Introduction
AIR POWER FACTS

COMPRESSED AIR
is used virtually everywhere, and is now a significant source of energy as well as a significant cost item for most enterprises.

Using compressed air in a planned and intelligent fashion will ensure its efficiency and limit costs associated with compressed air production and distribution.

AIR POWER FACTS

COMPRESSED AIR

represents approximately 10 % of industrial electricity usage and is present, either as a utility or an integral process raw material, on the vast majority of industrial sites.

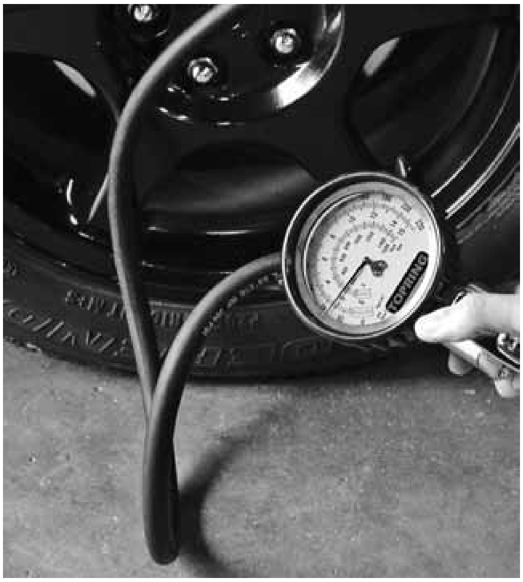
The versatility, flexibility and safety of compressed air as an energy transmitting medium ensure its use as an essential service. Typically, over a ten year period, total compressed air system costs are 56 % energy, 11 % capital and 33 % maintenance (ref: Hydro-Québec); an energy efficient compressed air system is therefore highly cost-effective, even if it costs slightly more to install initially.

Compressed air is a major source of industrial power, and yet a vast majority of engineers and maintenance managers really do not know how much they use, what it costs or how much is wasted. It is estimated that as much as 30 % of compressed air is wasted, through leaks and unnecessary overpressure. This will add significantly to total system costs as this compressed air will be produced without contributing to production increases.

Costs associated with lost efficiency due to inadequate tool performance are also little understood, even though these can also be significant. All too often the response to a complaint about inadequate tool or application performance is to just add more compressor horsepower in an attempt to solve pressure loss problems. In many compressed air systems, adding more compressor capacity can simply mean more wasted energy, as leaks and inadequate network piping prevent the added capacity from improving the situation. For example, if a given leak costs $1 000 per year in energy costs, it can easily become a $1 400 leak by adding more compressor horsepower.

Furthermore, it is important to realize that low pressure or flow at the point of use does not necessarily indicate a lack of compressor power. Poorly thought-out network configuration, inadequate piping sizes, inappropriate or worn compressed air accessories, excessive leakage and varying demand in different areas are all more likely causes for the majority of pressure problems in compressed air systems.

The key to understanding compressed air system performance therefore lies in understanding **PRESSURE**, **FLOW** and **PRESSURE LOSS**. Understanding of these three concepts will help compressed air professionals to design, operate and maintain efficient compressed air systems.



AIR POWER FACTS

PRESSURE

Compressed air **PRESSURE** is a way of measuring the potential energy stored in the compressed air system. Like voltage in electricity, pressure simply states what is available for work. Just as a wall plug still has voltage even if nothing is connected, so does a pressurized compressed air system have pressure even if nothing is being used.

MEASURING PRESSURE

Pressure is measured by calculating the force placed on the walls of the container in which the air is stored; this is usually stated in pounds per square inch, or PSI. Other measurements include BAR, for barometric pressure, ATM, for atmospheres, and kPa, or kiloPascals.

The table below illustrates some of these measurements and how to convert from one to another.

PRESSURE CONVERSION

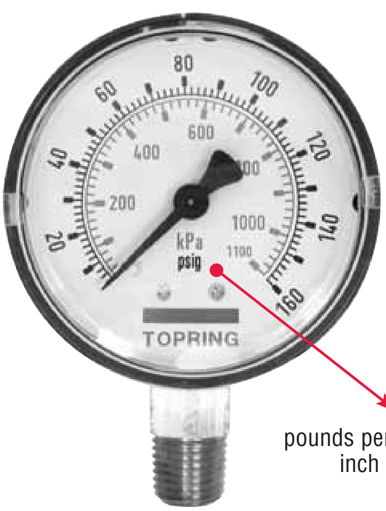
From ↓ / To →	mm Hg	in Hg	ft H_2O	atm	Bar	lb/in² PSI	kgf/cm²	kPa
mm Hg	1.000	0.0394	0.0446	0.0013	0.0013	0.0193	0.0013	0.133
in Hg	25.400	1.000	1.134	0.3342	0.0339	0.4912	0.0345	3.386
atm	760.000	29.920	33.900	1.000	1.0138	14.700	1.033	101.300
Bar	749.659	29.513	33.439	0.9864	0.0690	14.500	1.0189	99.922
lb/in² (PSI)	51.710	2.036	2.307	0.068	0.9815	1.000	0.0704	6.895
kg/cm²	735.600	28.960	32.840	0.9678	0.0100	14.220	1.000	98.050
kPa	7.500	0.2953	0.3349	0.0098	1.000	0.145	0.0102	1.000

For example, if a tool or application is rated at 6 Bar and we want to convert to PSI, we find the intersection of Bar on the left and PSI on the top line, which is 14.5 PSI, then multiply to get the result: 87 PSI.

ABSOLUTE PRESSURE VS. GAUGE PRESSURE

Atmospheric pressure is considered to be **14.7 PSI** (as a standard – following a conventional scenario at sea level with ambient temperature of 68°F and relative humidity of 36%). This is one "Atmosphere". Pressure gauges, however, do not indicate 14.7 PSI at rest; by convention, pressure gauges are set to 0 PSI at rest and this is what is known as "Gauge" pressure, or, PSI**G**, for "pounds per square inch – gauge". When we take atmospheric pressure into account, we use PSI**A**, for "pounds per square inch – absolute". Do not take the atmospheric pressure into account. Using this convention, therefore, atmospheric pressure is 14.7 PSI**A** or 0 PSI**G**.

PSIG is used for the vast majority of applications, as we do not usually need to take atmospheric pressure into account. This is done to the point where PSI and PSIG are often interchanged; a gauge that indicates just **PSI** will usually actually be in **PSIG**. While we do not often see PSIA outside of laboratories, it will be important to understand the difference in certain cases, such as when calculating compression factors.



psig: pounds per square inch – gauge

AIR POWER FACTS

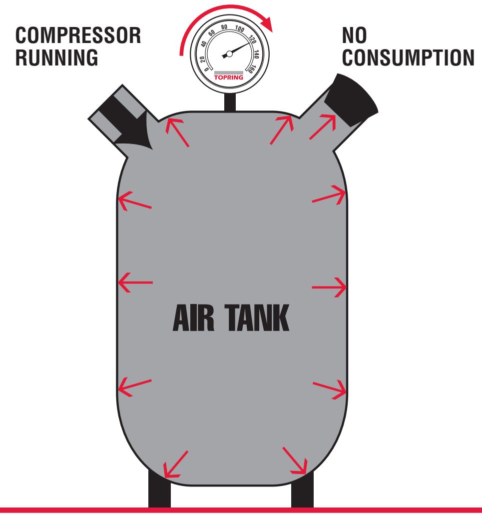
HOW IS PRESSURE BUILT?

PRESSURE is built by simply adding more air to a closed space; this is simply what a compressor does.

PRESSURIZATION:

As more air is forced into the air tank, there are more of the gas molecules that make up the air occupying the same space; these molecules bounce against one another more vigorously as they try to find a way out and back to atmospheric pressure. As they do this, the force on the container walls increases; this force is what we measure to indicate pressure.

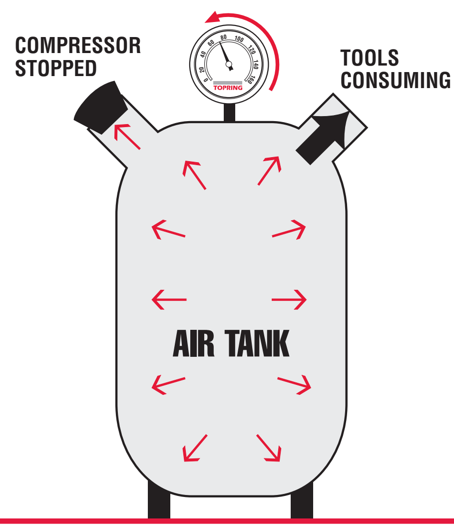
It is this compression effect that stores energy that can then be released, into a tool or application, to perform work. The more air is forced into the closed tank, the higher the pressure, and the more potential energy is stored.



DEPRESSURIZATION:

The opposite effect is also true.

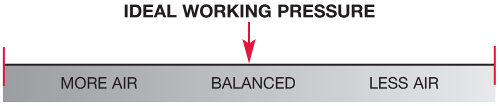
As air is taken out of the tank - for example, when applications consume air - pressure drops, since there will now be less air molecules in the same space. These molecules then bouce against one another with less vigour, and place less pressure on the container walls.

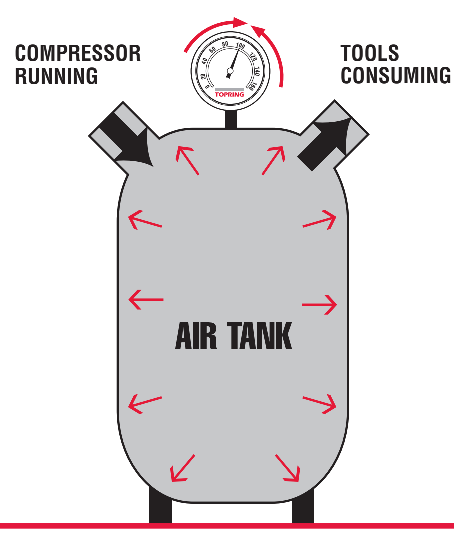


BALANCE:

The key is to find a balance between what is produced and put into the tank and what is consumed or taken out, in order to achieve a stable working pressure for the air applications and tools connected to the system.

As the applications and tools consume air, more molecules are added back into the tank by the compressor, and the system maintains a stable working pressure.





TOPRING

AIR POWER FACTS

THE COMPRESSION FACTOR

How much air is in a tank can be measured by calculating what is known as the “compression factor”. Since atmospheric pressure is 0 PSIG (or 14.7 PSIA), the air volume can be calculated, in terms of atmospheres, contained in a compressed air tank if the pressure in the tank is known.

The compression factor is calculated using the following formula:

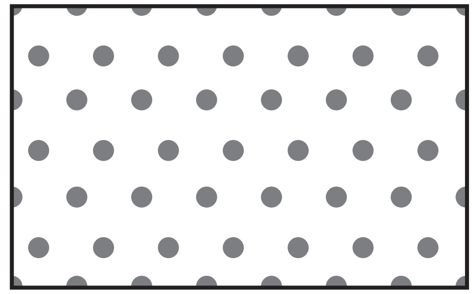
$$\frac{P_g + P_a}{P_a} = F_c$$

Where: P_g is **Pressure - Gauge**, the pressure indicated on the pressure gauge
P_a is **Atmospheric Pressure**, considered to be a standard at 14.7 PSIA
F_c is the **Compression Factor** of the air in the system

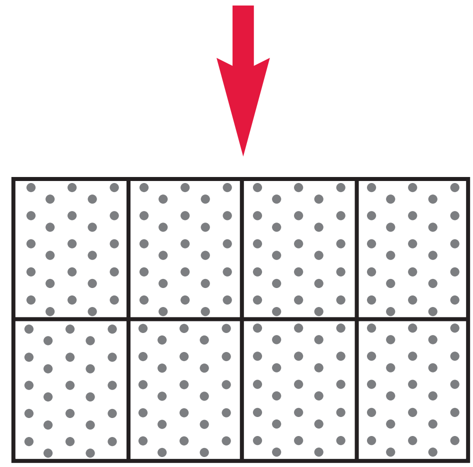
Therefore, at 100 PSIG on the gauge, a tank will contain roughly 7.8 times more air than at ambient conditions:

$$\frac{100 \text{ PSIG} + 14.7 \text{ PSIA}}{14.7 \text{ PSIA}} = 7.8$$

At 90 PSIG, this compression factor will be approximately 7.1, and so on. Why this is very important will become clear a bit later.



1 cubic foot at 14.7 PSIA (0 PSIG)



1 cubic foot at 114.7 PSIA (100 PSIG)
= 8 TIMES MORE AIR

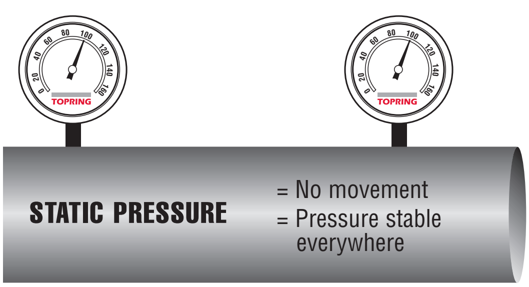
STATIC PRESSURE VERSUS DYNAMIC PRESSURE

The last element required to understand pressure concerns how the air moves within the compressed air system.

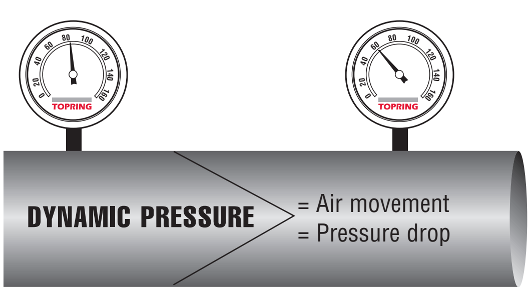
In order for air to move within a system, there must be a **PRESSURE DIFFERENTIAL** between two points in the system. This is quite simple to illustrate: as air exits a tool, for example, pressure drops at that end of the hose because air is being removed from the system. The higher pressure air next to it in the hose then rushes to replace the exiting air, and so on, all the way back to the beginning of the hose. This happens because there is a **PRESSURE DIFFERENTIAL** between the air at the end of the hose (at the tool connection) and the air at the beginning of the hose (at the supply end), allowing movement along its length.

This then is the difference between **STATIC PRESSURE** and **DYNAMIC PRESSURE**. Static pressure is what happens when the system is pressurized and there is no movement of air. Dynamic pressure is the pressure to which the system drops when there is air movement. Under normal circumstances, this dynamic pressure will not drop to zero, since the compressor and tank provide air to replace what is being consumed; the pressure will drop to a lower pressure than the static pressure, to a level dependent on the system’s ability to replace the air consumed.

Therefore, **PRESSURE** is a stored force, just like voltage, ready to be used. However, for it to perform work, it must **MOVE**; this is where **FLOW** becomes important.



AIR PIPE



AIR PIPE

TOPRING

FLOW

Compressed air **FLOW** is a way of measuring the volume of air running through a compressed air system, application, component or tool, over a given time. Like current (amps) in electricity, flow indicates us the volume of air required to maintain sufficient force to perform work.

MEASUREMENT

Flow is measured by taking the volume of air and dividing by a period of time. The most common unit of measurement is the **cubic foot per minute**, or **CFM**; liters per minute is another common measurement.

MEASURING EQUIVALENT FLOW – COMPARING APPLES TO APPLES

As explained in the section on **pressure**, pressurized air has many more molecules in the same space than air at atmospheric pressure. It is therefore important to understand if a flow measurement is stated in unpressurized or in pressurized cubic feet, since there can be a great difference in the actual quantity of air. Unfortunately, there is often confusion between these two different ways of measuring air flow: in **SCFM** (Standard Cubic Feet per Minute) and in **CFM** (Cubic Feet per Minute). Here's the difference:

SCFM differs from **CFM** in that the "S" indicates that the air is "standardised" at 14.7 PSIA, based on a specific scenario as determined by the ASME (American Society of Mechanical Engineers - see illustration). SCFM therefore establishes standard conditions to allow the comparison of the air consumption of air tools, the flow capacities of components and the production capacity of compressors, which may have been measured at differing pressures and, therefore, compression ratios.

CFM, on the other hand, must be stated at a specified pressure (for example, 10 CFM pressurized at 100 PSI). The **compression factor** at the stated pressure must therefore be used to calculate the actual volume of air. For example, 10 CFM pressurized at 100 PSI will be 7.8 times more air, or 78 SCFM, than at atmospheric pressure.

Therefore:

10 CFM pressurized at 100 PSI = 10 x F_c (Compression Factor)
for 100 PSI = 10 x 7.8 = 78.0 SCFM

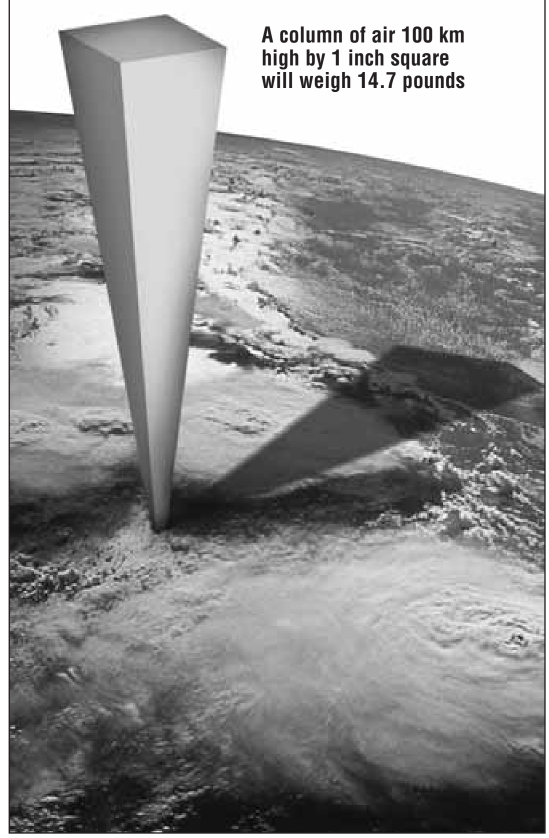
10 CFM pressurized at 90 PSI = 10 x F_c (Compression Factor)
for 90 PSI = 10 x 7.1 = 71.0 SCFM

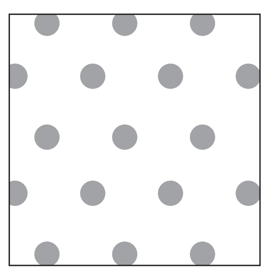
The formula for converting from pressurized to standard air volume is:

$$\text{SCFM} = (\text{CFM @ XX PSI}) \times F_c \text{ for XX PSI}$$

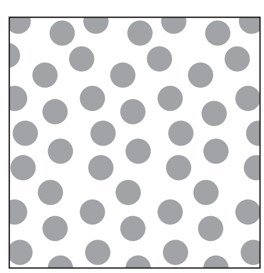
Comparing flow measurements in SCFM with measurements in CFM can therefore be a recipe for disaster, and the difference between CFM and SCFM is very important when choosing components for supplying tools. The **compression factor** therefore plays a significant role in trying to compare flow requirements and capacities of various elements of a compressed air system.

STANDARD ATMOSPHERIC PRESSURE (AS PER THE ASME)
- Altitude : Sea level
- Ambient temperature: 68 °F
- Relative humidity: 36%





1 SCF = 1 cubic foot at 14.7 PSIA (0 PSIG)



1 CF @100 PSIG = 1 cubic foot at 114.7 PSIA (100 PSIG) = 8 times more air

TOPRING

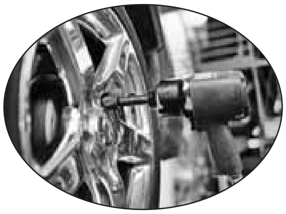
AIR POWER FACTS

PRESSURE AND FLOW ARE DIFFERENT!

Pressure and flow are often confused, interchanged and misunderstood; while they are related, they are not the same thing. As an example, knowing what voltage is present in an electrical system is important, but it will not provide the information needed to gauge usage vs. available power. The current (amperage) available will be much more important; the same can be said of compressed air systems.

While it is important to note supply pressure, as much in terms of the compressor as in terms of what is required by the tools or applications, it is the **volume of air available over time** that will determine if the system can keep up with the tools. What is important to understand is that system flow capacity allows the system to replace air consumed at the tool in order to maintain adequate pressure for the tool to function properly.

This can be demonstrated in how different types of tools function:



Rotating tools, such as screw drivers, impact guns or grinders, require **flow** to function well, since it is the **volume of air** running through a turbine or over a wheel that will drive the tool.

Pulse tools, such as nailers, staplers, etc., require a specific **pressure** to drive the fastener into the material; they will therefore be less affected by flow restrictions (as long as there is sufficient flow to replace the air used in the cycles).

THE PRESSURE TRAP

Despite this, users often increase the pressure at a rotating tool in order to improve performance. The impression is that the tool will function better if it has more pressure, but, in actual fact, it is lacking flow.

Since the tool is consuming more air than the system can supply, the amount of air at the tool connection point drops, causing excessive pressure drop. Boosting the pressure may buy some time and provide a momentary kick, but the reality is that if the flow capacity of the system is insufficient to replace the air being used, boosting pressure will not solve the problem and can actually cause more problems, such as additional strain on the compressor, damage to the tool, etc.

The key, then, lies in minimizing **excessive pressure loss** at the tool.

Increasing air pressure at the tool rarely provides improved tool performance

AIR POWER FACTS

PRESSURE LOSS

PRESSURE LOSS refers to the difference in pressure between what is present in the storage tank and what is available at various points along the compressed air network. Some pressure loss is inevitable, simply because there must be a pressure differential for the air to move within the system and the compressed air applications will consume air, leading to some pressure loss. Problems begin to occur when the system experiences **EXCESSIVE PRESSURE LOSS.**

Maintaining ideal pressure is the primary goal of air system design

EXCESSIVE PRESSURE LOSS

EXCESSIVE PRESSURE LOSS occurs when the air system is incapable of replacing the air being consumed by the tools or applications with sufficient speed. This then can cause the pressure to drop below the specified operating pressure of the tool or application, which can lead to poor tool performance, lost time, production and quality problems and even damage to the tool. **What is excessive ?** 10% pressure loss at the tool, e.g. between compressor tank pressure and tool inlet pressure, is considered to be acceptable for the majority of air tools, as is a total loss of no more than 3% throughout the distribution network itself. Losses in excess of these amounts are considered “excessive”.

Often, in an attempt to solve this problem, the supply pressure is increased; while this provides a higher pressure when the tool is first activated, the same inefficiencies in the system still exist, and the pressure simply drops once again to below ideal operating pressure after the initial kick, which can often damage the tool.

Ideally, the compressed air system, including the compressor, storage tank, distribution network, quick couplers, hoses, etc., will have been designed to provide sufficient flow to replace the air being used while avoiding excessive pressure loss at the tool.

EXCESSIVE PRESSURE LOSS
What is excessive?
- At the tool: 10%
- Over a network: 3%

THE COSTS OF EXCESSIVE PRESSURE LOSS

Compensating for excessive pressure loss will lead to additional costs:

- **Power costs**, as the compressor works harder to maintain a higher working pressure. In general, it costs 1% more in electricity for every 2 PSI additional pressure maintained in the system
- **Leak costs**, as the additional pressure in the system will push more SCFM out of the same openings
- **Maintenance costs**, at the compressor, as it will wear more quickly
- **Tool costs**, either replacement or repairs, as the tool sees an initial pressure higher than recommended and will wear or break faster
- **Personnel costs**, as workers waste time compensating for underperforming tools due to the excessive pressure loss
- **Product costs**, due to inferior quality and production problems due to tools not performing to specifications (example: wrong RPM of a grinder leading to product finish problems)

It is therefore very worthwhile to invest in improving compressed air system performance in order to avoid excessive pressure loss, since these costs can add up very quickly.

COMPENSATING FOR PRESSURE LOSS CAN BE EXPENSIVE

SCFM	10 PSI	20 PSI	30 PSI	40 PSI	50 PSI
20	$ 97.04	$ 194.09	$ 291.13	$ 388.18	$ 485.22
40	$ 194.09	$ 388.18	$ 582.27	$ 776.36	$ 970.44
60	$ 291.13	$ 582.27	$ 873.40	$ 1 164.53	$ 1 455.67
80	$ 388.18	$ 776.36	$ 1 164.53	$ 1 552.71	$ 1 940.89
200	$ 970.44	$ 1 940.89	$ 2 911.33	$ 3 881.78	$ 4 852.22
400	$ 1 940.89	$ 3 881.78	$ 5 822.67	$ 7 763.56	$ 9 704.45
600	$ 2 911.33	$ 5 822.67	$ 8 734.00	$ 11 645.34	$ 14 556.67

Based on a 720 hour usage per month with an average cost of $ 0.03 per kw/hr

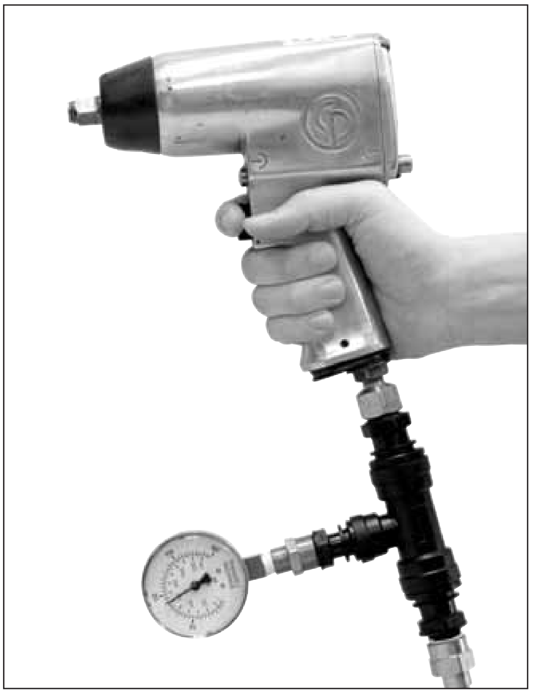
AIR POWER FACTS

MEASURING PRESSURE LOSS

Pressure loss should ideally be measured directly at the tool, where it is connected to the air hose. This will ensure that all potential sources of pressure loss are taken into account. Standard procedure is then to measure again, at each component connection, back to the air distribution network and, if possible, all the way back to the storage tank. This will allow isolation of problem components.

There are two very important mistakes that are often made when measuring air pressure at the tool, both of which lead to imprecise measurements and poor tool performance. The first mistake is regulating the pressure far from the air tool. A significant pressure drop can occur between the regulator and the tool, through the quick couplers and hose. To ensure accurate pressure at the tool, the pressure should always be checked at the tool inlet while adjusting the pressure regulator. The pressure regulator should also be located as close as possible to the tool. The second mistake is adjusting pressure with the tool in the static, or off, position. The tool must be operating in order for the pressure loss to be present (the system will catch up when at rest); the pressure must be measured and the regulator adjusted with the air tool running.

The loss measured at the tool, with the tool running, will therefore take into account all of the sources of pressure loss. Since the tool's performance is the ultimate goal, this pressure loss will be the key to ensuring performance.



Testing pressure drop at the tool with a differential pressure indicator

SOURCES OF PRESSURE LOSS

There are four principle causes of low air pressure at the tool:

- **Inadequate air distribution system**
- **Inadequate or poorly maintained air accessories**
- **Excessive leakage**
- **Insufficient compressor and storage capacity**

Each of these can contribute to total system pressure loss, and to the additional costs that it causes.

The following pages provide details on each cause and how to minimize its impact.

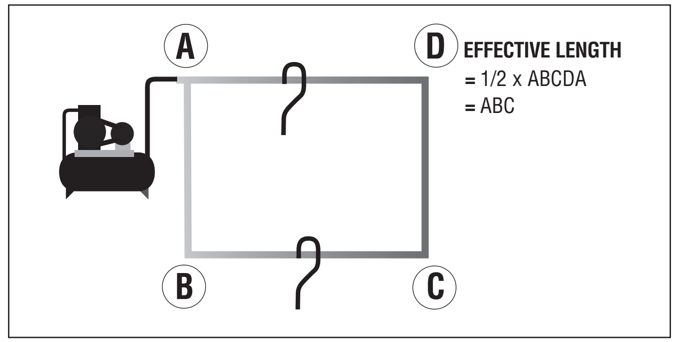
AIR POWER FACTS

INADEQUATE AIR DISTRIBUTION SYSTEM

PIPING DIAMETER

A large proportion of pressure loss is due to inadequate piping diameter. The longer the distance to be run, the larger diameter pipe must be used, and the same goes for air volume. The proper piping diameter must be calculated based on the total air volume to be conveyed and the total distance to be covered; see the section on designing an efficient compressed air distribution network on page 34 for more details on how to make these calculations.

CLOSED LOOP NETWORK

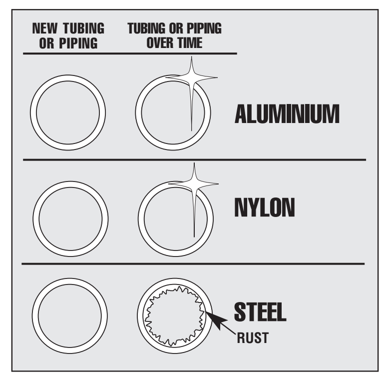


For a closed loop system, the fact that there are always at least two paths to any point on the loop means that only half of the total length must be considered when sizing the main air line

PIPING MATERIAL

Friction within the air distribution system also contributes to pressure loss, determined by piping material and condition, network design and restrictions.

Rough or deteriorated piping can severely increase pressure loss; several options now exist that provide superior flow characteristics to traditional materials as well as virtually eliminating deterioration due to corrosion.



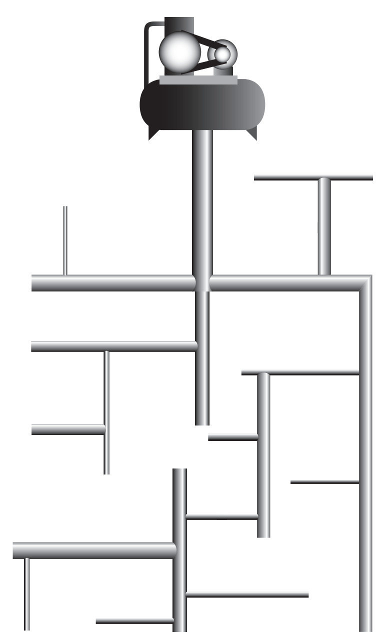
NETWORK DESIGN

Network design will also contribute to pressure loss; using modern, looped systems such as those proposed in the section on designing an efficient compressed air distribution network on page 34, will provide more flow with less pressure loss.

In addition, any fittings, bends, "T"s and other restrictions will add to pressure loss. The impact of these can be taken into account by adding "equivalent length" of piping to the total distance to be covered by the network. The table below illustrates the impact of each type of fitting.

EQUIVALENT LENGTHS FOR VARIOUS FITTINGS (IN LENGTH OF EQUIVALENT TUBE)

	INTERNAL DIAMETER OF FITTINGS				
	15 mm	22 mm	28 mm	40 mm	63 mm
Ball valve	+4"	+12"	+16"	+20"	+28"
Reducer	+16"	+20"	+24"	+28"	+39"
90° Elbow	+28"	+51"	+59"	+79"	+138"
"T" Fitting	+32"	+59"	+79"	+98"	+158"



Networks such as these will lead to excessive pressure loss

TOPRING

AIR POWER FACTS

INADEQUATE OR POORLY MAINTAINED AIR ACCESSORIES

AIR HOSES

The largest pressure loss in a system serving air tools is often caused by hoses that are too long and hoses that are too small in diameter. The longer the hose, the more friction is created, regardless of size; this can be addressed by increasing hose diameter. For this reason, small diameter hoses inevitably limit flow. Choosing the proper diameter hose for the distance and flow required will limit pressure loss at the tool. In addition, different hose materials offer different flow characteristics and resistance to deterioration.

RECOMMENDED FLEXIBLE HOSE SIZES (I.D.) FOR VARIOUS DISTANCES AND FLOWS

Flow		Distance				
(SCFM)	Pressure	25'	35'	50'	75'	100'
1	100 PSI	1/4	1/4	1/4	1/4	1/4
2	100 PSI	1/4	1/4	1/4	1/4	1/4
5	100 PSI	1/4	1/4	1/4	5/16	5/16
10	100 PSI	5/16	5/16	3/8	3/8	3/8
15	100 PSI	3/8	3/8	1/2	1/2	1/2
20	100 PSI	3/8	1/2	1/2	1/2	1/2
25	100 PSI	1/2	1/2	1/2	1/2	3/4
30	100 PSI	1/2	1/2	1/2	3/4	3/4
40	100 PSI	1/2	3/4	3/4	3/4	3/4
50	100 PSI	3/4	3/4	3/4	3/4	3/4

QUICK COUPLERS

Another source of pressure loss is the restriction caused by quick couplers. Different coupler designs and plug profiles offer varying flow capacities; the most commonly used designs actually provide insufficient flow for the majority of air tools, and yet they continue to be used. Changing to high flow, low pressure drop couplers will increase tool performance and limit pressure drop.

Series 31
QUIKSILVER

Series 31
TOPQUIK

QUICK COUPLER CHOICE WILL INFLUENCE FLOW TO THE TOOL AND PRESSURE DROP:

S20 • 1/4 INDUSTRIAL
S23 • ARO 210
S24 • 1/4 TRUFLATE
S26 • LINCOLN
5.5 mm
24-37 SCFM

S21 • 3/8 INDUSTRIAL
S23 • ARO 310
S25 • 3/8 TRUFLATE
7 mm
60-72 SCFM

S31 • ULTRAFLO EUROPEAN INTERCHANGE
7.8 mm
60-70 SCFM

FILTERS

One of the most routinely overlooked sources of pressure drop is the compressed air filter.

While usually providing sufficient flow when first installed, maintenance is often neglected and the filter elements allowed to saturate, causing additional pressure drop.

A simple maintenance program aimed at changing filter elements at regular intervals (maximum once per year) can go a long way to maximizing pressure available at the tool.

Saturated filter elements rob air tools of valuable pressure

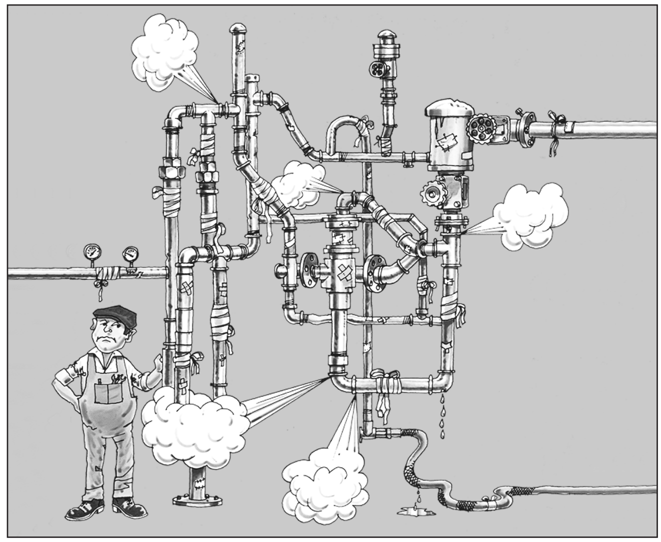
Changing filter elements regularly minimizes pressure drop

AIR POWER FACTS

EXCESSIVE LEAKAGE

Compressed air system audits indicate that the average plant loses 20% or more of compressor capacity to leakage. Leakage rates exceeding 50% of consumption are common. As a rule of thumb, every 2 PSI increase in pressure will require 1% more energy at the compressor; every PSI lost to leakage is therefore very costly.

Considering the cost of energy, this loss can be a considerable drain on resources. Since air leakage is not unsafe, it is often tolerated. Leakage also usually occurs in a multitude of small openings, none of which is sufficient to draw attention; while each leak may be minor, the cumulative effect is great. With compressed air costs averaging $0.26/1000 SCFM, an average plant can potentially save huge amounts simply by undertaking a leak identification and repair program.



The sources of leakage are numerous, but the most frequent problems are:

- Condensate drain valves left open
- Shut off valves left open
- Leaking pipes and pipe joints
- Leaking hoses and quick couplers
- Leaking pressure regulators
- Air cooling lines left open permanently
- Air-using equipment left in operation when not needed

It is possible to eliminate substantial leakage just by improving these few items.

Leakage is not only a direct source of wasted energy, but is also an indirect contributor to operating costs. As leaks increase, system pressure drops, air tools function less efficiently and production is affected.

AIR LEAKAGE COSTS

	Openings totalling (inch)	Air leakage at 90 PSI	Required compressoor capacity	Estimated annual cost of air leakage for 516 hours/month
		SCFM	KW	$$$
	1/32	2	0.3	$ 205
	1/8	21	3.1	$ 2 055
	3/16	57	8.3	$ 5 550
	3/8	222	33.0	$ 21 590
	1/2	307	42.0	$ 29 800

These figures are for illustration purposes only. Individual situations will vary based on many factors. Please contact *TOPRING* for more details

AIR POWER FACTS

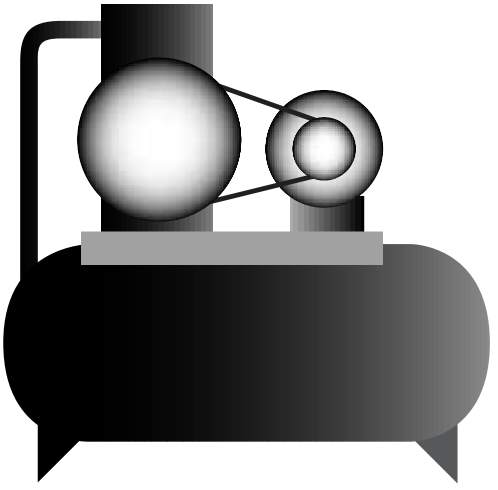
INSUFFICIENT COMPRESSOR AND STORAGE CAPACITY

As stated before, pressure loss in a compressed air system is the result of an imbalance between the volume of air required (consumption) and the volume of air available (capacity). Thus, when total tool consumption exceeds the capacity of the compressor to produce compressed air at the required pressure, total system pressure drops. The addition of storage capacity can help this situation, since the tank will provide additional cubic feet of air to lengthen the time before system pressure drops below minimum working pressure.

Inbalance can quickly be identified by adding up the total consumption (in SCFM) of all tools that could run simultaneously and comparing this number to the total capacity of the compressor (as a general rule, compressors ingest approximately 4 SCFM per horsepower when producing air at 100 PSIG).

Two methods are used to rate total air usage: average and continuous. **Continuous SCFM** is the amount of air the tool consumes under normal no load operation. **Average SCFM** is determined by multiplying the continuous SCFM by a use factor. The use factor is determined by industry as the amount of time that the tool is run. Tools such as impact wrenches have a shorter run time and thus lower use factors and lower average SCFM requirements. Tools that run for a long period of time, such as sanders, have a higher use factor and higher average SCFM requirements. **Average SCFM** is only used in matching tool consumptions to compressor capacities. **Continuous SCFM** is used to size air lines and fittings within the system.

Therefore, if the compressor produces less than the total average SCFM consumption of the tools, pressure drop will inevitably occur in the system, and, if pressure drops too low, additional tank and/or compressor capacity should be considered.



AIR CONSUMPTION CHART FOR TYPICAL TOOLS

Description	Continuous Air Consumption at 90 PSI	Description	Continuous Air Consumption at 90 PSI
18 Gauge Brad Nail Guns	0.02 SCF per cycle	Pull Type Air Nibbler	17.3 SCFM
22-18 Gauge Staplers	0.03 SCF per cycle	4" Angle Disc Grinder	18.4 SCFM
Finishing Nail Gun	0.03 SCF per cycle	Mini Belt Sander (10 mm)	18.9 SCFM
Coil Roofing Nail Gun	0.05 SCF per cycle	3/8" Ratchet	19.2 SCFM
Framing Nail Gun	0.09 SCF per cycle	D.A. Sander	19.2 SCFM
Riveter	0.08 SCF per cycle	Jitterbug Sander	19.2 SCFM
Grease Gun	0.8 SCF per cycle	Pistol Grip Shears	19.2 SCFM
Caulking Gun	0.1 SCFM*	Chisel/Hammer	21.9 SCFM
Engine Cleaner	6.1 SCFM	High Speed Sander	22.7 SCFM
Conventional Spray Gun	7.0 SCFM**	3/8" Reversible Drill	23.8 SCFM
HVLP Spray Gun	9.5 SCFM**	Abrasion Cut Off Tool	25.4 SCFM
Screwdriver	9.6 SCFM	Full Size Die Grinder	25.4 SCFM
Straight Line Sander	9.6 SCFM	1/2" Reversible Drill	26.4 SCFM
1/4" Mini Ratchet	12.5 SCFM	1/2" Impact Wrench	28.6 SCFM
1/4" Impact Driver	14.0 SCFM	7" Angle Sander	29.6 SCFM
Mini Die Grinder	16.5 SCFM	7" Vertical Polisher	31.0 SCFM
Random Orbital Sander	16.6 SCFM	3/4" Impact Wrench	34.7 SCFM
3/8" Angle Drill	17.3 SCFM	1" Impact Wrench	87.5 SCFM

* at 20 PSI
** at 40 PSI

IN CONCLUSION

The key to operating a successful compressed air system therefore lies in producing, storing and conveying adequate cubic feet of compressed air to match or exceed the consumption of all compressed air applications. Insufficient production, storage or flow capacity will prevent the system from replacing what is consumed by the applications, leading to excessive pressure drop and poor tool performance.

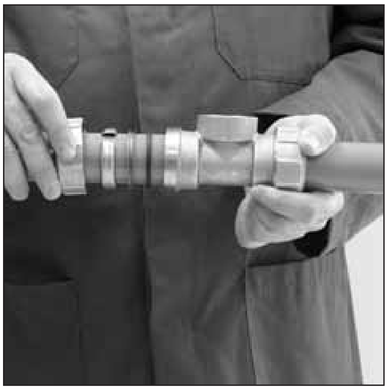
This will lead to additional compressed air production costs, tool maintenance and replacement costs, but most importantly, will have an impact on worker efficiency and product quality as workers try to compensate for poor tool performance. In the end, this can be the most significant cost item, but is hardly ever calculated.

Much of the problem of excessive pressure loss can be avoided by designing the compressed air distribution system from the outset with properly sized, good quality piping. Several options now exist that provide superior flow characteristics to traditional materials as well as virtually eliminating deterioration due to corrosion. Sizing the piping so as to minimise pressure drop and maximise flow will provide dividends almost immediately.

In addition, compressed air accessory selection is crucial to avoiding excessive pressure loss. The selection of quick couplers, valves, fittings, filtration units, hoses or other components, tool consumption should guide the process. Installation of a component with insufficient flow capacity (SCFM) for the application will inevitably lead to excessive pressure loss that will limit tool performance. For example:

- Most quick couplers used today offer insufficient air flow for the majority of rotating air tools; care should therefore be taken to choose a design and plug type that offers sufficient flow
- Different hose materials offer different flow characteristics and resistance to deterioration.
- Sizing hoses based on tool consumption and length will ensure that pressure drop is kept to a minimum
- Clogged filter elements lead to pressure drop; preventive maintenance programs designed to change them before saturation can save many PSI of pressure drop

A leak detection and repair program can also be an inexpensive method for reducing costly pressure drop. By replacing faulty couplers and leaking hoses, tightening fittings where required, maintaining filtration units and using adequate thread sealant, much of the problem can be fixed with little investment.



Finally, choosing the compressor based on present and future consumption needs is always a winning proposition. By calculating total air flow usage and future expansion requirements, it is possible to find the ideal compromise between compressor capacity and system needs.

The **TOPRING** products and systems in this catalogue, combined with the expertise of **TOPRING** sales and technical staff, can help achieve the ideal balance between system performance and costs.