PENFLEX

ENGINEERING BULLETIN #177

Why is Metal Hose Used?

IT'S THE BEST—OR ONLY—OPTION

Sometimes metal hose is the best, or only, suitable option for an application. To determine whether this is the case, ask yourself three questions.

- What are you moving?
- What are the operating conditions?
- What kind of movement will the hose accommodate?

CORROSIVE MEDIA

The Hazardous Materials Table of the United States "Code of Federal Regulations" categorizes 296 materials as Class 8 Corrosive.[1] That's a long list of corrosive media being transported around the country!

Whether talking about applications within the arena of transportation or not, if an application is conveying corrosive media a user will often opt for metal hose knowing it to be corrosion resistant. This desirable attribute comes from the inclusion of chromium and other alloying elements and while it doesn't mean metal hose is corrosion proof, it does mean that metal hose will often last longer in corrosive applications than hose made from another material of construction.

This concept of "lasting longer" refers to material wear. Corrosion is, in effect, the deterioration of a material. The better a material resists corrosion the slower the rate at which the material will wear away. This translates to longer service life.

Chemical resistance charts give us a way to compare compatibility of hose materials with various flow media. Compiling information from metal and non-metal hose manufacturers shows stainless steels offer better corrosion resistance across a wider range of chemicals than most

---

[1] Pipeline and Hazardous Materials Safety Administration, United States Department of Transportation. Hazardous Materials Safety Regulations (Title 49 CFR Parts 100-185). Retrieved 22 January 2025 from https://www.govinfo.gov/content/pkg/CFR-2008-title49-vol2/pdf/CFR-2008-title49-vol2-sec172-101.pdf.

rubber and plastic options.[2] The chart below, culled from Penflex's own corrosion resistance chart as well as those from leading non-metallic hose manufacturers, illustrates this point.

Chemical Resistance Comparison

Common Flow Media with Various Hose Materials

A : Excellent resistance, suitable for continuous operation
B : Good resistance, suitable for intermittent operation
C : Limited resistance, suitable for limited use
X : No resistance
-- : No information

	Stainless Steel					
	316	321	EPDM	NBR	PTFE	PVC
Benzene	A	A	X	X	A	X
Carbon Dioxide	A	A	C	A	A	B
Mercury	A	A	B	A	A	--
Naphtha	A	A	X	A	A	C
Natural Gas	A	A	X	A	A	--
Propane	A	A	X	A	A	B
Sodium Hydroxide	A	A	A	B	A	B
Sulfuric Acid	A	A	C	X	A	X

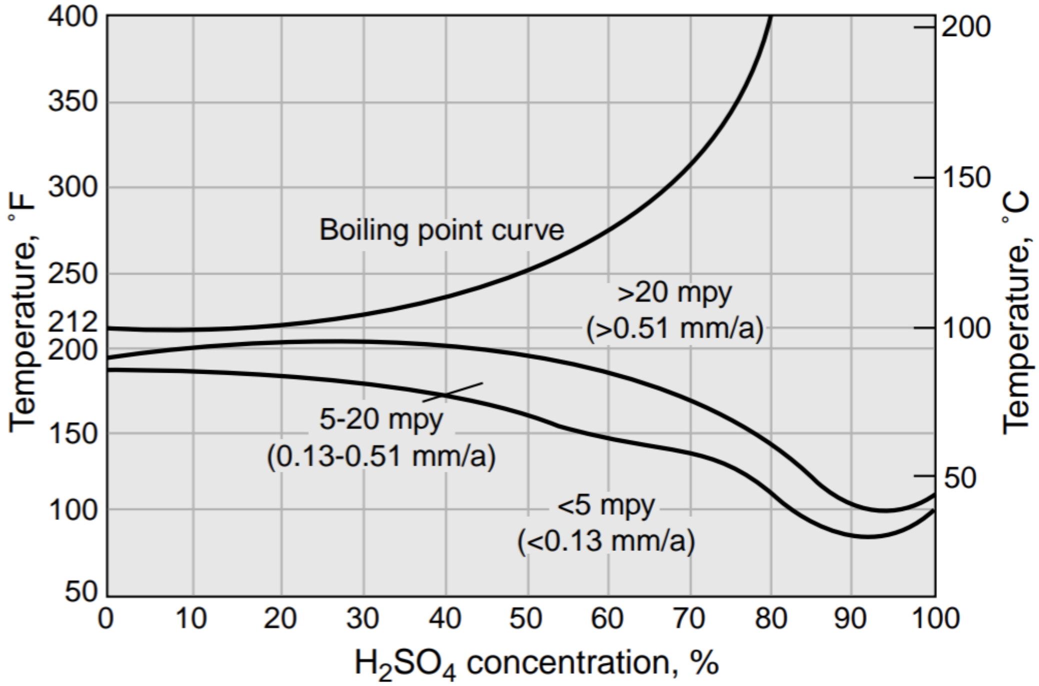
In applications with extremely aggressive media, other alloys like Inconel 625 and Hastelloy C-276 offer corrosion resistance superior to that of stainless steel.

It is important to note how the concentration of media as well as the operating temperature can exacerbate material wear. Often higher concentrations of a chemical and higher temperatures lead to increased rates of corrosion, but this is not always the case. Iso-corrosion charts illustrate this relationship, offering a deeper dive into chemical compatibility.

As an example, let's look at the compatibility of Inconel 625 with sulfuric acid. When the operating temperature climbs to 100°F, a solution with 50% concentration will have a corrosion

[2] Tubes International. Table of Hose Material Chemical Resistance. Retrieved 22 January 2025 from https://www.tubes-international.com/wp-content/uploads/catalogue-en-pdf/techinfo/table_of_hose_material_chemical_resistance.pdf

rate of less than 5 mils per year (mpy) while a solution with 90% concentration will have a corrosion rate between 5-20 mpy.[3]



SMALL PARTICLE MEDIA

One of the advantages of metal hose is impermeability. While a Penflex hose can convey small particle media like helium, rubber hose is not ideal for such an application. And while some plastic hoses may work, it is only under specific operating conditions that they do.

Rubber hoses, with their layers of inner tube, reinforcement and cover, are susceptible to permeation of gas molecules. The molecules form small bubbles in the material and get bigger over time as a result of repeated use or elevated working temperatures. This ultimately affects performance.

Plastic hoses are not susceptible to damage from small particle media, but their porosity does represent a safety risk to people working nearby when gases are harmful. For instance, while The Chlorine Institute's Pamphlet 6 does allow for the use of PTFE hoses in chlorine transfer, it specifically states that use be confined to an outdoor environment.

> *"Permeability (non-metallic): The inner core of non-metallic hoses is subject to some degree of permeability of chlorine. The braid and chafe guard shall be designed to allow chlorine which permeates the inner core to escape to atmosphere. Use of non-metallic*

---

[3] High Performance Alloys for Resistance to Aqueous Corrosion. Special Metals. 16.

hoses shall be limited to applications where adequate ventilation has been provided."

Section A-7.5, Appendix A: Chlorine Transfer Hose, Pamphlet 6 Piping Systems for Dry Chlorine, Edition 16, March 2013

PRESSURE REQUIREMENTS

A fundamental concept in physics and chemistry, pressure drives movement and causes chemical reactions. Consider the role it plays in creating lift in hydraulic systems, how it encourages molecules to collide in chemical reactors, and the way it moves media through a piping system.

The important role pressure plays across industrial sectors, and the potential risks associated with high pressure applications, can be seen in the number of organizations focused on pressure vessel safety. In the US, there is ASME and the American Petroleum Institute (API) while in Canada, provincial authorities like ABSA (Alberta Boilers Safety Association) and TSSA (Technical Standards and Safety Authority) in Ontario publish standards, certify designs and offer training.

While metal hose is synonymous with high-pressure applications, advances in plastic technologies have led to the introduction of materials that can withstand high working pressures–in some cases higher working pressures than seen with metal hose. In these cases, it is important to remember the relationship between heat and working pressure. At elevated temperatures, metal weakens while plastics degrade. End users must consider the potential impact of reduced material strength, not just pressure ratings, when assessing materials for high pressure applications.

Rubber is not suited to high pressure applications, and, in fact, excessive pressure is one of the leading causes of hydraulic hose failure. This often stems from improper assembly where the hose is not inserted into the fitting correctly. The end fitting is then susceptible to flying off in a high pressure situation, potentially causing harm. Aside from the safety issue, these situations can also lead to system contamination and, depending on media flow, a hazardous leak.

HIGH AND LOW TEMPERATURES

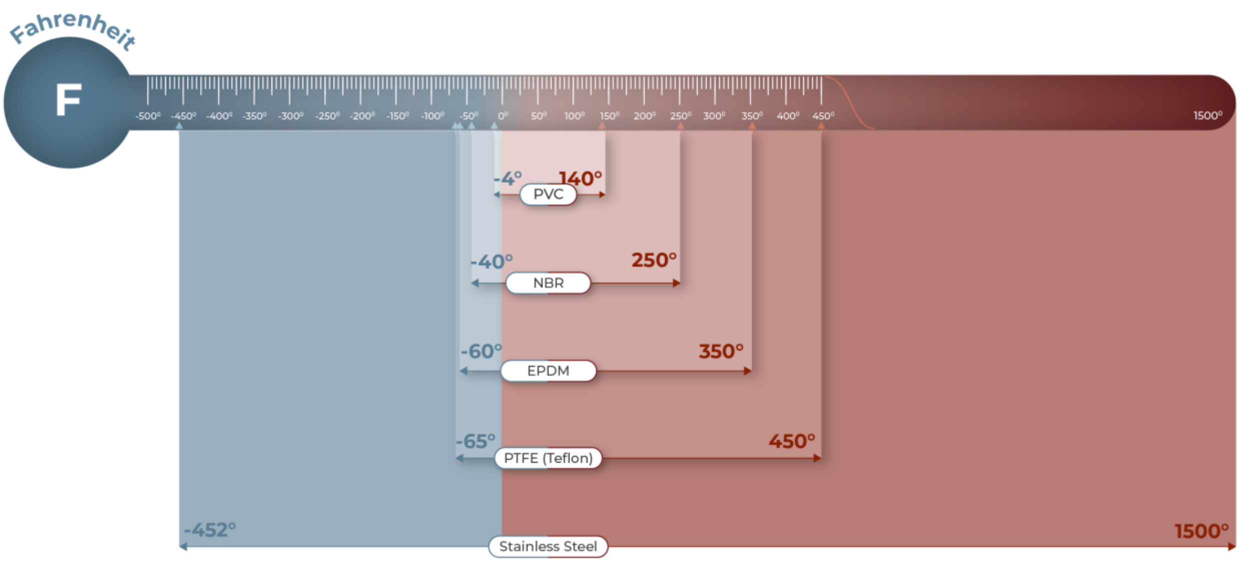
When an application is conveying hot or extremely cold media, or when the surrounding environment meets one of these temperature extremes–picture a steel mill or an Antarctic research station–metal will likely be the ideal material. It will perhaps be the only option.

Consider a steel mill where temperatures of the melt within an electric arc furnace can climb to 3000°F. In combination with the residual heat of the molten metal, it is certainly an extreme operating environment for surrounding equipment.

As metal retains its strength and ductility better than other materials at elevated temperatures, it is often the material of choice in high temperature applications. Heat actually accelerates the aging process of rubber and plastic hoses. The polymers harden and stiffen, leading to cracks and degradation over time.

Consider too the temperatures at which gases become liquid, a state better suited to storage and transportation. Natural gas condenses at -259°F. Helium at −452°F. Most materials become brittle and crack at these temperatures, but stainless steel maintains high ductility. Some mechanical properties of stainless steel, like tensile and yield strength, actually increase as temperatures decrease. It is no surprise, therefore, that cryogenics has become an increasingly important market for metal hose.

Operating Temperature Ranges for Hose Materials



While other materials of construction can offer corrosion resistance, high working pressures and are also capable of accommodating movement, when it comes to temperature, metal hose maintains a distinct advantage over other hose options.

UV DEGRADATION

While we tend to think of UV degradation affecting components outdoors, increasing use of UV light indoors now makes this consideration applicable to more situations. Rubber is susceptible to degradation from ultraviolet exposure. The effect is to embrittle the hose, leading to flaking and cracking. Plastics too are vulnerable to UV rays. We often notice the fading of plastics over time, but the exposure similarly causes embrittling. Metal hose is not susceptible to this kind of damage.

VACUUM APPLICATION

Metal is the preferred material in vacuum applications for two reasons: material strength and impermeability. Metal hose has the “hoop” strength to withstand higher pressures outside the hose than inside the hose, while other materials may collapse under external pressure.

Given concerns around outgassing discussed earlier–which make creating and maintaining desired levels of pressure and cleanliness difficult–permeation is a major deterrent in materials of construction for vacuum applications. Rubber and plastic all experience media loss as well as infiltration from the outside in due to their inherent permeability.

PIPING SYSTEM MOVEMENTS

With their ability to absorb heat and pressure induced expansion as well as vibration, flexible components are indispensable to a piping system. Without them, hard pipe and connected equipment would be vulnerable to cracking and damage.

Corrugated hoses, whether metal or plastic, have an advantage over non-corrugated hoses thanks to a more complex design. Without corrugations, the key elements of design geometry are diameter and hose thickness. These two inputs alone determine how easily a hose flexes to accommodate movement. Add corrugations—and the associated design parameters of corrugation width and height, along with the number of corrugations per foot (pitch)—and the range of “flexibility” greatly increases.

When considering a non-corrugated hose, note also that the hose is literally being squeezed and extended with movement. This leads to fatigue. The additional material in corrugated hose distributes stress across a greater surface area. This protects the hose from fatigue to a more significant degree.

SOMETIMES METAL HOSE IS PREFERRABLE

Once users have answered the questions posed above and found they have more than one option, the following considerations may help inform their final decision.

1. **SAFER FAILURE MODE** If a metal hose fails, it will most often leak. Cracks and drips will indicate that the hose has failed. Typically, these signs warn users in time to replace the component before significant media has escaped the system. Rubber and plastic hoses may experience leaks as well, but they are more susceptible to “catastrophic” failure when conveying compressible fluid.

2. **FIRE RESISTANT** Metal hoses are usually all-metal, unless a fitting contains a non-metallic seal, which makes them naturally fire-resistant. Other materials of construction will melt when exposed to flames. This is an attractive attribute in steel mills where hoses are vulnerable to sparks, slags and drips, as well as in the shipping industry

where cargo-related fires have seen an uptick in recent years.

3. **ELECTRICAL RESISTANCE** As metal is conductive, stainless steel hoses do not build up a static charge that could ignite flammable vapors.

4. **MORE ROBUST MATERIAL** One of the standout benefits of metal hose is its exceptional durability. Built to withstand the harshest of conditions, metal hoses resist weathering, corrosion and repeated use if handled properly and used in line with design limits.

5. **NO SHELF LIFE** Rubber hoses, like Buna-N and EPDM, are subject to aging and have a defined shelf life. SAE AS1933 is the oft-cited specification which gives hoses 12 years from cure to end of service before they must be scrapped, assuming proper storage. Exposure to high oxygen concentrations, ozone, UV light, swelling agents like fuels and solvents, corrosive vapors, mechanical stress and high temperatures can all exacerbate aging and shorten shelf life. For warehouse managers and procurement personnel this adds the responsibility of tracking hoses upon receipt and during storage to ensure shelf life is not exceeded. On the other hand, metal hoses and some plastics, like PTFE, are considered non-aging. Fewer headaches are associated with their procurement and storage.

Given all the competing considerations it's not surprising end users may struggle to identify the optimal material of construction for their application. Hopefully this bulletin provides a framework for understanding when a metal hose will be the best option. When it's a fit, choosing metal hose means investing in a product that is built to last, saving users time and money in the long run.