Air Compressor

Selection and Application

¼ HP through 30HP

COMPRESSED AIR
CAGI
AND GAS INSTITUTE

PREFACE

The purpose of this publication is to help users understand compressed air as a power source and to provide technical guidance for selecting the right air compressor for specific applications. The central focus is on packaged complete unit air compressors, most commonly used in sizes from 1/4 to 30 horsepower as measured according to standards for continuous duty compressors.

Content has been provided by members of the Stationary Single/Double Acting Unit Type Compressor Section. Products within the scope of this section are most frequently used for general purpose industrial air supply, but they also find use in off-shore drilling, construction jobs, locomotives, ships, mining, and other specialized applications.

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Compressed Air

How Can Air Generate Power?

The normal state of air, barometric, is called atmospheric pressure. When air is compressed, it is under pressure greater than that of the atmosphere and it characteristically attempts to return to its normal state. Since energy is required to compress the air, that energy is released as the air expands and returns to atmospheric pressure.

Our ancestors knew that compressed air could be used for power when they discovered that internal energy stored in compressed air is directly convertible to work. Air compressors were designed to compress air to higher pressures and harness that energy. Unlike other sources of power, no conversion from another form of energy such as heat is involved at the point of application. Compressed air, or pneumatic devices are therefore characterized by a high power-to-weight or power-to-volume ratio.

Not as fast as electricity, nor as slow as hydraulics, compressed air finds a broad field of applications for which its response and speed make it ideally suited. Where there is an overlap, the choice often depends on cost and efficiency, and air is likely to hold the advantage.

Compressed air produces smooth translation with more uniform force, unlike equipment that involves translatory forces in a variable force field. It is a utility that is generated in-house, so owners have more control over it than any other utility. In addition, air does not possess the potential shock hazard of electricity or the potential fire hazard of oils. The advantages of air power will be discussed further in the proceeding pages.

Where is Compressed Air Used?

Compressed air powers many different kinds of devices. It can be used to push a piston, as in a jackhammer; it can go through a small air turbine to turn a shaft, as in a dental drill; or it can be expanded through a nozzle to produce a high-speed jet, as in a paint sprayer.

Compressed air provides torque and rotation power for pneumatic tools, such as drills, brushes, nut runners, riveting guns, and screwdrivers. Such tools are generally powered by some form of rotary air motor such as the vane or lobe type, or by an air turbine.

Equally common are devices producing lateral motion and direct force, either steady or intermittent. Common examples are clamps, presses, and automatic feeds. Or, air pressure is used to accelerate a mass, which then exerts an impact upon an anvil, as in paving breakers and pile drivers.

Common applications in industrial plants and on construction sites are air-powered nailers and staplers. In paint spraying and in air conveying, the dynamic pressure of the air imparts motion.

Advantages of Air Power

When there are a dozen or more forms of energy to choose from, what advantages does air power offer? Here, compressed air stacks up against two of its competitors—electricity and hydraulics.

Air Power versus Electric Power

Cost: Air tools have fewer moving parts and are simpler in design, providing lower cost maintenance and operation than electric tools.

Flexibility: Air tools can be operated in areas where other power sources are unavailable, since engine-driven portable compressors are their source of air power. Electric power requires a stationary source.

Safety: Air-powered equipment eliminates the dangers of electric shock and fire hazard. Air tools also run cooler than electric tools and have the advantage of not being damaged from overload or stalling.

Weight: Air tools are lighter in weight than electric tools, allowing for a higher rate of production per man-hour with less worker fatigue.

Air Power versus Hydraulic Power

Cost: An air system has fewer parts than a hydraulic system, lowering service and maintenance costs. Also, the use of a single compressed air supply permits operation of many separate systems at once. Hydraulic systems require more complex and costly controls.

Flexibility: Compressed air systems offer simpler installation than hydraulics, particularly where tools are frequently interchanged. Compressed air systems also offer better adaptability for automation and flexibility for changing or expanding operations.

Maintenance: Air systems have less downtime than hydraulic systems because they have less complex controls. Less preventative maintenance is required with air, whereas hydraulic fluids must be monitored and replaced periodically.

Safety: Hydraulic devices operating near open flame or high temperatures present fire hazards, unless fire-resistant fluids are used. Leakage in hydraulic systems can result in the presence of dangerous hydraulic fluids and even complete system shutdown. In contrast, compressed air devices operate with lower system pressures, and accidental air leaks release no contaminants.

Weight: High ratio of power-to-weight in air tools contributes to a lower operator fatigue versus hydraulic tools.

Types of Compressors

Air compressors in sizes from 1/4 to 30 horsepower include both reciprocating and rotary compressors, which compress air in different ways. Major types of reciprocating compressors include reciprocating single acting, reciprocating double acting, reciprocating diaphragm, and reciprocating rocking piston type. Major types of rotary air compressors include rotary sliding vane, rotary helical screw and rotary scroll air compressors.

Reciprocating Single Acting Compressors

Reciprocating single acting compressors are generally of one-stage or two-stage design. Compressors can be of a lubricated, non-lubricated or oil-less design.

In the single-stage compressor, air is drawn in from the atmosphere and compressed to final pressure in a single stroke. The single-stage reciprocating compressor is illustrated in Figure 1. Single-stage compressors are generally used for pressures of 70 psi (pounds per square inch) to 135 psi.

Reciprocating Single Stage (Twin Cylinder)

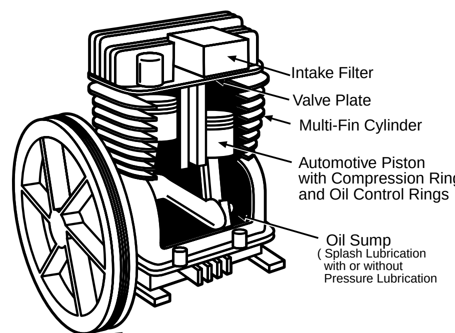


Figure 1

In the two-stage compressor, air is drawn in from the atmosphere and compressed to an intermediate pressure in the first stage. Most of the heat of compression is removed as the compressed air then passes through the intercooler to the second stage, where it is compressed to final pressure. The two-stage reciprocating compressor is illustrated in Figure 2. Single and two-stage reciprocating compressors are frequently used in auto and truck repair shops, body shops, service businesses, and industrial plants. Although this type of compressor is usually oil lubricated, hospitals and laboratories can purchase oil-less versions of the compressors as illustrated in Figure 3.

Reciprocating Two Stage

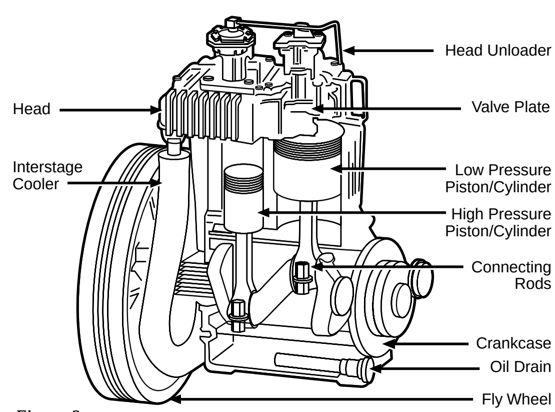


Figure 2

Reciprocating Single Stage, Oilless

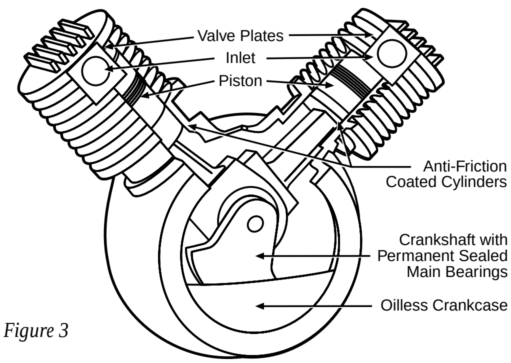


Figure 3

Rocking Piston Type

Rocking piston compressors are variations of reciprocating piston type compressors (Fig. 4). This type of compressor develops pressure through a reciprocating action of a one-piece connecting rod and piston. The piston head rocks as it reciprocates. These compressors utilize non-metallic, low friction rings and do not require lubrication. The rocking piston type compressors are generally of smaller size and lower pressure capability.

Rocking Piston Type

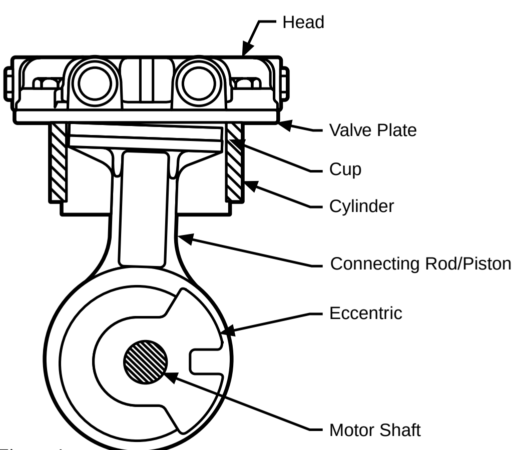


Figure 4

Diaphragm Type

Diaphragm compressors (Figure 5) are a variation of reciprocating compressors. The diaphragm compressor develops pressure through a reciprocating or oscillating action of a flexible disc actuated by an eccentric. Since a sliding seal is not required between moving parts, this design is not lubricated. Diaphragm compressors are often selected when no contamination is allowed in the output air line or atmosphere, such as hospital and laboratory applications. Diaphragm compressors are limited in output and pressure, and they are used most for light-duty applications.

Diaphragm Type

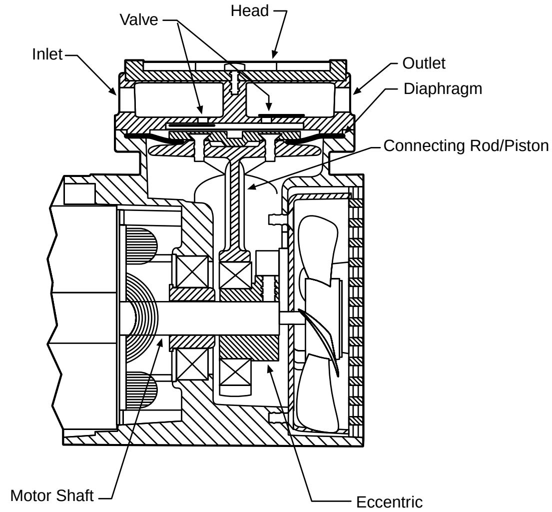


Figure 5

Rotary Sliding Vane Type

The rotary sliding vane compressor consists of a vane-type rotor mounted eccentrically in a housing (Figure 6). As the rotor turns, the vanes slide out against the housing. Air compression occurs when the volume of the spaces between the sliding vanes is reduced as the rotor turns in the eccentric cylinder. Single or multi-stage versions are available. This type of compressor may or may not be oil lubricated. Oil-free rotary sliding vane compressors are restricted to low-pressure applications because of high operating temperatures and sealing difficulties. Much higher pressures can be obtained with oil lubricated versions.

Some of the advantages of rotary sliding vane compressors are smooth and pulse-free air output, compact size, low noise levels, and low vibration levels.

Rotary Vane Type

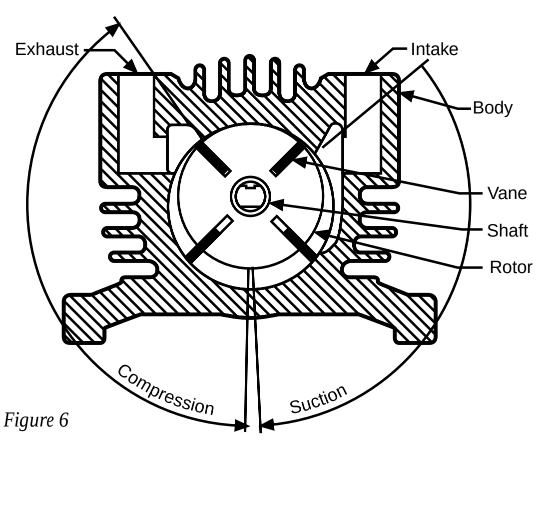


Figure 6

Rotary Helical Screw Type

Rotary helical screw compressors (Figure 7) utilize two intermeshing helical rotors in a twin-bore case. In a single-stage design, the air inlet is usually located at the top of the cylinder near the drive shaft end. The discharge port is located at the bottom of the opposite end of the cylinder. As the rotors unmesh at the air inlet end of the cylinder, air is drawn into the cavity between the main rotor lobes and the

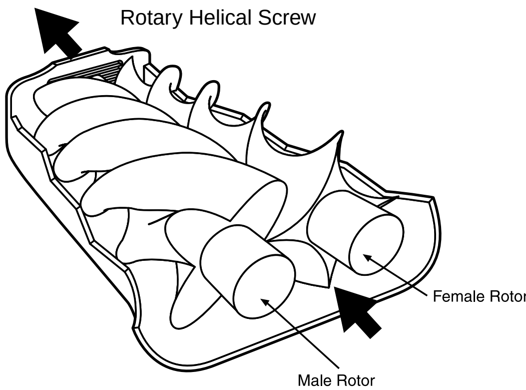


Figure 7

secondary rotor grooves. As rotation continues, the rotor tips pass the edges of the inlet ports, trapping air in a cell formed by the rotor cavities and the cylinder wall. Compression begins as further rotation causes the main rotor lobes to roll into the secondary rotor grooves, reducing the volume and raising cell pressure. Oil is injected after cell closing to seal clearances and remove heat of compression. Compression continues until the rotor tips pass the discharge porting and release of the compressed air and oil mixture is obtained. Single or multi-stage versions are available. This type of compressor can be oil lubricated, water lubricated or oil-free. Some advantages of the rotary helical screw compressors are smooth and pulse-free air output, compact size, high output volume, low vibrations, prolonged service intervals, and long life.

Rotary Scroll Type

Air compression within a scroll is accomplished by the interaction of a fixed and an orbiting helical element that progressively compresses inlet air (Figure 8). This process is continuously repeated, resulting in the delivery of pulsation-free compressed air. With fewer moving parts, reduced maintenance becomes an operating advantage. Scroll compressors can be of a lubricated or oil-free design.

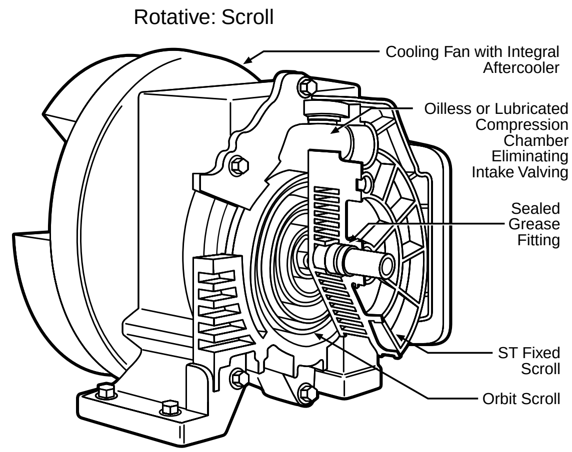


Figure 8

Types of Controls

Controls are required for all compressors in order to regulate their operation in accordance with compressed air demand. Different controls should be chosen for different types of compressor applications and requirements.

For continuous operation, when all or most of the air requirements are of a steady nature, **constant speed controls** are required. Use constant speed controls whenever the air requirement is 75 percent or more of the free air delivery of the air compressor or when motor starts per hour exceed motor manufacturer recommendations. Constant speed controls include load / unload control for all types and inlet valve modulation for rotary compressors.

Start-stop controls are recommended for a compressor when adequate air storage is provided and air requirement is less than 75 percent of the compressor free air delivery.

Dual controls allow for switching between constant speed and start-stop operation by setting a switch. With dual controls, the operator can select a different type of control to suit his or her specific air requirements each time the compressor is used. Dual controls are helpful when a compressor is used for a variety of applications.

Sequencing controls provide alternate operation of each compressor at each operating cycle and dual operation during peak demands. Sequencing controls are ideal for operating a group of compressors at peak efficiency levels.

Types of Drives

Most compressors are driven with electric motors, internal combustion engines, or engine power take-offs. Three types of drives are commonly used with these power sources.

V-Belt Drives are most commonly used with electric motors and internal combustion engines. V-Belt drives provide great flexibility in matching compressor load to power source load and speed at minimum cost. Belts must be properly shielded for safety.

Direct Drives provide compactness and minimum drive maintenance. Compressors can be flange-mounted or direct-coupled to the power source. Couplings must be properly shielded for safety. Lower horsepower compressors also are built as integral assemblies with electric motors.

Engine Drives, gasoline or diesel engine, or power takeoff drives, are used primarily for portability reasons. A gearbox, V-Belt, or direct drive is used to transmit power from the source to the compressor.

Air Compressor Packaged Units

Air compressor packaged units are fully assembled air compressor systems, complete with air compressor, electric motor, V-belt drive, air receiver, and automatic controls. Optional equipment includes aftercoolers, automatic moisture drain, low oil safety control, electric starter, and pressure reducing valve.

Air compressor units come with a variety of configurations: gasoline or diesel engines, optional direct drive, optional separate mounted air receivers, and more.

The most common type of packaged unit compressor configuration is the tank-mounted single acting, single- or two-stage reciprocating design. Models are offered in the range of 1/4 through 30 horsepower. Electric motors or gas engines drive the compressors. Typical examples are shown in Figures 9 through Figures 12.

Most compressors available in this horsepower range are air cooled. Installation is convenient because the unit requires only a connection to electrical power and a connection to the compressed air system.

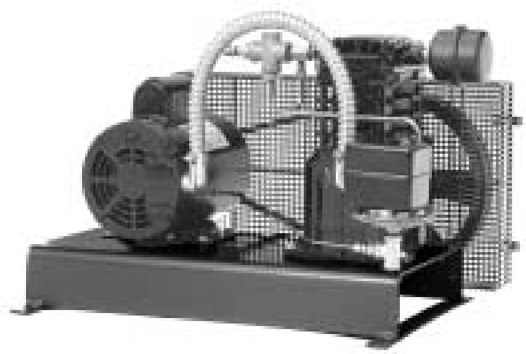


Figure 9 ***Base Plate Mounted Package***

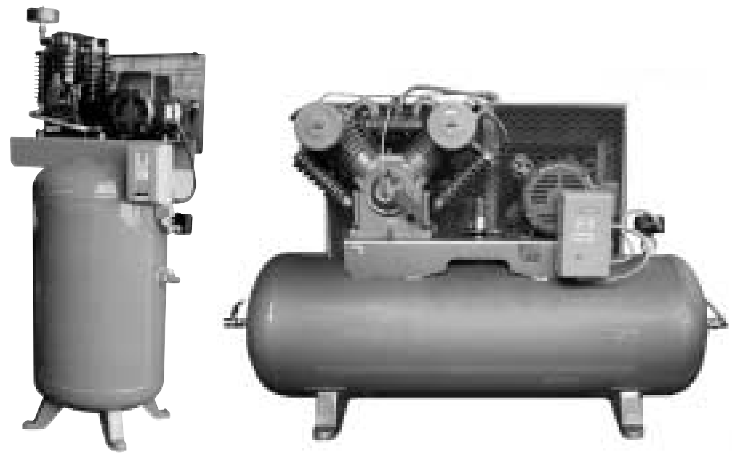


Figure 10 ***Tank Mounted Simplex Packages***

Figure 11 ***Tank Mounted Duplex Package***

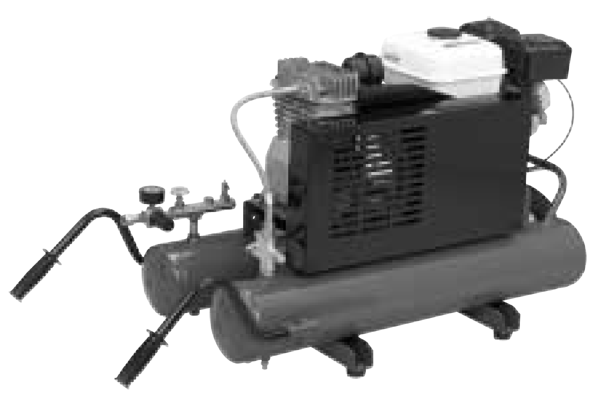


Figure 12 ***Gasoline Engine Drive Package***

Air Compressor Performance

Delivery (acfm/scfm)

The volume of compressed air delivered by an air compressor at its discharge pressure, normally is stated in terms of prevailing atmospheric inlet conditions (acfm). The corresponding flow rate in Standard cubic feet per minute (scfm) will depend upon both the Standard used and the prevailing atmospheric inlet conditions.

Varying flow rates for more than one discharge pressure simply reflect the reduction in compressor volumetric efficiency that occurs with increased system pressure (psig). For this reason, the maximum operating pressure of a compressor should be chosen carefully.

Displacement (cfm)

Displacement is the volume of the first stage cylinder(s) of a compressor multiplied by the revolutions of the compressor in one minute. Because displacement does not take into account inefficiencies related to heat and clearance volume, it is useful only as a general reference value within the industry.

Accessories

Standard accessories are available to help ensure reliable and trouble-free compressor operation. Some special purpose devices also are available to meet unusual requirements. Below is a list of commonly used accessories.

Air Receiver

A receiver tank is used as a storage reservoir for compressed air. It permits the compressor not to operate in a continuous run cycle. In addition, the receiver allows the compressed air an opportunity to cool.

Belt Guard

A belt guard protects against contact with belts from both sides of the drive and is a mandatory feature for all V-belt driven compressor units where flywheel, motor pulley, and belts are used.

Diagnostic Controls

Protective devices designed to shut down a compressor in the event of malfunction. Devices may include high air temperature shut down, low oil level shut down and low oil pressure shut down, preventative maintenance shut down, etc.

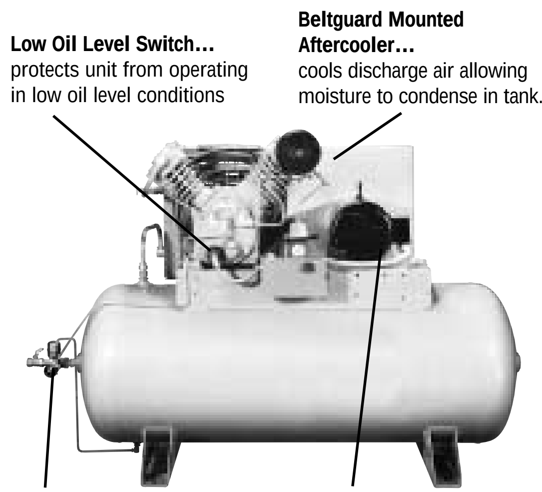


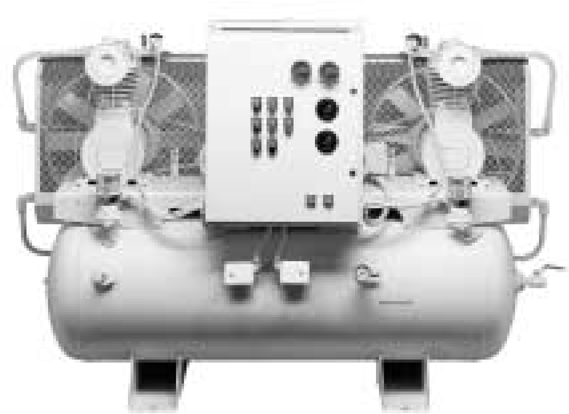
Figure 13

Intake Filter

The intake filter eliminates foreign particulate matter from the air at the intake suction of the air compressor system. Dry (with consumable replacement element) or oil bath types are available.

Manual and Magnetic Starters

Manual and magnetic starters provide thermal overload protection for motors and are recommended for integral horsepower and all three-phase motors. Local electrical codes should be checked before purchasing a starter.



Duplex Tank Mounted Compressor with Alternator Panel

Figure 14

Air Compressor Installation

Location

The air compressor location should be as close as possible to the point where the compressed air is to be used. It is also important to locate the compressor in a dry, clean, cool, and well-ventilated area. Keep it away from dirt, vapor, and volatile fumes that may clog the intake filter and valves. If a dry, clean space is unavailable, a remote air intake is recommended.

The flywheel side of the unit should be placed toward the wall and protected with a totally enclosed belt guard, but in no case should the flywheel be closer than 12 inches to the wall. Allow space on all sides for air circulation and for ease of maintenance.

Make sure that the unit is mounted level, on a solid foundation, so that there is no strain on the supporting feet or base. Solid shims may be used to level the unit. In bolting or lagging down the unit, be careful not to over-tighten and impose strain.

Motor Overload Protection

All compressor motors should be equipped with overload protection to prevent motor damage. Some motors are furnished with built-in thermal overload protection. Larger motors should be used in conjunction with starters, which include thermal overload units. Such units ensure against motor damage due to low voltage or undue load imposed on the motor.

Care should be taken to determine the proper thermal protection or heater element. The user should consider the following variables: the load to be carried, the starting current, the running current, and ambient temperature. Remember to recheck electric current characteristics against nameplate characteristics before connecting wiring.

CAUTION:

Fuses and circuit breakers are for circuit protection only and are not to be considered motor protection devices.

Consult your local power company regarding proper fuse or circuit breaker size.

Air Compressor System

A compressed air supply within a manufacturing plant or an automotive collision and body shop often consists of one compressor that can meet the overall air requirements. Makes sense, right? But consider an alternative: multiple smaller horsepower compressors positioned at strategic points throughout the plant or shop. These compressors would feed into a common air line or into individual lines serving one or more points of use.

In the central system, the compressor is of a size to supply total compressed air requirements, at least in the beginning. This option has the advantage of one compressor, one point of maintenance, and one electric power connection. The potential disadvantage is the requirement of more piping, which causes the system to be costly to install and more costly to maintain.

In the alternate system, the plant or shop starts with a single small compressor installation. Then, as expansion takes place, instead of replacing the single unit with a larger capacity single unit, another unit of the same size is installed.

Initial cost is less in the smaller multiple units than in the larger central unit. Maintenance cost is less, and cost of operation is also less, since each unit operates independently of the others. This is the optimum compressor installation—one that has the lowest installation, maintenance, and operating costs, and also the flexibility to meet changing requirements of a shop or plant. Hence, many plants have started to follow the trend towards smaller multiple compressor units.

Further advantages of multiple units are: one standby compressor can serve a number of departments; units are complete and ready for electric and air piping connections; no special foundation is required; units are usually air cooled, thus saving on water and installation cost; and units are easily moved from place to place. In addition, smaller units can meet a plant's special, occasional, or part-time requirements, with notable savings in cost of operation.

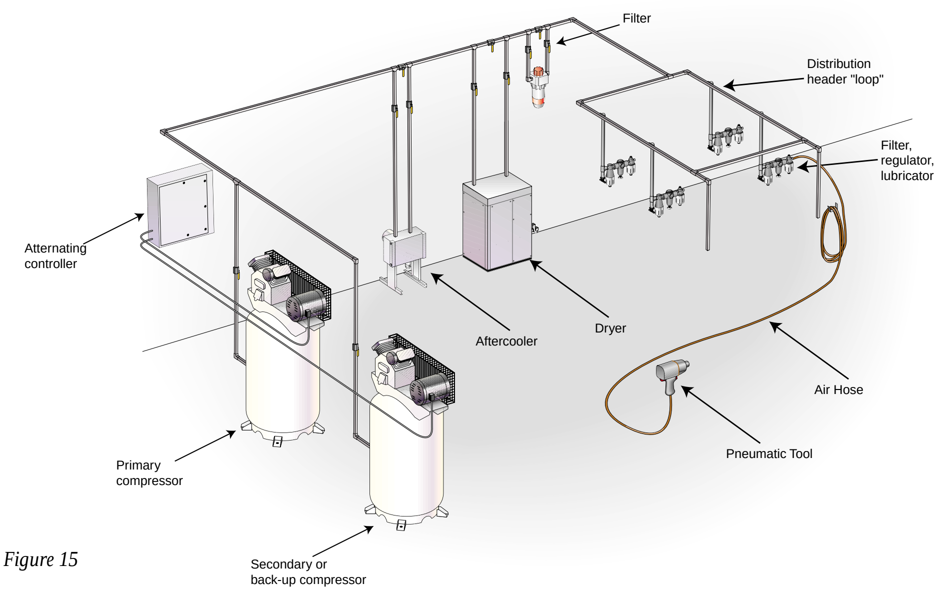


Figure 15

Air treatment is the next concern in designing a compressed air system. A by-product of the air compression process is oil and water. The clean up of compressed air begins with cooling. An air receiver allows the initial cooling of compressed air as it exits the compressor. Cooling allows oil and water vapor to condense into a liquid state where these contaminants can be drained from the system. Disposal of liquid condensate must comply with local, state, and federal requirements.

Compressed air treatment products are designed to remove oil and water in a liquid or gaseous state from the compressed air stream.

Compressed air system designs vary dependent upon application and installation requirements.

As you have seen, the compressed air system's design begins with the proper selection of the compressor. Selection must address compressor's type and size based upon the application. The compressor must be sized to support all compressed air requirements. Determine your flow (cfm) and pressure (psi) during the busiest time of the business day.

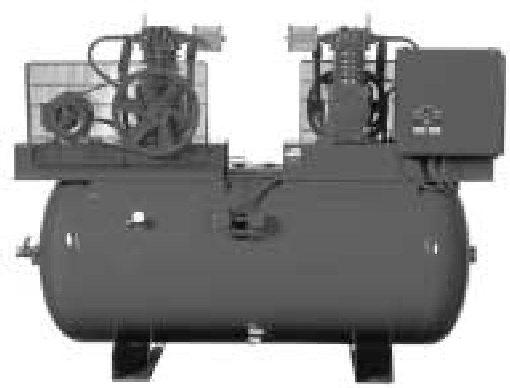
Other important considerations include the physical location of compressor, including space limitations, with appropriate access to compressor and accessories for proper operation, periodic inspections and routine maintenance.

Know the electrical service controlling the compressor. The compressor should be installed on a separate electrical circuit, which should be protected with a properly sized breaker and disconnect. The breaker should be sized for twice full load amps.

Since voltage drops over distance, electrical wiring that runs longer than 50' will require use of larger wire size to avoid voltage drop. Always use a licensed electrician when configuring your electrical requirements.

If your application requires an uninterrupted air supply, a back-up air compressor is recommended. This will ensure compressed air is available during scheduled maintenance and repair. With a second compressor, sequencing controls can be supplied, allowing the compressors to operate in a 'lead-lag' mode of operation providing additional compressed air during peak demand periods.

Sequencing controls can be supplied to balance the run time between the two compressors. Incorporating hour meters will allow scheduling of periodic maintenance.



Tank Mounted Duplex Package with Control Panel

Figure 16

Hot, saturated compressed air from the compressor's discharge is routed through an aftercooler. A cooling medium (ambient air or water) is passed across piping, conveying compressed air towards its intended use. Cooling of compressed air allows gross moisture in a vapor state to condense into a liquid. Liquid is separated from the compressed air stream and mechanically removed from the compressed air system.

The aftercooler's performance is based upon its ability to cool the compressed air stream to a lower temperature. The aftercooler can be supplied as a stand-alone unit or be supplied with the compressor.

All compressed air treatment components should be installed with bypass valving. This allows an individual component to be taken off line for maintenance or repair without interrupting the compressed air supply.

Secondly, once compressed air is cooled, further drying can be accomplished through the use of a compressed air dryer. There are many types of dryers. Dryers can be typically grouped into two major categories: refrigerant or desiccant. The design, performance and cost of a dryer will depend upon the application.

With a desiccant dryer, water vapor is removed through absorption and adsorption processes. In the event compressed air lines are exposed to temperatures below 32˚F (or 0˚C), the use of a desiccant dryer is required to eliminate the hazard of a compressed air line freezing.

Desiccant Dryer

Figure 17

Refrigerant type air dryers are the most economical compressed air dryers in terms of initial purchase price, cost of installation and operation. Within a refrigerant air dryer, compressed air is cooled, water vapor is condensed into liquid water where it is mechanically separated and drained from the compressed air system. Refrigerant air dryers are supplied with automatic condensate drains.

NOTE: An aftercooler and/or dryer can be supplied within a stand-alone air compressor package eliminating the additional field expense of installation (piping and wiring).

A properly sized dryer will prevent liquid water within a compressed air system. All dryers are rated for inlet conditions of 100°F, 100% relative humidity, and 100 psi. Increasing inlet pressure and lowering inlet temperature will improve dryer efficiency.

Once liquid condensate has been removed from the compressed air stream through the effective use of an after cooler and dryer, a compressed air filter is recommended for removal of solid particulates, aerosol mists and gaseous vapors.

A compressed air filter is designed with a replaceable element that allows contaminants to impinge upon the elements surface area. As the element becomes wetted, filtration efficiency actually improves. As

Refrigerated Dryer

Figure 18

liquids, aerosols and particulates randomly collide on small diameter fibers, the filtration process coalesced invisible contamination into larger droplets that gravitate to the base of the filter housing.

Lastly, liquids are drained from the filter through a drain valve. Compressed air filters are designed for specific applications. A properly sized and positioned compressed air filter eliminates contaminants from passing downstream. An electric drain provides a reliable alternative to float-type, gravity-feed drains that corrode and clog over time. Electric drains can be viewed as a low-cost alternative to manually draining the individual components of a compressed air system. Operation of all drains should be checked regularly to avoid costly loss of compressed air.

The compressed air piping system should be designed to deliver compressed air to the pneumatic application at the appropriate flow and pressure. The air distribution system should incorporate a leak-free piping system sized to minimize air pressure drop from its supply—the compressor and compressed air treatment components—to the point of use. Minimizing the number of 90-degree elbows will maximize delivered air pressure. It is estimated each elbow equates to 25’ of additional compressed air piping. Pipe diameter should not be less than the discharge port of your compressor. If multiple compressors are being utilized, pipe diameter should equal the sum of each compressor’s discharge. Avoid straight runs that dead-end. The most efficient design incorporates a “LOOP” that minimizes pressure drop at any one work station.

Different materials can be used for compressed air headers; materials include steel, black iron, stainless or anodized aluminum. It is critical that the material being installed has a pressure and temperature rating with an appropriate safety factor to support the compressed air pressure requirement. Do not under-size pipe. The cost difference between one pipe diameter and the next larger size is minimal. The larger the pipe diameter, the lower the pressure loss will be due to friction. A larger diameter pipe allows for additional compressed air during peak use periods and positions the system for future expansion. The compressed air velocity in the main distribution header should not exceed 30 ft / sec.

A compressed air drop leg, also referred to as a feeder line, begins with a TEE assembly that directs the compressed air in a vertical path. This unique flow pattern will guard against liquid or particulate contamination passing to a pneumatic process.

Each compressed air drop should include a TEE directing compressed air supply to its specified use. The base of the drop leg incorporates a drain valve. Each drop leg might include an FRL (point-of-use filter, regulator and lubricator).

The point-of-use filter is designed to trap any particulate matter that may have been generated in the distribution header. The regulator is designed to provide controlled, consistent air pressure as required for specific pneumatic equipment or application.

The lubricator ensures that the pneumatic device receives required lubrication to maintain operating performance, reduce wear and prolong service life. It is important to understand that lubricating oil carried over from the air compressor has gone through the compression process where it has been exposed to heat, water vapor and particulate matter. Oxidation has allowed this oil to become tacky and corrosive.

The entire compressed air treatment process and the FRL eliminates the possibility of contamination entering pneumatic equipment and processes.

Glossary

Absolute Pressure – Total pressure measured from zero. Gauge pressure plus atmospheric pressure. For example, at sea level, the gauge pressure in pounds per square inch (psi) plus 14.7 gives the absolute pressure in pounds per square inch (psi).

Absolute Temperature – See Temperature, Absolute.

Absorption – The chemical process by which a hygroscopic desiccant, having a high affinity with water, melts and becomes a liquid by absorbing the condensed moisture.

Actual Capacity – Quantity of air or gas actually compressed and delivered to the discharge system at rated speed and under rated conditions. It is usually expressed in cubic feet per minute (acfm) at compressor inlet conditions. Also called Free Air Delivered (FAD).

Adiabatic Compression – See Compression, Adiabatic.

Adsorption – The process by which a desiccant with a highly porous surface attracts and removes the moisture from compressed air. The desiccant is capable of being regenerated.

Aftercooler – A heat exchanger used for cooling air discharged from a compressor. Resulting condensate may be removed by a moisture separator following the aftercooler.

Air Receiver – See Receiver.

ASME National Board (U Type) – an air tank made, tested, inspected, and registered to meet standards of ASME. A certificate is supplied with each tank to indicate compliance and show register number. The ASME certificate is required by law in many cities and states to pass safety codes. It assures that (1) code-approved materials are used, (2) the steel plate is without defects and is of specified thickness, (3) proper welding techniques are employed by experienced operators, (4) openings and support are the correct size, and (5) the tank has passed rigid tests. ASME tanks must be used where OSHA compliance is required.

ASME Standard (UM Type) – an air tank made and tested in accordance with the American Society of Mechanical Engineers standards. ASME certificate of compliance is furnished with each tank.

Atmospheric Pressure – The measured ambient pressure for a specific location and altitude.

Automatic Sequencer – A device which operates compressors in sequence according to a programmed schedule.

Booster Compressor – Machine for compressing air or gas from an initial pressure that is above atmospheric pressure to an even higher pressure.

Brake Horsepower (bhp) – See Horsepower, Brake.

Capacity – The amount of air flow delivered under specific conditions, usually expressed in cubic feet per minute (cfm).

Capacity, Actual – The actual volume flow rate of air or gas compressed and delivered from a compressor running at its rated operating conditions of speed, pressures, and temperatures. Actual capacity is generally expressed in actual cubic feet per minute (acfm) at conditions prevailing at the compressor inlet.

Capacity Gauge –A gauge that measures air flow as a percentage of capacity, used in rotary screw compressors.

CFM, Free Air – Cubic feet per minute of air delivered to a certain point at a certain condition, converted back to ambient conditions.

CFM, Standard – Flow of free air measured and converted to a standard set of conditions of pressure, temperature and relative humidity.

Check Valve – A valve which permits flow in only one direction.

Clearance – The maximum cylinder volume on the working side of the piston minus the displacement volume per stroke. Normally it is expressed as a percentage of the displacement volume.

Clearance Pocket – An auxiliary volume that may be opened to the clearance space, to increase the clearance, usually temporarily, to reduce the volumetric efficiency of a reciprocating compressor.

Compressed Air – Air from atmosphere which has been reduced in volume, raising its pressure. It then is capable of performing work when it is released and allowed to expand to its normal free state as it passes through a pneumatic tool or other device.

Compression, Adiabatic – Compression in which no heat is transferred to or from the gas during the compression process.

Compression, Isothermal – Compression is which the temperature of the gas remains constant.

Compression, polytropic – Compression in which the relationship between the pressure and the volume is expressed by the equation PVn is a constant.

Compression Ratio – The ratio of the absolute discharge pressure to the absolute inlet pressure.

Constant Speed Control – A system in which the compressor is run continuously and matches air supply to air demand by varying compressor load.

Cut-In/Cut-Out Pressure – Respectively, the minimum and maximum discharge pressures at which the compressor will switch from unload to load operation (cut in) or from load to unload (cut out).

Cycle – The series of steps that a compressor with unloading performs; 1) fully loaded, 2) modulating (for compressors with modulating control),
3) unloaded, 4) idle.

Cycle Time – Amount of time for a compressor to complete one cycle.

Degree of Intercooling – The difference in air or gas temperature between the outlet of the intercooler and the inlet of the compressor.

Deliquescent – Melting and becoming a liquid by absorbing moisture.

Desiccant – A material having a large proportion of surface pores, capable of attracting and removing water vapor from the air.

Dew Point – The temperature at which moisture in the air will begin to condense if the air is cooled at constant pressure. At this point the relative humidity is 100%.

Demand – Flow of air at specific conditions required at a point or by the overall facility.

Diaphragm – A stationary element between the stages of a multi-stage centrifugal compressor. It may include guide vanes for directing the flowing medium to the impeller of the succeeding stage. In conjunction with an adjacent diaphragm, it forms the diffuser surrounding the impeller.

Discharge Pressure – Air pressure produced at a particular point in the system under specific conditions.

Discharge Temperature – The temperature at the discharge flange of the compressor.

Displacement – The volume swept out by the piston or rotor(s) per unit of time, normally expressed in cubic feet per minute.

Efficiency – Any reference to efficiency must be accompanied by a qualifying statement which identifies the efficiency under consideration, as in the following definitions of efficiency:

Efficiency, Compression – Ratio of theoretical power to power actually imparted to the air or gas delivered by the compressor.

Efficiency, Isothermal – Ratio of the theoretical work (as calculated on a isothermal basis) to the actual work transferred to a gas during compression.

Efficiency, Mechanical – Ratio of power imparted to the air or gas to brake horsepower (bhp).

Efficiency, Polytropic – Ratio of the polytropic compression energy transferred to the gas, to the actual energy transferred to the gas.

Efficiency, Volumetric – Ratio of actual capacity to piston displacement.

Exhauster – A term sometimes applied to a compressor in which the inlet pressure is less than atmospheric pressure.

Filters – Devices for separating and removing particulate matter, moisture or entrained lubricant from air.

Flange connection – The means of connecting a compressor inlet or discharge connection to piping by means of bolted rims (flanges).

Free Air – Air at atmospheric conditions at any specified location, unaffected by the compressor.

Full-Load – Air compressor operation at full speed with a fully open inlet and discharge delivering maximum air flow.

Gas – One of the three basic phases of matter. While air is a gas, in pneumatics the term gas normally is applied to gases other than air.

Gauge Pressure – The pressure determined by most instruments and gauges, usually expressed in psig. Barometric pressure must be considered to obtain true or absolute pressure.

Horsepower, Brake – Horsepower delivered to the output shaft of a motor or engine, or the horsepower required at the compressor shaft to perform work.

Horsepower, indicated – The horsepower calculated from compressor indicator diagrams. The term applies only to displacement type compressors.

Horsepower, Theoretical or Ideal. – The horsepower required to isothermally compress the air or gas delivered by the compressor at specified conditions.

Humidity, Relative – The relative humidity of a gas (or air) vapor mixture is the ratio of the partial pressure of the vapor to the vapor saturation pressure at the dry bulb temperature of the mixture.

Humidity, Specific – The weight of water vapor in an air vapor mixture per pound of dry air.

Indicated Power – Power as calculated from compressor-indicator diagrams.

Indicator card – A pressure-volume diagram for a compressor or engine cylinder, produced by direct measurement by a device called an indicator.

Inlet Pressure – The actual pressure at the inlet flange of the compressor.

Intercooling – The removal of heat from air or gas between compressor stages.

Intercooling, degree of – The difference in air or gas temperatures between the inlet of the compressor and the outlet of the intercooler.

Intercooling, perfect – When the temperature of the air or gas leaving the intercooler is equal to the temperature of the air or gas entering the inlet of the compressor.

Isentropic compression – See Compression, Isentropic.

Isothermal compression – See Compression, Isothermal.

Leak – An unintended loss of compressed air to ambient conditions.

Load Factor – Ratio of average compressor load to the maximum rated compressor load over a given period of time.

Load Time – Time period from when a compressor loads until it unloads.

Load/Unload Control – Control method that allows the compressor to run at full-load or at no load while the driver remains at a constant speed.

Modulating Control – System which adapts to varying demand by throttling the compressor inlet proportionally to the demand.

Multi-stage compressors – Compressors having two or more stages operating in series.

Perfect Intercooling –The condition when the temperature of air leaving the intercooler equals the temperature of air at the compressor intake.

Performance curve – Usually a plot of discharge pressure versus inlet capacity and shaft horsepower versus inlet capacity.

Piston Displacement – The volume swept by the piston; for multistage compressors, the piston displacement of the first stage is the overall piston displacement of the entire unit.

Pneumatic Tools – Tools that operate by air pressure.

Polytropic compression – See Compression, Polytropic.

Positive displacement compressors – Compressors in which successive volumes of air or gas are confined within a closed space and the space mechanically reduced, resulting in compression. These may be reciprocating or rotating.

Power, theoretical (polytropic) – The mechanical power required to compress polytropically and to deliver, through the specified range of pressures, the gas delivered by the compressor.

Pressure – Force per unit area, measured in pounds per square inch (psi).

Pressure, absolute – The total pressure measured from absolute zero (i.e. from an absolute vacuum).

Pressure Dew Point – For a given pressure, the temperature at which water will begin to condense out of air.

Pressure, discharge – The pressure at the discharge connection of a compressor. (In the case of compressor packages, this should be at the discharge connection of the package)

Pressure Drop – Loss of pressure in a compressed air system or component due to friction or restriction.

Pressure, intake – The absolute total pressure at the inlet connection of a compressor.

Pressure Range – Difference between minimum and maximum pressures for an air compressor. Also called cut in-cut out or load-no load pressure range.

Pressure ratio – See Compression Ratio.

Pressure rise – The difference between discharge pressure and intake pressure.

Pressure, static – The pressure measured in a flowing stream in such a manner that the velocity of the stream has no effect on the measurement.

Pressure, total – The pressure that would be produced by stopping a moving stream of liquid or gas. It is the pressure measured by an impact tube.

Pressure, velocity – The total pressure minus the static pressure in an air or gas stream.

Rated Capacity – Volume rate of air flow at rated pressure at a specific point.

Rated Pressure – The operating pressure at which compressor performance is measured.

Required Capacity – Cubic feet per minute (cfm) of air required at the inlet to the distribution system.

Receiver – A vessel or tank used for storage of gas under pressure. In a large compressed air system there may be primary and secondary receivers.

Reciprocating compressor – Compressor in which the compressing element is a piston having a reciprocating motion in a cylinder.

Relative Humidity – The ratio of the partial pressure of a vapor to the vapor saturation pressure at the dry bulb temperature of a mixture.

Rotor – The rotating element of a compressor. In a dynamic compressor, it is composed of the impeller(s) and shaft, and may include shaft sleeves and a thrust balancing device.

Seals – Devices used to separate and minimize leakage between areas of unequal pressure.

Sequence – The order in which compressors are brought online.

Shaft – The part by which energy is transmitted from the prime mover through the elements mounted on it, to the air or gas being compressed.

Sole plate – A pad, usually metallic and embedded in concrete, on which the compressor and driver are mounted.

Specific gravity – The ratio of the specific weight of air or gas to that of dry air at the same pressure and temperature.

Specific Humidity – The weight of water vapor in an air-vapor mixture per pound of dry air.

Specific Power – A measure of air compressor efficiency, usually in the form of bhp / 100 acfm.

Specific Weight – Weight of air or gas per unit volume.

Speed – The speed of a compressor refers to the number of revolutions per minute of the compressor drive shaft or rotor shaft.

Stages – A series of steps in the compression of air or a gas.

Standard Air – The Compressed Air & Gas Institute and PNEUROP have adopted the definition used in ISO standards. This is air at 14.5 psia (1 bar); 68 °F (20° C) and dry (0% relative humidity).

Start/Stop Control – A system in which air supply is matched to demand by the starting and stopping of the unit.

Temperature, Absolute – The temperature of air or gas measured from absolute zero. It is the Fahrenheit temperature plus 459.6 and is known as the Rankine temperature. In the metric system, the absolute temperature is the Centigrade temperature plus 273 and is known as the Kelvin temperature.

Temperature, Discharge – The total temperature at the discharge connection of the compressor.

Temperature, Inlet – The total temperature at the inlet connection of the compressor.

Temperature Rise Ratio – The ratio of the computed isentropic temperature rise to the measured total temperature rise during compression. For a perfect gas, this is equal to the ratio of the isentropic enthalpy rise to the actual enthalpy rise.

Temperature, Static – The actual temperature of a moving gas stream. It is the temperature indicated by a thermometer moving in the stream and at the same velocity.

Temperature, Total – The temperature which would be measured at the stagnation point if a gas stream were stopped, with adiabatic compression from the flow condition to the stagnation pressure.

Theoretical Power – The power required to compress a gas isothermally through a specified range of pressures.

Torque – A torsional moment or couple. This term typically refers to the driving couple of a machine or motor.

Total Package Input Power – The total electrical power input to a compressor, including drive motor, cooling fan, motors, controls, etc.

Unit type compressors – Compressors of 30 bhp or less, generally combined with all components required for operation.

Unload – (No load) Compressor operation in which no air is delivered due to the intake being closed or modified not to allow inlet air to be trapped.

Vacuum pumps – Compressors which operate with an intake pressure below atmospheric pressure and which discharge to atmospheric pressure or slightly higher.

Valves – Devices with passages for directing flow into alternate paths or to prevent flow.

Water cooled compressor – Compressors cooled by water circulated through jackets surrounding cylinders or casings and / or heat exchangers between and after stages.

How To Select An Air Compressor

After listing all the air operated devices to be supplied by the air compressor, determine, from chart, the pressure range and volume of air required by each device. The air compressor must maintain a minimum pressure at least equal to the highest of these pressure ranges. For example, if the highest pressure range required by any one device in a given group is 120 psi-150 psi, a compressor cutting in at not less than 120 psi and cutting out at 150 psi should be recommended.

Check electrical characteristics before ordering compressor.

Air Consumption Chart for Industrial Type Tools,

Cubic Feet Per Minute Required to Operate Various Pneumatic Equipment at Pressure Range 70-90 psig

Miscellaneous Portable Tools	Consumption (cfm) 15% Use FACTOR	Consumption (cfm) 25% Use FACTOR	Consumption (cfm) 35% Use FACTOR
Drill, 1/16” to 3/8”	4.0	6.0	9.0
Drill, 3/8” to 5/8”	5.0	9.0	12.0
Screwdriver # 2 to # 6 Screw	2.0	3.0	4.0
Screwdriver # 5 to 5/16” Screw	4.0	6.0	8.0
Trapper, to 3/8”	4.0	6.0	8.0
Nutsetters, to 3/8”	4.0	6.0	8.0
Nutsetters, to 9/16”	8.0	13.0	18.0
Nutsetters, to 3/4”	9.0	15.0	21.0
Impact Wrench, 1/4”	2.0	4.0	5.0
Impact Wrench, 3/8”	3.0	5.0	7.0
Impact Wrench, 1/2”	5.0	8.0	11.0
Impact Wrench, 5/8”	5.0	8.0	11.0
Impact Wrench, 3/4”	5.0	9.0	12.0
Impact Wrench, 1”	7.0	11.0	16.0
Impact Wrench, 1 1/4”	8.0	14.0	19.0
Die Grinder, Small	2.0	4.0	5.0
Die Grinder, Medium	4.0	6.0	8.0
Horizontal Grinder, 2”	5.0	8.0	11.0
Horizontal Grinder, 4”	9.0	15.0	21.0
Horizontal Grinder, 6”	11.0	18.0	25.0
Horizontal Grinder, 8”	12.0	20.0	28.0
Vertical Grinders and Sanders, 5” Pad	5.0	9.0	12.0
Vertical Grinders and Sanders, 7” Pad	11.0	18.0	25.0
Vertical Grinders and Sanders, 9” Pad	12.0	20.0	28.0

Miscellaneous Portable Tools	Consumption (cfm) 15% Use FACTOR	Consumption (cfm) 25% Use FACTOR	Consumption (cfm) 35% Use FACTOR
Burring Tool, Small	2.0	4.0	5.0
Burring Tool, Large	4.0	6.0	8.0
Rammers, Small	4.0	3.0	9.0
Rammers, Medium	5.0	9.0	12.0
Rammers, Large	6.0	10.0	14.0
Backfill Tamper	4.0	6.0	9.0
Compression Riveter	.2 cu. ft. per cycle		
Air Motor, 1 Horsepower	5.0	9.0	12.0
Air Motor, 2 Horsepower	11.0	18.0	25.0
Air Motor, 3 Horsepower	14.0	24.0	33.0
Air Motor Hoist, 1000 #	1. cu. ft. per foot of lift		
Air Motor Hoist, 2000 #	1. cu. ft. per foot of lift		
Paint Spray Gun (Production)	3.0	5.0	7.0
Hammers			
Scaling Hammer	2.0	3.0	4.0
Chipping Hammer	5.0	8.0	11.0
Riveting Hammer (Heavy)	5.0	8.0	11.0
Riveting Hammer (Light)	2.0	4.0	5.0
Saws			
Circular, 8”	7.0	11.0	16.0
Circular, 12”	10.0	16.0	24.0
Chain, Lightweight	4.0	7.0	10.0
Chain, Heavy Duty	13.0	22.0	31.0

Always check with tool manufacturers for actual air consumption of tools being used. The above is based on averages and should not be considered accurate for any particular make of tool.

Above tools are rated based upon typical “on-load” performance characteristics.

For other use factors adjust the cfm air consumption on a proportional basis. (Example: 30 seconds on; 30 seconds off use 50% as use factor).

Air Consumption Chart for Automotive Service Shops.

Cubic Feet Per Minute Required to Operate Various Pneumatic Equipment, for average service shop usage factor.

Equipment Air Pressure Range in psi	Portable Tools	Compressor cfm Required Per Unit
70-100	**Air Filter Cleaner	3.0
70-100	**Body Polisher	20.0
70-100	**Body Sander (Orbital)	10.0
70-100	Brake Tester	4.0
70-100	**Carbon Remover	3.0
90-100	Dusting Gun (Blow Gun)	2.5
70-100	Panel Cutter	4.0
70-90	**Drill, 1/16” to 3/8”	4.0
70-90	**Impact Wrench 3/8” sq. dr.	3.0
70-90	**Impact Wrench 1/2” sq. dr.	4.0
70-90	**Impact Wrench 5/8” sq. dr.	5.0
70-90	**Impact Wrench 3/4” sq. dr.	8.0
70-90	**Impact Wrench 1” sq. dr.	12.0
70-90	**Die Grinder	5.0
90-100	**Vertical Disc Sanders	20.0
90-100	**Filing and Sawing Machine, (Small)	3.0
90-100	**Filing and Sawing Machine, (Large)	5.0
90-100	**Burring Tool	5.0
Tire Tools		
125-150	Rim Stripper	6.0
125-150	Tire Changer	1.0
125-150	Tire Inflation Line	2.0
125-150	Tire Spreader	1.0
125-150	**Vacuum Cleaner	7.0

Equipment Air Pressure Range in psi	Portable Tools	Compressor cfm Required Per Unit
Hammers		
90-100	**Air Hammer	4.0
90-100	Tire Hammer	12.0
125-150	Bead Breaker	12.0
90-100	Spring Oiler	4.0
Spray Guns		
90-100	**Engine Cleaner	5.0
90-100	**Paint Spray Gun (production)	8.0
90-100	**Paint Spray Gun (touch up)	4.0
90-100	**Paint Spray Gun (undercoat)	19.0
Other Equipment		
120-150	**Grease Gun	3.0
145-175	Car Lift* (air powered hydraulic)	6.0
125-150	Floor Jacks (air powered hydraulic)	6.0
120-150	Pneumatic Garage Door	3.0
90-100	Radiator Tester	1.0
90-100	Spark Plug Cleaner	5.0
90-100	Spark Plug Tester	.5
70-100	Transmission and Differential Flusher	3.0
70-100	**Fender Hammer	9.0
70-100	**Car Washer	9.0
70-100	**6” Medium Duty Sander	40.0

* *This is for 8,000 lbs. capacity. Add .65 cfm for each 1,000 lbs. capacity over 8,000 lbs.*

** *These devices are rated based upon typical “on-load” performance characteristics.*

Always check with tool manufacturers for actual consumption of tools being used. The above is based on averages and should not be considered accurate for any particular make of tool.

Compressor Selector Chart

Compressor Pressures per square inch		Air Consumption in Cubic Feet Per Minute of Total Equipment		Horsepower of Compressor Required	
Cut In	Cut Out	Average Use*	Continuous Operation**	Two-Stage	One-Stage
80	100	Up to - 6.6	Up to - 1.9		1/2
80	100	6.7 - 10.5	2.0 - 3.0		3/4
80	100	10.6 - 13.6	3.1 - 3.9		1
80	100	Up to - 14.7	Up to - 4.2	1	
80	100	13.7 - 20.3	4.0 - 5.8		1 1/2
80	100	14.8 - 22.4	4.3 - 6.4	1 1/2	
80	100	20.4 - 26.6	5.9 - 7.6		2
80	100	22.5 -30.4	6.5 - 8.7	2	
80	100	26.7 - 32.5	7.7 - 10.2		3
80	100	30.5 - 46.2	8.8 - 13.2	3	
80	100	32.6 - 38.0	10.3 - 18.0		5
80	100	46.3 - 60.0	13.3 - 20.0	5	
80	100	60.1 - 73.0	20.1 - 29.2	7 1/2	
80	100	73.1 - 100.0	29.3 - 40.0	10	
80	100	100.1 - 150.0	40.1 - 60.0	15	
80	100	150.1 - 200.0	60.1 - 80.0	20	
80	100	201.0 - 250.0	80.1 - 100.0	25	
120	150	Up to - 3.8	Up to - 1.1		1/2
120	150	3.9 - 7.3	1.2 - 2.1		3/4
120	150	7.4 - 10.1	2.2 - 2.9		1
120	150	Up to - 12.6	Up to - 3.6	1	
120	150	10.2 - 15.0	3.0 - 4.3		1 1/2
120	150	12.7 - 20.0	3.7 - 5.7	1 1/2	
120	150	15.1 - 20.0	4.4 - 5.7		2
120	150	20.1 - 25.9	5.8 - 7.4	2	
120	150	26.0 - 39.2	7.5 - 11.2	3	
120	150	39.3 - 51.9	11.3 - 17.3	5	
120	150	52.0 - 67.5	17.4 - 27.0	7 1/2	
120	150	67.6 - 92.5	27.1 - 37.0	10	
120	150	92.5 - 140.0	37.1 - 57.0	15	
120	150	140.1 - 190.0	57.1 - 77.0	20	
120	150	190.1 - 240.0	77.1 - 97.0	25	
145	175	Up to - 11.9	Up to - 3.4	1***	
145	175	12.0 - 18.5	3.5 - 5.3	1 1/2	
145	175	18.6 - 24.2	5.4 - 6.9	2	
145	175	24.3 - 36.4	7.0 - 10.4	3	
145	175	36.5 - 51.0	10.5 -17.0	5*	
145	175	51.1 - 66.0	17.1 - 26.4	7 1/2	
145	175	66.1 - 88.2	26.5 - 35.3	10	
145	175	88.3 - 135.0	35.3 - 55.0	15	
145	175	135.1 - 185.0	55.1 - 75.0	20	
145	175	185.1 - 235.0	75.1 - 95.0	25	

** These figures are not to be regarded as the capacity of the compressor in free air output, but instead, are the combined free air consumption of all the tools in the establishment, as well as tools anticipated for future added equipment. (A factor has been introduced to take into account intermittent operation of tools likely to be in use simultaneously in the average garage or industrial plant. (See Example 1 on page number 17 for the use of the f igures given in this column.)*

***These figures are to be employed when the nature of the device is such that normal operation requires a continuous supply of compressed air. Therefore, no factor for intermittent operation has been used, and the figures given represent the compressor capacity in free air output. (See Example 2 on page number 17 for the use of the figures given in this column.)*

***Do not recommend a compressor of less than 1 1/2 H.P. if the pneumatic equipment includes a lift of 8,000 lbs. capacity.*

Example One

It is required to supply a compressor to operate the equipment listed below such as might be found in an average service station. Add the cfm required by all the devices.

2 – Car Lifts	@ 6.0 cfm - 12.0 cfm	145 to 175 psi
2 – Grease Guns	@ 3.0 cfm - 6.0 cfm	120 to 150 psi
1 – Spring Oiler	@ 4.0 cfm - 4.0 cfm	90 to 100 psi
1 – Spark Plug Cleaner	@ 5.0 cfm - 5.0 cfm	90 to 100 psi
2 – Tire Inflators	@ 2.0 cfm - 4.0 cfm	125 to 150 psi
1 – Dusting Gun	@ 2.5 cfm - 2.5 cfm	90 to 100 psi
1 – Trans. and Diff. Flusher	@ 3.0 cfm - 3.0 cfm	70 to 100 psi
Total	**25.5 cfm - 36.5 cfm**	

On this page, under the column "Average Use", and opposite the pressure range required (145 psi to 175 psi), find the line indicating 36.5 cfm or more. The compressor required will be a 3 HP, 2-stage unit.

Example Two

A compressor is needed to operate the following equipment, all of which is to be in operation continuously, or nearly so. Total of cfm required for all the devices and the pressure ranges.

1 – Fender Hammer	@ 9.0 cfm	70 to 100 psi
1 – Paint Spray Gun (Production Type)	@ 8.0 cfm	90 to 100 psi
1 – Body Polisher	@ 20 cfm	70 to 100 psi
1 – Touch-Up Spray Gun	@ 3.5 cfm	90 to 100 psi
1 – Vacuum Cleaner	@ 7.0 cfm	125 to 150 psi
Total	**47.5 cfm**	

On this page, under the column "Continuous Operation", and opposite the pressure range required (120 psi - 150 psi), find the line indicating 47.5 cfm or more. The compressor needed will be a 15 HP, 2-stage unit.

Example Three

In the case of an industrial plant where some of the pneumatic equipment will be operated under "Average Use" and part will be in operation continuously, total the cfm required, as well as the pressure ranges, of each group, as follows:

Below, under column "Average Use", select a unit having delivery of 12.5 cfm at 145-175 psi as that pressure range required to operate the equipment shown. It will be a 2 HP, 2-stage unit.

Below, under column "Continuous Operation", select a unit having a delivery of 10.75 cfm at 80-100 psi as that pressure range required to operate the equipment shown. This unit will be a 3 HP, 2-stage compressor.

To supply one compressor rather than two, for the above equipment, total the HP, which in this case would be 5 HP operating at a pressure range of 145 to 175 psi.

"Average Use"		
1 - Car Lift	@ 6.0 cfm	145 to 175 psi
5 - Dusting Guns	@ 2.5 cfm	90 to 100 psi
1 - Panel Cutter	@ 4.0 cfm	70 to 100 psi
Total	12.5 cfm	
"Continuous Operation"		
1 - Paint Spray Gun (Production Type)	@ 7.00 cfm	70 to 90 psi
1 - Impact Wrench	@ 3.75 cfm	70 to 90 psi
Total	10.75 cfm	

Note: Pressure regulators must be used to regulate to the allowable maximum pressure of the devices.

Selecting the Proper Air Compressor To Use with an Air Cylinder

Air cylinders use compressed air to produce force or motion. The compressed air is directed into a cylinder chamber and it forces a piston to move in a linear direction. The distance the piston travels is called the length of stroke. A piston rod attached to the piston exerts a force in pounds to produce work or motion to a mechanism at a rate of so many strokes per minute.

In commercial and industrial uses, a piece of equipment using an air cylinder of a given diameter will be rated as to force (thrust load) in pounds, length of stroke and the number of strokes per minute, and you should obtain this information from your supplier.

Using the thrust load and cylinder diameter figures, make your choice of a single or two stage air compressor and determine the pressure needed from chart "A".

Determine the cfm of free air needed by the air cylinder from chart "B" by using the factor shown opposite your cylinder diameter and pressure requirement (see example for explanation of how to determine factors not shown). Multiply this factor by the number of inches of stroke and the number of strokes per minute to determine the cfm requirement.

From selector charts, determine your air compressor selection.

Chart A – Cylinder Diameter Required to Develop Power to Overcome the Load Indicated:

Thrust Load in Pounds	Pressure in Cylinder – psi															
	70	80	90	100	110	120	125	130	140	150	160	170	175	180	190	200
500	3 1/8	2 7/8	2 3/4	2 1/2	2 1/2	2 3/8	2 3/8	2 1/4	2 1/4	2 1/8	2	2	2	2	1 7/8	1 7/8
1000	4 3/8	4	3 7/8	3 5/8	3 1/2	3 3/8	3 1/4	3 1/4	3 1/8	3	2 7/8	2 3/4	2 3/4	2 3/4	2 5/8	2 5/8
1500	5 1/4	5	4 5/8	4 3/8	4 1/4	4	4	3 7/8	3 3/4	3 5/8	3 1/2	3 3/8	3 3/8	3 3/8	3 1/4	3 1/8
2000	6 1/8	5 3/4	5 3/8	5 1/8	4 7/8	4 5/8	4 5/8	4 1/2	4 3/8	4 1/8	4	3 7/8	3 7/8	3 7/8	3 3/4	3 5/8
2500	6 7/8	6 3/8	6	5 3/4	5 1/2	5 1/8	5 1/8	5	4 7/8	4 5/8	4 1/2	4 3/8	4 3/8	4 1/4	4 1/8	4
3000	7 1/2	7	6 5/8	6 1/4	6	5 3/4	5 5/8	5 1/2	5 1/4	5 1/8	5	4 3/4	4 3/4	4 5/8	4 1/2	4 3/8
	▲ Single-Stage			▲ Two-Stage												

Chart B – Cubic Feet of Air Required for Single Acting Air Cylinder*:

Piston Dia. (in.)	90 psi	125 psi	Piston Dia. (in.)	90 psi	125 psi	Piston Dia. (in.)	90 psi	125 psi	Piston Dia. (in.)	90 psi	125 psi
1 3/4	.0102	.0131	3 1/4	.0350	.0454	4 3/4	.0748	.0970	6 1/4	.1300	.1681
1 7/8	.0115	.0149	3 3/8	.0378	.0489	4 7/8	.0789	.1020	6 3/8	.1346	.1742
2	.0133	.0172	3 1/2	.0405	.0524	5	.0832	.1076	6 1/2	.1402	.1813
2 1/8	.0150	.0194	3 5/8	.0434	.0562	5 1/8	.0872	.1127	6 5/8	.1460	.1888
2 1/4	.0168	.0217	3 3/4	.0467	.0605	5 1/4	.0913	.1180	6 3/4	.1510	.1955
2 3/8	.0187	.0242	3 7/8	.0496	.0642	5 3/8	.0957	.1237	6 7/8	.1570	.2060
2 1/2	.0207	.0268	4	.0530	.0685	5 1/2	.1004	.1299	7	.1630	.2105
2 5/8	.0228	.0296	4 1/8	.0564	.0730	5 5/8	.1050	.1361	7 1/8	.1684	.2181
2 3/4	.0250	.0324	4 1/4	.0599	.0775	5 3/4	.1096	.1416	7 1/4	.1746	.2257
2 7/8	.0275	.0355	4 3/8	.0635	.0822	5 7/8	.1146	.1482	7 3/8	.1802	.2332
3	.0299	.0386	4 1/2	.0672	.0870	6	.1200	.1550	7 1/2	.1870	.2419
3 1/8	.0323	.0418	4 5/8	.0708	.0915	6 1/8	.1250	.1623			

**To obtain CFM required; multiply factor above by 2 if cylinder is double acting: then multiply by number of inches of stroke; then multiply by number of strokes per minute.*

Example

A 2 1/4 dia. cylinder, double acting, with an 8” stroke is required to clamp a casting during machining. A pressure of 100 psi will be required and it is expected that 16 castings will be clamped every minute. To determine cfm required, multiply factor opposite 2 1/4 dia. cylinder in 90 psi column by 2 for double acting (2 x .0168), then multiply this by 8 for 8” stroke (2 x .0168 x 8), then multiply this by strokes per minute (2 x .0168 x 8 x 16). The result is 4.3 cfm of free air required at 90 psi. This same calculation is repeated using the factor in the 125 psi column.

The result is (2 x .0217 x 8 x 16) 5.56 cfm required at 125 psi. Since the cfm at 100 psi is required and it is known that 100 psi is about 1/3 the way from 90 psi to 125 psi, it can be estimated that the cfm required at 100 psi will be about 1/3 the difference of that required at 90 and 125 psi.

$\frac{(5.56 - 4.3)}{3}$ = .42. The approximate cfm required at 100 psi will then be 4.3 plus this difference (4.3 + .42) or 4.72 cfm.

Air Flow Chart

Another industrial use for compressed air is using a blast of compressed air, released at the proper moment, to blow away small parts from a punch after forming and blanking.

An automatic valve allows air to flow from a properly positioned and aimed nozzle against the work pieces. The pressure employed and the diameter of the passage through the nozzle determine the volume of free air which will flow through the nozzle.

The chart below indicates the rate of flow (volume) per minute, through various sizes of orifices at definite pressures.

Flow is expressed in cubic feet per minute (cfm), and is assumed to take place from a receiver or other vessel, in which air is contained under pressure, into the atmosphere at sea level. Temperature of air in receiver is assumed at 60 deg. F. This table is only correct for orifices with narrow edges; flow through even a short length of pipe would be less than that given below.

Gage Pres. in Receiver (lbs.)	Flow of Free Air (cfm) Through Orifices of Various Diameters							
	1/64”	1/32”	3/64”	1/16”	3/32”	1/8”	3/16”	1/4”
1	.027	.107	.242	.430	.97	1.72	3.86	6.85
2	.038	.153	.342	.607	1.36	2.43	5.42	9.74
3	.046	.188	.471	.750	1.68	2.98	6.71	11.9
5	.059	.242	.545	.965	2.18	3.86	8.71	15.4
10	.084	.342	.77	1.36	3.08	5.45	12.3	21.8
15	.103	.418	.94	1.67	3.75	6.65	15.0	26.7
20	.119	.485	1.07	1.93	4.25	7.7	17.1	30.8
25	.133	.54	1.21	2.16	4.75	8.6	19.4	34.5
30	.156	.632	1.40	2.52	5.6	10.	22.5	40.0
35	.173	.71	1.56	2.80	6.2	11.2	25.0	44.7
40	.19	.77	1.71	3.07	6.8	12.3	27.5	49.1
45	.208	.843	1.9	3.36	7.6	13.4	30.3	53.8
50	.225	.914	2.05	3.64	8.2	14.5	32.8	58.2
60	.26	1.05	2.35	4.2	9.4	16.8	37.5	67
70	.295	1.19	2.68	4.76	10.7	19.0	43.0	76
80	.33	1.33	2.97	5.32	11.9	21.2	47.5	85
90	.364	1.47	3.28	5.87	13.1	23.5	52.5	94
100	.40	1.61	3.66	6.45	14.5	25.8	58.3	103
110	.43	1.76	3.95	7.00	15.7	28.0	63	112
120	.47	1.90	4.27	7.58	17.0	30.2	68	121
130	.50	2.04	4.57	8.13	18.2	32.4	73	130
140	.54	2.17	4.87	8.68	19.5	34.5	78	138
150	.57	2.33	5.20	9.20	20.7	36.7	83	147
175	.66	2.65	5.94	10.6	23.8	42.1	95	169
200	.76	3.07	6.90	12.2	27.5	48.7	110	195

The capacity of an air compressor cannot be checked accurately by use of this table and a narrow edge orifice. Specialized equipment is necessary to check compressor capacity.

Example: An air ejector is being used on a punch press. It is connected to an air line with pressure at 120-150 psi. It has a nozzle orifice 3/32 in. in diameter, and, through use of a stop watch, it delivers compressed air for a total of 30 seconds out of each one minute of operation.

Reference to the chart indicates at 150 psi a 3/32 in. diameter orifice will allow 20.7 cfm to flow through the nozzle in one minute. However, air flow intakes place only for 30 seconds out of each 60 seconds or 30/60 of the time, therefore, only 1/2 of 20.7 or 10.35 cfm will flow for each elapsed minute.

From page 17, under the column “Continuous Operation” and opposite the pressure range 120-150 psi, select the air compressor, which will be a 3 HP, 2-stage unit.

Useful Formulae

1. Comp. R.P.M = $\frac{\text{motor pulley dia. x motor r.p.m.}}{\text{comp. pulley dia.}}$

2. Motor Pulley p.d. = $\frac{\text{comp. pulley dia. x comp. r.p.m.}}{\text{motor r.p.m.}}$

3. Comp. Pulley p.d. = $\frac{\text{motor pulley dia. x motor r.p.m.}}{\text{comp. r.p.m.}}$

4. Motor R.P.M. = $\frac{\text{comp. pulley dia. x comp. r.p.m.}}{\text{motor pulley p.d.}}$

5. Free Air = piston displacement x volumetric eff. (%)

6. Required Piston Displacement = $\frac{\text{free air}}{\text{vol.eff.}}$

7. Piston Displacement In Cu. Ft. Min.* =

$$\frac{\text{Cyc. bore in In. x Cyl. bore x stroke in In. x r.p.m.}}{2200}$$

8. Cu. Ft. Compressed Air = $\frac{\text{cu. ft. free air x 14.7}}{\text{(p.s.i.g. + 14.7)}}$

9. Cu. Ft. Free Air = $\frac{\text{cu. ft. compressed air x (p.s.i.g. + 14.7)}}{14.7}$

10. Cu. Ft. Free Air Req'd. To Raise Rec. From 0 Gage To Final Pressure =

$$\frac{\text{vol. of rec. in cu. ft. x p.s.i.g.}}{\text{(atmospheric pressure) p.s.i.a.}}$$

11. Cu. Ft. Free Air Req'd. To Raise Rec. From Some Press. Greater Than 0 Gage To A Final Higher Pressure =

$$\text{vol. of rec in cu. ft.} \times \frac{\text{(final p.s.i.g. – initial p.s.i.g.)}}{\text{(atmospheric pressure) p.s.i.a.}}$$

12. Piston Speed In Ft. Per Min. = $\frac{\text{2 x stroke (in inches) x r.p.m.}}{12}$

13. Gallons = $\frac{\text{cu. ft.}}{.134}$

14. Cu. Ft. = gallons x .134

15. Total Force in lbs. of Air Cylinder =

$$\text{Area of the Cylinder Dia. in sq. inches} \times \text{P.S.I.G. of air press. used}$$

16. C.F.M. of Free Air req'd to operate Air Cylinder (Single Acting) = $\text{Vol. of Cyl. in cu. ft.} \times \text{Cycles Per Min.} \times \frac{\text{(Gage Press p.s.i.g. + 14.7}}{14.7}$

17. Pump Up Time (Min) = $\frac{\text{V (tank size in gal.) x (final tank press. – initial tank press.)}}{\text{7.48 x atmos. press. (p.s.i.a.) x pump delivery (c.f.m.)}}$

**Piston displacement for multi-stage compressors – only the low pressure cylinders are considered.*

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