WHEN SELECTING AIR CYLINDERS,
DON'T OVERLOOK
CHEMICAL COMPATIBILITY

FABCO-AIR
A member of Festo Group

It's no secret that pneumatic cylinders often operate in harsh environments. While it's important to select a cylinder that can stand up to tough conditions, some of the materials used to fortify cylinder components may not react well when they come in contact with certain chemicals. These incompatibilities sometimes result in cylinder damage or degradation, or worse. That's why machine builders must exercise care to ensure that the cylinder they choose is made from materials that remain stable when used or stored with these incompatible chemicals.

This white paper will provide an overview of some of the materials used in cylinder bodies and internal components, such as pistons and seals. The review will indicate both their chemical compatibility characteristics as well as incompatibility issues you should be aware of when considering implementing a pneumatic cylinder in your equipment. Examples will draw from Fabco-Air's wide range of air cylinders and customization capabilities.

MATERIAL CONSIDERATIONS FOR AIR CYLINDER BODIES

Many standard air cylinders are constructed with anodized or hard anodized aluminum bodies. The anodizing process creates a protective oxide layer that bonds completely to the aluminum. The finished surface stands up to tough industrial conditions including fabrication, installation, operation and cleaning with virtually no wear and tear. According to the Aluminum Anodizers Council™, an anodized finish is chemically stable, will not decompose, is non-toxic, non-hazardous and produces no harmful or dangerous byproducts. It melts at 1,221°F, so we suggest that the anodized aluminum part or sheet does not come in contact with temperatures exceeding 320°F (160°C) in order to avoid or minimize thermal crazing. Anodized aluminum is economical and easy to clean, requiring just mild soap, water or a mild abrasive cleanser, if necessary.

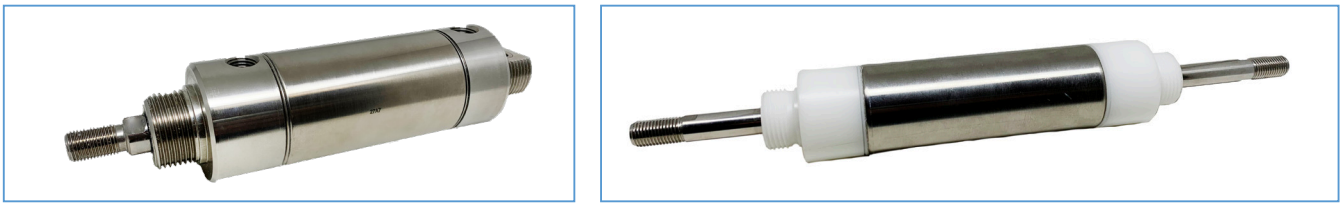

Figure 1. Fabco-Air's F Series air cylinders are available in an all stainless steel version for food applications (left), or customized with Delrin® construction to withstand washdowns (right).

For food industry equipment subject to frequent cleaning with often harsh chemicals, many air cylinders are offered with food-grade stainless steel construction. Because more than 10.5 percent of stainless steel's composition includes chromium, the material reacts quickly to oxygen and forms an active barrier that protects both the surface and interior structures against corrosion. Stainless steel's durability allows for effective cleaning, thereby preventing bacteria growth. Fabco-Air offers stainless steel versions of its F and H Series round body cylinders and FAE Series of ISO 6432 interchangeable cylinders.

Not all washdown-resistant cylinders have metal bodies. Polyoxymethylene, an acetal homopolymer resin with the brand name Delrin®, is characterized by its mechanical strength and chemical resistance. This plastic is positioned as a durable replacement for metal in parts, giving them corrosion resistance and lighter weight. Delrin is well-suited for washdown applications or for parts exposed to industrial solvents, lubricants, agricultural chemicals, fuels, weak acids and bases as well as water.

Figure 2. This special Delrin Pancake cylinder features a smooth exterior to resist washdowns.

If a food industry device requires a short-stroke, low-profile cylinder, Fabco-Air can create a special Delrin Pancake cylinder with a smooth exterior to resist washdowns, along with a food-grade lubricant. Like stainless steel, Delrin is not suitable for all situations. The manufacturer does not recommend the resin for:

- Strongly basic environments with a pH higher than 9 or strongly acidic environments.
- Environments with chloride or zinc chloride solutions.
- Aggressive fuels with acidic character.
- Long-term exposures to temperatures greater than 90°C (194°F).
- Long-term immersion in hot water greater than 60°C (140°F).
- Applications requiring flammability ratings above HB.

AIR CYLINDER COMPONENT MATERIALS

After reviewing the chemical compatibility of materials used for the air cylinder's body, do not overlook the chemical characteristics of the constituent components and component options. Three cylinder components — pistons, bearings and seals — are often made from different materials and also require careful analysis. Here is a brief overview:

Pistons. Many pistons and shafts are made from stainless steel with hard chrome plating. In addition to considering the characteristics of stainless steel presented earlier, be sure to examine hard chrome plating. Nonmagnetic hard chrome-plated surfaces are exceptionally durable for use in harsh industrial environments, exhibiting low coefficient of friction, hardness between 65 to 70 Rc and low wettability. Hard chrome offers good resistance to citric acids, nitric acids, sodium chloride and copper sulfates. Keep in mind that its effectiveness often depends on temperature. Some acids can attack chrome, such as hydrochloric acid, sulfuric acid, aqua regia and hydrofluoric acid.

Another piston material, brass, may be an appropriate choice if the cylinder will be used with or near neutral and non-corrosive chemicals. Avoid sea water and distilled water.

Bearings and Bushings. Many bearings are constructed from synthetic polymers, either from the nylon family or Teflon™, the trademarked name for Polytetrafluoroethylene (PTFE). Brass is also an option.

The nylon family of polymers, composed of polyamides, is characterized by long and heavy molecules. They get their hardness or softness from variations in the adipic acid and hexamethylenediamine. Advantages include good mechanical and compressive strength, the ability to absorb shock, and good resistance to alkali, most salt solutions and weak acids. Nylons are hygroscopic and can deteriorate easily with moisture. They also melt easily, lack UV resistance and may not stand up to strong acids or oxidants.

Duralon®, a nylon variant typically found in bearings, can be engineered for exceptional strength and impact resistance. In addition to its stiffness and dimensional stability, Duralon resists flames and corrosion. Because it is non-metallic, Duralon is a good insulator.

PTFE or Teflon® is a popular plastic material known for its non-stick properties. High-strength carbon-fluorine bonds make Teflon very non-reactive with resistance to many organic solvents, depending on temperature and pressure, and nearly insoluble versus all solvents. Teflon is flexible and bendable, offers a wide operating temperature range, high thermal stability, weather resistance and good anti-embrittlement properties, and it is considered safe for use with food processing equipment. When overheated, PTFE can emit toxic fumes. Additional disadvantages include low radiation resistance and creep under compression. PTFE can only be joined by mechanical means.

Bronze, an alloy, consists primarily of copper and is known for its strength, ductility and machinability. Bronze's outer layer oxidizes when exposed to air, but that same layer protects the metal below from corrosion. However, chlorides, such as from seawater, can cause severe damage. Bronze conducts heat and electricity, and its melting point is between 950 to 1,050°C. Remember that bronze bushings may be oil permeated or oil filled as well as sintered.

Lubrication Considerations To Address Pneumatic Cylinder Challenges

Simply put, pneumatic cylinders will fail without proper lubrication. For most industrial applications, soap-based lubricants like lithium greases can reduce friction and prolong the lifetime of various machines and components. There are many soap-based lubricants to choose from, each with their own unique properties. They generally offer good protection against water, oxygen, corrosion as well as wear and tear.

Lithium has excellent adhesion to metals, can withstand heavy loads, high pressure and shock, and it is stable when it interacts with other chemical substances. Operating temperatures are approximately 130°C continuous with a 190 to 200°C dropping point. Disadvantages include dust and dirt collection, and it may speed up decay for rubber and plastic parts due to its petroleum base.

Although soap-based greases are widely used in industrial machinery, pneumatic cylinders present challenges that can exceed the capabilities of soap-based lubricants. After all, pneumatic cylinders have aggressive duty cycles and operate under high pressures in high-heat or corrosive environments.

One non-soap polyurea lubricating grease is well-suited to address these challenges. Magnalube® is a PTFE-impregnated grease with proprietary additives that inhibit rust and oxidation. Many Fabco-Air cylinders come standard with Magnalube-G for effective lubrication across a wide temperature range and a long operating life. Additional features include:

- Constant performance from -40 to +276°C and a dropping point of ~287°C.
- Resistance to mechanical wear and surface degradation.
- Lubricity under high pressures.
- Exceptional film strength.
- Excellent dispersion properties.
- Mechanically stable and doesn't soften or harden.
- Non-conducting with high dielectric strength.

Note that while Magnalube-G is used in a wide variety of pneumatic cylinders, it cannot come into contact with food.

Seals. As you evaluate seal materials, you'll find two widely used elastomers: Nitrile rubber and Viton®.

Nitrile (acrylonitrile butadiene) rubber also goes by the names Buna, Buna-N and NBR, and its properties vary depending on the composition. This versatile rubber typically offers high tensile strength, resistance to water, non-polar solvents and a wide range of oils and fuels as well as many alcohols, hydraulic fluids and silicone greases. Limitations include poor ozone, sunlight, flame and oxidation resistance.

Like nitrile rubber, **Viton or FKM** has different compositions and corresponding properties and performance characteristics. It is well-known for its resistance to fluids, and it is compatible with lubricating oils, hydraulic oils, fuel oils, kerosene, alcohol, diluted acids as well as halogenated and aromatic hydrocarbons. Viton also resists tears and abrasion. Compared to Buna-N, Viton is better suited for harsh-environment and high-temperature applications, with a temperature range of -20 to 210°C versus up to 120°C for Buna-N. However, Viton can decompose and release toxic hydrogen fluoride at extremely high temperatures. Incompatible chemicals include acetone, methyl ethyl ketone, as well as various ester solvents and organic acids.

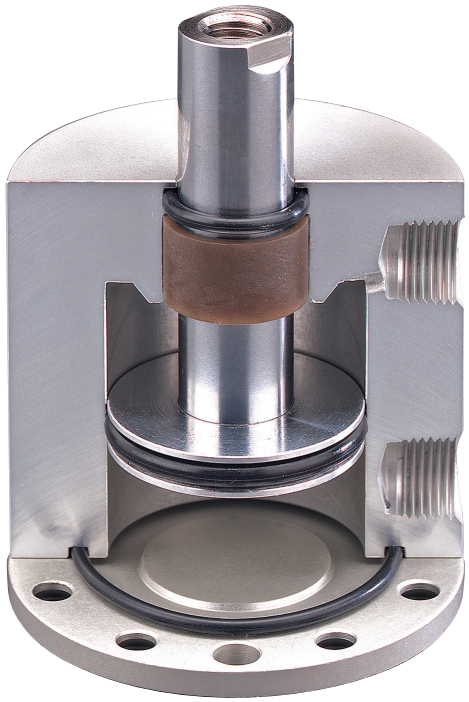

Figure 3. Fabco Air's Original Pancake cylinder is made from aluminum bar stock and features a Duralon® rod bushing, hard chrome plated stainless steel piston rod and comes pre-lubed with Magnalube®-G Grease. A PTFE piston bearing version is also available.

OTHER COMPONENTS AND ACCESSORIES

In addition to pistons, bearings and seals, other cylinder components and associated materials to keep in mind should include, but are not limited to:

- Anodized aluminum covers.
- Aluminum end caps.
- Internally lubricated o-rings.
- Stainless steel tie rods.
- Fiber seal gaskets.

Common Air Cylinder Materials — Characteristics At-a-Glance

Materials	Pros/Cons	Notes
Cylinder Body		
METALS/ALLOYS		
Anodized Aluminum	Relatively inert	
Stainless Steel	Relatively inert	
PLASTICS		
Delrin®	**Pros:** Compatibility with lubricants, agricultural chemicals, fuels, weak acids, bases and water **Cons:** Not suitable for strong basic environments (especially pH>9), strong acid, chlorine or zinc environments, aggressive fuels with acidic character, hot water >60°C	
Component Material		
METALS/ALLOYS		
Hard Chrome (nonmagnetic)	**Pros:** Compatibility with citric and nitric acids, sodium chloride and copper sulfates **Cons:** Not suitable with hydrochloric, hydrofluoric and sulfuric acids, aqua ragia	Effectiveness depends on temperature
Brass	**Pro:** Can be used with or near neutral or non-neutral chemicals **Con:** Not suitable with distilled water	
Bronze	**Con:** Not suitable with chlorides or sea water	Melts between 950 to 1,050°C
SYNTHETIC POLYMERS		
Nylon Polymers	**Pro:** Compatibility with alkali, most salt solutions and weak acids **Con:** May not stand up to strong acids or oxidants	Has different compositions and corresponding properties and performance characteristics
Duralon® (Part of the Nylon family)	**Pro:** Good insulator	
PTFE/Teflon®	**Pro:** Compatibility with many organic solvents, depending on temperature and pressure **Con:** Nearly insoluble versus all solvents	Can only be joined by mechanical means
ELASTOMERS		
Nitrile Rubber	**Pros:** Compatibility with water, non-polar solvents, a wide range of oils and fuels, and many alcohols, hydraulic fluids and silicone greases **Con:** Poor ozone resistance	Has different compositions and corresponding properties and performance characteristics
Viton	**Pros:** Compatibility with lubricating oils, fuel oils, kerosene, alcohol, diluted acids and halogenated and aromatic hydrocarbons; resists fluids **Cons:** Not suitable with methyl ethyl ketone, various ester solvents and various organic acids	Has different compositions and corresponding properties and performance characteristics

**Table. This chemical reference provides general information on materials and chemicals used in air cylinders.*

**This table is not intended to predict the air cylinder's performance or be a substitute for lab testing, experiments or consultation with the manufacturer.*

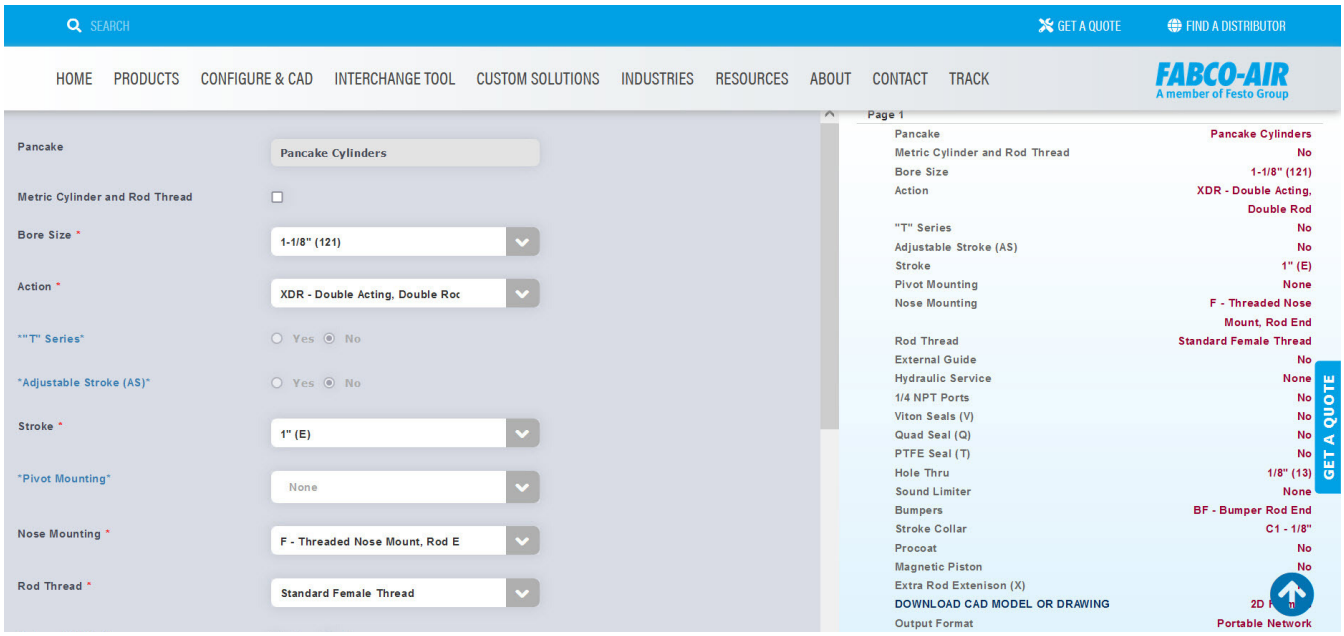

Figure 4. Fabco-Air's online Configure & CAD Tool lets users select a product to configure from the ground up, option by option.

WORK WITH YOUR PNEUMATIC CYLINDER MANUFACTURER

When it comes to plastic and metal materials used in air cylinders, a host of chemical compositions, environmental conditions and other factors will affect their performance, compatibility and stability with other materials, chemicals and gases. If you are unsure if a cylinder's constituent materials are appropriate for your application, consult with the manufacturer to help determine the best unit and parts to meet your requirements.

Fabco-Air can help you modify a standard cylinder or custom-engineer cylinder components so your unit will be stable in its intended environment. In fact, over 50 percent of the products we manufacture are special items designed to address unique application requirements. You can also use our online Configure & CAD Tool to select and configure your cylinder from the ground up, option by option.

REVIEW YOUR OPTIONS

Depending on the dynamics of your air cylinder application and operating environment, it's important to review your choice of material construction and parts options. Be sure to understand the chemical compatibility implications of your choices and work with a cylinder manufacturer that has the materials expertise and robust custom capabilities to ensure your cylinder achieves a long, trouble-free lifetime in its intended environment.

For more information, visit www.fabco-air.com