Hose Selection and Troubleshooting

Top issues and considerations to remember

Swagelok

Selecting the right hose for the job

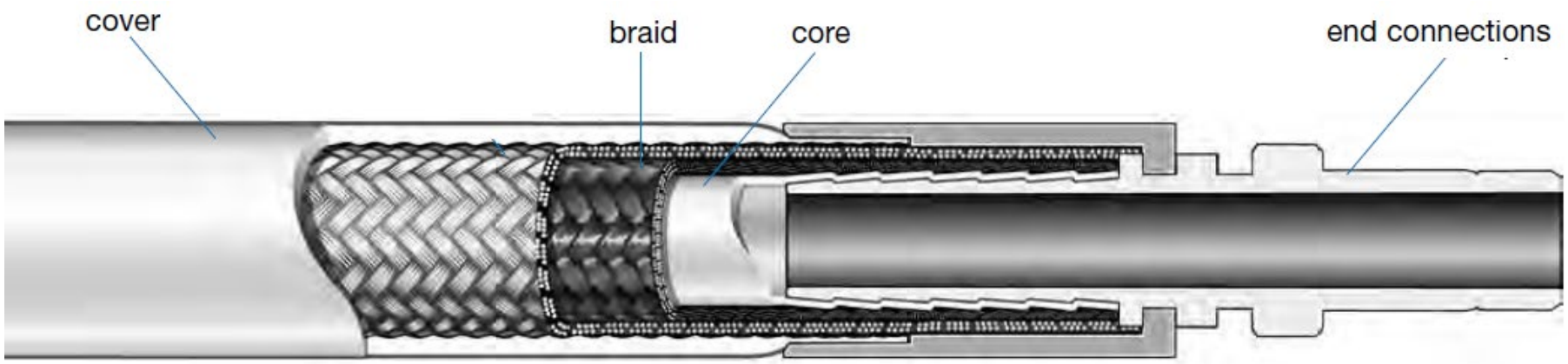
1. Background on hose types
2. Proper routing and anticipating hose motion
3. Beware of static dissipation
4. Permeation differences in hose types
5. Metal hose fatigue

Section 1: Background on hose types

Hose construction impacts performance

Typically a hose assembly will consist of four components:

1. Core tube
2. Reinforcement (braid)
3. Cover
4. End connections



All hoses are NOT created equal

Types of hose products available

Metal

Fluoropolymer

Thermoplastic

Rubber

Hose construction greatly impacts performance

Application parameters impact on hose types

	Metal Core	PTFE	Thermo-plastic	Rubber
Temperature	🟢	🟡	🔴	🔴
Pressure	🟢	🟢	🟡	🔴
Impulse	🔴	🟡	🟢	🟢
Dynamic Bend	🔴	🟢	🟢	🟡
Permeation	🟢	🟡	🔴	🔴
Cleanliness	🔴	🟢	🟡	🟡
Compatibility	🟡	🟢	🔴	🔴

Other factors include correct routing, vibration, burst rating, and many others.

Selecting proper hose will impact overall efficiencies

Tire press application

- Hoses running steam on a tire press were failing in 3-4 weeks
- High dynamic movement was tearing the rubber hoses
- Selecting a highly flexible PTFE core hose was 50% more expensive but increased life more than 20X

Selecting proper hose will impact overall efficiencies

Biopharm application

- Hoses are wear items (similar to tires on a car) and need preventative maintenance programs
- Selecting a “cleanable” hose and starting a PM program saved over $500k annually

Selecting proper hose will impact overall efficiencies

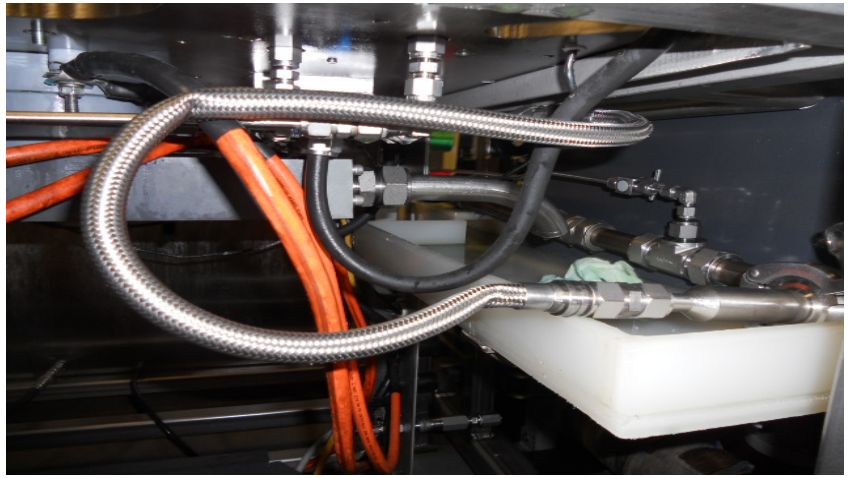
Steam hoses can be a safety concern

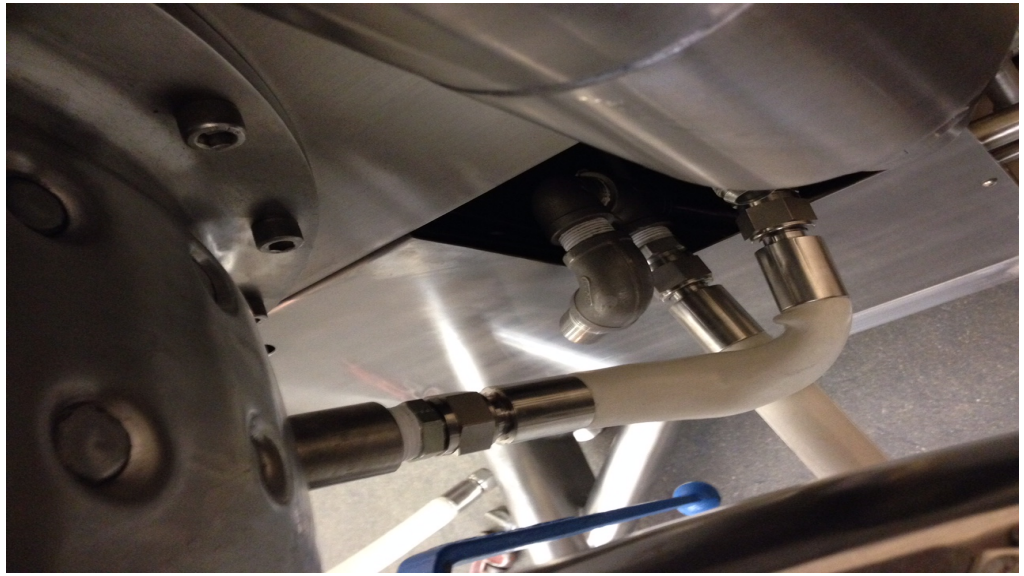
- The movement of hoses can cause safety hazard, especially when transferring hot media
- Properly insulating a hose will greatly reduce external temperatures and improve safety

Section 2: Proper installation and anticipating hose motion

Proper routing is key in overall lifecycle of a hose

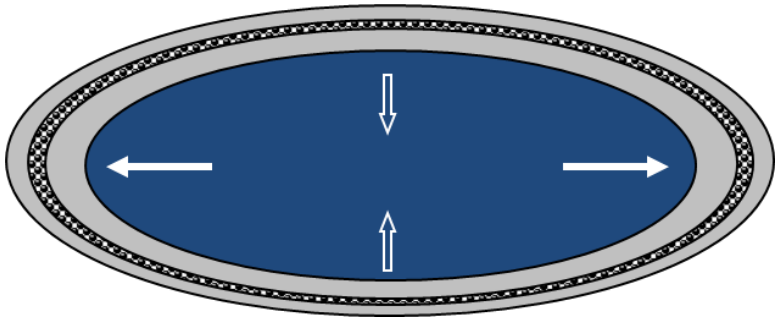
Examples of successful installations





Hose “kinking” is the top cause of failure in hose

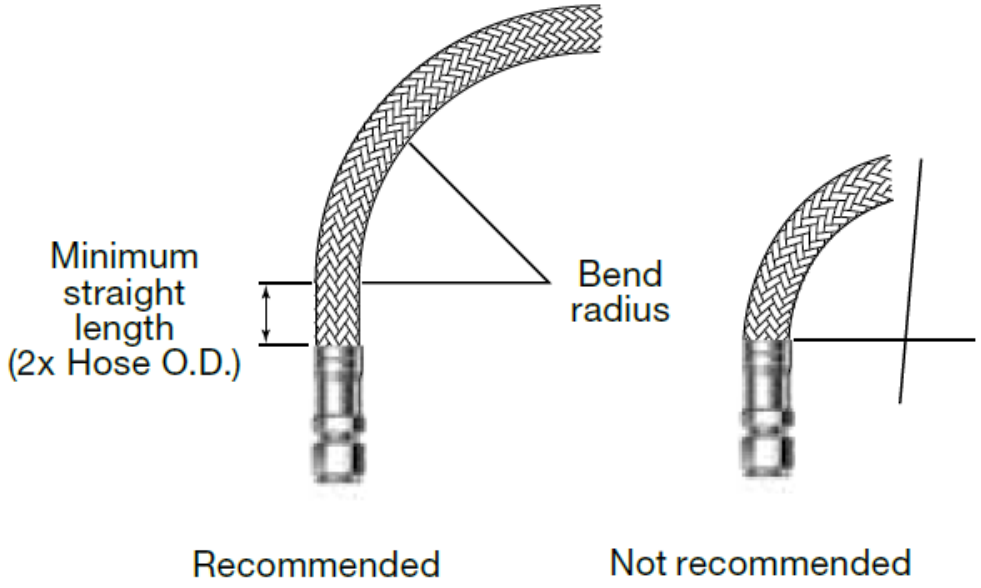
- Kinking is the result of a hose being bent beyond the minimum bend radius
- The over-bending causes the hoop strength of a hose to collapse, resulting in permanent damage to a hose core
- A hose that has been kinked will never withstand full burst pressure again in its life
- Kinking is almost always due to incorrect length or routing of a hose



Permanent damage

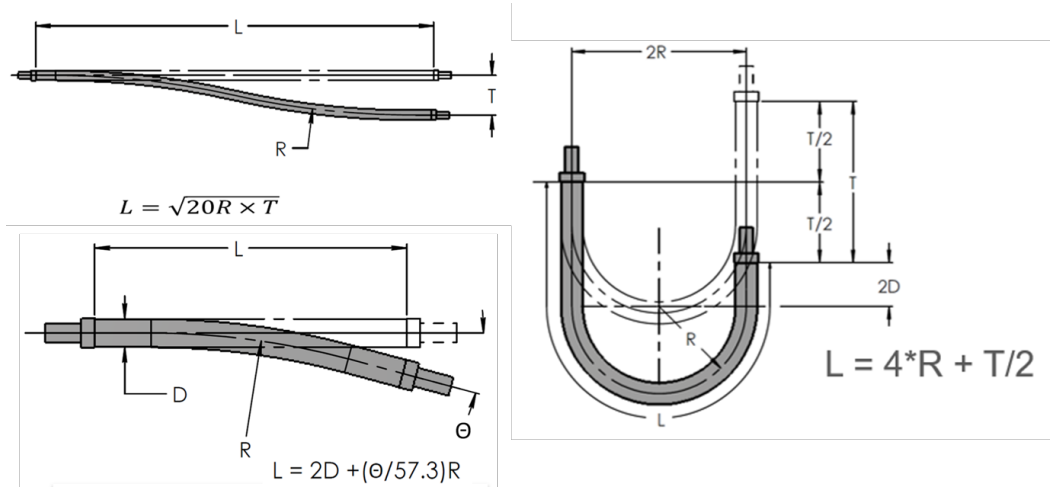
Minimum Bend Radius (MBR) determines when a hose is kinked

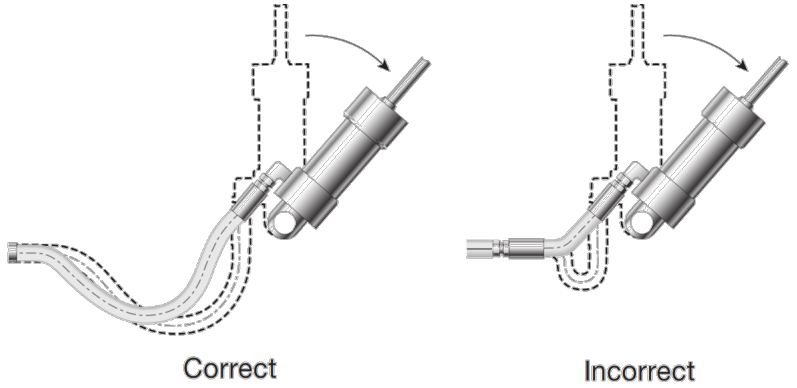
- Follow minimum bend radius requirements for your hose. Installing hose with smaller bends may kink hose and reduce hose life
- Allow for a straight length at the end connection to eliminate strain



MBR in dynamic applications is larger than static applications

- Hose motion can cause a hose to kink if not properly sized.
- Understand the motion is critical to selecting a hose that is right for the application



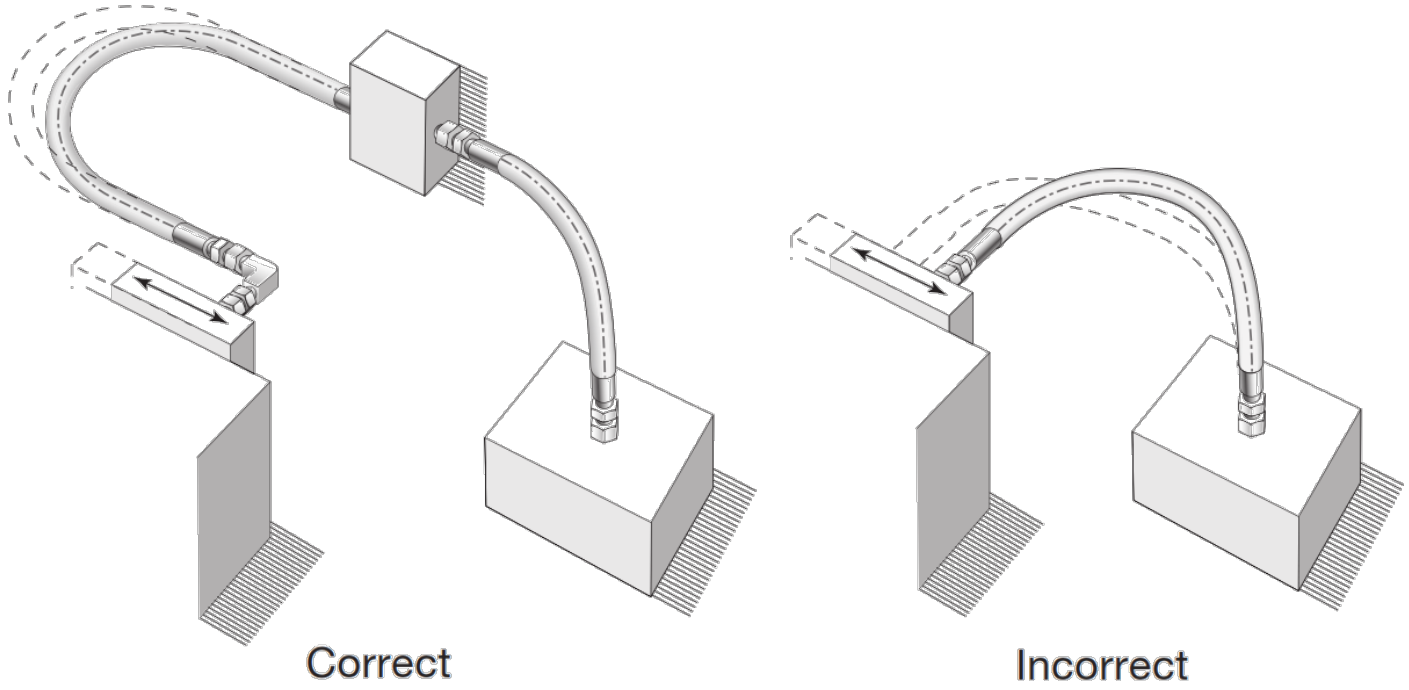


Hose Strain

- The weight of a hose can cause it to kink if not properly installed
- Elbows and adapters can be used to relieve hose strain

Bending in multiple planes will twist and damage a hose

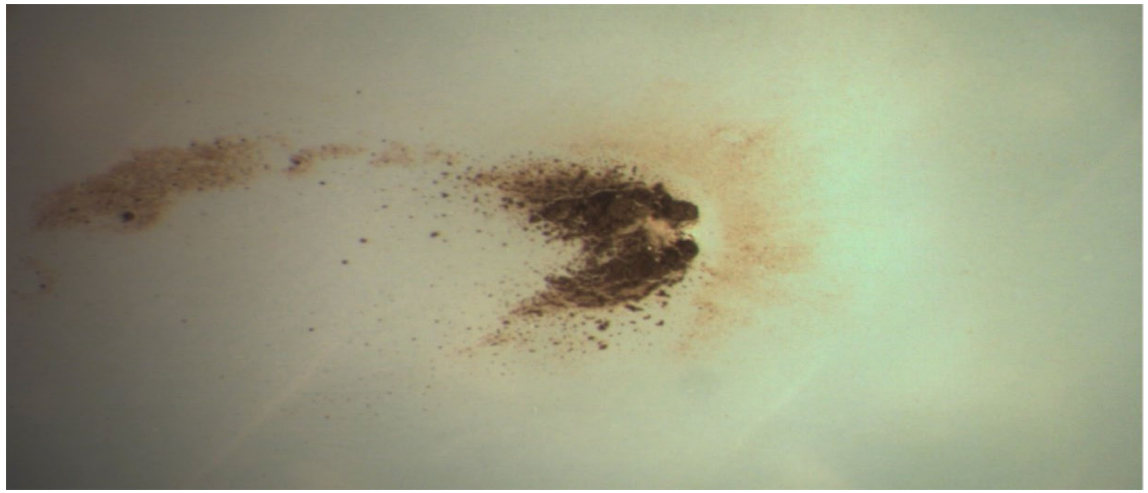
- Avoid twisting the hose in multiple planes.
- Assure that bending occurs in one plane only by using elbows, adaptors, and other methods of securing the hose.



Section 3: Beware of static dissipation

Background on Static Dissipation

- Static electricity can be generated by media passing through the hose
- Discharge of static electricity can create severe hazards where a small electrical spark might ignite explosive mixtures
- Static discharge can puncture the core tube



Various media will cause this more often than others

- Factors
- Conductivity of core material
- Conductivity of media
- Velocity
- Filter (Metal vs Paper)
- External
  - Humidity
  - Temperature

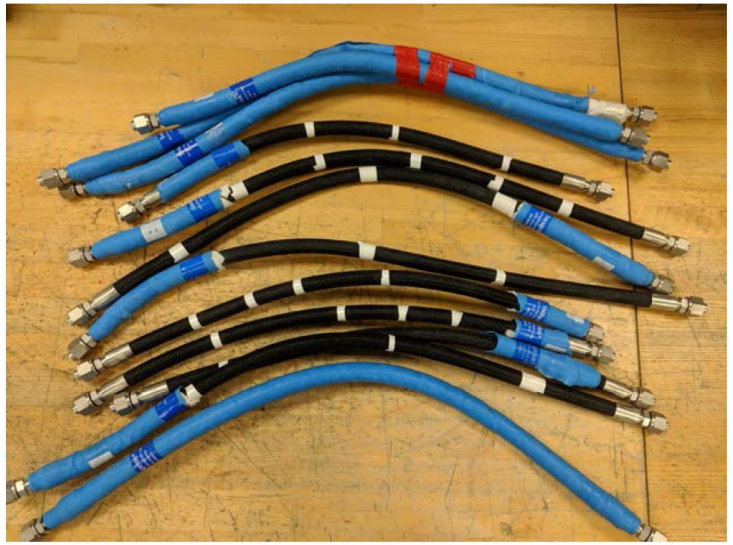
Following is a list of some of the chemicals that meet at least one of the criteria necessary to create electrostatic discharge:

> Cyclohexane
> Decalin
> Diacetone
> Dibutyl Ether
> Dibutyl Phthalate
> Dibutyl Sebacate
> Dimethyl Phthalate
> Dioctyl Phthalate
> Dipentene
> Fuel Oil
> Gasoline
> Hexane
> Hexene
> Hydrazine
> Kerosene
> Lacquers
> Lacquer Solvents
> Naphtha
> Naphthalene
> Octane
> Paint
> Petroleum
> Pinene
> Silicone Oils
> Skydrol 500 & 700
> Steam
> Toluene
> Transformer Oil
> Turpentine
> Varnish
> Versilube

Some hoses can dissipate static

Static Dissipative hose is the ability to safely discharge static build up on the CORE TUBE

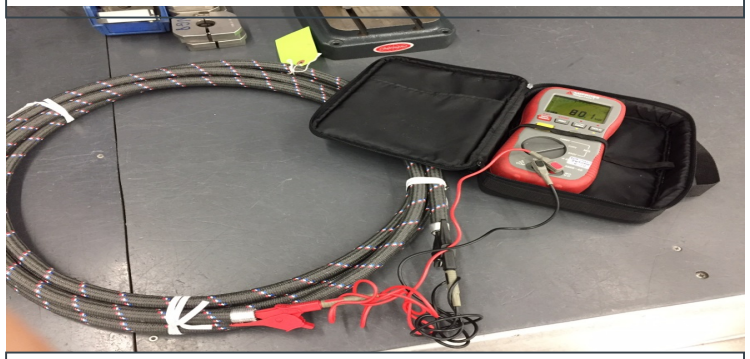
- Metal core hoses
- PTFE hoses with carbon infused core



Product return at Swagelok for “pin hole” leaks at the yellow tape marks

Static dissipation and conductivity are very different features

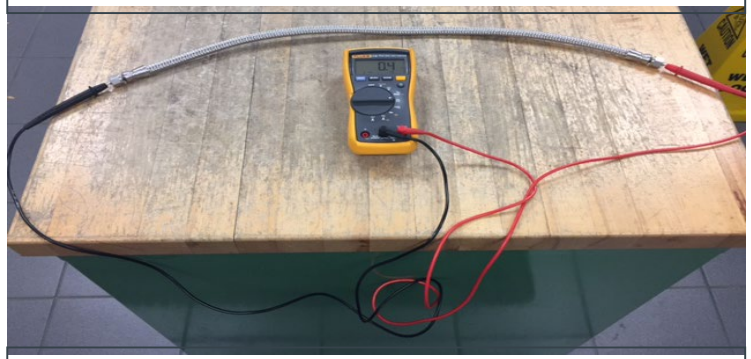
PTFE Carbon Core Hose



80.1 Mohms (80,100,000 ohms)
V/R=I= .006 mA

- Static dissipative
- NOT conductive

Metal Core Hose



0.4 ohm
V/R = I = 22.5A

3.75 MILLION times more!!!

- Static dissipative
- Conductive

A PTFE core without carbon will have infinite Resistance

- Not static dissipative

Static Dissipation versus Conductivity Summary

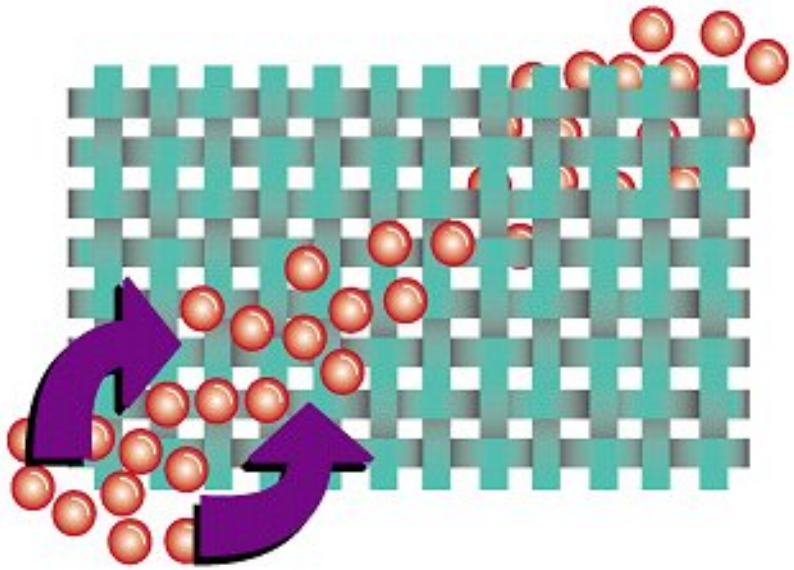
1. Understand the media's likeliness of causing static charge. When in doubt, use a carbon core PTFE hose.
2. Just because a hose dissipates static, it does NOT make it conductive. The current (flow rate) is millions of times lower (22.5 A compared to 0.006 mA)

Section 4: Permeation differences in hose types

Permeation occurs in PTFE, Thermoplastic, and Rubber hoses

Permeation should be considered for:

- Applications with small molecules such as
  - Helium
  - Hydrogen



Caution!

- Permeation in confined areas can be a safety concern
- Even in open areas, permeation can lead to expensive losses in gas

Many factors affect permeation rate

Examples of variables that affect permeation

Factor	Description	Affect
Surface area	Hose length and hose diameter have a linear affect on total permeation	 Linear
Pressure	Pressure increases linearly with molecular count (2x Pressure means 2X gas molecules). Permeation rate is also linear with gas molecule count	 Linear
Temperature	Higher temperature molecules are moving faster, therefore permeate faster.	 Linear (absolute T)
Wall thickness	The core tube wall thickness (0.025” thru 0.050”) will determine how easily gas molecules can find a path to permeate	 Sq. Root
Sintering method	“Sintering” PTFE tightens the bonds and makes permeation rates lower	 Depends

Hose lab will further quantify permeation

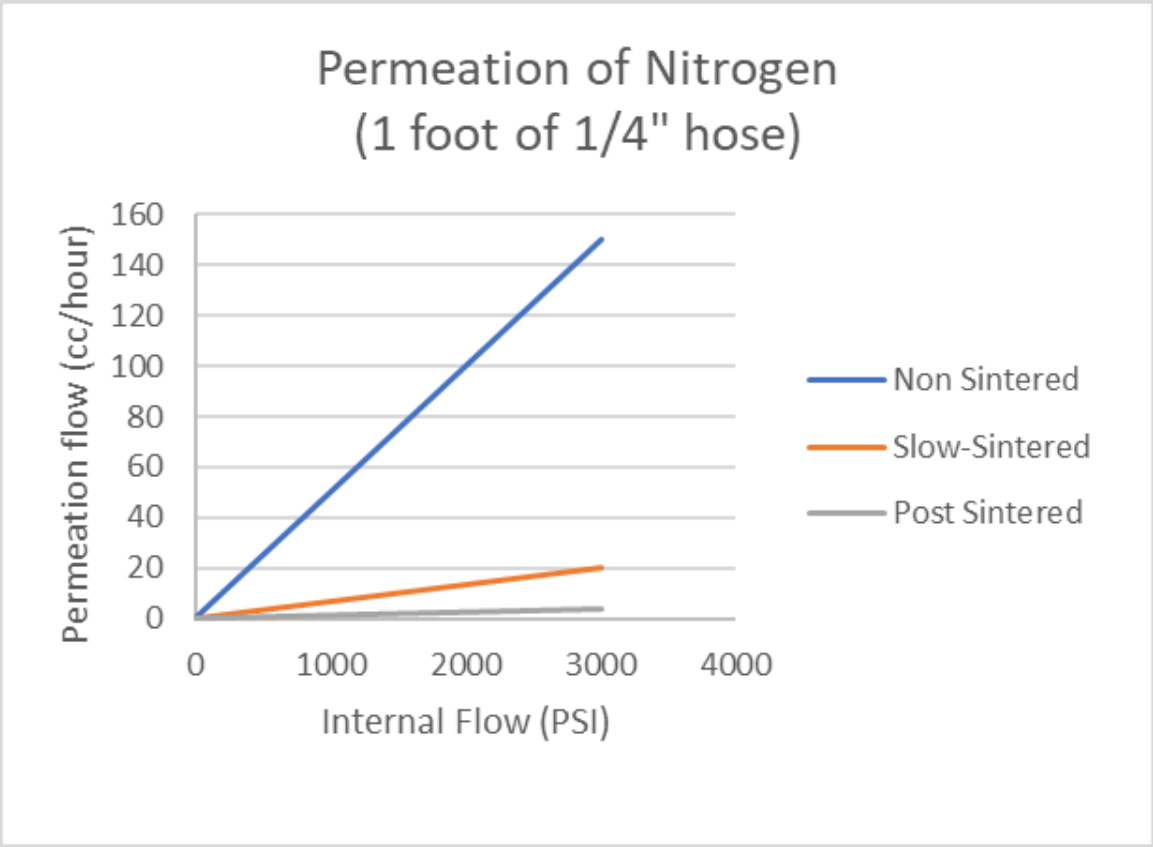
Relative permeation by hose type

Examples of PTFE core hoses:

- A non-sintered ¼” hose at 3,000 psi nitrogen permeates ~ 150 cc/foot/hour
- A slow-sintered core (pizza oven) ¼” hose at 3,000 psi nitrogen permeates ~ 20 cc/foot/hour
- A post-sintered core (cake oven) ¼” hose at 3,000 psi nitrogen permeates ~ 4 cc/foot/hour

Sintering method is critical in PTFE performance

Relative permeation by hose type



Sintering a PTFE core greatly improves performance in gas applications, but comes at a cost.

Sintering method and permeation summary

1. POST-sintering a PTFE core will maximize performance with regards to permeation
2. SLOW-sintered will greatly improve permeation performance, but not as much as POST-sintering.
3. Understand the importance of permeation for your application. It could mean the difference between selecting a PTFE series of hose or a potential supplier.

Section 5: Metal hose fatigue

Metal hose core tube is created from stainless strip

Convoluted tube forming process of Swagelok metal hose

High quality stainless strip

Rolled into tube. Strong, clean, non-oxidizing seam weld

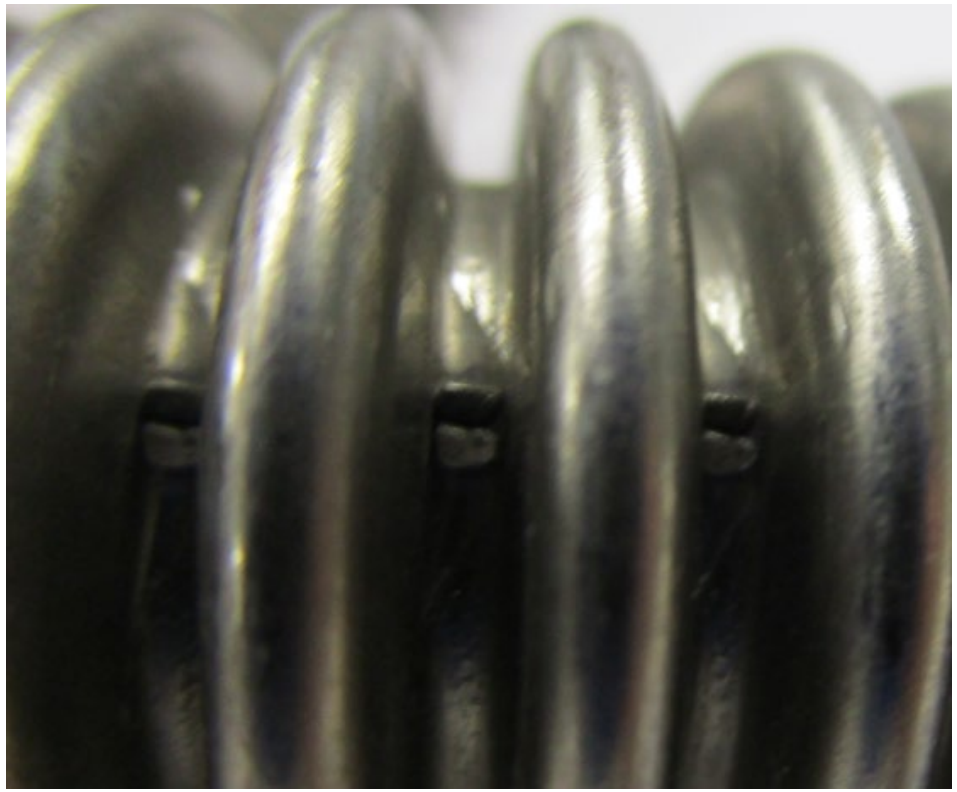
Corrugated

Convoluted tube forming method impacts performance

Metal hose mechanical forming method disadvantages

Mechanical forming imparts twist

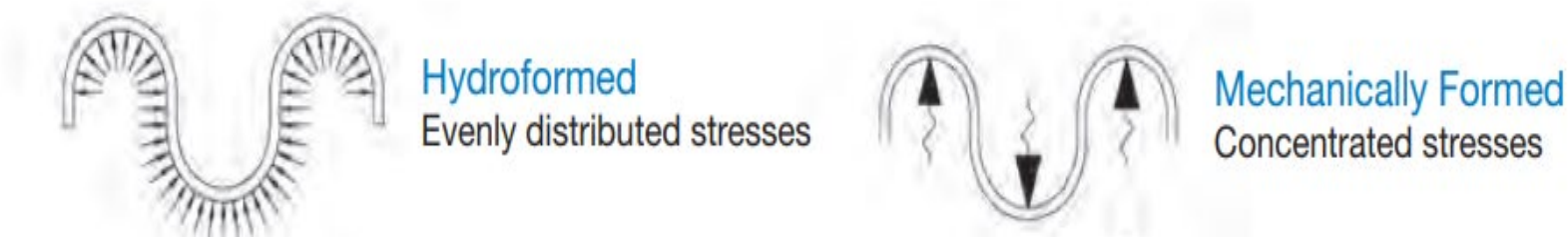
Die marks can create scratches and stress risers



Convoluted tube forming method impacts performance

Metal hose forming methods, advantages & disadvantages

Forming method	Advantages	Disadvantages
Hydro Forming & Crimp Forming	• Minimizes stress risers that cause work hardening & premature failure	• Can be more expensive (crimp forming more economical)
Mechanical	• Faster & typically less expensive	• Material thinning, requiring heavier walled strip (less flexibility) • Stress risers & torsion through manufacturing process reduces life cycle



Metal hose hydroforming summary

1. Mechanically formed hose work-hardens, thins, and torques a metal core tube. Eventually the hose will break at a convolution root.
2. Hydroformed hoses provide equal pressure throughout the forming process, minimize work hardening, and do not twist the core tube.
3. In dynamic applications, hydroformed hoses last up to 10 times longer than a mechanical “rolled” metal hose.

Summary

1. Understand which hose type is best for your application
2. Plan for safe and efficient routing of the hose, especially in dynamic applications
3. Know when a hose needs to dissipate static charge
4. Ask your hose supplier how their hoses are made to ensure maximum life

    - Sintering method for PTFE core
    - Forming method for metal core

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