CHOOSE THE RIGHT HOSE:

A PRACTICAL GUIDE TO HOSE SELECTION

SWAGELOK HOSE SELECTION ARTICLE
By Patrick Werrlein

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HOSE SELECTION

Hoses cost more than thier purchase price.

The right hose keeps your process performing safely and cost effectively. The wrong hose could undermine your process, put personnel at risk, and compromise your bottom line – sometimes without you being aware of it.

For example, an improperly chosen hose may kink. This permanent buckling of the hose disrupts the system media flow and creates a rupture threat. But because kinked hoses are not easily detected, they are in operation throughout industry.

Despite its importance, hose selection is often treated as an afterthought. Proper hose selection starts with an understanding of the four main parts of a hose (Figure 1):

1. Core tube material and construction

2. Reinforcement layers

3. Covers

4. End connections

Selection requires making choices in those areas while paying attention to the variables in your application. Temperature, pressure and flow requirements, as well as requirements ranging from chemical compatibility to drainability, are some of the specifications that will dictate your choice.

Hoses cost more than their purchase price. Selecting wisely also requires the consideration of hose longevity, maintenance and replacement costs, and other cost of ownership factors.

CORE TUBE MATERIAL AND CONSTRUCTION

Here are some basic questions to answer when selecting the core tube material. You can address these with the help of product catalogs and your sales and service representative.

1. Is the material chemically compatible with the system media? Will it corrode or deteriorate over time?

2. Can it tolerate the temperature range of the system media?

3. Will the material prevent or limit permeation and absorption? All materials, even metals, are subject to permeation and absorption, so this question is one of degree. Permeation occurs when media passes through a material, whereas absorption is when media absorbs into and becomes part of a material. Depending on your application, permeation and/or absorption may not be an issue.

4.Will the core material stand up to the cleaning practices for your system, both in terms of temperature, pressure, and material compatibility with any solvents and cleaning agents employed?

When selecting a hose, the place to start is the core tube, which is the hose's innermost layer, the one that comes into contact with the system media.

First, let's review the materials that core tubes are made of; then, we will review some choices for core tube wall construction. For a summary, refer to the Selection Guideline Overview table.

METAL

Metal cores (commonly 316L stainless steel) are a good choice for general needs. They are usually rated for temperatures between -325°F and 850°F (-200°C and 454°C), which makes them an especially good choice – sometimes the only choice – for system media at extreme temperatures.

A metal core is also a good choice when there is little allowance for permeation or absorption. With the advent of fluoropolymers, metal is usually not chosen for highly caustic or acidic media because of issues with corrosion.

SILICONE

Historically, silicone has been a common choice for sanitary applications. A typical temperature range for silicone is from -65°F to 500°F (-53°C to 315°C). Silicone became the material of choice for sanitary applications because of its flexibility. However, that advantage has disappeared with advancements in fluoropolymer hose construction (see SELECTION GUIDELINE OVERVIEW).

Silicone, which is incompatible with common solvents, has limited chemical compatibility overall. In addition, it is absorptive, which can lead to contamination. If a fluid is absorbed into the walls of the core tube, it may remain there for a period of time before leaching out, at which point it may contaminate the media currently in the system.

With silicone, removing the absorbed fluid is usually not possible. Steam cleaning, one of the most common sterilization methods for silicone, may not remove it, and the high temperatures may cause premature failure. The hose will become brittle and break down.

FLUOROPOLYMER

In place of silicone, fluoropolymer cores are becoming the material of choice for sanitary applications. PTFE, PFA, and FEP are three common fluoropolymers, with a typical temperature range from -65°F to 450°F (-53°C to 230°C).

Fluoropolymer cores are the most chemically inert cores available. They are nonaging, nonstick, easy to clean, and can withstand repetitive steam cleaning. Like metal, fluoropolymers also have a low absorption rate. In addition, advancements in the use of reinforcement layers have allowed fluoropolymer cores to overcome their stiffness and gain flexibility comparable to that of silicone.

New technology has enabled a bonding technology that allows a fiberglass braid to be added as a layer for increased flexibility. The bonding technology uses no glue. The glue-free process means there is no potential for glue absorbing into the core walls and later contaminating the process.

PTFE cores comply with FDA regulation 21CFR Part 177.1550, USP <88> Class VI, and 3-A.

One drawback of fluoropolymers is that they are highly permeable. If your application cannot tolerate permeation, then you can specify a less permeable core material, such as metal.

With many fluoropolymer hoses, you can specify a carbon black filled core if your process requires static dissipation. Carbon allows the charge to travel to the end connections and exit. Static dissipative cores are important because fluid can generate electrostatic as it passes through the hose. Static sparking can damage hose and pose a safety hazard.

THERMOPLASTIC

Thermoplastic (nylon) hoses, which can contain high pressures, are often chosen for hydraulic applications. They are available in sizes up to 1 inch and have a typical temperature range from -40°F to 200°F (-40°C to 93°C).

RUBBER

Rubber hoses are economical general purpose hoses with a typical temperature range like that of thermoplastic. They are only for low-pressure uses. An advantage of rubber hoses is their ability to be crushed without permanent damage. They are also made in sizes above 2 inches. The other hoses described typically range in size from 1/8 or 1/4 inch to 2 inches.

Before you make your final choice in core tube material, you must first understand core tube wall construction. You will need to decide whether the core tube wall should be smooth or have “convolutions,” which allow it to bend like a flexible straw. Your application’s requirement for hose bendability will guide your decision, as will pressure, flow, and drainability needs.

SMOOTH-BORE

In a smooth-bore core, the tube’s inner wall is smooth. All core materials except for metal are offered in smooth bore (Figure 2).

Choose smooth bore if precise flow control is a priority. With smooth bore, precise flow control is possible because there are no irregularities in the wall to cause interruptions. Smooth bore also promotes drainability. The primary disadvantage is kinking, particularly in larger diameters. Reinforcement layers, discussed later, help solve kinking.

CONVOLUTED

In the other wall construction choice, convoluted, the walls of the tube are folded in a pattern that increases the hose’s ability to bend without kinking. Metal and fluoropolymer cores are offered with convolutions. This construction is chosen when flexibility is the priority.

Convoluted cores come in two types – helical and annular. The helical design, found primarily in fluoropolymer cores, is a single convolution that spirals down the length of the hose (Figure 3A). Sometimes you must choose a convoluted core because you need flexibility, but at the same time flow maintenance and drainability are also important. In that case, select a helical design, because it promotes better flow downstream than annular convolutions.

Annular design, typical in metal cores, is a series of connected rings (Figure 3B). Annular metal cores come with deep convolutions for maximum flexibility. Despite their flexibility, convoluted metal hoses are not well suited to operations where they are moving in a repetitive pattern, because the movements can cause metal fatigue and breaking.

REINFORCEMENT LAYERS

Proper reinforcement layers improve pressure containment and flexibility in the hose.

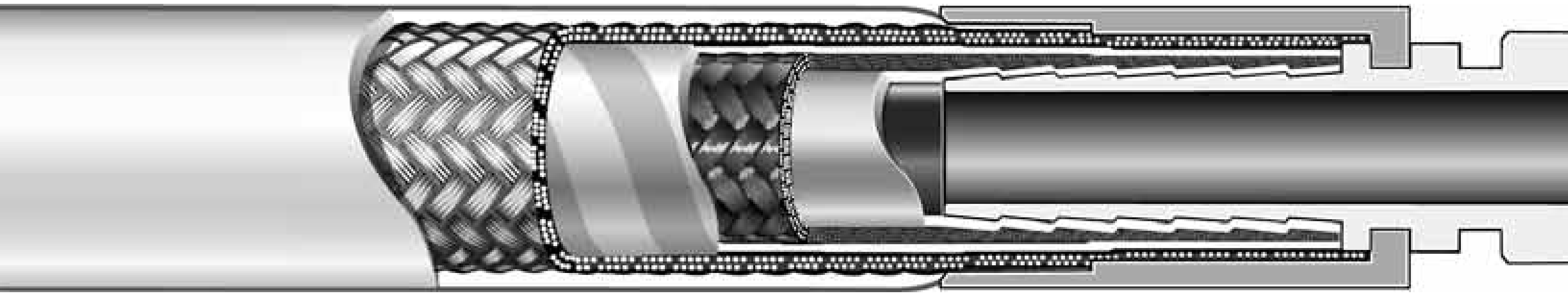
Reinforcement layers are your next consideration. In most cases, the core tube is reinforced by a flexible, stainless steel woven braid, which is layered on top of the core tube. Proper reinforcement layers improve pressure containment and flexibility in the hose. To compare pressure ratings among hoses, you can consult product catalogs.

Comparing flexibility is trickier. To do so, you need to understand bend radius. All hoses have a minimum bend radius, which measures how far a hose can bend before kinking (Figure 4). Measurements for minimum bend radius are standard in industrial hose literature.

However, there's more to flexibility than bend radius – and many people in the industry do not understand this. Also consider the force required to bend an unpressurized hose. A hose with a good bend radius is not much help to you if the force required to bend it is too great.

Is the hose so stiff that an operator can't bend it or has difficulty installing it? Will it slow down or break a machine in a dynamic operation?

Force-to-bend is just as important as bend radius but not as easy to measure, and guidelines don't exist across hose manufacturers. You may ask your sales and service representative to show you hose samples that you can test with your own hands.



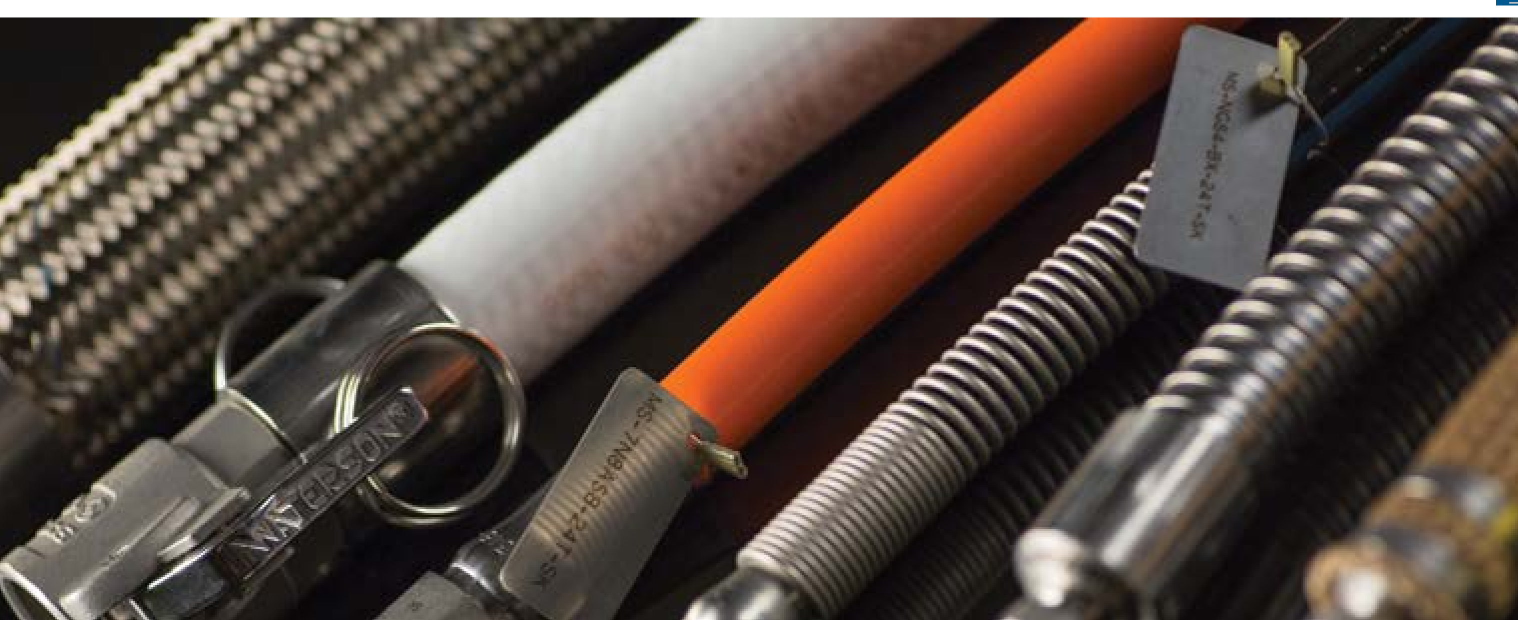
COVERS

Next, you'll need to decide if your hose should have a cover – and, if so, what kind. A cover is an outer layer that protects underlying layers, personnel, and surrounding equipment. Covers come in materials such as silicone and rubber and are integral to the hose.

The most common cover for general purposes is made of silicone. Silicone covers help prevent fraying of the braids in stainless steel reinforcement layers, which can happen from abrasion. Frayed braids weaken the hose and create a burst threat, and can injure the hands of operators. Silicone covers can provide enhanced burn protection for operators who grab or bump hoses that are carrying very hot fluid. They provide insulation as well, helping to maintain process temperature.
Silicone covers are a particularly good choice for sanitary applications. Their smoothness makes them easy to wash down. And by covering the stainless steel reinforcement layer, they eliminate bacteria buildup in the braid's crevices.

You'll also find covers for specialty applications. For maximum burn protection, consider a fire jacket, a fiberglass cover coated in silicone rubber (Figure 5). Keep in mind, however, that fire jackets connect loosely to the hose and can snag and rip. Another cover type, bend restrictors, help prevent the hose from being bent beyond its bend radius.

On the downside, covers add cost, restrict flexibility, and make the hose larger, a concern for routing and angling. In most applications, the goal in cover selection is to achieve the smallest diameter and not decrease the flexibility of the hose.



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END CONNECTIONS

Proper reinforcement layers improve pressure containment and flexibility in the hose.

End connections, usually made of metal, are where most leaks occur. The performance of the hose assembly you purchase depends largely on the hose manufacturer's ability to attach end connections, so choose a reputable manufacturer.

For metal hoses, there are a variety of end connection choices. The connections are welded, which completely and permanently seals the product.
For fluoropolymer hoses, you will choose between swaging or crimping. Swaging puts pressure on the hose itself, while crimping squeezes the end connection. While both methods are widely accepted, crimping has a slight advantage in that it is less likely to damage the hose, because the pressure is exerted in a carefully controlled manner.

Many chemical applications require that fluoropolymer-wetted surface end connections be used. The industry has devised some creative solutions. One is called "flare-through," because the core tube is flared such that it covers the entire inner surface of the metal end connection. The chief benefits of the flare-through approach are that there is no step or drop between the core tube and fitting, ensuring smooth flow, and the result is an all fluoropolymer-wetted surface. However, flare-through is costly and fragile and is not recommended for high-temperature applications.

Another common solution is called "encapsulation," because the stainless steel end connection is entirely encapsulated in fluoropolymer, inside and out. Advantages are cost and availability. Disadvantages are reduced orifice size, raising the possibility of reduced flow and entrapment.

To make the best hose selection, consider your choices in the main parts of a hose – core tube material and wall construction, reinforcement layers, covers, and end connections. You will find many options in each of these areas. The variables in your application, including the temperature, pressure, and flow of your system media, will direct your decision making.

In selecting the right product for your application, look to the manufacturer's representative as your guide. Product catalogs are also useful resources in refining your hose choice.

HOSE SELECTION TIPS

USE IDENTIFICATION TO YOUR ADVANTAGE.

Customize your hoses with tags or text. Personnel can see at a glance what the hose function is, which helps with safety and plant efficiency. Proper identification also allows fast and accurate ordering of replacement hose. In another identification method, silicone covers are differently colored – one color for hoses going to the process, for example, and another for hoses coming from it – so operators can see hose function from a distance.

CHOOSE TRACEABILITY.

Select from manufacturers that offer fully traceable products. Lot numbers on hose assemblies, including fluoropolymer core tubes and stainless steel end connections, allow the manufacturer to better limit your potential loss in the event of a recall. For example, if you get a bad hose in an order of 100 hoses, traceability enables the manufacturer to determine if the problem goes beyond the one bad hose – without this knowledge, you might automatically replace all 100 hoses.

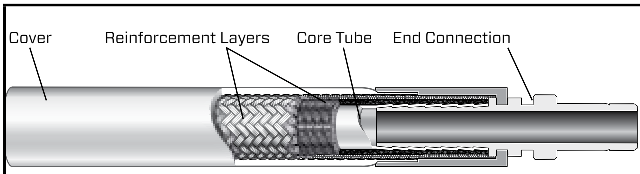
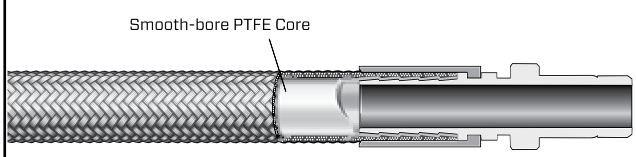
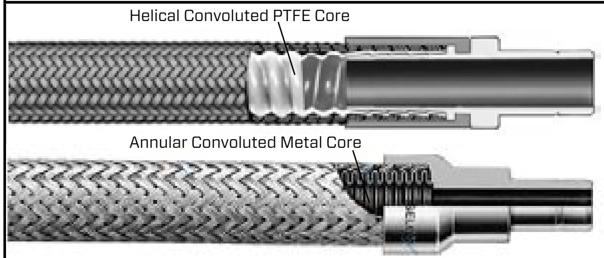
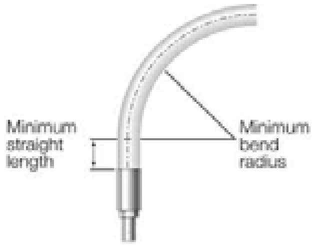
THINK ABOUT COST OF OWNERSHIP.

Make decisions based on the true cost of a hose, which is the purchase price plus the cost of owning and maintaining or replacing the assembly over time. All hoses wear out. Determine how often hose replacement will be necessary. Calculate the cost of replacement parts, labor, and downtime.

AUTHOR BIOGRAPHY

Patrick Werrlein a disributor principal, was the former product manager, hose products, for Swagelok Company. He joined Swagelok in April 2008, bringing with him 16 years of experience in the hose industry. He is responsible for marketing and product integration of the Coreflex™ series hose product line into the established Swagelok hose business group. Patrick has a specialized focus on identifying growth opportunities and product positioning in the competitive hose market. Prior to joining Swagelok, Patrick was sales manager and principal of Coreflex LLC. He was responsible for developing and maintaining a global marketing strategy, as well as supporting a global distribution network for the company's patented products. Patrick attended the University of South Carolina, where he earned a bachelor's degree in economics and business administration.

CORE TUBE MATERIAL	SUMMARY	WALL CONSTRUCTION
METAL	Good general purpose hose Widest temperature range Resists permeation and absorption Not compatible with highly caustic or acidic system media Not well suited for operations with repetitive movements	Available in convoluted core only, typically annular, to be used when flexibility is a priority
SILICONE	Very flexible Limited chemical compatibility Highly absorptive Poor cleanability	Available in smooth-bore core only
FLUOROPOLYMER (PTFE, PFA, FEP)	Good chemical compatibility Advancements have made it very flexible Good cleanability Low absorption Available with static dissipation Highly permeable	Available in smooth-bore core, for maximum flow control and drainability Also available in convoluted core, typically helical, to be used when flexibility is a priority Smooth-bore cores can kink, particularly in larger sizes, but reinforcement layers limit kinking Helical is better than annular for flow control
THERMOPLASTIC (Nylon)	Economical, general purpose hose Good for hydraulic fluids Limited temperature range	Available in smooth-bore core only
RUBBER	Economical, general purpose hose Durable Available in large sizes (above 2 inches) Limited temperature and pressure range	Available in smooth-bore core only

	Figure 1 Hose selection requires making choices in the four main areas of a hose – core tube material and construction, reinforcement layers, covers, and end connections.
	Figure 2 Smooth-bore cores, built with a smooth inner tube wall, are a good choice when precise flow control and drainability are priorities.
	Figure 3 (A and B) In convoluted cores, the tube walls are folded in a pattern to increase the hose's flexibility. The two types of convoluted cores are helical, found primarily in fluoropolymer cores, and annular, typical in metal cores.
	Figure 4 Minimum bend radius measures how far a hose can bend before kinking. Although not as easy to measure as minimum bend radius, force-to-bend is an equally critical factor in your selection.
	Figure 5 A common cover for specialty applications is the fire jacket, a fiberglass cover coated in silicone rubber that offers maximum burn protection.

H.E. Lennon, Inc.
23920 Freeway Park Drive
Farmington Hills, MI 48335

248.474.6624
info@swagelok.lennon.com
helennon.com