

Compressed air quality can have a BIG impact on your shop's bottom line

a closer look at air treatment components and the benefits of each to a shop's work flow



Figure 1: a typical compressed air system with air treatment components including a tank, drain traps, dryers, filters, piping, etc.

When planning, designing, and installing a compressed air system for an automotive shop, most buyers focus on the compressor and possibly a tank. Many fail to consider compressed air treatment components (dryers, filters, drain traps, etc.), but the impact of air quality on a body shops' work flow and performance is huge. Compressed air contaminants—including water, oil, dirt, dust—can cause many problems including poor finish quality, product rejects/rework, and increased materials costs as well as increased equipment wear and maintenance costs.

Making sure you remove contaminants from your compressed air system is extremely important. The costs of rejects and tool wear far outweigh the initial investment costs for installing a properly functioning air treatment system. Below, we outline how common system components impact system performance, with an emphasis on air quality because of its roll in paint quality and tool life. We will also discuss energy benefits where it applies.

As shown in figure 1, typical system components include:

- Compressors
- Receiver tanks
- Drain traps
- Dryers
- Filters
- Piping
- Point of use: FRL's

COMPRESSORS

Most automotive shops use piston, screw or vane compressors. Each of these types of compressors have different properties when it comes to moisture, oil, pressure and energy. When considering the best type of compressor for your shop, you should know your flow (cfm), pressure and air quality needs. Also, consider the duty cycle and operating temperature as well as the discharge temperature and noise levels of the compressors you are evaluating in your purchase decision.

The operating temperature is an important factor to remember because every 20° rise in temperature doubles air's ability to hold moisture in vapor state. Higher operating temperature makes it more difficult to cool and dry the compressed air effectively. Also, you should consider the location of the compressor. The hotter the room, the higher the compressor operating temperature.

RECEIVER TANKS

Air storage tanks (also referred to as receivers) are a critical air system component, so it's important to understand some of their functions and benefits other than just storing air. Air coming out of the compressor's aftercooler is usually fully saturated at 100% humidity, and some water has already been condensed to liquid. The tank provides a space for the liquid water to drop out and be drained away. Additionally, some moisture vapor will cool and condense also (unless the tank is placed in a hot environment). Tanks trap large volumes of air so a reliable automatic drain is a must.

Additionally, tanks allow the compressor to shut off to save energy as well as prevent piston compressors from overheating. Although screw and vane compressors offer a 100% duty cycle, reduced cycling extends the life of all compressors. Tanks are also beneficial for storing air for periods of high demand and dampening pulsations from piston compressors.

Receiver tanks should not be placed directly in the air exhaust of the compressor, near any other heat source, or in direct sunlight because this will hinder proper cooling and moisture separation.

When selecting a tank, allow 2 to 4 gallons per cfm and be sure the tank pressure rating exceeds the highest possible system pressure. You should make sure the tank has a safety relief valve, a pressure gauge, and a drain to remove liquids. The receiver tank should meet ASME or other required code for safety precautions.

DRAIN TRAPS

Drain traps may be the least expensive component in a compressed air system but they are critical for air quality. Drains remove liquid contaminants from the system. If the filtered and separated contaminants (mostly water with some oils and particulate) aren't drained and removed from tanks, refrigerated dryers, and filters, they build up and find their way back into the air lines. Further, liquid accumulation in tanks will gradually eliminate the air storage capacity in the tank, causing periods of inadequate air flow/pressure and possibly causing a reciprocating compressor to exceed its duty cycle and overheat.

Several types of drains are available: manual, timed and automatic demand (a mechanical or electric device that activates when the liquid level reaches a certain point inside the drain).

Manual. These are inexpensive, but are not the best choice for consistent, reliable moisture protection since they rely on someone to open them on a routine basis.

Timed electric. These drains discharge based on a timer, which makes them more reliable than manual drains, but they don't adapt to seasonal changes in how much condensate is created. For example, in Winter they will open when there is no moisture present, which can waste compressed air, and in Summer they may not open enough to remove accumulating water.

Demand. This type only opens when moisture is present, so no compressed air is wasted. It is more expensive to purchase but saves in the long run.

Drains should be checked and periodically serviced. Lack of effective drains on tanks, dryers, and filters can reduce your air storage as well as increase the risk of contaminants, hurt compressor efficiency, increase the need for maintenance and repair, increase downtime, and add energy costs. Invest in quality drains to protect your investment in filters and dryers.

DRYERS

Dryers are key components in a compressed air system as they remove even more moisture vapor from the air stream. There are many types of dryers and they vary in the amount of moisture in the air that is sent downstream to the point of use.

Dryer performance is stated in terms of specific conditions (ambient temperature, compressed air inlet pressure and compressed air temperature). Without this set of conditions, suppliers could make performance claims based on installation conditions you never have. Quality industrial dryers are usually rated at 100°F ambient temperature, 100°F compressed air inlet temperature and 100 psig. And of course they are sized according to the air flow (cfm) you feed into them.

Dryers must be appropriately sized, and unless your shop conditions are constantly the same as the dryer's rated conditions, you need to look beyond the cfm rating. You have to consider the temperatures in the compressor room, keeping in mind that if the compressor room is not climate controlled, seasonal changes directly impact dryer performance. You should size your dryers for worst case which is typically the summer months.

Your dryer vendor should be able to make some simple calculations to account for differences in flow, temperatures, and pressure. If they look at you funny when you ask, find another vendor.

Refrigerated dryers are the most common type of dryers. They employ a refrigeration system to lower the compressed air temperature below the ambient temperature. This condenses the moisture that's in vapor form at higher temperatures into liquid form that can be drained out of the system. This lowers the

Know What You're Treating

What are these compressed air contaminants and how bad are they? Compressed air contaminants are classified in three categories: particulates, moisture, and hydrocarbons (oils). These contaminants include water, oil, dirt, dust, and vapor to name a couple. When introduced into your air system, they can cause many issues for body shops including ruined paint jobs and additional equipment maintenance.

Contaminant	Description	Issues Caused	Prevention
Particulates	Solids, such as dirt and dust, that can be picked up from ambient air and ingested into the compressor inlet. Particulate contamination can also come through piping, as rust and scale builds up in iron pipes and flakes off.	<ul style="list-style-type: none"> • Causes poor finish quality • Causes tools to malfunction or break • Causes pressure drop from build up in piping 	Removed by filtration - Install after the tank and before oil removal filters and dryers
Moisture	When compressed air is heated and then cooled, moisture forms. Depending on the ambient humidity and temperature, this can be many gallons per hour.	<ul style="list-style-type: none"> • Causes poor finish quality • Softens clear coats • Extends flash times • Causes rust or excessive wear in tools • Causes rust in piping 	Removed by aftercoolers, tanks, dryers, liquid separators, and drains
Oils/Hydrocarbons	These contaminants can be in either liquid or vapor form. It is common for oils or hydrocarbons to be ingested from the ambient environment if solvents, spray lubricants, or other volatile compounds are present.	<ul style="list-style-type: none"> • Ruins paint jobs • Increases scrap and production losses • Can combine with particulates to clog tools and spray guns 	Removed by <i>coalescing</i> filters - Install after refrigerated dryer and before desiccant dryer or membrane dryer

“pressure dew point” of the compressed air. As long as the compressed air isn’t cooled below this new dew point, any remaining moisture will remain in vapor form. Most refrigerated dryers are designed to produce dew points near 40°F when properly sized.

High-temperature refrigerated dryers are refrigerated dryers that include an aftercooler and are primarily used with piston compressors. Since pistons run hotter than rotary compressors, the air must be pre-cooled prior to entering the dryer. These are usually designed to achieve dew points near 50°F.

Figure 2, shows you how ambient temperature impacts the actual capacity of a dryer. Just a ten degree difference can greatly reduce the amount of air a refrigerated dryer is able to properly dry.

In most cases, a properly sized refrigerated dryer of good quality will produce clean, dry air for spraying good

finishes with waterborne and clears. However, there are cases when the ambient conditions or existing air system may need extra drying. If this is absolutely necessary, we recommend two options: desiccant dryers and membrane dryers.

Desiccant dryers operate differently from refrigerated dryers. They work by directing the compressed airflow across a bed of desiccant material that adsorbs moisture vapor out of the air. Desiccant dryers are often set for 0°F dew points and are recommended when air quality requirements are extremely high. Desiccant dryers cannot accept any oil or dirt which will clog the desiccant bed and reduce dryer performance. A good coalescing oil removal filter is a must upstream of the desiccant dryer.

Ambient/ Room Temperature	Air Pressure	Compressed Air Temp at Dryer Inlet	Correction Factor	Actual Capacity of 100 cfm Dryer
80	125	100	1.19	119
100	100	100	1.00	100
100	125	115	0.74	74

Figure 2: Ambient temperature impacts the actual capacity of a dryer. Just a ten degree difference can greatly reduce the amount of air a refrigerated dryer is able to properly dry.

Energy Savings Aren't Just for Big Manufacturing Plants

Air quality significantly impacts the time and materials spent on paint finishes, but in many shops, power is costly and compressors are usually the biggest electricity consumers in the shop. Many shop owners do not know it but are probably spending thousands in electricity.

An average shop running a 15 hp compressor 6 hours per day, 5 days per week could expect to pay approximately \$1,600 in power at the national average of \$.10 per kWh each year. Increase the horsepower, the hours of operation, or the cost per kilowatt hour and it goes up. In the Northeast or Southern California it would be closer to \$2,700 per year.

With that in mind, below are some additional tips for improving energy efficiency:

1. Operate at the lowest possible pressure
2. Find and fix leaks
3. Eliminate inappropriate uses of compressed air
4. Size pipes and tank properly
5. Use zero-loss automatic drains
6. Change filters on schedule to reduce pressure drop
7. Use CAGI datasheets to compare compressor efficiencies before buying
8. Turn off compressors when not needed

Because these consume air and are expensive, they should only be applied where absolutely needed (e.g. the spray booth). It is a waste of money and energy to use a desiccant dryer for the whole shop.

Membrane dryers are another way to further dry air just for the paint booth in high moisture conditions. They use a water-permeable membrane which allows air to pass through, but pulls the moisture out and expels it.

Unlike the desiccant style they provide dew point suppression—not a fixed dew point. So they are best used in conjunction with refrigerated dryers. They have a very simple operation with no moving parts and no desiccant to replace. Membrane dryers don't need electricity either. Like the desiccant, they must have a good coalescing oil removal filter in front of them. If they get oil in them they will be quickly ruined. Also like the desiccant dryer, they consume air. If you decide you need one, use it just where you need it.

FILTERS

Filtration is another vital component in the compressed air system. For body shops, or any shop spraying paint, filtration is a must and should be serviced regularly in order to maintain air quality.

Filters are categorized based on the contaminants they're designed to capture (liquids, particles, and hydrocarbons/oils) and may be designed to capture more than one type. They often look similar on the outside, but they are not all the same.

- Moisture separators are designed to mechanically separate liquid water and oil from the air stream. One point to make clear: moisture vapor cannot be filtered out of air. Any water in a vapor state can only be removed by a dryer, but if it is liquid, it can be removed by a moisture separator that spins the water out. Some moisture separators include a filter element to remove particles, too.
- Particle filters are designed to capture dirt, dust, etc., but may remove some water and oil mists.
- Coalescing oil filters are finer filters designed to remove oil aerosols/mist and fine particles. These are usually placed after a refrigerated dryer. Coalescing filters are not only essential for all paint applications, but are critical to protecting membrane and desiccant dryers.

Filters should be installed in order—remove liquids, then particles, then oils. Staging the filters in a system provides more effective filtration, lower pressure drop at each filter, and longer filter life. Some have differential pressure gauges, liquid level indicators, and built-in drains. Keep in mind that filters removing liquids also need drains and that differential pressure

Material	Advantages	Disadvantages
Black Iron	<ul style="list-style-type: none"> • Moderate materials costs • Readily available in multiple sizes 	<ul style="list-style-type: none"> • Labor intensive installation • May rust and leak • Rough inside promotes contaminant build-up and creates pressure drop
Galvanized Iron	<ul style="list-style-type: none"> • Moderate materials cost • Readily available in multiple sizes • Some rust protection 	<ul style="list-style-type: none"> • Often exterior is coated • Labor intensive installation • Rough inside promotes contaminant build-up and creates pressure drop • May rust at joints and leak
PVC	<ul style="list-style-type: none"> • Lightweight • Inexpensive • Readily available in multiple sizes 	<ul style="list-style-type: none"> • Lower safety • In certain areas, not compliant with certain codes • Carries static charge • Subject to bursting • Adhesives not compatible with compressor oils
Copper	<ul style="list-style-type: none"> • No rust, good air quality • Smooth interior—low pressure drop 	<ul style="list-style-type: none"> • Requires quality brazing to prevent leaks • Susceptible to thermal cycling • Installation requires open flame
Aluminum	<ul style="list-style-type: none"> • Corrosion resistant • Lightweight • Easy to install • Lower cost of ownership • Smooth interior—low pressure drop 	<ul style="list-style-type: none"> • Materials costs

Figure 3: Common compressed air piping materials with their advantages and disadvantages.

gauges will indicate when the filter elements need replaced. Periodic filter changes will minimize pressure drop and ensure good air quality.

PIPING

Piping plays a role in air quality as well. It is common for shops to invest in new compressed air equipment only to send clean, dry air through old, dirty pipe. Piping materials can be a source of contaminants that can flake off and migrate to the production equipment.

The most common piping materials includes black iron, galvanized, copper, and PVC. Aluminum compressed air piping is a relative newcomer but is on the rise. Figure 3 lists the advantages and disadvantages of each. PVC is included in the chart because it's commonly used since it is inexpensive, lightweight, and easy to find at local building supply stores. It is not a material that is recommend to use because of the safety concerns associated with installing it. Also, it is not code compliant in many areas.

Piping selection directly affects three key elements in your compressed air system: flow, pressure, and air quality. Re-

strictions in airflow (rust, build-up, etc.) create air turbulence that results in reduced system pressure. The degree to which this occurs depends on the materials you've chosen and pipe size. To have clean, dry air, consider piping that is copper or aluminum. They are not prone to build-up and will provide years of low pressure drop air delivery. Smooth clean pipe is good not only for air quality, but also good flow and stable system pressure. Figure 4 shows an example of each.



Figure 4: Cut-away of corroded galvanized pipe with rust build-up compared to newer, smooth pipe.

When selecting piping for your compressed air system, consider the following:

Air quality: Can your shop tolerate contamination from rust or other build-up flaking off from the pipe? (Black iron and galvanized iron are notorious for this).

Installation: Will you need to outsource? Also, do you anticipate growth or making changes to your piping? (Aluminum pipe can be disassembled easily and adding in drops to accommodate growth is fast. Copper is not as quick to install as aluminum, but it is still faster than threaded pipe).

Material cost: Will you need to purchase special tools to install or maintain the pipe?

Maintenance: Do you have the time and manpower to continually monitor and fix leaks that can occur with materials that are more susceptible to rusting at joints and leaking? (A concern for black iron and galvanized iron. Also, the brazing on copper should be inspected regularly).

Look at more than the cost of the material and installation. Think about how your shop is set up and the flow of the work. Piping should be sized and looped to reduce overall air velocity and pressure drop. Think about your system needs today and long term.

POINT OF USE: FRLS

Point of use filters, regulators and lubricators (FRLs) should be used selectively at hose disconnects to ensure that your tools receive a clean, lubricated, pressure regulated supply of compressed air at the point of use. They come in multiple combinations of air treatment and are commonly found installed by your paint booth and air tools. If your main air lines have little or no air treatment, FRLs will extend tool life. If you have a good dryer and filters in line up stream, you may not need the filter, but may still need pressure control and lubrication, depending on the tool used.

Not all tools need the same pressure. Running tools above their recommended pressure will not improve their performance. It will wear them out faster and it will waste energy. Impact wrenches, DA sanders, and grinders typically need 90 psig. If you have a piston running at 145 or 175 psig, it pays to regulate the pressure down to 90 or 100 psig. If your compressor is running at 115 or 125, your losses are less but if you are short on air you will be better off putting regulators at those tools.

Don't confuse pressure and flow, if you are running a 90 psig tool and it is not working right, the problem is likely insufficient flow, not pressure. Turning up the pressure may help a bit but it is just starving the rest of your users. Time to turn down pressure at other points of use and find and fix those leaks at fittings and in hoses. If these don't help, you may need another or larger com-

pressor. If your piping is old black iron or galvanized look inside to see if the inner walls have rust and dirt build up. If so, replace it.

If you are using HVLP spray guns and/or air amplifiers, you must regulate them down to get proper performance. Air amplifiers are air hogs even at recommended pressure. An amplifier that uses 30 scfm at 30 psig uses 90 scfm at 100 psig. 50 psig is often the recommended pressure for these tools. Not all amplifiers use the same flow at a given pressure.

Some tools need to be lubricated. A lubricator at the quick disconnect ensures they get good, clean oil that is right for the type of tool. We've heard many piston users say, "I'll just let the compressor oil lube my tools". Mistake. Most of the liquid in compressed air lines is water, not oil. Plus the oil is dirty and may not be the right type. Would you brush your teeth with used bath water?

SUMMARY

Every component plays a part in air quality and performance which both have an effect on your product quality. The compressor selection influences system performance, air quality, maintenance costs, and long term reliability of the air system. It can also affect the amount of moisture and oil that is carried over into the system. The receiver tank helps maintain proper system pressure and to remove bulk liquids before dryers and filters. Filters and dryers can be used to remove all types of contaminants and pipe size and material affect the pressure flow.

When looking at your compressed air system, remember to carefully consider each system component and its impact on the application. No one wants to spend more money on compressed air equipment than what is necessary, but a little more initial investment can save you time, labor, and material costs later. ■

Location, Location, Location

The type of compressor used affects where it's installed. Compressors are often installed where their noise, vibration and heat will be least bothersome to staff and customers rather than where they'll best perform and be easily serviced.

Here are some guidelines for where to install a compressor:

- Avoid extreme hot or cold temperatures.
- Ensure an adequate airflow for cooling as well as ventilation for heat exhaust generated from the equipment
- Avoid dirty/dusty areas.
- Allow enough space around the compressor for maintenance access.