mentioned in this module typically have manufacturer-recommended operating pressures of 90 psi. The tools will operate at pressures above 90 psi, which will increase torque and possibly improve performance. However, in the long run, this will reduce the life expectancy of the tool. Operating pressures less than 90 psi will result in tool inefficiency and decreased performance. One common mistake made by operators is to set the air regulator at the tool operating pressure and never give it a second thought. However, by the time the air reaches the actual tool, the pressure may be significantly reduced. Several factors (such as air leaks, hose configurations and lengths, the number and types of couplings, etc.) can reduce air pressure. So if the tool is not functioning as it should, this could be one possible cause.

All of the pneumatic tools discussed in this module contain many internal moving parts. To maintain peak efficiency and improve tool life expectancy, these internal components must be clean and well lubricated. Air tool oil provides the necessary lubrication and rust prevention for the internal moving parts. Some pneumatic tools are equipped with in-line oilers that



introduce oil into the tool air during normal use. Tools without oilers must be manually lubricated on a regular basis. In addition, many pneumatic tools have grease fittings that require periodic service. It is important to follow manufacturer's recommendations for the types of lubricants and their proper use.



Hoses and couplings can be a source of water, dirt, grit, and other contaminants that will cause damage and excessive wear to internal tool components. Be sure to inspect all couplings before connecting them. If necessary, clean and dry them before use. Store all pneumatic equipment in a clean, dry environment. Regular preventive maintenance will help ensure the tools perform as they should when needed.

Paratech Airgun and Pakhammer

The Paratech Airgun and Pakhammer are two pneumatic impact tools designed specifically for fire/rescue applications. The two are used for forcible entry (piercing, cutting, and breaking) as well as medium duty breaching and breaking of masonry walls. They utilize a piston much like a traditional air hammer. However, Paratech designed to Airgun and Pakhammer with air conservation in mind. Both tools only use air on the power stroke; an integrated spring retracts the piston on the return

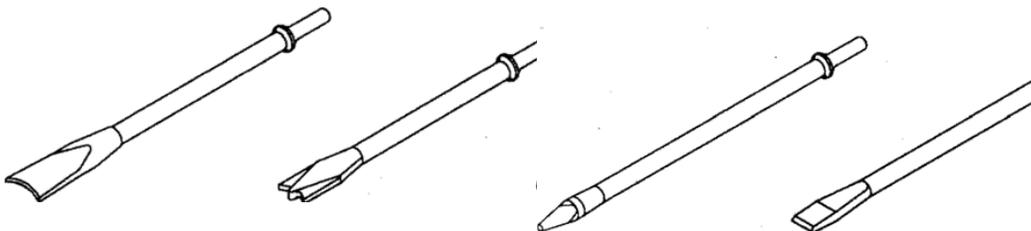


stroke.

Airgun and Pakhammer operating pressures range from 40 up to 200 psi, depending on the application. However, increasing operating pressures will increase air consumption. For the Airgun, air consumption is rated at 5 SCFM @ 40 psi but 15 SCFM @ 200 psi. The larger Pakhammer consumes air at a rate of 8.5 SCMF @ 40 psi and 19 SCMF @ 200 psi.

One of the large benefits of the Airgun and Pakhammer over traditional air hammers is power output. Both tools are designed for rescue and therefore provide increased cutting/breaching/breaking force. The Airgun is rated for 71 ft-lbs. @ 50 psi up to 369 ft-lbs. at 200 psi. The Pakhammer is rated for 158 ft-lbs. @ 50 psi up to 876 ft-lbs. @ 200 psi.

The Airgun and Pakhammer can be used with a wide variety of bits on a broad range of materials. The user manuals for each tool list recommended tool bits and operating pressures for specific applications, whether it's cutting automobile posts, breaking concrete, or shattering castings.



Routine maintenance of the Airgun and Pakhammer will keep them operating at peak efficiency. The surface of the tools should be kept clean of dirt, grease, etc. If the tool has been operated in a dusty, abrasive environment or if the tool bit retainer assembly is subjected to a damp or wet material, Paratech recommends cleaning the retainer assembly with dry cleaning solvent and lubricating with air tool oil afterwards.



Both tools are fitted with an in-line oiler. As air passes through the oiler, a controlled volume of lubrication is picked up with the air to maintain continuous fog lubrication of the internal components. The oil level should be periodically checked. If empty, fill the oiler housing until half-full with Marvel[®] Air Tool Oil.

