



# TECHNICAL BULLETIN

## WHAT YOU SHOULD KNOW ABOUT BUYING AN AIR COMPRESSOR, BEFORE YOU BUY.

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### INTRODUCTION

Today, compressed air is one of industries most widely used and versatile utilities.

However, faced with the wide array of available equipment and a baffling maze of compressed air terminology, users of compressed air equipment must often make bewildering choices without adequate information.

The purpose of this bulletin is to give the reader a clear understanding of the basic fundamentals of selecting a used air compressor.

1. **Gain a Clear Understanding of Compressed Air Terminology**

This terminology is clearly defined in the glossary at the end of this article

2. **Compile a List of the Relevant Information That You Will Be Required To Provide To The Compressor Vendor**

- What volume of compressed air is required?
- What pressure is required to operate the equipment?
- What will the duty cycle be (continuous or intermittent)?
- Is there a source of available cooling water (cooling tower, cooling pond etc) or is an air-cooled unit required?
- What electrical classification is required (unclassified, Class 1 Div 2, Class 1 Div 1)?
- What electrical power will be available (voltage, amperages and phase)?
- Where will the compressor be located?
- Does the location have adequate ventilation?
- Will the compressor be subjected to freezing conditions?
- What level of noise can be tolerated from the compressor (will the compressor be located in a compressor room or in the plant production area)?

3. **Determine What Classification Your Compressed Air requirements Fall Into?**

General plant utility air:                   - Air tools  
  - Manufacturing machinery

Instrument air                               - Valve actuators  
  - Climate control  
  - Sampling units



b. Free Air Delivery (CFM) or Actual Delivery

Free air or actual delivery is the correct method of evaluating the performance of an air compressor.

This is the unit of measure used by most reputable compressor manufacturers, and is defined as the volume of air discharged by the compressor and measured at the outlet of the compressor.

A good quality compressor will generally produce the following volume of air for each horsepower of input:

3.8 – 4 CFM per horsepower @ 100 PSIG  
3.6 – 3.8 CFM per horsepower @ 150 PSIG  
3 – 3.6 CFM per horsepower @ 200 PSIG  
2.75 – 3.0 CFM per horsepower @ 250 PSIG

In other words a good quality 5 horsepower compressor should deliver 20 – 21 CFM @ 100 PSIG.

**NOTE:** As the pressure increases in an air compressor, the CFM output decreases. To properly evaluate the capacity of an air compressor the 'free air delivery' should therefore be stated at the actual working pressure that you would require. This is generally 100 PSIG. Some manufacturers will state their compressor capacity at 40 PSIG because this gives the illusion of having higher capacity. Be sure to ask what the capacity will be at 100 PSIG and compare these figures

6. **Never Buy A Compressor Based On The Motor Horsepower Alone!**

Look beyond the horsepower of a compressor. Often compressors are selected on the basis of horsepower, when the correct method of evaluating a compressor should be it's free air delivery in CFM.

Evaluating an air compressor based on motor horsepower is further aggravated by the fact that some air compressor manufacturers bend the definition of horsepower and quote "peak" horsepower rather than "continuous" or "running" horsepower.

Peak horsepower is the instantaneous horsepower that a motor could develop just before it burns out. This is frequently quoted by manufacturers of smaller compressors, but is very deceptive. It is never quoted by manufacturers of heavy-duty industrial compressor who without exception will quote the CONTINUOUS horsepower rating of the motor.

Always ask for the RUNNING or actual operating horsepower.

7. **Don't Assume That The Bigger The Air Receiver Tank, The Better!**

The size of the air receiver is matched to a compressor, by the manufacturer, based on the CFM output of the compressor.

The common notion is that the larger the air receiver tank, the longer it takes for the pressure to drop, which is correct.

What users forget to consider however, is that the larger the receiver tank, the longer it takes for the compressor to pump the tank back up to pressure.

This is particularly important with piston compressors since an excessively large receiver tank will result in excessively long run times, causing overheating and valve damage.

If a compressor and air receiver are correctly sized the stop/start cycles should not exceed 8 starts per hour. (i.e.: 2 minutes running and 5 minutes off). This allows the compressor to adequately cool between starts.

### **TYPES OF AIR COMPRESSORS – How They Produce Air**

As a compressor distributor, we are often asked for our opinion on which is better: reciprocating (piston), rotary vane and rotary screw compressors.

Simply stated, the answer is not which is better, but which is better for a specific application.

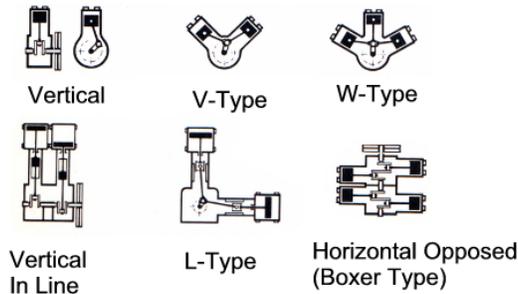
All three offer reliable service for their designated application, however, each has specific features that make them attractive to the potential buyer.

Several variables will determine which is best for a specific application. These variables are:

- Hours of operation per month
- Is the demand for compressed air steady or intermittent
- What are the pressure requirements

The following describes some guidelines as to the benefits of each type of compressor and where they are best suited.

### **RECIPROCATING (PISTON) COMPRESSORS**



Much like a conventional car engine, reciprocating or piston type compressors compress air through the action of a piston moving in a reciprocating (or backwards and forward motion), within a cylinder.

Their low relative costs and suitability for operation with an automatic start-stop control system make reciprocating compressors the unchallenged favorite, for applications where the demand for air is occasional or intermittent.

For maximum service life a good rule of thumb is that an air-cooled piston compressor should not start and stop more than about 6 – 8 times an hour and should not run for longer than 2 – 3 minutes when it does start. In other words 2 – 3 minutes on, 4 – 5 minutes off.

Their ability to be easily multi-staged also makes reciprocating units the most suitable for high-pressure applications (i.e.: pressure above 200 PSIG).

As well, because piston compressors have a strong similarity to conventional automotive engines, they can be easily serviced or repaired by the owner's maintenance staff without the need for extensive factory training.

## Single Versus Two Stage Piston Compressors

When the air is drawn from the atmosphere and compressed to its final pressure in cylinders, which are all of equal size, the compressor is referred to as a “Single Stage” compressor. Single stage units are normally used in pressure ranges up to 100 PSI for continuous service and a maximum of 125 PSI for intermittent service. They are available in single or multi-cylinder compressors. Avoid SINGLE-STAGE air compressors that claim to be capable of 125 – 150 PSIG, since the resulting discharge air temperature may be as high as 600°F., well above the acceptable limits for a good equipment life expectancy.

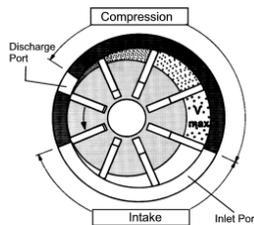
When the air drawn from the atmosphere is compressed first to a larger low-pressure cylinder, and then further compressed to a higher pressure in a smaller cylinder, it is referred to as a two-stage compressor. The first stage of compression takes place in the large bore cylinder or cylinders and, after passing through an intercooler; air is compressed to the higher pressure in the small-bore cylinder or cylinders. Two-stage compressors are generally used for pressure ranges from 100 – 250 PSI. Due to the dissipation of heat between stages, by means of an intercooler, two-stage compressors run cooler and deliver more air per horsepower at pressures over 100 PSI.

Estimated discharge temperature of air compressors at 80°F ambient:			
	<u>100 PSIG</u>	<u>150 PSIG</u>	<u>200 PSIG</u>
Single-stage	510°F	615°F	--
Two-stage	325°F	365°F	395°F

## ROTARY VANE COMPRESSORS

The rotary vane compressors are best suited for applications requiring a continuous flow of compressed air for long intervals, and may be operated at full load twenty four hours a day, seven days a week, without excessively high repair costs.

Rotary vane compressors, like reciprocating and rotary screw compressors are positive displacement units. That is they confine a specific volume of air within a chamber and elevate the pressure by decreasing the volume of the chamber.



The volume between the blades increases during the intake cycle and decreases during the compression cycle.

Rotating within a cylindrical compression chamber or stator is an eccentrically mounted slotted rotor, which is fitted with sliding vanes. As the rotor spins, these vanes are held in contact with the stator wall by centrifugal force.

The decreasing volume of the compartments formed by the rotor, stator and vanes compresses the air.

Sealing and lubrication are accomplished by injecting filtered oil into the compression chamber using pressure differential.

No oil pump is therefore generally required on a rotary vane compressor. However, in order to ensure adequate oil circulation, it is important that an adequate pressure differential always be maintained across the compressor.

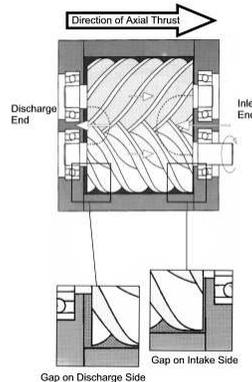
The compressed air and oil moisture is then discharged from the compression chamber into an air/oil separation system where the oil is trapped and filtered by a series of internal separator elements. The separated oil is then returned to the compressor intake where it can be re-circulated. Control of the discharge pressure is generally accomplished by means of a fully modulating inlet valve.

The position of this valve is infinitely variable, responding instantly to varying plant air demands, so that plant air pressure remains virtually constant.

Although available for pressures as high as 150 PSIG and in sizes as large as 150 HP, the ideal installation for rotary vane compressors will be in applications which have a continuous demand for air in the 100 – 110 PSIG range and from 5 – 60 HP (20 – 250 CFM). In this range, rotary vane compressors offer several technical benefits over rotary screws.

The main feature of the rotary vane compressor lies in its simple design, which incorporates only a single rotor and shaft. Because vane compressors operate without any axial forces on the bearings, they realize a greatly extended bearing life; virtually double that of comparable rotary screw compressors.

Due to the geometry of the screws in a twin-screw compressor, the air under pressure produces axial thrust on the rotors. This is not the case with monoscrew or rotary vane compressors. This thrust develops because high-pressure air at the discharge end tries to push the rotors back toward the inlet end. Since the male rotor has a larger surface area the discharge pressure will exert a greater force on it than the female rotor. When the compressor is unloaded, reverse thrust occurs from the inlet to the discharge.



If these forces are not controlled, the discharge pressure will cause the rotors to make contact with the end plates at the inlet end of the compressor resulting in severe damage.

To absorb these axial forces, rotary screw compressor manufacturers use several angular contact ball bearings or tapered bearings to prevent the rotors from touching the end plates. Each set of thrust bearings consists of two bearings; one for thrust force from discharge to suction and the other one for reverse direction (suction to discharge).

Because rotary screws require up to seven roller type bearings, compared with the two simple shell type bearings used in rotary vane compressors, the bearing replacement costs of screws is generally 5 – 6 times higher than rotary vanes.

Further, because there is no axial force, bearing life is normally between 50,000 to 100,000 hours compared to 30,000 – 40,000 hours for comparable screw compressors.

In addition, rotary vane compressors are coupled directly to the motor through a flange-mounted motor without speed increasing gears or v-belts. This arrangement results not only in perfect alignment of the motor and compressor, but also in very low rotational speeds (generally 1760 RPM).

This low rotational speed also contributes to extend bearing life.

Because of their compact size and normally lighter weight than rotary screw compressors, vane compressors lend themselves well to installations requiring limited floor space.

Since most are manufactured as integrated modules, they are easily adapted to drive arrangements requiring hydraulic motors or power take offs.

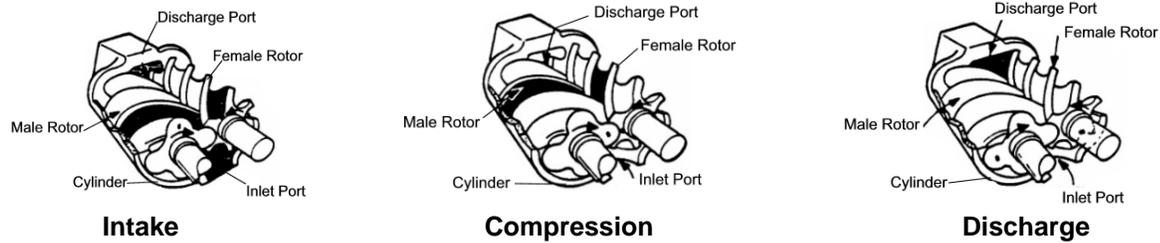
## **ROTARY SCREW COMPRESSORS**

The rotary screw compressor is also best suited for steady loads under long hours of operation.

Although available in capacities as low as 20 CFM (5 HP), rotary screws dominate the market when required capacities are 100 – 200 CFM or greater.

This is due primarily to the fact that at lower capacities, rotary screw compressor manufacturers often use smaller air-ends turning at high speeds, in order to be cost competitive.

### **Twin Screw Design:**



The most common rotary screw compressor consists of an intermeshing male and female rotor mounted within a close tolerance housing.

Speed optimizing gears are often used to turn the drive rotor at the correct speed.

In most conventional oil lubricated screws, the male rotor, with the male rotor absorbing approximately 85% of the input power, drives the female rotor. A thin film of oil, which is injected into the compressor, prevents metal-to-metal contact.

The use of one rotor driving the other is known as a “pitch line” drive system. The stronger male rotor being used as the drive rotor and the female rotor acting as an idler.

As the two rotors revolve in counter rotating directions, air is trapped within the pockets between the rotors and compression is accomplished by moving the trapped volume of air away from the inlet and towards the discharge.

As the position of the lobes completes the discharge phase, with the lobes fully intermeshed at the discharge end, the voids at the opposite (inlet) end begin to fill with air through the inlet port. When the female lobe is filled with air its entire length, the intake phase is completed.

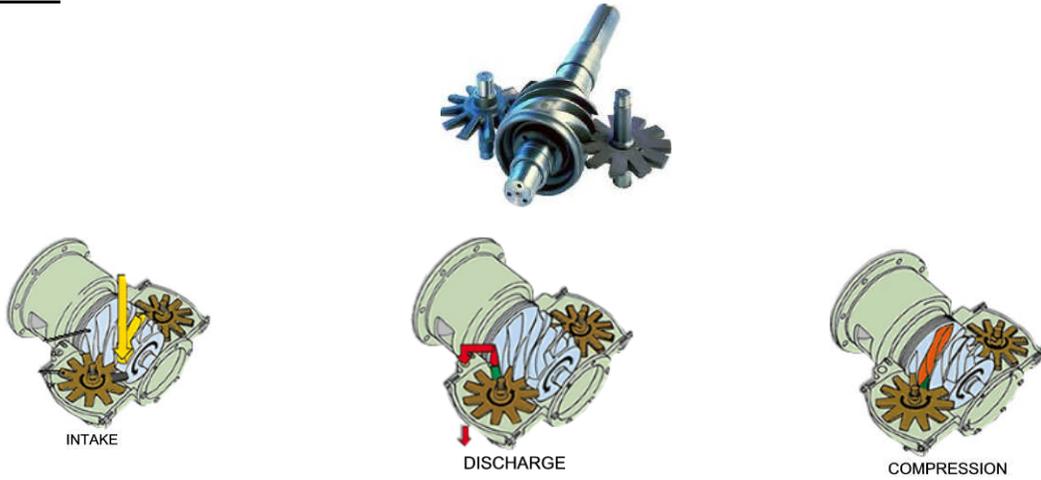
Further rotation causes the male lobe to mesh with the female rotor, trapping the air that has been taken in.

The male rotor then begins to squeeze the trapped air toward the discharge end of the compressor. As the male rotor progressively reduces the trapped air volume, oil is injected into the compression chamber.

Upon reaching its maximum discharge pressure, the rotors pass over the discharge port and the air is discharged.

Discharge pressure is controlled by regulating the amount of air which enters the compression chamber using either a modulating or full load/no load control system.

## Monoscrew



Puegeot first produced the monoscrew rotary compressor in France, in about 1960. Although similar in operation to a twin-screw, the more recently developed monoscrew design consists of a single female rotor and two intermeshing male gate-rotors mounted on opposite sides of the rotor.

As the fingers of the gate-rotors travel through the groove in the female rotor, it reduces the volume until the compressed air is forced out of the discharge port in the casing.

Compressing air on both sides of the grooved female rotor doubles the number of compressions cycles per revolution. This allows for slower rotating speeds and reduced noise levels. Axial bearing loads are also reduced.

With the exception of the compression element, the flow and operation of both the twin-screw and monoscrew compressors are identical.

Once compressed, the air/oil mixture leaves the air end and enters the air/oil separator system, which consists of a reservoir for oil storage and a final separator element, located in the tower section of the oil reservoir. Oil is then cooled, filtered and returned to the compressor.

Rotary screw compressors are available from 2 to more than 500 HP in size and suitable for pressures to 210 PSIG in a single stage. They are therefore more suitable for higher pressure and larger capacity applications.

In addition, while rotary vanes prefer to operate continuously at close to full load, comparable rotary screws may be operated with an automatic dual control system which allows the compressor to run continuously during periods of high air demand and stop automatically during periods of intermittent air demand.

Because most smaller rotary screw compressors (up to approximately 30 HP) are v-belt driven, with some being of modular unitized construction, they also lend themselves well to applications where the customer wishes to replace an existing piston compressor with a rotary unit, while using an existing electric motor and tank/base plate.

## GLOSSARY OF TERMS

### **ABSOLUTE PRESSURE:**

Is the actual gauge pressure added to the atmospheric or barometric pressure at a specific elevation. The absolute pressure at sea level will be the gauge pressure plus 14.7 PSIA.

### **ACTUAL CAPACITY:**

The volume of air compressed and delivered at a specific discharge pressure. Generally, it is expressed in cubic feet per minute.

**AFTERCOOLERS:**

Is either an air or water-cooled heat exchanger used to remove the heat of compression following the final stage of compression?

**AIR COOLED COMPRESSOR:**

A compressor cooled by blowing atmospheric air around the cylinders and heads to dissipate heat. These units normally have deep fins cast into the cylinders and heads to provide maximum area for better cooling.

**AIR INTAKE FILTER:**

A device for separating and removing fine particles of dust and dirt before it enters the compressor.

**AIR RECEIVER:**

Vessel used to store air under pressure.

**AMBIENT TEMPERATURE:**

The temperature of the surrounding cooling medium (room temperature, outside temperature etc.)

**AUTOMATIC CONDENSATE DRAIN:**

A device designed to automatically eject any accumulation of water from the compressed air system.

**CONTINUOUS DUTY:**

The ability to stand indefinite sustained operation without damage.

**DISCHARGE PRESSURE:**

The actual pressure that is available at the outlet of the air compressor.

**DISPLACEMENT:**

Otherwise referred to as swept volume. The volume displaced by the piston, rotor, or diaphragm of a compressor. Expressed in CFM, it does not take into account losses, friction, or heat. All air compressors have losses due to slippage, valve losses and clearances. These cause in-efficiencies and reduce the actual amount of air that the compressor will deliver.

**DUTY CYCLE:**

The relationship between the operating and resting times of a compressor.

**INSTRUMENT AIR:**

Dry, contaminant free compressed air used with pneumatic instruments and controls.

**INTERCOOLER:**

A heat exchanger for removing the heat of compression between two stages. It may be either air cooled or water cooled.

To have a true two-stage compressor, you must have intercooling between the stages. Otherwise you have only a two step compressor, where the second stage is taking inlet air the same temperature as discharged by the first stage. Intercooling decreases the heat of the air going from the first stage to the second stage thereby improving the efficiency of the compressor and reducing the amount of horsepower required to compress the air. True two-stage compressors with proper inter-cooling are generally more efficient than single-stage compressors, especially when compressing air to pressures above 100 PSIG.

**MOTOR SERVICE FACTOR:**

A 1.15 Service Factor means the motor can be loaded past its nameplate rating by 15%. A 1.0 Service Factor means it cannot be loaded past its nameplate rating. Most open drip-proof and TEFC motors have a 1.15 Service Factor while explosion-proof motors have a 1.0 Service Factor.

**MULTI STAGE COMPRESSORS:**

Are compressors in which compression from the initial to the final pressure is completed in two or more distinct stages?

**OIL-FREE:**

The term generally applies to the condition of the air either when it leaves the compressor, or after filtration. An oil-free compressor will have no lubrication on the compression side of the machine. However this may not result in oil-free compressed air, simply due to the fact that the ambient air being sucked into the compressor will contain hydrocarbons which will condense into liquid oil further down stream.

**PISTON DISPLACEMENT:**

The swept volume, which is displaced by the compressor piston at the rated speed, and generally expressed in CFM. For multi-stage compressors, only the piston displacement of the first stage is considered.

**PRESSURE:**

The force per unit area exerted by a gas on a body or surface. In the British system, pressure is usually measured in pounds per square inch (PSI); in international usage, in kilograms per square centimetres, or in atmospheres; and in the international metric system (SI), in Newtons per square meter.

**PSIG – POUNDS PER SQUARE INCH:**

This is the pressure of a system, which you would see displayed on a normal pressure gauge. It is the pressure of the system, over and above atmospheric pressure.

**ROTARY SCREW COMPRESSOR:**

A compressor that uses two intermeshing helical rotors, which are mounted in a close tolerance casing. Air is trapped between one convex (male) rotor and one concave (female) rotor, and compressed as the volume of air is decreased along the length of the rotor.

**ROTARY VANE COMPRESSOR:**

A compressor that uses vanes, which slide radially in an eccentrically mounted rotor. As the rotor rotates air is trapped between the vanes, compressed and discharged.

**SINGLE STAGE COMPRESSOR:**

Are those in which compression from the initial pressure to the final pressure takes place in a single stage.

**STANDARD CUBIC FEET PER MINUTE (SCFM):**

Is delivered air at specific conditions of 68 degrees F, an atmospheric pressure of 14.70 PSIA and a relative humidity of 36 percent (0.0750 density).

**STANDARD TEMPERATURE AND PRESSURE:**

Standard temperature of 68<sup>0</sup> F and a standard pressure of 14.7 PSIA.

**SYSTEM PRESSURE:**

The minimum pressure that the system requires to operate satisfactorily. The compressor must be capable of supplying enough volume at a sufficiently high pressure so that all losses can be met and the resulting pressure still exceeds the required system pressure.

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