Technical Tips

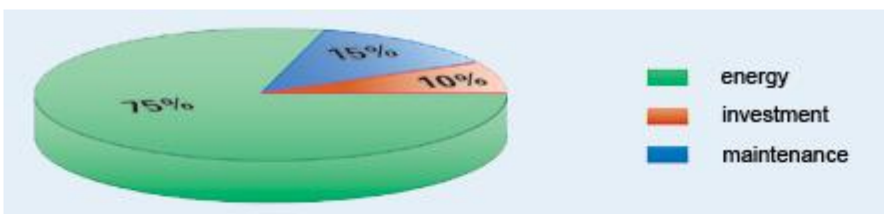
Compressed Air

Introduction

A quality paint job begins with quality air. A true statement. The question is: How many shops can actually say that they have quality air? The answer is: not many!

Compressed air as the second source of energy after electricity, requires a close understanding of the characteristics of compressed air to optimize its production for use.

Optimizing productivity while reducing operation costs is the common goal shared by nearly every manufacturing plant. Compressed air is considered the phantom utility, it cannot be bought, you must produce it. The initial capital cost of a compressed air system is minor compared to the operational cost.



The pie chart above illustrates the typical cost breakdown for an average compressed air system (compressor, pipe system, and operating costs) over a 10 year period.

Since the mandated use of HVLP spray guns, the demand for large volumes of high quality air has risen dramatically. If you combine this with hot, humid summer temperatures, you have the potential for lots of problems when refinishing a vehicle. This will become even more critical as we transition to waterborne paints in the near future.

We already know that we must pay close attention to each shop's air supply to ensure that it can supply the volume required to achieve acceptable results. From horse power to plumbing sizes to airhose size and couplers, all can have an effect on product performance. But…what about temperature and humidity?

What is relative humidity?

The percentage of relative humidity is the relation between: the quantity of water vapor present in a volume of air the quantity of water corresponding to the saturation of this same volume of air (saturation causing condensation of excess water vapor) The maximum quantity of water which can be absorbed in a volume of air increases with temperature.

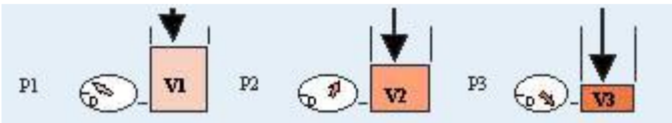
Let's take a look at how humidity and temperature changes can affect compressed air.

All air in the atmosphere contains some water vapor (relative humidity). Changes in relative humidity and temperature will have an effect on water forming in shop air lines and the storage tank.

How it happens….

Air is compressed; the increased pressure turns the water vapor in the air into a liquid (condensation).

This relation is used within the compressor: constant air volume is pumped from the compressor chamber, and the volume decreases. This decrease causes an increase in both the pressure and the temperature of the air.



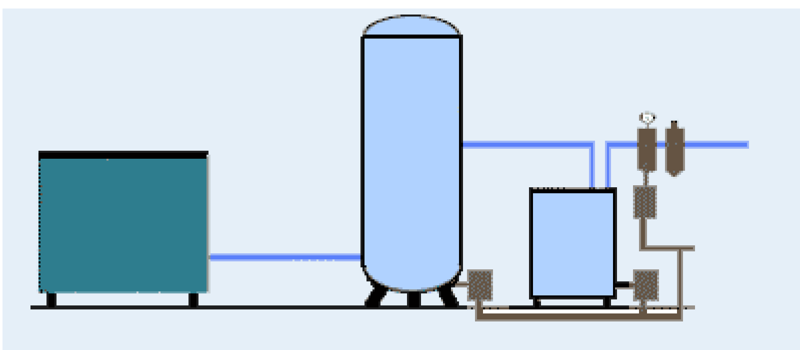
Also, it's temperature increases during the compression process, as does the ability to hold more water vapor, which can condense in the airline.

Compressed air production

Compressed air can be produced by two processes:

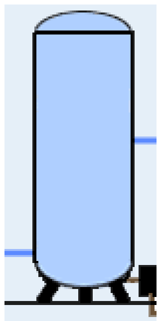
- Dynamic compression (conversion of the air velocity into pressure): radial and axial compression.
- Displacement compression (reduction of the air volume): reciprocating compressors (piston type) and rotary compressors (screw type).

The necessary elements of compressed air



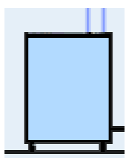
The compressor

The air receiver enables: storage of compressed air in order to meet heavy demands in excess of the capacity of the compressor; balancing of pulsations from the compressor; cooling of the compressed air; and collection of residual condensate.



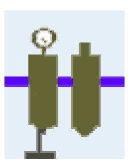
The air receiver

The air dryer reduces the water vapor content of compressed air. Moisture can cause equipment malfunction, product spoilage and corrosion. Two methods are used: absorption and refrigeration.



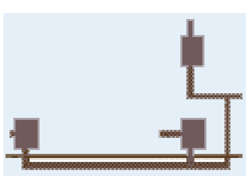
The air dryer

Filters restrict the passage of oil and water particles conveyed by compressed air within the system.



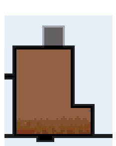
Air filters

Drains eliminate condensate (condensate water mixed with other impurities generated by compressed air and sources of pollution).



Condensate Drains

The separator receives condensate from the drains. It separates oil and water avoiding any polluting discharge.

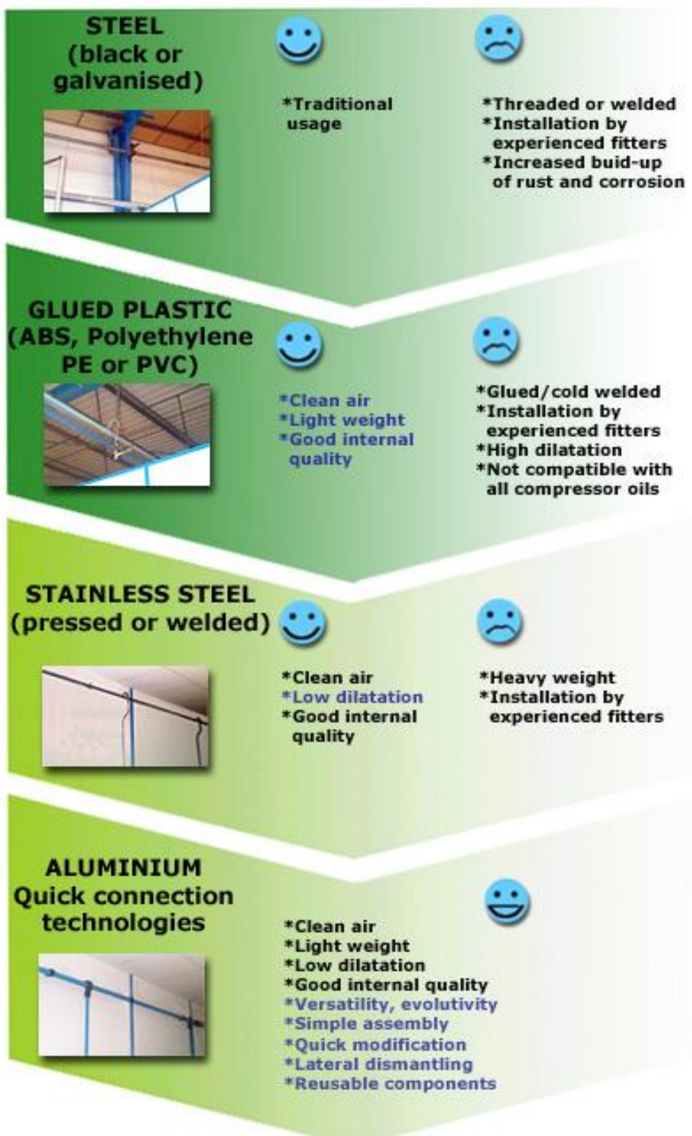


The separator

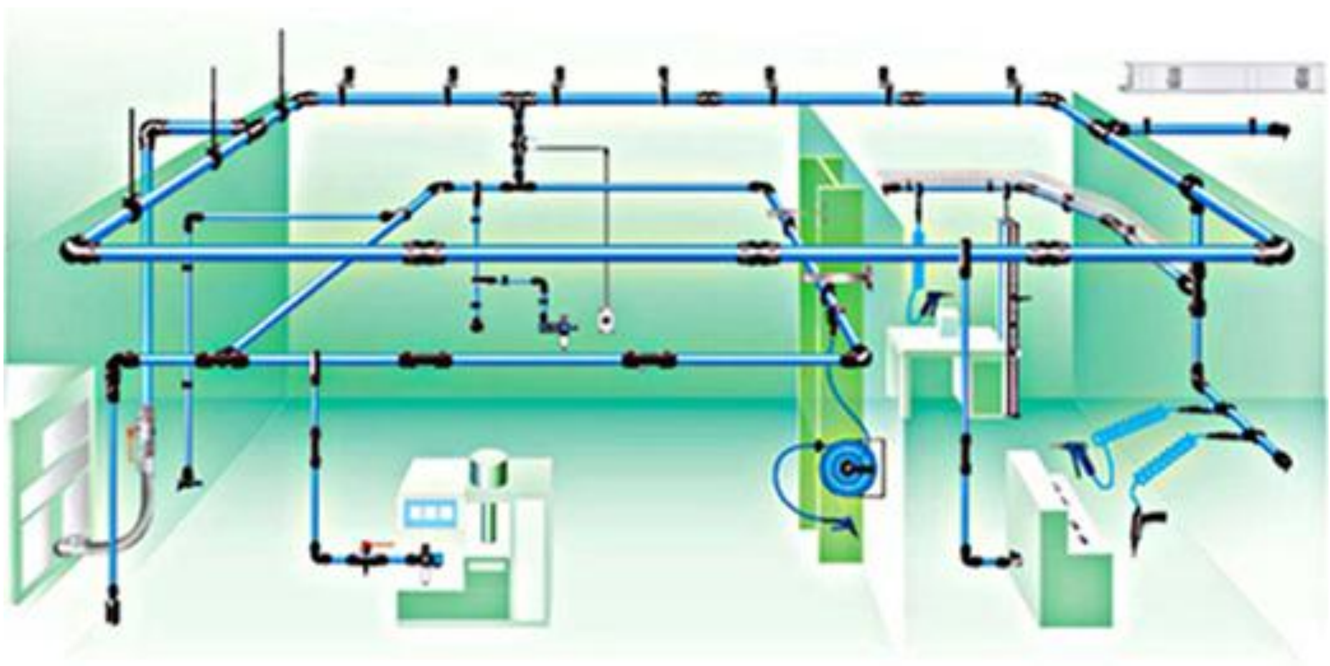
Purpose of a compressed air pipe system

The purpose of the compressed air piping system is to deliver compressed air to the points of usage. The compressed air needs to be delivered with enough volume, appropriate quality, and pressure to properly power the components that use the compressed air. A poorly designed compressed air system can increase energy costs, promote equipment failure, reduce production efficiencies, and increase maintenance requirements. It is generally considered true that any additional costs spent improving the compressed air piping system will pay for them selves many times over the life of the system.

History of a compressed air pipe system



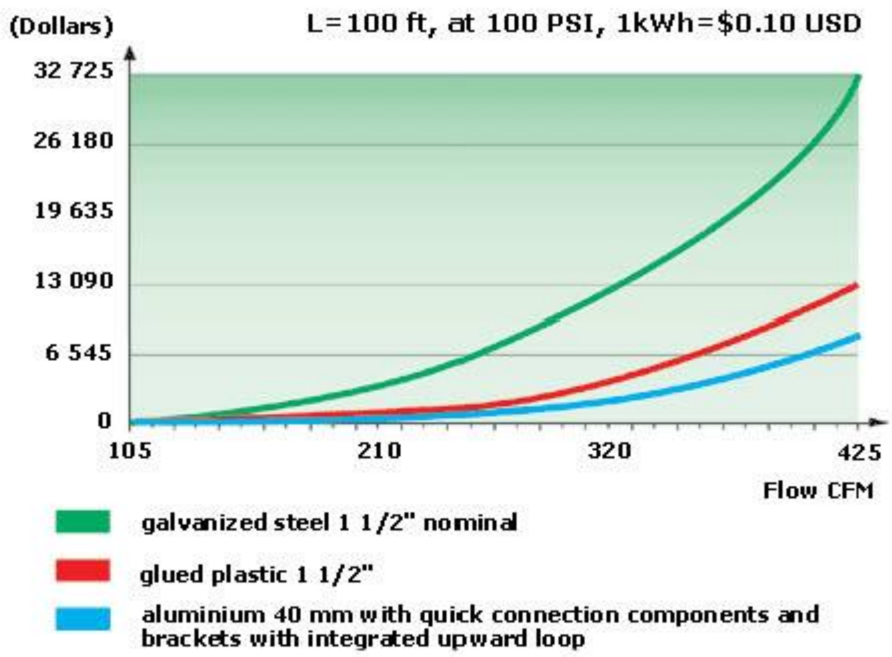
Example of a compressed air pipe system



Controlling operating cost

Pressure drop costs: To compensate for pressure drops, the compressor must work harder, which implies more energy consumption and additional costs.

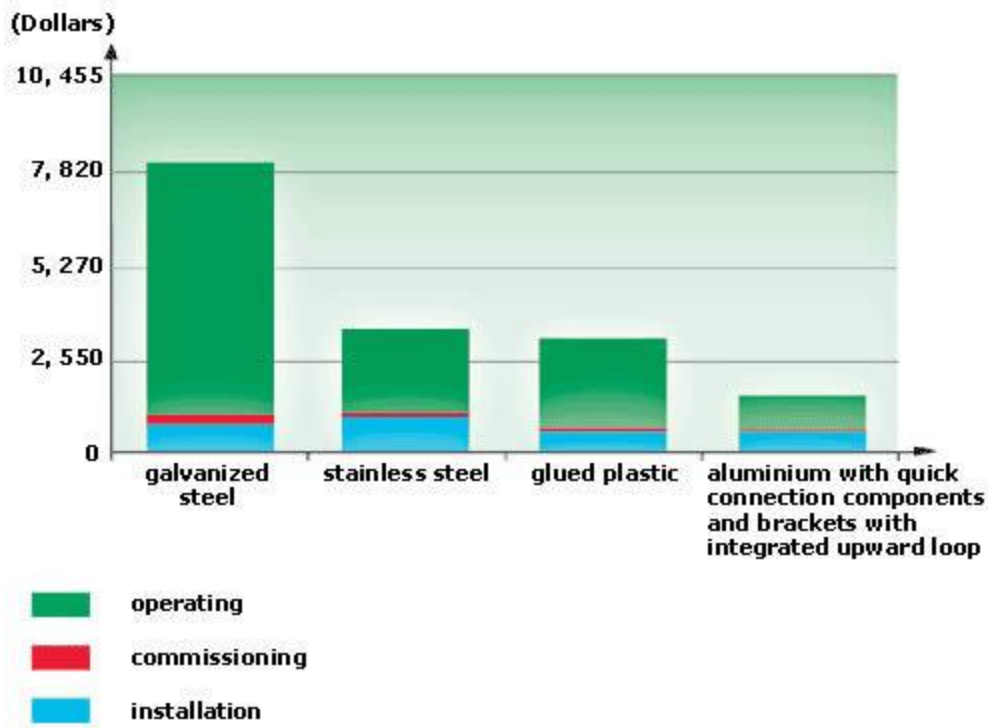
Costs of pressure drops over a ten year period….



Technologies offering smooth bore pipe work (aluminum, plastic) provide a high reduction in pressure drop and thus also operating costs. Conversely galvanized steel systems, affected by rust and pitted interior surfaces after several years of use, result in higher operating costs.

Annual costs: In terms of overall performance versus costs, the choice should not only depend on technology and purchasing price. The exact cost of a system also includes annual operating costs (such as installation and commissioning of a system).

Examples of annual costs for a 650' system:



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Guidelines for optimizing an air pipe system

The installation of an air pipe system should be completed in accordance with certain guidelines. These pages include various recommendations to be observed in order to obtain the expected performance, reliability and security of your air pipe system.

- Bends and bypasses involve pressure drops. To avoid them, use assemblies: they allow modification of a system and the bypass of obstacles.
- Limit excessive reductions in pipe diameters, which also involve pressure drops.
- Threaded components create ever increasing leaks over time. Choose materials that do not corrode.
- Ensure consistent quality clean air.

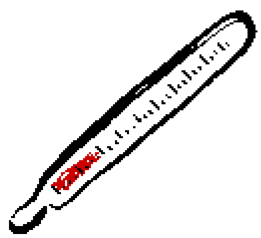
- The size of a system has direct influence on the good performance of tools: choose the appropriate diameter according to the required flow rate and acceptable pressure drop.
- To facilitate access for maintenance, do not position a system underground.
- Install drops as close as possible to areas of operation, therefore where tools require maximum energy for optimal working.

- Install pipe supports as follows: two supports per 10' pipe length and three supports per 20' pipe length.

Shop scenario

For example: If a shop air compressor is 10hp, you can estimate that it will deliver 4 cubic feet per minute (cfm) per hp, or 40 cfm. If a compressor runs for half the work day (4 hours, or 240 minutes), that compressor is delivering 9,600 cubic feet of air per day (40 cfm x 240 minutes).

Note: This example allows for the compressor to be running only ½ of the 8 hour work day.



On a day when the temperature is 70 degrees and the relative humidity is 70%, this compressor would produce .83 pints of water vapor per 1000 cubic feet of air.

At 9,600 cubic feet of air per day, 9.6 x .83 pints would result in 7.97 pints of water, almost a gallon, being pumped into the airlines.

With the same compressor and a 90 degree day with 90% relative humidity, the water vapor being introduced into the airline is 1.98 pints per 1000 cubic feet, or 19 pints of water (almost 2 1/2 gallons!). As you can see, increases in temperature and relative humidity have a drastic effect on the amount of water vapor introduced into the airlines.

How and where will water condense?

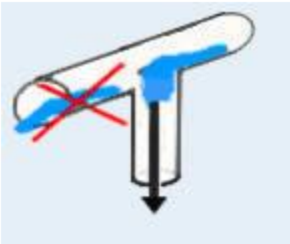
Water vapor will turn into liquid when the air reaches its saturation point, or 100% relative humidity. The temperature at 100% relative humidity is called the “dew point”. This is the temperature at which water vapor begins to condense into liquid “dew”.

As for where, anywhere in the closed air system can be a condensation point. That is why it is critical to eliminate moisture starting with the compressor and laying out a system of plumbing, drying equipment, and filtration to keep it dry until you need to use it.

From our first example, .83 pints of water at 100% relative humidity will condense at approximately 59 degrees and water vapors will begin to form.

In theory, the airline farthest from the air compressor will have the coolest air. It will also contain the most moisture.

The temperature variance between the outside air and the air within the pipe system will create a drop in the temperature of the pipe network air and cause condensation of water vapor present in the system.



Condensate collects within the pipeline and circulates throughout the system.

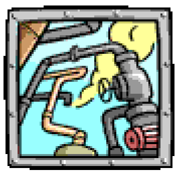
Condensate matter adversely affects pneumatic applications, therefore we must ensure that it does not reach the work station, if we want to prevent breakdowns.

The traditional method is to install an upward loop.

Condensate water thus remains in the system and the work station is not affected by poor quality air. Equipping compressed air pipe systems with brackets that incorporate an upward loop is essential even when a dryer is used. Dryers remove only a portion of the water that is present in compressed air since condensation continues to occur due to variations in temperature levels. Furthermore, such brackets increase the safety and protection of pneumatic tools and equipment should the dryer break down or malfunction. For example: 2.9 gallons of water per hour can be produced by a compressor generating 294cfm @ 68 degrees F.

How can we remove water vapor and liquid from the air lines?

First let's look at the selection of plumbing materials and layout.



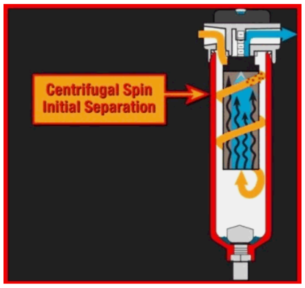
Some form of metal piping should be used and not a plastic (like a PVC) since the metal will help the heated air to dissipate faster. Black pipe is the most commonly used material. The compressor should be positioned in an area where the noise is not annoying and where it can have free access to plenty of fresh air and ventilation. When plumbing the airlines, make sure there is a minimum of 25’ linear feet and have drain legs for condensate to escape before entering any filters.

This will allow the compressed air to cool down (condensate) and will allow the filters to function within their designed performance range.

It is important when possible to route your airlines in a “loop” system. This style layout will give each person accessing the air supply equal right to the air. That means that everyone will have the same amount. In a system running from point A to point B, the person at the end of the run not only gets all the moisture, he gets only the remaining air that hasn’t been used up stream.

Other than the proper plumbing materials and routing techniques, there are two types of equipment for drying air…….mechanical and chemical.

Mechanical dryers are designed to remove liquid water (condensation) from compressed air. The most commonly found are water traps, aftercoolers, and refrigerated dryers.



The water traps remove liquid already condensed in the airline. Aftercoolers and refrigerated dryers reduce the air temperature to a low dew point where the water vapor condenses and is removed before being distributed to the shop plumbing for use by the technicians.

When installing a drying system, it should be placed a minimum of 25 plumbing feet from the compressor. This will allow the compressed air to cool down to around 100 degrees before entering the dryer, allowing the unit to function properly (each refrigerated dryer has it’s own manufacturer suggested air inlet temperature recommendation).

> *Note: Physically, the compressor and dryer can be placed side-by-side. The required distance can be obtained with plumbing by building a “ladder” before connecting the two units.*

Chemical dryers are designed to remove water vapor by absorbtion as the air passes through a desiccant material. Desiccants are a type of clay or a synthetic material that effectively absorbs water vapor.

Because desiccants are very sensitive to contaminants such as oil and dirt, pre-filters are necessary for maximum efficiency. (a Devilbiss DAD-500 is a good example) This three stage filter system is becoming more popular and should be placed close to the work station.

Additional storage capacity

When plumbing your airlines use a larger size pipe if possible. This will increase your storage capacity significantly. The question is, "How can we determine the additional storage space achieved within the plumbing itself?" The following is the formula used to determine the answer to our question.

The calculation

To determine the additional capacity use the following formula:

- Determine the radius of the pipe by multiplying the pipe diameter by ½.
- Multiply the radius of the pipe x the radius of the pipe. (radius = ½ of the diameter of the pipe: i.e. 11/2" pipe = ¾" radius; 2" pipe = 1" radius, etc)
- Multiply that number by pi (3.1475)
- Multiply that number by 12" = cubic inches per foot.
- Now convert the cubic inches to US gallons by multiplying cubic inches x .004329. This will give you gallons of air per linear foot.
- Now divide 1 (ft) by the gallons per linear foot number. This will give you
- the total number of feet required to achieve a gallon of additional storage .
- Now multiply the shop total linear plumbing feet x the 1 gallon of additional storage space number. The result will be the total additional storage space provided by your shop plumbing.

Confused? Let's do an example.

Example:

- The shop has a 1 ½" loop system existing. Multiply 1 ½" x 1/2 = ¾" (the radius).
- Multiply the radius x the radius. ¾ x ¾ = 0.5625.
- Multiply 0.5625 x 3.1475 (pi) = 1.7704687 (=1") x 12" = 21.245624 cubic inches per foot.
- Multiply cubic inches per foot 21.245624 x 0.004329 = 0.0919723 gallons per foot.
- Next divide 1 ft by 0.0919723 = 10.87 feet of 1 ½" pipe = 1 additional gallon of storage.
- The shop size is 100' x 70'.
- Add all the measurements to achieve linear footage. (100+100+70+70=340 linear feet).
- Divide total linear feet 340 by 10.87 (feet required to achieve 1 gallon storage) = 31.278 gallons of additional air storage.

So, if this shop has a 120 gallon storage tank, when considering the additional storage provided by the airlines, their total available air capacity is 151.278 gallons. (an additional 21%)

What does this mean to a painter?

Ultimately the painter is striving to achieve 10psi at the cap of his HVLP spray gun. That is because 10 psi at the cap is the maximum amount permissible by law and the level at which high solids low VOC products perform their best.

We have found that by lowering the required psi at the wall and still achieving 10 psi at the cap, combined with larger fittings, bigger hoses and couplers, several things happen while still achieving operating gun requirements. IE if a gun requires 100 psi at the wall to operate at 10 psi at the cap, and the compressor operating range is 80-100 psi (i.e. Kaeser), by having gun operating requirements below that of the compressor low psi turn on pressure, the spray gun will not starve for air due to the compressor fluctuating air delivery between 80-100 psi.

If the compressor is full of air and the painter begins to spray, he will have sufficient air volume. As he continues to spray and the compressor reaches the low pressure turn on point (80 psi in this example), if the operating pressure at the wall required to achieve 10 psi at the cap is below 80 psi, no problem. What happens if he needs 100 psi? As the pressure lowers so does the sir supply to the spray gun affecting atomization of the product being sprayed. In this example only the painter was drawing off the compressor.

Sizing considerations

A common error we see in compressed air systems, in addition to poor piping practice, is line sizes too small for the desired air flow. This isn't limited to the interconnecting piping from the compressor to a dryer. It also applies to the distribution lines conveying air to the production areas. Undersized piping restricts the air flow and reduces the discharge pressure, thereby robbing the user of expensive compressed air power. Small piping worsens poor piping practices by increasing the velocity and turbulence induced back pressure.

Pipe size and layout design are the most important variables in moving air from the compressor to the point of use. Poor systems not only consume significant energy dollars, but also degrade productivity and quality.

The objective in sizing interconnecting piping is to transport the maximum expected volumetric flow from the compressor discharge, through any dryers, filters, and receivers, to the main distribution area with minimum pressure drop.

Contemporary designs that consider the true cost of compressed air target a total pressure drop of less than 3 psi.

Beyond this point, the objective for the main header is to transport the maximum anticipated flow to the production area and provides an acceptable supply volume for drops or feeder lines. Again, modern designs consider an acceptable header pressure drop to be 0 psi.

Finally, for the drops or feeder lines, the objective is to deliver the maximum anticipated flow to the work station or process with minimum or no pressure loss. Again, the line size should be sized for near zero loss. The lower the pressure drop in transporting air, the lower the system's energy input.

Airline cleanliness

Air cleanliness is another factor that affects consistent airflow. Dirt and dust particles passing through the piping system are gradually deposited on the interior surface of piping. As these deposits accumulate, friction increases and system pressure decreases. Black iron and galvanized steel piping systems are more prone to build-up than stainless steel. Meanwhile, smooth bore piping materials, such as aluminum piping offer more resistance to build-up.

Airline restrictions

Our goal here is to lower the required wall (regulator) psi while still achieving 10 psi cap pressure at the gun.

- Remove any restrictions between the spray gun and the regulator.
- Use HVLP type quick disconnects.
- Eliminate cheater valves or valves in general.
- Use minimum 3/8” id air hose 25-35 ft. (one on each side in the booth is best)
- Minimum 50 cfm regulators.
- No Motor Gard filters (hand grenade filters)
- Make sure to have a regulator in the booth (preferably 2; 1 on each side with a shorter hose will give less line drop)
- Make sure gauges on regulators are clean and readable.
- Document required level to achieve 8 and 10 psi at the regulator. A piece of tape on the wall etc will do.
- Pay attention to how the air flows through the regulator. If you notice a large swing in pressure on the regulator once you pull the trigger, you may need a higher cfm regulator.

Reference information

By using the previously discussed formula, we have determined the additional air storage capacity of the most common piping sizes found in shops.

- 2” plumbing – 6.116 feet = 1 gallon additional air storage.
- 1 ½” plumbing – 10.87 feet = 1 gallon additional air storage.
- 1” plumbing – 24.46 feet = 1 gallon additional air storage.
- ¾” plumbing – 43.49 feet = 1 gallon additional air storage.
- ½” plumbing – 97.85 feet = 1 gallon additional air storage.

Remember: To determine the additional capacity for the entire shop, you need to divide the total linear feet of the shop air plumbing system by the appropriate number above. Example: 200’ / 10.87 = 18.39 gallons additional storage space.

What more can you do?

Request a technical analysis of your compressed air system. We have the tools and the know how to help you determine where the problem areas may be and provide possible solutions.

- Test airlines for moisture.
- Test for air temperature.
- Examine existing plumbing layout.
- Make sure you have drip legs in the layout to allow a place for moisture to escape.
- Examine existing filtration.
- Examine existing compressor.
- Install an automatic drain pop off valve on the compressor. (or assign one person to manually drain the system a minimum of once per day)
- Examine compressor room
- Look at room air flow
- Fix the leaks

    - Inherent in threaded steel piping systems, non productive leaks also waste compressed air, thus electrical energy and your dollars. Difficult to trace and repair, they can have a huge impact on operating budgets. A typical threaded compressed air system leaks 35% of its volume, that's one third of the electrical bill associated with compressed air!

Safety

Do's and don't's

While compressed air is quite handy in a work area, it can be dangerous if not used properly.

- A blast of air under 40 psi from 4 inches away can rupture an eardrum or cause brain damage.
- As little as 12 p.s.i can pop an eyeball from its socket.
- Air can enter the navel, even through a layer of clothing, and inflate and rupture the intestines.
- Directed at the mouth, compressed air can rupture the lungs.

The following guidelines will reduce the risk of injury when using compressed air piping systems:

- Examine all hoses and connections to see they are in good condition before turning pressure on.
- Never point the air hose nozzle at any part of your body or at any other person.
- Never look into the end of a compressed air device.
- No horseplay with air hose.
- Never kink the hose to stop airflow - turn it off at the control valve.
- When using air for cleaning, make sure the pressure is no higher than 30 p.s.i.

Always wear eye protection when using compressed air.

Compare pipe alternatives

Black iron & copper piping

For many years, copper and black iron have been the overwhelming favorite for plumbing compressed-air systems. However, recent advances in materials technology have made thermoplastic pipe a safe and economical alternative to traditional materials. A big advantage of metal pipe, tubing, and fittings is that installers are familiar with them and the techniques for joining them. While black iron is inexpensive, installation is time consuming and labor intensive. Moreover, threaded joints often serve as a source of leakage. This leads to higher operating costs because compressors must operate overtime to compensate for the leakage. Although connections between copper pipe and fittings are less prone to leakage, copper components are more expensive, and installation, again, is labor intensive especially when large diameters are involved.

These aren't the only drawbacks to metal piping systems. Interior corrosion can cause scaling and pitting on inside surfaces. As the corrosion products combine with moisture and other contaminants, they accumulate on the inner surfaces of the pipe and fittings, increasing their roughness. As the internal diameter becomes rougher, pressure drop though the system increases. Again, this ends up costing money by reducing efficiency of the compressed air system. Perhaps more importantly, particles can dislodge and clog or damage end-of-line equipment.

PVC Piping

Because of the drawbacks, compressed air system users have been seeking alternatives to traditional metal pipe and tubing. Over the past ten years, industrial plastics have been developed that present an attractive alternative to metal piping.

PVC piping is relatively inexpensive, easy to install, lightweight, and corrosion resistant. However, **PVC has one major drawback, it is brittle**. An inadvertent impact could cause the piping to shatter, endangering surrounding personnel. Most PVC pipe manufacturers warn against using PVC for compressed air service due to potential liability from such failures. The Plastic Piping Institute, in their Recommendation B, states that plastic piping used for compressed air transport in above-ground systems should be protected in shatter-proof encasements, unless otherwise recommended by the manufacturer.

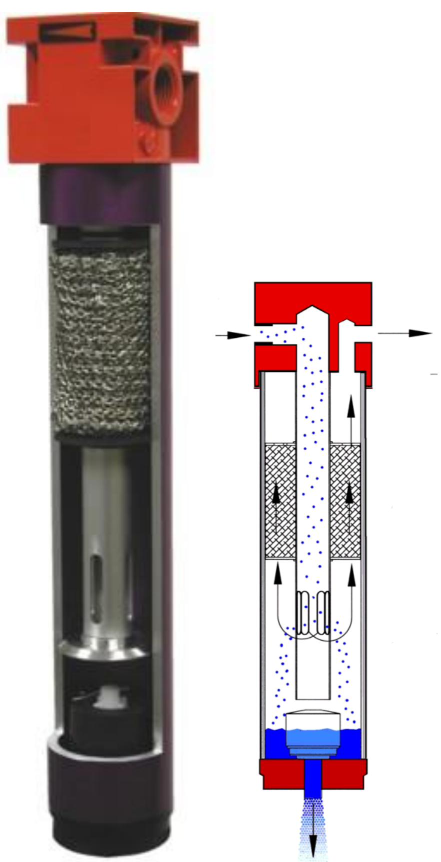
Note:

In many states, the Occupational Health and Safety Administration (OSHA) has stepped in and regulated against using brittle plastics such as PVC in these applications, and additional states are following suit.

The strictest standard in the country has been issued by California's OSHA. It includes five tests, as well as a requirement for comprehensive marking of the pipe and fittings. These tests include long-term hydrostatic, short-term burst, and three specialized impact tests -- all to ensure the safety and ductility of the system. The impact tests include striking frozen, pressurized pipe with both blunt and sharp strikers, using various forces, and striking a frozen pipe with a hemispherical striker, using various forces. Manufacturers are required to present the results of these tests for review upon request. When specifying a thermoplastic system, for safety's sake it is important that your supplier meets CAL-OSHA regulations, regardless of the state in which the system will be installed.

Solenoid drain valve from Tsunami.

- **Adjustable Cycle**
- **Built in, Self Cleaning strainer**
- **Easy Installation**
- **Discharges up to 25 gallons/hour.**



Air enters the unit and goes down through the center tube. Moisture then gathers in the bottom bowl to be drained while the dry air goes back up and exits the unit.

Diagram showing how the Tsunami™ works

Shown 10 hp Dryer, 45 SCFM. PN 21999-0260

SFD Dryer packages are complete with an oil coalescer, zero-loss energy efficient piston drain, and mounting brackets.

- Lowest Operational and Maintenance cost of any regenerative air dryer.
- High Tech molecular sieve will not disintegrate like silica gel desiccant.
- Up to 150° F Inlet air temperature.
- No post particulate filter needed after the dryer to stop desiccant migration.
- Very compact design includes universal mounting bracket
- Installs in minutes between receiver tank and piping.
- Can also be mounted downstream.
- Optional automatic tank drain kit available (PN 21999-0083)