GUIDE

For the Fabrication of Fluoropolymer Hose Assemblies

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Section F1- Scope

This NAHAD Guideline is intended to complement existing industry standards and federal regulations. This document recommends methods and requirements necessary for the selection of components, fabrication, and testing of fluoropolymer hose assemblies.

Aerospace and hydraulic brake hose assemblies are excluded from this document.

This document is not intended to prohibit either supplier or customer from attaching additional requirements for hose, couplings or hose assemblies, if necessary, to satisfy the application. It is the responsibility of the fabricator and user to separately qualify these applications and their unique requirements necessary to ensure performance capability.

The purpose of this document is to assist sales engineers, fabricating distributors and metal hose assembly shops in the proper methods and techniques for fluoropolymer hose fabrication. This document supplements the NAHAD Hose Safety Institute Handbook© which should be referenced for additional information. This document should be used in conjunction with all applicable federal, state, and local building codes, as well as any applicable industry guides.

This document provides general guidelines and is not intended to provide all information or requirements for the design, engineering, assembly and testing of hose assemblies or for compliance with applicable laws, standards, and regulations. Always refer to and follow the supplier’s instructions and warnings.

This document assumes that all equipment used in the fabrication of the hose assembly has been properly maintained and calibrated on a regular basis.

This document is subject to revision. Users should obtain the latest version.
Important Notice About This Document

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Hose, hose fittings and hose couplings come in various sizes and designs. Although there are standards published by manufacturers and independent standards and testing organizations, such as ANSI, ASTM, UL, SAE, ARPM, which relate to hoses and hose fittings, there are no generally recognized standards or guidelines for hose assemblies.

NAHAD, The Association for Hose and Accessories Distribution, has published these Guidelines in order to create a reference work that compiles information of value to NAHAD members, manufacturers and customers in developing hose assemblies that meet specific individual needs. To the extent that a hose assembly has unique characteristics or specific requirements, it must be custom designed, engineered and tested.

The Guidelines incorporate pressure recommendations, corrosion recommendations and temperature recommendations published by hose and coupling manufacturers and others. NAHAD has not independently tested or verified these recommendations and specifically disclaims all liability, direct or indirect, for these recommendations.

In making this document available, NAHAD is not undertaking to render professional or other services for or on behalf of any person or entity. Anyone using this document should rely on their own judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. Any certification or other statement of compliance with the requirements of this document shall not be attributable to NAHAD and is solely the responsibility of the certifier or the person making the statement.
**DISCLAIMER:**

In compiling standards and recommendations published by others and in developing these Guidelines, NAHAD has not and will not engage in independent testing or verification of the information provided to it. Users of these Guidelines should not and cannot rely on these Guidelines as a standard, certification or approval of the data published herein. NAHAD does not assume and expressly declines and denies any and all liability for any product failures, damages or injuries that result in any way from utilization of these Guidelines or products based on these Guidelines. The NAHAD Guidelines incorporate pressure recommendations, corrosion recommendations and temperature recommendations published by hose manufacturers. NAHAD has not independently verified these recommendations and specifically disclaims any and all liability, direct or indirect, for any failures, damages or injuries resulting in whole or in part from the failure of any product, including hoses, fittings, and assemblies described in the Guidelines.

The ARPM requires that hose working pressures include a safety factor commensurate with their intended application. Most hoses are required to meet a 4x safety factor. (For example: a 150 PSI-rated air hose has a 4x safety factor and must be successfully tested to a minimum of 600 PSI.) **Never exceed the working pressure of the lowest rated component in the hose system.** Maximum working pressure includes the highest pressure the system will experience, such as spikes, surges, and water hammer effects. (For example: If a system consists of a hose rated to 150 PSI and the couplings are rated to 500 PSI, the system should never be used in excess of 150 PSI.)

**Thanks and Recognition**

NAHAD wishes to acknowledge the contributions of many organizations which have made this document possible. In particular, the International Fluid Power Society (IFPS) has made significant contributions; many portions of their *Connector and Conductor Study Manual* (rev. 4/1/11) were used by permission in whole, or in part.

**History of Changes**

1995

NAHAD commits to take on the multi-year challenge of creating a comprehensive set of performance recommendations for the Specification, Design and Fabrication of Industrial, Hydraulic, Fluoropolymer, Corrugated Metal and Composite hose assemblies. Scores of volunteer member engineers are recruited to serve on five different technical teams to draft what will become **NAHAD’s Hose Assembly Guidelines**. The comprehensive 420-page document is produced and presented to the membership at the 2000 Convention in Monterey, CA.

2003

The NAHAD Board appoints a new **Standards Committee** to re-craft the Guidelines to be more useful for members and end-users.

2005

Version 1: **Hose Assembly Specification Guides**, along with **Design and Fabrication Guides** are created for Corrugated Metal, Industrial, Composite, Hydraulic, and Fluoropolymer Hose assemblies. These are made available for purchase and use with customers, for supporting internal training, and for providing guidance for related hose assembly technical and business processes.
2008-9
Custom Hose Guide added 2008
Ducting Guide added 2009

2010-12
NAHAD creates the Hose Safety Institute to formalize the work of driving safety, quality and reliability of hose assemblies. The Hose Assembly Guidelines are updated and republished as the Hose Safety Institute Handbook.

2013-14
The Fabrication Guides within the Hose Assembly Guidelines are updated and republished for use by Hose Safety Institute members only.

Changes: Materials updated and all 7 Specification manuals plus Design Guides for industrial, hydraulic, composite, fluoropolymer and corrugated metal hoses integrated in one master document; Fabrication Guide materials for all five hose groups are all updated.
Section F2 – Fabrication Methods for Fluoropolymer Hose Assemblies

F2.1 Key Steps in the Fabrication Process for Fluoropolymer Hose Assemblies – Quality Checklist

This section is intended to provide a high level overview of the fabrication process; specific instructions and related details are provided in the following sections.

1. Select and Inspect Components
   - Ensure all hose, collar and crimp fittings conform to manufacturer specifications; proper component selection helps ensure the right product for the right application; components may look similar, but have been carefully chosen as part of the specification process
   - inspect for damage and imperfections as these impact assembly quality
   - ensure components match assembly specification (hose type and dimensions, fitting material, as specified by the manufacturer)

2. Prepare and cut hose
   - there are different ways to measure the length of a hose assembly which require appropriate length calculation for the hose itself
   - select the right cutting tool – different hose types may require different cutters to avoid damaging the hose (in all cases, proper personal protection equipment must be used)
   - hose must be cut squarely; angular cuts can result in poor assembly quality
   - clean all debris from the coupling area as this can impact assembly integrity

3. Coupling procedure
   - different hose constructions require different coupling procedures to ensure reliability and consistency of hose assembly performance
   - verify selected components meet manufacturer’s dimensional requirements; for example, it’s important to make sure the wall thickness of the fluoropolymer tube is within specifications and the end fitting components are appropriate for that hose

4. Fitting insertion
   - proper fitting insertion plays a key role in fitting retention
   - lubrication may be required
   - mark fitting depth on the hose cover
   - insert fitting to proper insertion depth without damaging the hose

5. Inspection and testing
   - ensure hose assembly meets the design requirements
   - identify appropriate test for this assembly if required; due to the critical nature of many fluoropolymer hose applications, integrity testing would be recommended in most cases.
   - ensure appropriate safety equipment is used and the procedures are carefully followed
   - verify assembly functionality meets requirements
   - make sure any special customer requirements have been met

6. Cleaning
   - various types and degrees of cleaning may be required for certain applications; extends life of the hose, prevents contamination of media, etc.
   - identify appropriate cleaning process for assembly
   - verify any special customer requirements have been met

7. Documentation
   - documentation enables traceability
   - identify any certifications or labels required
   - complete internal record keeping requirements

8. Packaging
   - identify any special packaging and marking requirements
   - proper packaging and packaging techniques are required to protect hose assembly integrity
F2.2 Fabrication - Preparation Procedures for Fluoropolymer Hose Assembly

F2.2.1 Prepare and cut hose

Measuring Hose to determine hose cut-off length: With some assemblies, the length must be within tight tolerances for proper installation. This is especially true for shorter hose assemblies, and assemblies made from inherently inflexible construction.

Note: Before cutting the hose, make sure you understand the difference between “cut hose length” and “assembly overall length” (OAL)

Measuring OAL of Hose Assemblies

OAL measurements are normally taken with the assembly in a straight position. For most assemblies, the OAL is measured from the end of one fitting to the end of the other fitting. Assemblies with certain types of fittings, however, require different measuring procedures. Fittings with both a sealing seat and a moveable or retractable nut are measured from the sealing seat. Elbow fittings should be measured to the center line.

Table 1 Tolerances

This chart is intended for smooth bore hose with stainless steel braid. For other styles of hose, consult your manufacturer for actual tolerances.

<table>
<thead>
<tr>
<th>Assembly Length Tolerances</th>
<th>Inches</th>
<th>MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length ≤ 18”</td>
<td>+/- .125”</td>
<td>Length ≤ 450mm</td>
</tr>
<tr>
<td>Length &gt;18” or ≤ 36”</td>
<td>+/- .25”</td>
<td>Length &gt; 450mm or ≤ 900mm</td>
</tr>
<tr>
<td>Length &gt;36” or ≤ 50”</td>
<td>+/- .5”</td>
<td>Length &gt;900mm or ≤ 1270mm</td>
</tr>
<tr>
<td>Length &gt; 50”</td>
<td>+/- 1%</td>
<td>Length &gt; 1270mm</td>
</tr>
</tbody>
</table>

Note: When pressurized, fluoropolymer hose will typically grow by 2% or shrink by 4%.

Method of Measurement

Normal length measurements shall be taken using a tape measure with the hose laying on a flat surface. If the centerline of the end connection is above the hose centerline, the hose should be supported accordingly. On most hose assemblies the developed length is the end to end dimension at the centerline (Figure 1). End connections with a seating face shall be measured from the seat face and not from the end of any loose fitting (e.g. JIC type end fittings) (Figure 2). Hose assemblies using elbows shall be measured from the centerlines (Figure 3).
Figure 1 Measurement of Hose Assembly

Figure 2 Measurement of Hose Assembly having an End Connection with a Seating Face

Figure 3 Measurement of Hose Assembly having an Elbow Fitting
**Measuring Hose Cut Length**

The cut length of the hose shall be determined from the overall hose assembly length.

The hose cut length shall be determined from the following formula:

\[
\text{Hose cut length} = \text{overall assembly length} - (\text{coupling no. 1 minus hose insertion depth}) - (\text{coupling no. 2 minus hose insertion depth})
\]

**Hose Cutting**

The hose should be cut in such a manner to ensure a straight cut that is perpendicular to the hose axis. Angular cuts should not be used because this causes poor assembly characteristics. The cut angle should be perpendicular to the centerline of the hose.

A stainless steel braided fluoropolymer hose should be cut with a power driven circular knife edge blade, or appropriate shears (if approved by the manufacturer.)

Abrasive blades are never acceptable for cutting stainless steel braided fluoropolymer hose. The drawback to this type of blade is the amount of debris it creates from cutting.

Caution: When cutting hose always wear safety glasses and avoid loose fitting clothing. Hearing protection is also strongly recommended.

**Cutting Machines**

In optimizing the cutting of hoses, regular blade maintenance should include daily inspection of the saw blade looking for cracks and/or chipping prior to any cutting. A new blade on a saw require tempering to properly “break-in” the saw blade; please refer to the manufacturer and/or owner’s manual for further details on this procedure. The sharpening of blades is per the recommended instructions from the manufacturer and owner’s manual for details.

If the cutting machine is equipped with a scrap bin or catch basin for material residue such as rubber dust and/or rubber scrap should be emptied prior to any cutting. Scrap build-up can cause fires if not properly emptied and maintained.
F2.2.2 Orientation

For double elbow assemblies, it is imperative that the method of description and measurement provide the desired displacement rather than its mirror image. To achieve this, either end may be selected as the reference point, provided angle displacement is determined appropriately (clockwise or counterclockwise) for the reference selected.

As shown below, with the centerline of the near end as a base reference, angular displacement is measured counterclockwise to the centerline of the far end.

![NEAR END REFERENCE—MEASURED COUNTER-CLOCKWISE](image)

As shown below, with the centerline of the far end as a base reference, angular displacement is measured clockwise to the centerline of the near end.

![FAR END REFERENCE—MEASURED CLOCKWISE](image)

Displacement angle may have any value up to 360 degrees. Please note that making the angle determination in the wrong direction will result in an unacceptable part.

Unless otherwise specified, a tolerance of ±3 degrees is acceptable for assembly lengths up to 610 mm inclusive, and ±5 degrees for assembly lengths over 610 mm.
Try to avoid use of double elbow hose assemblies. Twisting of the hose during installation may occur. The relative location of the natural curvature in the hose may induce a twist during pressure cycling. Twisted hose may reduce the life of the hose assembly.

F2.2.3 Coupling Insertion

1. To ensure proper alignment, the coupling or hose should be held by means necessary to prevent movement during insertion. This will prevent damaging the tube.

2. If necessary, lubricate the inner tube and/or hose shank to help the coupling go into the tube. Use soap and water or other materials compatible with the application for lubrication. Consult hose or coupling manufacturer before using other lubricants. Note: for some applications, lubrication is not appropriate; if needed, it is important to ensure that proper cleaning is performed as well to remove any lubricant materials from completed assembly. Petroleum lubricants are not recommended or appropriate.

3. Insert the coupling into the hose. Note that some manufacturer’s products require tube expansion with proper expansion tooling to properly insert hose fittings into hose. Please consult manufacturer for proper assembly procedures.

4. Do not alter the shank of the coupling. This might alter the coupling integrity or create sharp edges that could puncture the hose tube.

5. After insertion, inspect the hose end for cuts and bulges, and verify that the coupling was inserted to the correct depth.
Section F3 – Fabrication Process

This chapter will discuss the key steps and the proper fabrication techniques for various combinations of hose, coupling and attachment methods referenced in the Hose Safety Institute Handbook. The following most common methods typically used to fabricate fluoropolymer hose assemblies are detailed in the following pages.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Crimp - ferrule or sleeve</td>
<td>2. Swage</td>
</tr>
<tr>
<td>3. Welding (Fluoropolymer-lined metal hose)</td>
<td>4. Flared-through fluoropolymer hose</td>
</tr>
<tr>
<td>5. Reusable or field attachable</td>
<td></td>
</tr>
</tbody>
</table>

F3.1 - Crimp Method

This method utilizes a machine that reduces the diameter of the fitting collar or sleeve simultaneously along its length. The sizing die set usually consists of eight or ten “fingers” that are machined to a prescribed diameter. When placed in a series inside the throat of the crimper the reduced diameter can usually be adjusted with minor changes to the crimper. Crimp diameters are established by the hose manufacturer based on the successful completion of a series of qualification tests. When crimping the collar, the fitting remains stationary to the die set and is reduced through radial loading of the fingers. It is anticipated that the resulting outside surface of the collar or sleeve will exhibit multiple axial tool marks along its length. Care should be exercised to insure that the tooling does not leave deep marks that could be detrimental.

**Figure F3.1 Typical Crimped Collar**

![Figure F3.1 Typical Crimped Collar](image)

**Preparation for Crimping**

Prior to crimping it is important to insert the hose into the fitting to a depth specified by the manufacturer. Some provide depth gauges for ease in marking the hose before insertion into the fitting. The hose can also be laid alongside the fitting and marked with the insertion depth.

It is not recommended to reuse a stem which has been previously crimped and salvaged by cutting away the ferrule. (Note: a change to the body or scarring to the stem may occur when the stem has been previously crimped and the hose removed. Either instance makes the stem unusable.)
Fabrication Procedures:

1. Per Section F2 Fabrication Preparation Procedures, determine the required cut length of the hose. Cut the hose square, and ensure hose is clean of any residue, oil, dirt, etc. from cutting or storage.
2. Select the proper ferrule when using two piece fittings; see manufacturer for recommendations.
3. Slide the ferrule over the stem collar. On one-piece fittings, the ferrule is already assembled on the stem. Some ferrules are attached to the hose prior to coupling insertion, and some assemblies require that the ferrule be attached to the hose prior to coupling insertion; follow manufacturer’s instructions.
4. Insert the stem into the hose squarely without causing damage to the tube. Lubrication should only be used if necessary. If a lubricant must be used to aid full insertion, it is suggested to use water or a slightly soapy water solution, or other material compatible with the application. Petroleum lubricants are not recommended or appropriate.
5. Select the desired crimp length and crimp OD using manufacturer’s recommendations.
6. Based on #5, select the proper die set using the crimp machine selection or manufacturer’s recommendations.
7. Place the hose assembly in the die opening.
8. Jog the crimp dies to the closed position until they just contact the ferrule. Be sure the ferrule and crimp dies are lined up properly to achieve the desired crimp length.
9. Crimp the ferrule to the desired diameter.
10. Retract the dies and remove the hose assembly.
11. Measure the crimp diameter across the flats to ensure it meets manufacturer’s specifications.*
12. If the initial crimp OD is too large, re-crimp the ferrule or sleeve until it meets the required specification. If the crimp diameter is too small, start over with a new fitting and ferrule; or consult the coupling manufacturer.
13. Repeat steps 1 through 13 for the other end.

*To properly measure the crimp diameter:

1. Measure the diameter in the middle of crimped portion of the collar in 3 or 4 positions and the crimp dimension is the average of those measurements.
2. Place the caliper in a position to allow a measurement across the pressed (flat) portion of the crimp.
3. Measure halfway between ridges. When using a dial caliper be sure the caliper fingers do not touch the ridges.
4. When measuring small crimp diameters a jaw type micrometer is recommended or a caliper with special pointed tips.
5. Use reference dimension charts provided by the fitting and hose manufacturer.
6. Check the crimp machine periodically for ovality and taper. Taper or ovality outside the manufacturer’s ± tolerances should be reviewed with manufacturer for acceptance.

Testing:
Proof testing as required.

Crimp Machines

In order to optimize the crimp performance of the crimp machine, it is important to inspect the crimper periodically for wear and tear. Preventative maintenance is important for all types of machinery. Most crimpers are designed with components that required interval inspection and changing of wear parts. It is important to contact the crimp machine manufacturer or reference the crimper owner’s manual for further details.
The crimp dies that come into contact with the fittings to be crimped should also be maintained and inspected for wear such as chipping and/or cracks. It is important to keep crimp dies clean and free of debris before and after the crimping process.

A crimp machine that requires hydraulic oil should be inspected at an interval recommended by the manufacturer. Hydraulic oil not changed over a period of time may cause damage to the internal parts of a crimper. Some crimper models may also have an oil filter that will require changing over a recommended interval.

When adding new hydraulic oil, the oil should be filtered through a 20 micron filter or finer to remove excess impurities and minimize build-up of debris in the hydraulic system.

**Verification of Set Up (Tooling)**

The first step in verifying the tooling set up is to review the manufacturers’ recommendations. Read the tooling and/or machine setting specifications and follow the instructions. If instructions are not available, consult your supervisor or contact the manufacturers of the hose, coupling and crimping equipment.

*Note: Some crimping/swaging equipment may be generic, but with tooling packages supplied or manufactured by the coupling supplier. In these instances, contact the coupling manufacturer for crimping recommendations.*

**Verify Crimp Dimensions (First piece only)**

Insert the hose and fitting into the crimp machine, and perform the crimping/swaging operation as specified. Remove the crimped/swaged assembly and with the appropriate gauging tools, check the first part for correct crimp/swage diameter and location. If the crimp diameter and location are correct, proceed to the next steps in assembly. It is recommended that a log of these crimp/swage measurements be kept for future reference. This will help with future fabrications and monitor tooling wear.

If there is an error, verify tooling and set up. Make the needed adjustments and proceed. Any crimped/swaged part that cannot be brought within specification must be discarded. Both over-crimping/swaging and under-crimping/swaging can cause an assembly to fail. Crimp/swage diameter and location should be verified each time tooling is changed. This will ensure that the correct tooling and/or machine setting are used.
F3.2 - Swage Method

This method utilizes a machine that reduces the diameter of the fitting collar or sleeve progressively along its length. The sizing die set usually consists of two halves that are machined to a prescribed diameter and cannot be adjusted. Swage diameters are established by the hose manufacturer based on the successful completion of a series of qualification tests. When swaging the collar, the fitting is pushed progressively into the stationary die thus reducing the collar to a prescribed diameter. It is anticipated that the resulting outside surface of the collar or sleeve will exhibit two axial tool marks along its length.

Figure F3.2 Typical Swaged Collar

Special Tools Required:
Swaging equipment and appropriate dies

Preparation for Swaging
Prior to swaging it is important to insert the hose into the fitting to a depth specified by the manufacturer. Some provide depth gauges for ease in marking the hose before insertion into the fitting. The hose can also be laid alongside the fitting and marked with the insertion depth.

It is not recommended to reuse a stem which has been previously swaged and salvaged by cutting away the ferrule. (Note: a change to the body or scarring to the stem may occur when the stem has been previously swaged and the hose removed. Either instance makes the stem unusable.)

Fabrication Procedures:
1. Per Section F2 Fabrication Preparation Procedures, determine the cut length of the hose. Cut the hose square, and ensure hose is clean of any residue, oil, dirt, etc. from cutting or storage.
2. Select proper die set and accessories using manufacturer’s recommendations.
3. Insert the stem into the hose squarely without causing damage to the tube. Lubrication should only be used if necessary. If a lubricant must be used to aid full insertion, it is suggested to use water or a slightly soapy water solution, or other material compatible with the application. Petroleum lubricants are not recommended or appropriate.
4. Note: On some stems the ferrule is assembled on the stem prior to insertion; consult coupling manufacturer.
5. Slide the ferrule over the end of the stem and hose as described by the manufacturer.
6. Bring the hose stem and ferrule through the bottom of the die bed. Make sure there is enough clearance between the bottom of the ferrule and the die holders for the swaging dies to be put into place. Lubricate the inside of the swaging die and the outside of the ferule with oil or grease.
7. Lower the swaging dies into the die holders. Using the required pusher for the style coupling being assembled, start the swaging process. Depending on coupling style, it may be necessary to put pressure against the pusher to keep the ferrule properly placed until the ferrule has been
reduced to the point that it comes in contact with the hose OD. Continue the swage until desired length has been achieved. Consult the coupling manufacturer for the swage length needed for proper assembly.

8. After the ram cylinder has retracted, lift the dies out of the die bed and remove the assembly from the machine. Wipe off lubricant from ferrule and hose.

9. Repeat above steps for other end of hose.

*To properly measure the swage diameter:

1. Measure the diameter in the middle of swaged portion of the hose end.
2. Place the caliper in a position to allow a measurement across the pressed (flat) portion of the swage.
3. Measure halfway between ridges. When using a dial caliper be sure the caliper fingers do not touch the ridges.
4. When measuring small swage diameters a jaw type micrometer is recommended or a caliper with special pointed tips.
5. Use reference dimension charts provided by the fitting and hose manufacturer.
6. Check the swage machine periodically for ovality and taper.

Swage Machines

In order to optimize the performance of the swage machine, it is important to inspect the swager periodically for wear and tear. Preventative maintenance is important for all types of machinery. Most swagers are designed with components that required interval inspection and changing of wear parts. It is important to contact the swage machine manufacturer or reference the swager owner’s manual for further details.

The swage dies that come into contact with the fittings to be swaged should also be maintained and inspected for wear such as chipping and/or cracks. It is important to keep swage dies clean and free of debris before and after the swaging process.

A swage machine that requires hydraulic oil should be inspected at an interval recommended by the manufacturer. Hydraulic oil not changed over a period of time may cause damage to the internal parts of a swager. Some swager models may also have an oil filter that will require changing over a recommended interval.

When adding new hydraulic oil, the oil should be filtered through a 20 micron filter or finer to remove excess impurities and minimize build-up of debris in the hydraulic system.

Testing:

Proof testing as required.
F3.3 – Welding (Fluoropolymer-lined Metal Hose)

Metallic hose with a smooth inner liner of Fluoropolymer should meet the following criteria:

A. Metal hose assembled to Hose Safety Institute Corrugated Metal Hose Fabrication Guide.

B. Hose must incorporate a smooth transition from the convoluted I.D. to the fitting with vent hole(s) burr free, no sharp edges, no metal chips, machined radii transition at the fitting sealing surface

C. Hose features same flared over fluoropolymer (PTFE) liner

Consult manufacturer for actual fabrication /assembly features. (This type assembly is usually a factory produced item due to the requirements of liner fit.)

F3.4 - Flared-through Fluoropolymer Hose

Typically, these types of hoses feature a heavy wall fluoropolymer tube (either smooth or a straightened portion of the convoluted hose) extending through the fitting. The liner is then formed over the fitting sealing surface to provide an area for sealing against a mating fitting. Typically done by the manufacturer.

F3.5 – Reusable or Field Attachable

Different fabrication processes are available, depending on manufacturer; check with the manufacturer for specific recommendations and processes. Sample process below.

**Special Tools Required:**
Wrench and vise

**Fabrication Procedures:**

1. Per Section F2 Fabrication Preparation Procedures, determine the required cut length of the hose. Cut the hose square, and ensure hose is clean of any residue, oil, dirt, etc. from cutting or storage.
2. Measure the outer diameter of the hose with an O.D. tape; alternatively determine the average wall thickness (times two) plus nominal I.D.
3. Based on the hose outer diameter, select the proper size fitting and ferrule combination, see manufacturer for recommendations.
4. Slide the ferrule portion only over the end of the hose. Make sure it is completely bottomed out and fits snug to the end of the hose.
5. Mark a line on the hose cover using a marking pen at the tail of the ferrule.
6. Place the ferrule facing up in a vise making sure that the hex is not deformed by over tightening.
7. Lubricate the shank of the fitting. It is suggested to use water or a slightly soapy water solution. Be sure that whatever is used is compatible with the assembly components and application, or by approved methods of the manufacturer.
8. Thread the stem into the ferrule starting the procedure by hand. Thread 2-3 turns and then back off 1 full turn. This will allow the hose to relax during the insertion process. The hose should rotate inside the ferrule. Continue the 2-3 turns and back off 1 turn using the proper size wrench until the fitting touches the ferrule.

9. Measure the distance of the mark and the tail of the ferrule. If it is greater than 1/8", remove the fitting and re-install by pushing the hose end all the way into the ferrule and repeat steps 6-9 until a distance of less than 1/8" is achieved.

10. Repeat above steps for other end of hose.

Testing:

Proof testing as required.
Section F4 – Accessories
Guards

Fluoropolymer hose assemblies frequently need to be insulated or otherwise protected from external damage. Guards can be used over the entire length of the assembly or, in shorter lengths to protect the ends only. Guards may not be used for steam tracing.

Insulating Jackets, typically made of braided fiberglass covered with silicon rubber, can be used as a thermal barrier for the assembly.

Metal Guard is a stripwound metal hose crimped over the corrugated assembly. This is a very rugged covering, but it is also fairly heavy.

Spring Guard is a lighter protector that also allows for continued visual examination of the corrugated hose. However, this is not a complete covering for the assembly.

Scuff Guard is a light weight, inexpensive, baggy sleeve on the hose. It is a non-metallic abrasive barrier.
Heat shrink can be used for a variety of reasons. Color coding, abrasion resistance, cleanability, and bundling.

HDPE high density polyethylene spiral wrap and silicone hose covers.
Section F5 – Quality Plan

The purpose of this section is to outline a quality plan that helps to support the fabrication of high quality hose assemblies. The assurance of an acceptable hose assembly reaching the customer depends upon the quality of the components and the workmanship of the fabricator.

An effective quality control plan is based on statistical sampling principles. Responsibility for supervising the quality plan must be designated. Corrective action procedures must be formalized to deal with nonconformance.

Sampling Plan

An effective sampling plan is based on the statistical history of a design that demonstrates quality performance and sets confidence levels.

Sampling is performed in an effort to statistically evaluate a product or process against tolerances that are considered acceptable as determined by national standards, customer requirements, etc. This monitoring of product or process with an adequate sampling plan is done in an effort to provide 100% acceptable product to the customer. In an ideal world, if inspection capability is 100% effective, then the only way to assure 100% acceptable product is to inspect everything 100%. Due to practical considerations of time and resources (both manpower and financial), 100% inspection will probably not occur as a standard method of operation.

Many areas or processes may be sampled. These may vary from operation to operation. However, some constants should apply no matter what the operation.

A. Inspection of incoming material - You cannot guarantee the quality of the outgoing product, if the quality of incoming materials has not been verified.

B. In process inspection - This may be as simple as inspection of the first assembly produced. Or it may be quite complicated, such as doing a complete dimensional audit on so many pieces per production run and plotting these results on Statistical Process Control (SPC) charts in order to track trends and potential problems.

C. Final Inspection - This may be relatively simple, such as verifying piece counts before shipping to the customer, or as complicated as checking specific criteria to ensure compliance with the customer’s requirements.

Inspection characteristics, the corresponding documentation, and the personnel responsible must be defined, regardless of what is being sampled.

When establishing the frequency of sampling, many factors need to be considered. These include but are not limited to:

1. Cost
2. Complexity of process
3. Application
4. Liability
5. Stability of procedure

If a process is very stable as indicated by past performance, the frequency of sampling can be decreased. There is no specific sampling plan that can be considered best suited to all applications.
Material Receiving Inspection

Couplings

Upon receipt of a shipment of couplings, the assembly fabricator should perform, at minimum, the following inspection steps:

1. Compare the couplings received with the purchase order by making sure part numbers agree between order and packing slip.
2. Check the count between packing slip and actual quantity received.
3. Check the product in the package to make sure it agrees with the part number on the package. Supplier catalogs are a good reference.
4. When possible, leave the couplings in the original container with the original date code. If a coupling problem arises later, all the couplings of that size and date code can be separated out for 100% inspection purposes.
5. At least one coupling from every box should be inspected for dimensions, defective plating, concentricity, snap rings attached to the swivels, any damage from shipping.

Hose

Upon the receipt of a shipment of hose, the assembly fabricator should perform, at a minimum, the following inspection steps:

1. Check product numbers on the packing list with numbers on the packages of the actual merchandise.
2. Check total footage against the packing slip, making sure they agree.
3. Check the product, making sure it agrees with the label on the packaging.
4. Check the hose inside diameter, outside diameter and reinforcement, and verify against the manufacturer’s product information.
5. All hose should be visibly inspected for damage due to shipping, kinks, loose cover, bulges, ballooning, cuts, crush, and tears. A certificate of conformance may be requested with the hose, couplings, and attachments.
Section F6 - Assembly Testing

The purpose of this section is to define minimum test requirements and identify other types of tests. This is inclusive of leak and proof pressure testing.

All hoses are made to a specific spec; this could be the manufacturer’s own spec or that of a standard such as J517. The testing methods for many of the SAE specs are spelled out in J343 which is also called out in J517 and in most cases, these specs call out an ASTM test method to perform these tests.

Bottom line: the hose assembly shop needs to test:
- Integrity of the finished hose assembly
  - Are the couplings properly secure
  - Are there any leaks
- Electrical continuity

Pressure integrity of the assembly is tested using a hydrostatic test of 1.5 times the WP of the assembly.

It must be noted that the test adapters used so fittings are not damaged during these pressure tests may not have a pressure rating high enough to perform tests at these pressures. Test pressures of 2X and higher are considered destructive to the hose by many manufactures and this should be considered when requested by a customer.

If the hose requirements call out for a specific electrostatic discharge (ESD) spec, then that was adhered to during the creation of the hose by the manufacturer; some tests can be done to see if it is in fact static dissipative, but proper adherence to the standard is not feasible, as the standard is a test for a lab, is destructive, and is not done in the field. 1000 VDC can be applied to the bore of the product to see if it passes or not but this does not equal the lab test done on a 12” piece when done on a 50 foot assembly. J517 or J343 detail the method and intent of this testing.

All fluoropolymer hose assemblies shall be tested in a condition such that the end fittings and the section of hose immediately behind the fittings is visible. However if you are using an automated system, you do not need to see the assembly during test. Do not obstruct the access to these areas with any type of optional chafe or fire sleeve that may be required to complete the assembly.

Leakage Tests

After hose assembly, each hose assembly shall be subject to a leakage test protocol. Testing may either be based on a sampling, or every assembly, depending on the criticality of the application. The test protocol must evaluate leakage, pressure capacity, and motion of the fitting relative to the hose, broken wire and all other permanent damage. The object of the test is to assure a high quality and safe hose assembly.

Due to the cutting and injection hazard of high pressure testing, personnel should be shielded from the assembly during testing.

One or more assemblies from each lot or batch shall be tested.

Considerations

Hydrostatic vs. Pneumatic Pressure
Due to the stored energy of pneumatic pressure testing, pressure capacity also known as structural integrity should be done hydrostatically. Pneumatic testing should be consigned to leakage testing.

**Sampling vs. 100% Testing**

Sampling is more cost effective than 100% testing. 100% testing is more risk effective than sampling. The balance requires knowing the product, process and application. What can go wrong? How consistently can the assembly procedure be controlled? How critical or hazardous is the application?

**Hydrostatic Proof Pressure**

The following testing procedure is recommended:

1. Lay the hose out straight whenever practical, slightly elevating one end to ensure trapped air is expelled, allowing space for elongation under pressure, preferably on supports to allow free movement under pressure.
2. Blank off one end and fill hose with water, taking particular care to ensure that all trapped air is released from the hose.
3. When testing a fluoropolymer assembly, the MAWP of all components should be considered. The assembly test pressure should be 1.5 times the working pressure of the lowest rated component. While pressure is maintained, examine the assembly for leaks and any unusual appearance and test for electrical continuity between the end fittings.
4. When tested using the procedure above, the tested assembly should be totally leak free for the duration of the test (one minute).

The hose assembly shall be subjected to a proof pressure test at a value defined by the contract or typically 1.5 times the maximum working pressure of the assembly.

It is important for safety reasons and test reliability that all entrapped air residing inside the hose assembly is purged prior to testing. This may be accomplished by having a vent port to relieve the entrapped air while filling the assembly with liquid.

Steadily increase the pressure, using water or other suitable test liquid. Dwell at the required pressure for one minute. Any evidence of leakage, permanent deformation, or coupling slippage is cause for rejection. Leakage is defined as a continuous stream of water droplets emitted from a single or multiple locations.

Assemblies should be thoroughly drained of all test media after hydrostatic testing.

**Pneumatic Proof Pressure**

Because liquids may block gaseous leaks, the assembly must be thoroughly dry inside. The hose assembly shall be subjected to a proof pressure test at a value defined by the contract or the maximum working pressure using gaseous nitrogen as the media while the assembly is immersed in a bath of water for at least one minute. An alkaline or neutral pH wetting agent may be added to the water bath to assist in defining the leakage. Water temperature should be room temperature for consistent testing.

Care should be exercised to remove all entrapped air residing under the braid during the test so as not to confuse it with actual leakage. This may be accomplished by flowing water over the assembly and into the braid while the assembly is immersed in the water bath. Any evidence of
leakage or permanent deformation is cause for rejection. Leakage is defined as a continuous stream of bubbles emitted from a single or multiple locations.

Depending on the gaseous media and pressure, fluoropolymer hose held at pressure under water for extended periods of time may permeate. These gaseous emissions through the hose wall, due to permeation are not leakage.

**WARNING** **WARNING** **WARNING** **WARNING** **WARNING**

Wherever particular skills are required, only specially trained persons should engage in those applications or testing procedures. Failure to do so may result in damage to the hose assembly or to other personal property and, more importantly, may also result in serious bodily injury.

Hoses must be properly cleaned prior to inspection and testing. Always wear safety glasses, gloves, and protective clothing to protect from leaks or high pressure spray. Also, use shields to protect people in the work area in the event of a hose burst, spray, or coupling blow-off.

Great care should be taken when positioning the test operator to avoid being hit by potential coupling blow-offs during pressure testing. Also make sure that the hose is sufficiently shielded during pressure testing to stop a coupling in case of a coupling blow-off.

Any failure during testing is likely to be of an explosive nature!

NOTE: Not every fluoropolymer hose is or should be hydrostatically tested; pneumatic testing is perfectly appropriate in certain situations. Ultimately it should be up to the customer to determine what testing is required, but the NAHAD Guidelines provide guidance regarding how those tests are performed. Testing requirements are dictated by both the application and the pressure rating. SAE J517 is the appropriate standard in this case.

Other Leakage Tests

When leak rates are critical, consult the manufacturer for more sensitive testing methods. These may include but are not limited to the following: Mass Spectrometer Leak Testing, Pressure Decay, Vacuum Decay, Mass Flow, and Halogen Leak Test.

Electrical Continuity Test

There are two types of electrical grounding paths for hoses: metallic and non-metallic. Hoses should be tested with a calibrated multi-meter from end fitting to end fitting to determine if the assembly is electrically continuous.

Electrical continuity means you can light a light bulb or make a buzzer buzz, this cannot be done with a tube measurement. The helix or wire outer braid properly connected to both end fittings of an assembly will give you electrical continuity but not provide any electrostatic dissipation (ESD). White tube: no conductivity or ESD, period; helix wire, wire braid or not. Not all black tubes will give ESD, but a properly created black tube will provide ESD (but this will not, by itself, provide electrical continuity.)

Electrostatic dissipation meets a minimum conductance of 20 micro amps with a 1000 volt DC applied over a 12 inch piece.

Proof testing for electrical continuity and static dissipation are different and should be conducted according to manufacturer recommendations as necessary for the application.
Visual Inspection

All sample assemblies should be visually inspected for substandard quality conditions in the hose or couplings. Each assembly should be visually inspected for kinks, loose covers, bulges or ballooning, soft spots, cuts, broken wires, or any obvious defect in the hose. The fittings and attachments should be inspected for any type of visible defects that may affect the performance of the assembly.

Visual inspection checkpoints should include but are not limited to the following:

A. Hose Identification - Size and type must correspond to the fabrication order (work order).

B. Coupling Identification - Coupling size, type, and product number must correspond to information on the fabrication order (work order) and specifications. Identified with date code, part number, etc. when required.

C. Inspection Items –
   - Bulge behind the coupling.
   - Cocked couplings.
   - Cracked couplings.
   - Exposed reinforcement.
   - Freedom of swivels.
   - General appearance of the assembly.
   - Hose cover pricked if required.
   - Internal contaminants.
   - Protective caps or plugs.
   - Restriction in the tube.
   - Rusted couplings.
   - Braid integrity – frayed, discolored, broken strands, etc.

Calibrations

Inspection and testing equipment used in the production or testing of coupled hose assemblies should be calibrated at prescribed intervals according to written procedures. All gauging equipment shall be calibrated regularly by means traceable to NIST (National Institute of Standards and Technology). The tag giving date of last calibration, next calibration due date and signature of the inspector shall be attached to the gauge and a record filed for future reference.

Test Documentation

If required by the customer, a test certificate may be issued to provide written confirmation that the assembly has been tested, and conforms to certain performance criteria. If a test certificate is not supplied, test results should be maintained and kept on file for five years.

Each test certificate should bear a unique number for traceability.

Test certificates should include the following information as a minimum:

A. Test Certificate Number
B. Customers Name and Purchase Order Number
C. Suppliers Name and Job Number
D. Hose Serial Number(s) (as required by customer)
E. Hose details including length, type of hose and diameter
F. End fitting details with types of ferrules and seals used
G. Test Date  
H. Test Pressure  
I. Electrical Continuity Conformance  
J. Suppliers Authorization Signature

Other Documentation

Other types of documentation may be requested by the customer. All certificates and reports required should accompany the shipment, unless otherwise specified.

Certificate of Conformance

When required, a Certificate of Conformance (C of C) shall be supplied with the order, confirming in the form of a text, and without expressed mention of the test results, that the product being supplied meets the requirements of the customers purchase order, as agreed upon order acceptance. The C of C should have the following information, if applicable:

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Test Report

A request for a C of C may require that actual test results be included.

Certified Material Test Reports

When required, a Certified Material Test Report (CMTR) shall be supplied showing the materials meet the requirements of the customer's purchase order. These may be supplied as copies of the raw material CMTR's provided by the materials supplier or on the manufacturer's form providing certified test results.

Third Party Certification

When required by the customer, an authorized inspection party shall inspect and certify that the product being supplied meets the requirements of the customer's purchase order as agreed upon order acceptance. Upon request, copies of these certifications shall be supplied.
Section F7 - Storage (Labeling, Environment, Time)

Proper storage will maximize hose shelf life. All hose should be stored in such a manner to protect them from degrading factors such as humidity, temperature extremes, ozone, sunlight, direct light from fluorescent or mercury lamps, oils, solvents, corrosive liquids, insects, rodents, and any other degrading atmosphere.

Care should be taken when stacking hose, as its weight can crush hose at the bottom of the stack. The stack could also become unstable, creating a safety hazard.

It is also recommended to apply tape or other protective measures to the ends of coiled bulk hose as the braided wires are very susceptible to poking through and puncturing the fluoropolymer innercore.

*Note:*

Store components in a cool, dry area. If stored below freezing, pre-warming may be required prior to handling, testing and placing into service.

Components should be stored in original date-coded containers. Steps should be made to rotate inventory on a first-in, first-out basis, to insure that the products are exposed to the shortest shelf time possible.
Section F8 - Assembly Identification, Cleaning and Packaging

This section is intended to establish methods and content of applying hose assembly identification markings and identify minimum cleaning and packaging requirements.

Hose Assembly Markings - Method of Marking

The marking of hose assemblies may be achieved in several ways including:

a. Information pre-marked in legible characters on metal tag or band affixed to the assembly by approved durable method.

b. Information in legible characters marked directly onto the ferrule or fitting.

Cleaning

Each assembly shall be supplied to the customer free of water, debris, metal shavings, dirt or any foreign material that may cause problems to the application. Air may be blown through the assembly to remove loose particles. Some customers have stringent cleanliness requirements that may require flushing the assembly. End connection openings should be sealed or capped to assure that cleanliness is maintained.

Reason for Cleaning:

The cleaning process ensures that contamination generated during the assembly process has been removed. The primary source of contamination in a fluoropolymer hose assembly is the result of the cutting process. Therefore it is recommended that the hose be cleaned immediately after the cutting process and always before stem insertion.

Stem insertion should be done as cleanly as possible. If lubricants are necessary they should be kept clean and never stored in an open container such as a coffee can. Atmospheric contamination in the shop air will enter the open container and contaminate the lubricant. Never dunk the stem or hose into a lubricant as this will add contamination back into the cleaned piece of hose. Apply clean lubricants sparingly to the O.D. of the stem only.

During the crimping or swaging process stem deformation occurs to insure the proper coupling retention. The crimping or swaging process may cause metal and plating flash to occur inside the stem. The hose assembly should go through a final cleaning process.

Immediately cap or plug each end of the hose to keep airborne contaminants from entering the clean hose assembly. Caps and plugs will protect the fitting threads and keep the assembly contamination free.

Other sources of contamination include dust, moisture and airborne particles that can enter a completed hose assembly. Customer requirements and the specific application will dictate the required cleanliness level.
Cleaning Methods:

Projectiles:

The projectile cleaning method requires clean, dry compressed air or an inert gas source such as nitrogen as the propellant. A pneumatic launcher is then used for propelling the projectile through the hose or hose assembly. A virgin polyurethane foam projectile wipes the tube wall clean and pushes contamination out of the assembly.

Fluid Flushing:

Clean fluids that are compatible with the hose and tube stock can be flushed through the assembly to remove contamination. A flushing system that provides a high turbulent flow is desirable to make sure that the contamination is removed from the tube wall. The fluid flushing system should have filtration to ensure that the flushing fluids are clean. After flushing the hose assembly will then need to have the flushing fluid removed and the tube should be dry.

Air Blow:

Clean dry air can be used to blow loose particles of contamination from the hose or hose assembly. Long lengths of hose or hoses with inside diameters of more than a ½" may present a problem when using air only as the cleaning method.

The customer’s cleanliness requirement and the specific application will dictate the required level of cleanliness and cleaning method. The only sure way to know if you are meeting a specific ISO, NAS or SAE cleanliness code is testing.

Consult the customer information for specific cleaning requirements.

Packaging

Hose assemblies shall be packaged in such a manner to insure that external abuse during shipping and handling does not damage the hose or fittings.

Hose shall be packed in a clean and dry state.

Containers, boxes, banding and pallets shall be of sufficient size and strength to withstand handling and transit without failure. When packaged, hose assemblies should not be coiled tighter than the specified minimum bend radius. Check customer information for any specific labeling or packaging requirements.
Section F9 – Safety

Safety is a critical factor in any hose assembly fabrication process, or in any shop. Recommendations for specific safety processes and/or equipment are provided in many of the chapters of this document. In addition, it is important to consider:

Safety procedures

- Appropriate signage posted in the shop
- Company safety plan which should include:
  - Overall philosophy
  - Audit process and timing
  - Incident reports
  - Drug and alcohol policy
  - Proper storage of chemicals and other hazardous materials along with appropriate documentation

Personal Protection Equipment (PPE)

- Steel-toed shoes
- Safety glasses
- Ear plugs
- Avoiding loose-fitting jewelry/clothing that can get caught in machinery
- Gloves
- Seatbelts on forklifts
Appendix A – Definitions

The following Terms, as utilized in the hose industry, include some definitions from The Hose Handbook, published by the Rubber Manufacturers Association.

**abrasion**: external damage to a hose assembly caused by its being rubbed on a foreign object; a wearing away by friction.

**abrasion resistance**: the ability of the hose to withstand abrasion. **Internal**: the ability of the hose assembly to withstand failure caused by media passing through the hose. **External**: the ability of the hose assembly to withstand abrasion caused by foreign objects rubbing against the cover.

**abrasion tester**: a machine for determining the quantity of material worn away by friction under specified conditions.

**ABS**: acrylonitrile butadiene styrene, a common rigid plastic used for injection molding for components such as fittings.

**absorption**: regarding hose, the process of taking in fluid. Hose materials are often compared with regard to relative rates and total amounts of absorption as they pertain to specific fluids.

**accelerated life test**: a method designed to approximate in a short time the deteriorating effects obtained under normal service conditions.

**acid resistant**: having the ability to withstand the action of identified acids within specified limits of concentration and temperature.

**adapter, adaptor**: 1) fittings of various sizes and materials used to change an end fitting from one type to another type or one size to another. (i.e., a male JIC to male pipe adapter is often attached to a female JIC to create a male end union fitting); 2) the grooved portion of a cam & groove coupling.

**adhesion**: the strength of bond between two adjoining surfaces, i.e., between cured rubber surfaces or between a cured rubber surface and a non-rubber surface.

**adhesion failure**: (1) the separation of two bonded surfaces at an interface by a force less than specified in a test method; (2) the separation of two adjoining surfaces due to service conditions.

**adhesive**: a material which, when applied, will cause two surfaces to adhere.

**aerostatic testing**: see pneumatic testing.

**afterglow**: in fire resistance testing, the red glow persisting after extinction of the flame.

**air flow**: the volume of air that can flow through a duct in a given time period (see CFM)

**air oven aging**: a means of accelerating a change in the physical properties of rubber compounds by exposing them to the action of air at an elevated temperature at atmospheric pressure.

**air under water testing**: see pneumatic testing.

**air velocity**: the speed at which air passes through a duct.

**Algaflon**: registered trademark of Ausimont USA. See PTFE.

**ambient temperature**: the temperature of the atmosphere or medium surrounding an object under consideration.

**ambient/atmospheric conditions**: The surrounding conditions, such as temperature, pressure, and corrosion, to which a hose assembly is exposed.

**amplitude of vibrations and/or lateral movement**: the distance of reciprocating motion of a hose assembly laterally. Half this deflection occurs on each side of the normal hose centerline.

**anchor**: a restraint applied to eliminate motion and resist forces.

**angular displacement**: displacement of two parts defined by an angle.

**annular**: refers to the convolutions on a hose that are a series of complete circles or rings located at right angles to the longitudinal axis of the hose (sometimes referred to as “bellows”).

**anodize, anodized**: an electrolytic process used to generate controlled oxidation for protective or cosmetic coatings in a variety of colors on metal, primarily used with aluminum.

**ANSI**: American National Standards Institute.

**anti-static**: product designed to reduce the build-up of static electricity in the application; not measurable with a standard ohm meter (10 *8 or higher ohms);

**API**: American Petroleum Institute

**application working pressure**: unique to customer's application. See pressure, working.
application: the service conditions that determine how a hose assembly will be used.
Aramid fibers: a class of heat-resistant and strong synthetic fibers in which the chain molecules are highly oriented along the fiber axis, so the strength of the chemical bond can be exploited.
armor: a protective cover slid over and affixed to a hose assembly; used to prevent over bending or for the purpose of protecting hose from severe external environmental conditions such as hot materials, abrasion or traffic.

ARPM: Association for Rubber Products Manufacturers (was RMA)
ASME B31.1: The ASME (American Society of Mechanical Engineer Standards) B31.1 / B31.3 Power and Process Piping Package prescribes the requirements for components, design, fabrication, assembly, erection, examination, inspection and testing of process and power piping.
assembly: a general term referring to any hose coupled with end fittings of any style attached to one or both ends.
ASTM E162/E662: refers to the spread of the flame/smoke if the product ignites
ASTM E662-06 Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials (Smoke Generation)
ASTM E84-08a Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E84: refers to smoke...
attachment: the method of securing an end fitting to a hose (e.g., banding, crimping, swaging, or screw-together-2 piece or 3 piece-style-reusable fittings).
attachment weld: method of attaching a metal fitting to the cap weld of a metal hose.
autoclave: an apparatus using superheated high pressure steam for sterilization, vulcanization and other processes.
axial movement: compression or elongation along the longitudinal axis.

backing: a soft rubber layer between a hose tube and/or cover and carcass to provide adhesion.
bond: (1) a metal ring that is welded, shrunk, or cast on the outer surface of a hose nipple or fitting; (2) a thin strip of metal used as a non-bolted clamp. See hose clamp.
barb: the portion of a fitting (coupling) that is inserted into the hose, usually comprised of two or more radial serrations or ridges designed to form a redundant seal between the hose and fitting.

barbed and ferrule fitting: a two-piece hose fitting comprised of a barbed insert (nipple), normally with peripheral ridges or backward-slanted barbs, for inserting into a hose and a ferrule, usually crimped or swaged.
basket weave: a braid pattern in which the plaits of wire alternately cross over and under two strands (two over-two under).
bead: another mechanical feature designed to facilitate a leak free interface between a hose or duct cuff; unlike a barb, they provide significantly lower resistance to removal and are easier to reuse. Not for high pressure applications without a secondary clamp.
**beamed braid:** braid construction in which the wires in a carrier are parallel.

**bench marks:** marks of known separation applied to a specimen used to measure strain (elongation of specimen).

**bench test:** a modified service test in which the service conditions are approximated in the laboratory.

**bend radius:** the radius of a bent section of hose measured to the innermost surface (R1) of the curved portion. Some manufacturers may measure to the centerline (R2) of the curved portion.

**bend radius, minimum:** the smallest radius at which a hose can be used without kinking, and while maintaining a circular cross section along the entire hose.

**bend radius, dynamic:** the smallest radius at which a hose can be used without kinking while constant or continuous flexing occurs.

**bend radius, static:** the smallest radius at which a hose can be used without kinking while bent or flexed into a fixed position.

**bending force:** an amount of stress required to induce bending around a specified radius and hence, a measure of stiffness.

**bevel seat fitting:** see fitting, Bevel Seat.

**beverly shear:** hand or pneumatically operated, table mounted, metal cutting shear used to cut fluoropolymer hose.

**bias angle:** the angle at which the reinforcement, either fabric or cord, is applied to the hose relative to the horizontal axis.

**bias lap:** the area where plies of bias cut reinforcement overlap.

**billet:** a solid piece of material from which a fitting is manufactured.

**bleeding:** surface exudation. See bloom.

**blister:** a raised area on the surface or a separation between layers usually creating a void or air-filled space in a vulcanized article.

**bloom:** a discoloration or change in appearance of the surface of a rubber product caused by the migration of a liquid or solid to the surface, (e.g. sulfur bloom, wax bloom). Not to be confused with dust on the surface from external sources.

**blow molding:** process of making corrugated duct using positive pressure in a continuous fashion.

**blow out force:** the force generated from the internal pressure attempting to push the fitting from the hose.

**body wire:** normally a round or flat wire helix embedded in the hose wall to increase strength or to resist collapse.

**bolt hole circle:** a circle on the flange face around which the center of the bolt holes are distributed.
**bore:** (1) an internal cylindrical passageway, as of a tube, hose or pipe; (2) the internal diameter of a tube, hose, or pipe.

**bowl:** (1) the exterior shell of an expansion ring type coupling; (2) the larger internal diameter of the internal portion of a ferrule.

**braid:** the woven portion of a hose used as reinforcement to increase pressure rating and add hoop strength. Various materials such as polyester, cotton or metal wire are used. A hose may have one or more braids, outside or between layers of hose material.

**braid angle:** the angle developed at the intersection of a braid strand and a line parallel to the axis of a hose.

**braid coverage:** the relative amount of braid material covering a hose expressed as a percent.

**braid makeup:** description of braid (i.e., 32-12-.015, T321 SS) where 32 is the number of carriers, 12 is the number of wires on each carrier, .015 is the wire diameter in inches, and T321 SS is the material. (Type 321 Stainless Steel.)

**braid sleeve/ring/ferrule:** a ring made from tube or metal strip placed over the ends of a braided hose to contain the braid wires for attachment of fitting and ferrule, and to immobilize heat affected corrugations.

**braid wear:** motion between the braid and corrugated hose, which normally causes wear on the outside diameter of the corrugation and the inside diameter of the braid.

**braid window:** (see interstice)

**braided braid:** a braid where the strands of wire on each carrier of the braiding machine are braided together, and then braided in normal fashion.

**braided ply:** a layer of braided reinforcement.

**braid-over-attachment:** metal hose attachment method where the braid is pulled over a fitting which has been welded to the inner core and welded directly to the fitting along with a braid sleeve.

**braid-over-braid:** multiple plies of braid having no separating layers.

**brand:** a mark or symbol identifying or describing a product and/or manufacturer, that is embossed, inlaid or printed.

**brass:** a family of copper/zinc alloys.

**brazing:** a process of joining metals using a non-ferrous filler metal having a melting point that is lower than the “parent metals” to be joined, typically over +800°F.

**breaker layer:** (See backing)

**bridge clamp:** a worm gear clamp capable of bridging over the wire helix in order to create a tight seal; must define whether helix is left or right handed.

**bronze:** an alloy of copper, tin and zinc.

**buffing (sizing):** grinding a surface to obtain dimensional conformance or surface uniformity.

**bunch braid:** braid applied to hose in bundles rather than flat strands (plaits), usually done to achieve high pressure versus hose weight.

**burst:** a rupture caused by internal pressure; the destructive release of hose pressure.

**burst pressure:** the pressure at which rupture occurs.

**butt weld:** process in which the edges or ends of the metal sections are butted together and joined by welding.

**butt weld splicing:** a method of joining two pieces of corrugated metal hose innercore together to make one piece.

**C of C or COC:** certificate of conformance or certificate of compliance; a document, typically signed and dated pertaining to a particular lot or purchase order of item(s), which describes any standards, specifications, tests, materials and/or performance attributes to which the referenced item(s) have met or will meet.

**calender:** a three-roll or four-roll piece of equipment used to produce elastomer plies for a hose at the thickness and width required; also used to skim elastomer onto reinforcing cord or fabric; also used to friction coat (flood) reinforcing fabrics with elastomer.

**cam & groove:** see fitting/coupling - Cam & Groove.

**capped end:** a hose end covered to protect its internal elements; usually not pressure-bearing.

**CARB:** California Air Resources Board

**carcass:** the fabric, cord and/or metal reinforcing section of a hose as distinguished from the hose tube or cover.

**casing:** see armor.
cement: unvulcanized raw or compounded rubber in a suitable solvent used as an adhesive or sealant.
cement cover: a braided cover hose without a rubber cover using a liquid adhesive to keep the yarns in place.
cemented end: a hose end sealed with the application of a liquid coating.
certification: see C of C
CFIA: Canadian Food Inspection Agency
CFM: cubic feet per minute
CGA: Can refer to Compressed Gas Association or Canadian Gas Association
chafe sleeve: an outer sleeve providing resistance to chafing and external resistance to damage to braided hoses, available in wide variety of materials to meet the application requirements (e.g., chafe sleeves include slip-on, heat shrinkable, integrally extruded).
chalking: the formation of a powdery surface condition due to disintegration of surface binder or elastomer by weathering or other destructive environments.
checking: the short, shallow cracks on the surface of a rubber product resulting from damaging action of environmental conditions.
chemical compatibility: the relative degree to which a material may contact another without corrosion, degradation or adverse change of properties.
chemical resistance: the ability of a particular polymer, rubber compound, or metal to exhibit minimal physical and/or chemical property changes when in contact with one or more chemicals for a specified length of time, at specified concentrations, pressure, and temperature.
clamp: see hose clamp.
cloth impression: see fabric impression.
coefficient of flow: When calculating the measure of the loss of air flow through a duct due to length, bends or any restriction, the coefficient of flow pertains to the resistance of the duct to pass the volume of air flowing through it. Generally measured in a per foot basis.
coefficient of friction: a relative measure of the surface lubricity.
cohesive failure: A failure of bonded items or the adhesive near (but not at) the surface interface where the adhesive was applied (i.e. the adhesive interface was stronger than the bonded items or the adhesive itself). An example of cohesive failure would be office tape to paper where the adhesive tears off the outermost layer of paper upon removal. Cohesive failures are often a sign of exceeding the capabilities of the materials in practice, particularly when the failure occurs in one of the bonded items rather than the adhesive itself.
cold flex: see low temperature flexibility.
cold flexibility: relative ease of bending while being exposed to specified low temperature.
cold flow: continued deformation under stress. See creep.
collar: 1) the portion of a fitting that is compressed by swaging or crimping to seal the hose onto the fitting barbs and create a permanent attachment; also called a ferrule. (With reusable fittings, the lock and seal are accomplished mechanically by the collar without swaging or crimping); 2) a raised portion on the hose shank which functions as a connection for a ferrule or other locking device or functions as a hose stop.
combustible liquid: a combustible liquid is one having a flash point at or above +100°F (37.8°C).
composite hose: non-vulcanized hose that consists of the following:
  - An internal wire helix;
  - A multi-ply wall of thermoplastic films and reinforcing fabrics in proportions that give the required physical properties and provide a complete seal. (Note: The film content may be built of tubular films.)
  - A cover consisting of fabric with an abrasion resistant polymeric coating;
  - An external helix wire.
compound: the mixture of rubber or plastic and other materials, which are combined to give the desired properties when, used in the manufacture of a product.
compression fitting: see fitting/coupling - Compression
compression ratio: a measurement shown in percentages reflecting axial compressibility of a duct
compression set: the deformation which remains in rubber after it has been subjected to and released from a specific compressive stress for a definite period of time at a prescribed temperature. (Compression set measurements are for evaluating creep and stress relaxation properties of rubber.)
concentricity: the uniformity of hose wall thickness as measured in a plane normal to the axis of the
hose.
- **conditioning**: the exposure of a specimen under specified conditions, e.g., temperature, humidity, for a specified period of time before testing.
- **conductive**: the ability to transfer electrical potential
- **configuration**: the combination of fittings on a particular assembly.
- **continuity**: the electrical connection of a hose assembly between fittings.
- **control**: a product of known characteristics, which is included in a series of tests to provide a basis for evaluation of other products.
- **controlled flexing**: occurs when the hose is being flexed regularly, as in the case of connections to moving components (e.g., platen presses, thermal growth in pipe work).
- **convoluted**: description of hose or inner core having annular or helical ridges formed to enhance flexibility.
- **convolution/corrugation**: the annular or helical flexing member in corrugated or strip wind hose/corrugation.
- **convolution count**: the number of ridges or corrugations per inch of a hose.
- **copolymer**: a blend of two polymers.
- **core**: the inner portion of a hose, usually referring to the material in contact with the medium.
- **corrosion**: the process of material degradation by chemical or electrochemical means.
- **corrosion resistance**: ability of metal components to resist oxidation.
- **corrugated cover**: a ribbed or grooved exterior.
- **corrugated hose**: hose with a carcass fluted, radially or helically, to enhance its flexibility or reduce its weight.
- **corrugation**: description of a duct having annular ridges formed to enhance flexibility.
- **coupler**: the female portion of the cam & groove connection with the cam arms.
- **coupling**: a frequently used alternative term for fitting.
- **cover wear**: the loss of material during use due to abrasion, cutting or gouging.
- **cover**: the outer component usually intended to protect the carcass of a product.
- **CPE**: ASTM designation for chlorinated polyethylene; a rubber elastomer.

**CPMA: Concrete Pumping Manufacturers Association**
- CR: Chloroprene Rubber; ASTM designation for neoprene; a rubber elastomer.
- CRES: refers to corrosion-resistant steel, or stainless steel
- **cracking**: a sharp break or fissure in the surface, generally caused by strain and environmental conditions.
- **creep**: the deformation, in material under stress, which occurs with lapse of time after the immediate deformation.
- **crimp diameter**: the distance across opposite flats after crimping; the external diameter of the collar, ferrule.
- **crimp/crimping**: a fitting attachment method utilizing a number of fingers or dies mounted in a radial configuration. The dies close perpendicular to the hose and fitting axis, compressing the collar, ferrule, or sleeve around the hose.
- **crimped style**: a mechanical lock hose construction whereby the external metal helix acts as a filler and securely crimps the overlapping folds of fabric. No adhesives or glues are required and the style is engineered for higher temperatures and acoustic applications
- **crush proof**: the ability to rebound to 75% of its original ID when crushed all the way closing off the ID; no structural damage such as cracking the helix should be encountered
- **crush resistance**: the force required to crush a hose to 50% of its original diameter; this typically refers to wire supported hose which will not regain its original diameter.
- **CSM**: ASTM designation for chlorosulfonated polyethylene; a rubber elastomer.
- **cuff**: soft wall, wireless, injection molded, or built-in end configurations
- **cure**: the act of vulcanization. See vulcanization.
- **cut off factor**: the hose length to be subtracted from the overall assembly length that allows for the hose coupling end connection extension beyond the end of the hose.
cut resistant: having that characteristic of withstanding the cutting action of sharp object.
cycle-motion: movement from normal to extreme position and return.

date code: any combination of numbers, letters, symbols or other methods used by a manufacturer to
identify the time of manufacture of a product.
debug: to remove ragged edges from the inside diameter of a hose end; an important fabrication step for
assembling hose of fluoropolymer in order to insure a good seal.
deduct length: the amount of fitting length deducted from a hose to result in the desired finished
assembly length. Also see: set back, and cut off factor.
design factor: a ratio used to establish the working pressure of the hose, based on the burst strength of
the hose.
design pressure: see application working pressure and pressure, working.
developed length: see overall length.
diamond weave: braid pattern in which the strands alternately cross over one and under one of the
strands (one over-one under); also known as “plain weave.”
die: a tool used to swage or crimp a fitting onto a hose. Swage dies usually consist of two halves
 machined to a predetermined diameter, designed for a specific hose type and size. A crimp die set is
typically six to eight “fingers” designed for infinite diameter settings within a range or preset to a specific
diameter for a given hose type and size.
dielectric strength: the relative measure of a material’s ability to resist conducting an electrical charge.
DIN: Deutsches Institut für Normung; DIN, the German Institute for Standardization, is the acknowledged
national standards body that represents German interests in European and international standards
organizations.
displacement: the amount of motion applied to a hose defined as inches for parallel offset and degrees
for angular misalignment.
dog-leg assembly: two hose assemblies joined by a common elbow.
DOT: Department of Transportation.
dry-rot: loss of plasticizer (flexibility) over time, often resulting in cracks or splits in the material
duplex assembly: an assembly consisting of two hose assemblies—one inside the other, and connected
at the ends; also known as “jacketed assemblies.”
durometer: an instrument for measuring the hardness of rubber and plastic compounds.
durometer hardness: a numerical value, which indicates the resistance to indentation of the blunt
indentor of the durometer.
dye penetrant inspection/test: non-destructive inspection method for detecting surface defects.
dynamic bend radius: see bend radius, dynamic.
eccentric wall: a wall of varying thickness.
eccentricity: the condition resulting from the inside and outside diameters not having a common center.
See eccentric wall.
ECTFE: ethylene-chlorotrifluoroethylene.
effective inside diameter: minimum inside diameter of a duct
effective thrust area-hose: cross-sectional area described by the mean diameter of the hose.
elastic limit: the limiting extent to which a body may be deformed and yet return to its original shape after removal of the deforming force.
elastic/intermittent flexure: The smallest radius that a given hose can be bent to without permanent deformation to the metal in its flexing members (convolutions or corrugations).
elastomer: any one of a group of polymeric materials, usually designated thermoset, such as natural rubber, or thermoplastic, which will soften with application of heat.
electrically continuous assembly: refers to the electrical conductivity between coupling ends. To get an "electrically continuous" assembly you need to have the helix or static wires terminated to the couplings; it is measured in Ohms (typically less than 100 ohms). **Note:** an electrically continuous hose is not necessarily a static dissipating hose
electrically discontinuous assembly: refers to the electrical conductivity between coupling ends. To get an "electrically discontinuous" assembly, the wire helix or static wire MUST NOT be terminated to the couplings and the rubber component should have a high electrical resistance; it is measured in thousand of Ohms (electrical resistance typically > 25,000 Ohms)
electrostatic discharge: the sudden discharge of static electricity from an area of buildup to a grounding point; known to cause leak paths.
elongation: the increase in length expressed numerically as a percentage of the initial length.
EN: a document that has been adopted by one of the three recognized European Standardization Organizations: CEN, CENELEC or ETSI. An EN is available, in principle, in the three official languages of CEN (English, French and German).
encapsulated fitting: see fitting/coupling-Encapsulated fittings.
endurance test: a service or laboratory test, conducted to product failure, usually under normal use conditions.
enlarged end: an end having a bore diameter greater than that of the main body of the hose, in order to accommodate a larger fitting.
EPDM: ASTM designation for Ethylene Propylene Diene Monomer; an elastomer.
EVA: Ethylene vinyl acetate
exothermic: releasing heat.
extrude/extruded/extrusion: forced through the shaping die of an extruder; extrusion may have a solid or hollow cross section.
fabric impression: impression formed on the rubber surface during vulcanization by contact with fabric jacket or wrapper.
fabricator: the producer of hose assemblies.
fatigue: the progressive weakening or deterioration of a material occurring with a repetitious or continuous application of stress reducing strength and leading to failure.
FDA: United States Food and Drug Administration.
FEP: ASTM designation for fluorinated ethylene propylene.
ferrule: a metal cylinder placed over a hose end to affix the fitting to the hose.
See braid sleeve, interlocking ferrule, and sleeve.

Ferrule

fire sleeve: slip-on or integrally extruded sheath used to retard the effects of fire in certain applications; most often made with silicone and/or ceramic fiber.
fitting/coupling: a device attached to the end of the hose to facilitate connection. The following is only a partial list of types of fittings available:
- **Banjo Fitting** - a through bolted designed featuring a hollow circle or “donut” attached to one end of the fitting barb so that the inner diameter is along the hose axis.
- **Butt Weld Fittings** - a hose fitting designed to be permanently welded to a connecting member such as another pipe or a butt weld flange.
- **Cam & Groove Fittings** - a type of fitting that allows connection and disconnection by means of arm(s) or cam(s) on the female fitting. The seal is accomplished by means of a gasket, available in various materials. These fittings are frequently used on product transfer hose assemblies.
- **Compression Fitting** - a fitting style that seals on a mating tube by compressing an internal ferrule against the tube O.D.
- **Encapsulated Fittings** - a metal fitting of various styles usually encased in a thermoplastic or fluoroplastic material by means of molding or coating. Most often done for sanitary purposes or to eliminate corrosion.
- **Field Attachable Fitting** - a fitting designed to be attached to hose without crimping or swaging. This fitting is not always aReusable type fitting.
- **Flange Retainer Fittings** - a hose fitting flared to a 90° surface, designed to hold a circular rotating flange, such as a slip-on or lap joint style flange.
- **Flange Style Fittings** - pipe flanges and flanged fitting standards are listed under ANSI B16.5. Flanges are rated for pressure and listed as “American Class 150, 300, 400, 600, 900, 1,500 or 2,500”.
- **Inverted Flare Fitting** - a fitting consisting of a male or female nut, trapped on a tube by flaring the end of the tube material to either 37° or 45°.
- **JIC Fittings** - joint Industrial Council (no longer in existence). An engineering group that established an industry standard fitting design incorporating a 37° mating surface, male and female styles. These standards now governed by SAE.
- **Lined Fitting** - any fitting of which the wetted surface or entire fitting is covered with a protective material. The covering process may be by spray coating, molding or by inserting hose liner through the I.D. of fitting and anchoring.
- **O-ring Fittings** - a fitting that seals by means of an elastomeric ring of a specified material.
- **Pipe Thread Fittings** -
  - NPT- National Pipe Taper. Pipe thread per ANSI B1.20.1
  - NPTF- National Pipe Tapered for Fuels. Same as above except dry-seal per ANSI B1.20.3
  - NPSH- National Pipe Straight Hose per ANSI B1.20.7
  - NPSM- National Pipe Straight Mechanical. Straight thread per ANSI B1.20.1
  - NPSL- National Pipe Straight Loosefit per ANSI B1.20.1
- **Quick Connect Fitting** (or quick disconnect) - a fitting designed to quickly connect and disconnect. These fittings come in many styles and types.
- **Reusable Fitting** - a fitting designed to be attached and unattached to a hose, allowing all or most of the fitting to be reused.
- **Sanitary Fittings** - a fitting whose seal is accomplished by means of a round gasket in a groove on the face of the fitting. The design eliminates the need for a male and female, since the fitting mates to itself. A re-attachable clamp is also used for coupling.
- **Bevel Seat** - a type of sanitary fitting incorporating a 45° beveled sealing surface. Used in the food and pharmaceutical industries.
- **Split Flange Fitting** - a fitting consisting of a flange retainer and a flange of two halves. This design
allows the flanges to be installed after the retainer has been attached to the hose, making the flange reusable. SAE Code 61 and 62.

- **Tube Fitting** - a hose fitting of which the mating end conforms to a tube diameter. The mate or male end of a compression fitting.
- **2-Bolt Flange Fitting** - an elliptical flange with two bolt holes. Typically used in steam applications such as laundry and tire presses.

**flame retardant**: Material added to a compound to resist burning

**flame spread/propagation**: rate at which a flame will proceed along a duct

**flammable gases/liquid/media**: a flammable gas, including liquefied gas, is one having a closed cup flash point below +100°F (+37.8°C) and a vapor pressure greater than 25 psi. (174.2 KPa)

**flat spots**: flat areas on the surface of cured hose caused by deformation during vulcanization.

**flex cracking**: a surface cracking induced by repeated bending and straightening.

**flex life**: the relative ability of an article to withstand bending stresses.

**flex life test**: a laboratory method used to determine the life of a rubber product when subjected to dynamic bending stresses.

**flexing, occasional**: when the hose is only required to flex occasionally, such as manual handling

**flexing, constant**: when the hose is required to flex continuously, usually on moving machinery

**flow rate**: a volume of media being conveyed in a given time period.

**fluid**: a gas or liquid medium.

**fluid temperature**: The fluid temperature is the temperature of fluid being conveyed inside of the hose during operation.

**fluid velocity**: the speed of fluid through a cross section expressed in length divided by time.

**fluorocarbon**: an organic compound containing fluorine directly bonded to carbon. The ability of the carbon atom to form a large variety of structural chains gives rise to many fluorocarbons and fluorocarbon derivatives.

**fluoropolymer**: a high molecular weight (long chain) chemical containing fluorine as a major element; most common hose types are PTFE, PFA and FEP.

**free length**: the lineal measurement of hose between fittings or couplings.

**frequency**: the rate of vibration or flexure in a given time period.

**galvanic corrosion**: corrosion that occurs on the less noble of two dissimilar metals in direct contact with each other in an electrolyte, such as water, sodium chloride in solution, sulfuric acid, etc.

**GPM**: gallons per minute.

**guide (for piping)**: a device that supports a pipe radially in all directions, but directs movement.

**Halar®**: Solvay Solexis registered trademark. See ECTFE.

**hand built hose**: a hose made by hand on a mandrel, reinforced by textile or wire or combination of both; also referred to as Custom Made hose.

**hardness**: resistance to indentation. See durometer hardness.

**Hastelloy®**: registered trademark of Haynes International, Inc. Refers to corrosion-resistant metal alloy.

**heat resistance**: the property or ability to resist the deteriorating effects of elevated temperatures.

**heat sealed**: see strip wound.

**heat-shrink sleeving**: tubular thermoplastic sleeve used for chafe protection or identification. The sleeve is slipped over the hose and shrunk down by the application of heat to fit tightly on the hose.

**helical wire armor/spring guard**: an abrasion resistance device.

**helical**: used to describe a type of corrugated hose having one continuous convolution resembling a screw thread.

**helix**: a shape formed by spiraling a wire or other reinforcement around the cylindrical body of a hose; typically used in suction hose.

**hertz**: unit of frequency defined by the International System of Units as the number of cycles per second of a periodic phenomenon. Symbol: Hz.

**Hg**: mercury (inches of mercury measurement of vacuum)

**higbee**: the thread of a hose coupling, the outermost convolution of which has been removed to such an extent that a full cross section of the thread is exposed, this exposed end being beveled to reduce cross threading.
homopolymer: A polymer comprised of a single monomer in a polymerized chain (e.g. polypropylene, PVC)

hoop strength: the relative measure of a hose’s resistance to collapse of the diameter perpendicular to the hose axis.

hose: a flexible conduit consisting of a tube, reinforcement, and usually an outer cover.

hose assembly: see assembly.

hose clamp: a device used to hold a hose onto a fitting.

HVAC: heating, ventilation, air conditioning

hydrostatic testing: the use of a pressurized liquid, usually water, to test a hose or hose assembly for leakage, twisting, and/or hose change-in-length.

Hypalon®: a DuPont registered trademark. See CSM.

Hytrel®: a DuPont registered trademark.

IAPMO: International Association of Plumbing and Mechanical Officials

I.D.: the abbreviation for inside diameter.

identification yarn: a yarn of single or multiple colors, usually embedded in the hose wall, used to identify the manufacturer.

impression: a design formed during vulcanization in the surface of a hose by a method of transfer, such as fabric impression or molded impression.

impulse service: an application parameter characterized by continuous cyclical pressure changes from low to high.

impulse: an application of force in a manner to produce sudden strain or motion, such as hydraulic pressure applied in a hose.

inches of mercury (inHg): measure of air pressure or vacuum

inches of water (inH2O): measure of air pressure or vacuum

indentation: 1) the extent of deformation by the indentor point of any one of a number of standard hardness testing instruments; 2) a recess in the surface of a hose.

innercore: see Core.

insert: optional term for nipple. See nipple.

inside diameter: measurement of the duct from interior wall to interior wall

interlocked hose: formed from profiled strip and wound into flexible metal tubing with no subsequent welding, brazing, or soldering; may be made pressure-tight by winding in strands of packing.

interlocking clamp: a clamp which engages the fitting in a manner which prevents the clamp from sliding off the fitting, typically a bolt or U-bolt style with interlocking fingers which engage an interlock ring on the fitting.

interlocking ferrule: a ferrule, which physically attaches to the fitting preventing the ferrule from sliding off the fitting.

interstice: a small opening, such as between fibers in a cord or threads in a woven or braided fabric.

IPT: iron pipe threads; a reference to NPT or NPTF.


jacket: a seamless tubular braided or woven ply generally on the outside of a hose.

jacketed assembly: see duplex assembly

JIC: see fitting/coupling-JIC.

kinking: a temporary or permanent distortion of the hose induced by bending beyond the minimum bend radius.

Kynar®: Arkema registered trademark. See PVDF.

lap seam: a seam made by placing the edge of one piece of material extending flat over the edge of the second piece of material.

lay: 1) the direction of advance of any point in a strand for one complete turn; (2) the amount of advance of any point in a strand for one complete turn. See pitch.

layer: a single thickness of rubber or fabric between adjacent parts.

leaker: 1) a crack or hole in the tube which allows fluids to escape; 2) a hose assembly which allows fluids to escape at the fittings or couplings.
life test: a laboratory procedure used to determine the resistance of a hose to a specific set of destructive forces or conditions. See accelerated life test.
light resistance: the ability to retard the deleterious action of light.
lined bolt holes: the bolt holes, which have been given a protective coating to cover the internal structure.
liner: flexible sleeve used to line the inside diameter of hose when conveying a high velocity media, also prevents erosion.
live length: see free length.
LJF (lap joint flange): see fitting/coupling - Lap Joint Flange
long shank: a shank length greater than the nominal diameter, typically two diameters in length, which allows more than a single clamp.
loop installation: the assembly is installed in a loop or “U” shape, and is most often used when frequent and/or large amounts of motion are involved.
low temperature flexibility: the ability of a hose to be flexed, bent or bowed at low temperatures without loss of serviceability.
LPG, LP Gas: the abbreviation for liquefied petroleum gas.

MAWP: see pressure, maximum allowable working.
mandrel: 1) a form, generally of elongated round section used for size and to support hose during fabrications and/or vulcanization. It may be rigid or flexible; 2) a tapered expanding device, fixed in diameter, which is pulled through a shank of a fitting thus expanding the diameter to exert force on the hose between the shank and ferrule.
mandrel built: a hose fabricated and/or vulcanized on a mandrel.
mandrel, flexible: a long, round, smooth rod capable of being coiled in a small diameter. It is used for support during the manufacture of certain types of hose. (The mandrel is made of rubber or plastic material and may have a core of flexible wire to prevent stretching.)
mandrel, rigid: a non-flexible cylindrical form on which a hose may be manufactured.
manufactured length: length of duct as produced prior to packing
manufacturer’s identification: a code symbol used on or in some hose to indicate the manufacturer.
mass flow rate: the mass of fluid per unit of time passing through a given cross-section of a flow passage in a given direction.
material handling hose: hose that is used to transport bulk materials; typical abrasive materials include dry cement, crushed rock, screenings, limestone, grain etc. in dry, slurry (wet) or air suspension. Typical large bore material handling hoses are Sand Suction, Suction & Discharge (S&D), Dredge, Discharge Material Handling, etc. Such applications are found in Mine, Mills, Quarries, Sea Ports, etc.
MAWP: see pressure, maximum allowable working pressure.
maximum intermittent ambient temperature: Hose constructions which use a rubber inner tube and/or cover can have significant change in properties when exposed to extreme heat or cold. This may require some hoses to be rated to a lower operating pressure when exposed to such conditions.
maximum temperature: The maximum temperature is the highest temperature to which the fluid or environment may reach. This temperature is typically short in duration and occurs under extreme operating conditions. The hose selected for an application should be rated at or above the maximum ambient and maximum fluid temperature.
mean diameter: the midpoint between the inside diameter and the outside diameter of a corrugated/convoluted hose. Also used in the calculation of braid strength.
mechanical fitting/reusable fitting: a fitting attached to a hose, which can be disassembled and used again.
media, medium: the substance(s) being conveyed through a system.
mender: a fitting or device used to join two sections of hose.
metal hose: thin wall metal tubing formed into flexible hose with helical or annular ridges and grooves, often braided with stainless steel to increase the operating pressure capability. With fittings welded on, assemblies are used in applications outside temperature range of rubber, thermoplastic and fluoroplastic.
minimum temperature: The minimum temperature is the lowest temperature to which the hose assembly will be exposed. For a hydraulic system, this is based on the minimum ambient temperature. A hose should be rated at or below the minimum ambient temperature to which the assembly may be exposed.
misalignment: a condition where two parts do not meet true.
Monel®: registered trademark of Special Metals Corporation.

monomer: A basic structural molecule that can link with other monomers into a polymer chain to form unique materials with unique characteristics and properties (e.g. vinyl chloride, various base hydrocarbons).

NAHAD: the abbreviation for the Association for Hose and Accessories Distribution.

necking down: a localized decrease in the cross-sectional area of a hose resulting from tension.

negative pressure: vacuum

Neoprene®: a registered trademark of DuPont.

NFPA: National Fluid Power Association

NFPA: National Fire Protection Association

nipple: the internal member or portion of a hose fitting.

NIST: National Institute of Standards and Technology

nitrile rubber (NB/Buna-N): a family of acrylonitrile elastomers used extensively for industrial hose.

nominal: a size indicator for reference only.

nomograph: a chart used to compare hose size to flow rate to recommended velocity.

non-conductive: the inability to transfer an electrical charge. Non-conductive hoses normally are recommended in applications where the electrical charge is transferred from the OUTSIDE ENVIRONMENT to the hose. Air hoses used around electrical furnaces and multipurpose hoses used in proximity to high voltage power lines should have non-conductive ratings as prescribed by the respective industry. In essence, the hose acts as an insulator protecting the user from EXTERNAL electrical sources. Non-conductive hoses generally are manufactured WITHOUT a metal helix or “bonding” wire. An industry standard for “non-conductive” hose follows the Alcoa specification for potroom air hose which requires a resistance of ONE MEGAOHM PER INCH PER LENGTH OF HOSE.

non-interlocking ferrule: see sleeve.

nozzle end: an end of hose in which both the inside and outside diameters are reduced.

NPT/NPTF: abbreviation for national pipe threads. See fitting/coupling - Pipe Thread Fittings.

NSF: National Sanitation Foundation

nylon: a family of polyamide materials.

OAL: see overall length

O.D.: the abbreviation for outside diameter.

OE/OEM: original equipment manufacturer.

off-center: see eccentricity.

offset: the perpendicular distance between fitting axes when motion of the assembly occurs and fittings remain parallel.

offset-lateral, parallel: the distance that the ends of a hose assembly are displaced in relation to each other as the result of connecting two misaligned terminations in a system, or intermittent flexure required in a hose application.

oil resistance: the ability of the materials to withstand exposure to oil.

oil swell: the change in volume of a rubber article resulting from contact with oil.

open steam cure: a method of vulcanizing in which steam comes in direct contact with the product being cured.

operating conditions: the pressure, temperature, motion, and environment to which a hose assembly is subjected.

operating pressure (see working pressure)

optimum cure: the state of vulcanization at which a desired rubber compound combination is attained

orientation: the displacement angle of two elbow type couplings in a hose assembly, measured as an off-set value.

orientation index: the ratio of longitudinal to transverse strength in plastic tube extrusions.

O-ring fitting: see fitting/coupling, O-Ring.

OS & D hose: the abbreviation for oil suction and discharge hose.

outgassing: the release of chemicals from the material of the duct over time

outside diameter: measurement of the duct from exterior wall to exterior wall

overall length (OAL): the total length of a hose assembly, which consists of the free hose length plus the length of the coupling(s); need to clearly define whether the basis is overall seat x seat, or end of fitting to
end of fitting. (see STAMPED section, “Size”)

**Measurement of Hose Assembly**

**Measurement of Hose Assembly having an End Connection with a Seating Face**

**Measurement of Hose Assembly having an Elbow Fitting**

**oxidation**: the reaction of oxygen on a material, usually evidenced by a change in the appearance or feel of the surface or by a change in physical properties.

**ozone cracking**: the surface cracks, checks or crazing caused by exposure to an atmosphere containing ozone.

**ozone resistance**: the ability to withstand the deteriorating effects of ozone (generally cracking).

**PC**: Polycarbonate, a rigid plastic material with excellent impact strength and optically clarity

**penetration (weld)**: the percentage of wall thickness of the two parts to be joined that is fused into the weld pool in making a joint.

**performance test** *(see service test)*

**permanent fitting**: the type of fitting which, once installed, may not be removed for re-use.

**permeation**: the process of migration of a substance into and through another, usually the movement of
a gas into and through a hose material; the rate of permeation is specific to the substance, temperature, pressure and the material being permeated.

**PET**: Polyethylene terephthalate, also commonly known as polyester

**PFA**: Perfluoroalkoxy, a fluorocarbon material used for tubes

**Pharmacopeia Class VI**: a standard for sanitary fittings, designating the form, fit, function and finish. The testing of elastomers, plastics, polymeric materials and their extracts as described in the US Pharmacopeia XXII General Chapter 88, designed for evaluating biocompatibility of plastics materials. This *in vivo* testing consists of three tests: systemic, interacutaneous, and implantation. The materials and their extracts are then classified according to the test results as meeting Plastics Class I – Class VI.

**pick**: the distance across a group of braid wires from a single carrier, measured along the axis of the hose.

**pig**: a mechanical projectile used for cleaning hose.

**pin pricked**: perforations through the cover of a hose to vent permeating gases.

**pipe spacer**: a section of pipe used to facilitate the connection of a fitting to a hose.

**pitch**: 1) the distance from one point on a helix to the corresponding point on the next turn of the helix, measured parallel to the axis; 2) the distance between the two peaks of adjacent corrugation or convolution.

**pitch count**: typically measured in turns per inch (tpi)

**pitted tube**: surface depressions on the inner tube of a hose.

**plain ends**: fitting ends without threads, groove, or a bevel typically used for welding, as in a flange.

**plaits**: an individual group of reinforcing braid wires/strands that fill one carrier.

**plating**: a material, usually metal, applied to another metal by electroplating, for the purpose of reducing corrosion; typically a more noble metal such a zinc is applied to steel.

**ply**: an individual layer in hose construction, usually a braid or wrap.

**pneumatic testing**: the use of compressed gas to test a hose or hose assembly for leakage, twisting, and/or hose change-in-length. NOTE: Use of high pressure gas is extremely hazardous.

**Polyflon**: (trademark) a registered trademark of Daikin USA. See PTFE.

**polymer**: a macromolecular material formed by the chemical combination of monomers, having either the same or different chemical compositions.

**Polypropylene (PP)**, also known as **polyproppene**, is a thermoplastic polymer used in a wide variety of applications; it is rugged and unusually resistant to many chemical solvents, bases and acids.

**Polyurethane** (PU): An organic polymer with a wide range of stiffness, hardness, viscosities and densities, ranging from flexible foams to rigid plastics to wood and floor finishes; see TPU

**post-sinter**: the technique of re-heating PTFE innercore to process temperature in order to stabilize permeability and reduce orientation index.

**preform**: the compressed cylinder of PTFE resin that is used to extrude into raw tubing. Also called a billet.

**pre-production inspection or test**: the examination of samples from a trial run of hose to determine adherence to a given specification, for approval to produce.

**preset**: the process of pressurizing a hose to set the braid and minimize length change in final product.

**pressure**: force ÷ unit area. For purposes of this document, refers to PSIG (pounds per square inch gauge).

**pressure drop**: the measure of pressure reduction or loss over a specific length of hose.

**pressure, burst**: the pressure at which rupture occurs. See burst.

**pressure, deformation**: the pressure at which the convolutions of a metal hose become permanently deformed.

**pressure, gauge**: relative pressure between inside and outside of an assembly.

**pressure, maximum allowable working**: the maximum pressure at which a hose or hose assembly is designed to be used.

**pressure, operating**: see pressure, working.

**pressure, proof**: a onetime test pressure performed by the factory on every new hose prior to shipment, specific to fire hose and mill hose. The proof test pressure shall not be less than two times the specified service test pressure

**pressure, proof test**: a non-destructive pressure test applied to hose assemblies.

**pressure, pulsating**: a rapid change in pressure above and below the normal base pressure, usually associated with reciprocating type pumps.
**pressure, rated working**: see pressure, maximum allowable working.

**pressure, service**: see working pressure.

**pressure, set**: the conditioning pressure to align and balance braid.

**pressure, shock/spike**: the peak value of a sudden increase of pressure in a hydraulic or pneumatic system producing a shock wave.

**pressure, working**: the maximum pressure to which a hose will be subjected, including the momentary surges in pressure, which can occur during service. Abbreviated as WP.

**printed brand**: see brand.

**profile**: used in reference to the contour rolled into strip during the process of manufacturing strip wound hose, or the finished shape of a corrugation/convolution.

**proof pressure**: see pressure, proof test

**propane**: see LPG, LP Gas.

**psi**: pounds per square inch.

**PTFE**: polytetrafluoroethylene, a high molecular weight fluoroplastic polymer with carbon atoms shielded by fluorie atoms having very strong inter-atomic bonds, giving it chemical inertness.

**pull off force**: the force required to pull the hose from its attachment not generated by the internal pressure.

**pulled-down tube**: see loose tube, delamination or tube separation.

**pulsation**: the rapid cyclic fluctuations in pressure

**PVC**: ASTM designation for polyvinyl chloride. A low cost thermoplastic material typically used in the manufacture of industrial hoses.

**PVDF**: ASTM designation for polyvinylidene fluoride.

**quality conformance inspection or test**: the examination of samples from a production run of hose to determine adherence to given specifications, for acceptance of that production.

**RAC**: Rubber Association of Canada.

**random motion**: the uncontrolled motion of a metal hose, such as occurs in manual handling.

**reinforcement**: the strengthening members, consisting of either fabric, cord, and/or metal, of a hose. See ply.

**relaxed length**: length of stretched out duct after compression packing

**reusable fitting/coupling**: see fitting/coupling, reusable.

**RMA**: The Rubber Manufacturers Association, Inc.

**ROHS**: Reduction of Hazardous Substances (standard) The RoHS acronym references the Restriction of Hazardous Substances Directive 2002/95/EC. It is a directive of the European Union which took effect on 1 July 2006. It prohibits the use of six banned substances: lead, mercury, cadmium, hexavalent chromium, poly-brominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE), in the manufacture of Electronics and Electrical Equipment. May be required for products shipped to Europe or otherwise specified by the customer.

Ref: [www.rohs.eu](http://www.rohs.eu).

**rough bore**: a hose whose interior is not smooth, usually manufactured with a corrugated construction.

**SAE**: Society of Automotive Engineers.

**safety factor**: see design factor.

**sampling**: a process of selecting a portion of a quantity for testing or inspection.

**Santoprene®**: a registered trademark of Exxon Mobil.

**SBR**: ASTM designation for Styrene-butadiene; a rubber elastomer.

**scale**: the oxide in a hose assembly brought about by surface conditions or welding.

**self-extinguishing**: property of material to extinguish a flame once started

**serrations**: bumps, barbs, corrugations, or other features that increase the holding power of the device.

**service temperature**: see working temperature.

**service test**: a test in which the product is used under actual service conditions.

**service test pressure**: a hydrostatic test usually for fire and mill hose rated at 10% greater than the operating pressure at which the hose is expected to be used; branded on the hose at the conclusion of the test.

**set back**: see cut off factor.
shank: that portion of a fitting, which is inserted into the bore of a hose. See nipple.

shell/storage life: the period of time prior to use during which a product retains its intended performance capability.

shell: see ferrule.

shock load: a stress created by a sudden force.

short shank: shank length, approximately equal to the nominal diameter, but long enough to allow a single clamp at minimum.

simulated service test: see bench test.

skive: the removal of a short length of cover and/or tube to permit the attachment of a fitting directly over the hose reinforcement.

sleeve: (1) a metal cylinder, which is not physically attached to the fitting, for the purpose of forcing the hose into the serrations of the fitting. (2) see jacket.

Sleeve

smoke generation: a measure of the quantity and content of smoke when the material is burning

smooth bore: a term used to describe the type of innercore in a hose other than convoluted.

smooth transition attachment: special fabrication technique used for metal hose.

socket: the external member or portion of a hose fitting, commonly used in describing screw-together reusable fittings.

soft cuff: a duct end in which the rigid reinforcement of the body, usually wire, is omitted soft end: a hose end in which the rigid reinforcement of the body, usually wire, is omitted.

specification: a document setting forth pertinent details of a product.

spikes: see surge

spiral: a method of applying reinforcement helically in which there is not interlacing between individual strands of the reinforcement.

spiral angle: the angle developed by the intersection of the helical strand and a line parallel to the axis of a hose. See braid angle.

splice: a method of joining two sections of hose.

splicer: a fitting or device used to join two sections of hose.

spring guard: a helically wound component applied internally or externally to a hose assembly, used for strain relief, abrasion resistance, collapse resistance.

square cut: a straight cut perpendicular to the hose axis

squirm: a form of failure where the hose is deformed into an “S” or “U” bend, as the result of excessive internal pressure being applied to unbraided corrugated hose while its ends are restrained or in a braided corrugated hose which has been axially compressed.

standard: a document, or an object for physical comparison, for defining product characteristics, products, or processes, prepared by a consensus of a properly constituted group of those substantially affected and having the qualifications to prepare the standard for use.

static bend radius: the centerline radius to which a hose is bent in a stationary installation.

static bonding: use of a grounded conductive material on the ID of a hose between fittings to eliminate static electrical charges.

static conductive: having the capability of furnishing a path for a flow of static electricity.

static discharge: see electrostatic discharge.

static dissipating hose (also referred to as semi-conductive hose): Static dissipating hose refers to the electrical properties of the rubber materials making up the hose, usually the tube and/or cover material; it is measured in M-Ohms (million Ohms). It is used in applications where the conveyed material can generate static electricity build-up. Such hoses will dissipate static electricity through rubber material to the hose ends, provided the correct coupling type is specified. Note: Non-black and many black rubber compounds will not dissipate electricity. Only black compounds formulated with high carbon black will dissipate static electricity.
**static installations**: when the flexible hose is used to connect pipe-work out of alignment and remain in a static position

**static wire**: wire incorporated in a hose to conduct static electricity.

**stem**: see nipple.

**stress corrosion**: a form of corrosion in metal accelerated by loading.

**stretch hose**: duct that is self-retracting that can be stretched to a multiple of its original length

**stretch ratio**: percentage of stretch allowed; rated for a certain load

**strip wound**: see interlocked hose.

**surge (spike)**: a rapid and transient rise in pressure.

**swage**: the method of fitting attachment that incorporates a set of die halves designed to progressively reduce the collar or ferrule diameter to the required finish dimension by mechanically forcing the fitting into the mating die.

**swelling**: an increase in volume or linear dimension of a specimen immersed in liquid or exposed to a vapor.

**taber**: a type of abrasion tester, used to evaluate abrasion resistance of materials

**tape wrapped convoluted**: a type of flexible hose incorporating layers of tape to form helical ridges and grooves.

**tapered end**: a reduction built in on one or both ends of a rubber hose to simulate a nozzle.

**tear resistance**: the property of a rubber tube or cover of a hose to resist tearing forces.

**Teflon (trademark)**: a registered trademark of E.I. DuPont. See PTFE, FEP, and PFA.

**tensile strength**: a measurement of a material’s ability to resist tearing; the maximum tensile stress applied while stretching a specimen to rupture.

**TFE**: polytetrafluoroethylene. See PTFE

**thermoset**: polymer that irreversibly cures at elevated temperatures. **Thermoplastic Polyurethane (TPU)**: Polyurethanes that are formulated to be processed via melt extrusion for profile extrusions and injection molding; typically considered highly abrasive resistant and flexible for ducting; can refer to both polyether based or polyester based material.

**thermoset**: polymer that irreversibly cures at elevated temperatures (vulcanizes).

**thread**: a helical or spiral ridge on a nut or screw

**tig weld/GTAW**: the gas tungsten arc welding process sometimes refered to a “shielded arc” or “heliarc”

**tolerance**: The upper and lower limits between which a dimension must be held; the permissible limit of variation in a physical dimension.

**TPE**: Thermoplastic elastomer, also commonly referred to a thermoplastic rubber (TPR). A class of materials that demonstrate both plastic and elastomeric properties than can be extruded and injection molded.

**TPI**: turns per inch of helix; see pitch count

**TPR**: Thermoplastic rubber

**TPU**: Thermoplastic polyurethane

**TPV**: Thermoplastic vulcanizate, a compound where a rubber component vulcanizes during the melt extrusion process, becoming partially thermoset to give rubber-like properties.

**traveling loop, Class A Loop**: an application wherein the radius remains constant and one end of the hose ends parallel to the other end.

**traveling loop, Class A Loop**: a condition wherein a hose is installed in a U shaped configuration and the ends move perpendicular to each other so as to enlarge or decrease the width of the loop.

**tube**: the innermost continuous all-rubber or plastic element of a hose.

**tube fitting**: see fitting/coupling-Tube.

**tubing**: a non-reinforced, homogeneous conduit, generally of circular cross-section.

**twist**: (1) the turns about the axis, per unit of length, of a fiber, roving yarn, cord, etc. Twist is usually expressed as turns per inch; (2) the turn about the axis of a hose subjected to internal pressure, the direction defined as Z or S.

**unsintered**: material that has not undergone primary heat processing. (Post sintered: material that has undergone primary heat processing.)

**UL**: Underwriters Laboratories
UL181: Specifies requirements that apply to materials for the fabrication of air duct and air connector systems for use in accordance with the Standards of the National Fire Protection Association for the Installation of Air-Conditioning and Ventilating Systems, NFPA No. 90A, and the Installation of Warn Air Heating and Air-Conditioning Systems, NFPA No 90B. The 181 Standard for Factory-Made Air Ducts and Air Connector, defines two categories of flexible “ducts”. The UL listed Air Duct must pass all of the tests in the UL 181 Standard. Air Ducts are labeled with a square or rectangular shaped label showing their respective listing. There is no limitation on the length of runs when using UL Listed Air Ducts. (Class 1 Air Ducts). The UL Listed Air Connector must pass only a limited number of the UL 181 tests, and is labeled with a round shaped label which states “for installation in lengths not over 14 feet”. Class 0 air ducts and air connectors have surface burning characteristics of zero. Class 1 air ducts have a flame spread index of not over 25 without evidence of continued progressive combustion and a smoke developed index of not over 50.

UL94: The UL94 standard is a test specification for evaluating flammability of plastic materials used in devices and appliances. All tests are performed on a uniform test specimen of the component material(s) of a specified thickness (usually 3.0mm when rated by the raw materials manufacturer). Application of these standards at the product level must consider application, wall thickness and component materials to determine acceptability at the finished product level. Note: contact your UL representative for further clarification.

UL94HB: Horizontal Burn: Horizontally flammability (UL94 HB) – The material (or product) under test positioned in a horizontal orientation has a burning rate of:
- <75mm per minute for thicknesses less than 3.0mm or <40mm per minute for thicknesses between 3.0mm and 13mm
- Or it ceases to burn in less than 100mm regardless of wall thickness and burn rate

UL94V: Vertical flammability (UL94 V and VTM) – The material (or product) under test positioned in a vertical orientation must self-extinguish as follows:
- V-0 and VTM-0 – Must self-extinguish within 10 seconds after flame is removed with no flaming particles or smoldering drips
- V-1 and VTM-1 – Must self-extinguish within 30 seconds after flame is removed with no flaming particles or smoldering drips
- V-2 and VTM-2 – Must self-extinguish within 30 seconds after flame is removed; flaming particles and smoldering drips are acceptable; V and VTM (Very Thin Material) test procedures are similar except for the test sample preparation

USP: United States Pharmacopoeia
UV resistance: Ability to withstand decay due to the damaging effect of the ultraviolet rays of the sun.
U.S.C.G.: United States Coast Guard
USDA: United States Department of Agriculture

vacuum formed convoluted: smooth bore hose that is made flexible by the formation of ridges and grooves during a process that utilizes heat and vacuum to mechanically form convolutions.
vacuum formed corrugated: process of making corrugated duct using die blocks, positive pressure and vacuum in a continuous fashion.
vacuum resistance: the measure of a hoses ability to resist negative gauge pressure.
velocity: the speed (e.g., feet/second) at which the medium flows through the hose.
velocity resonance: vibration due to the elastic response of a high velocity gas or liquid flow.
vibration: amplitude motion occurring at a given frequency.
viscosity: the resistance of a material to flow.
Viton®: brand of synthetic rubber and fluoropolymer elastomer commonly used in O-rings and other molded or extruded goods. The name is a registered trademark of DuPont Performance Elastomers L.L.C..
volume change: a change in dimensions of a specimen due to exposure to a liquid or vapor.
volume swell: see swelling.
volumetric expansion: the volume increase of hose when subjected to internal pressure.
vulcanization: a process during which a rubber compound, through a change in its chemical structure, improves or extends elastic properties over a greater range of temperature.
warp: (1) the lengthwise yarns in a woven fabric or in a woven hose jacket, (2) the deviation from a straight line of a hose while subjected to internal pressure

water resistant: having the ability to withstand the deteriorating effect of water.

wear strip: added external material designed to increase the external resistance to abrasion

weathering: the surface deterioration of a hose cover during outdoor exposure, as shown by checking, cracking, crazing and chalking.

web: unreinforced section of the duct between the helix (wall) typically found in plastic ducts.

WEEE: Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC is often used in conjunction with RoHS. It sets collection, recycling and recovery targets for electrical goods.

weft: a term used for filling in a fabric. See filling.

WG: water gauge, or inches of water measurement

wire gauge: diameter of the helical wire

wire reinforced: a hose containing wires to give added strength, increased dimensional stability; crush resistance. See reinforcement.

working pressure: see Pressure, Working

working temperature: the temperature range of the application, may include the temperature of the fluid conveyed or the environmental conditions the assembly is exposed to in use.

WP: the abbreviation for working pressure.

wrapped cure: a vulcanizing process using a tensioned wrapper (usually of fabric) to apply external pressure.
### Appendix B – Pressure Conversion Chart

<table>
<thead>
<tr>
<th>psi</th>
<th>Atms</th>
<th>inches H₂O</th>
<th>inches Hg</th>
<th>mm Hg (Torr)</th>
<th>mbar</th>
<th>Bar</th>
<th>Pa (N/m²)</th>
<th>kPa</th>
<th>MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0681</td>
<td>27.71</td>
<td>2.036</td>
<td>51.715</td>
<td>68.95</td>
<td>0.0689</td>
<td>6895</td>
<td>6.895</td>
<td>0.0069</td>
</tr>
<tr>
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<td>1</td>
<td>407.2</td>
<td>29.92</td>
<td>760</td>
<td>1013</td>
<td>1.013</td>
<td>101,325</td>
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<td>0.1013</td>
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<td>0.249</td>
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<td>133.3</td>
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</tr>
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<td>0.0001</td>
</tr>
<tr>
<td>14.504</td>
<td>0.987</td>
<td>401.9</td>
<td>29.53</td>
<td>750</td>
<td>1000</td>
<td>1</td>
<td>100,000</td>
<td>100</td>
<td>0.1</td>
</tr>
<tr>
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<td>0.00001</td>
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<td>0.000001</td>
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<td>10,000</td>
<td>10</td>
<td>1,000,000</td>
<td>1000</td>
<td>1</td>
</tr>
</tbody>
</table>

To use this chart:
1. Locate the column with the units you want to convert from.
2. Move DOWN that column until you locate the “1”.
3. Move HORIZONTALLY to the column with the units you want to convert to.
4. MULTIPLY the number in the box by the amount you are changing from to get the converted value.

**Length**
- 1 cm = 0.3937 in = 10 mm = 0.01 m
- 1 m = 3.2808 ft = 1000 m = 100 cm
- 1 in = 2.540 cm = 25.40 mm
- 1 ft = 0.3048 cm = 0.3048 m

**Volume**
- 1 L = 0.0353 ft³
- 1 L = 0.2642 gal
- 1 L = 61.025 in³
- 1 L = 0.001 m³
- 1 ft³ = 28.3286 L
- 1 Gal = 0.1336 ft³

**Pressure**
- 1 psi = 0.0681 atm
- 1 psi = 27.71 in H₂O
- 1 psi = 703.8 mm H₂O
- 1 psi = 2.036 in Hg
- 1 psi = 51.715 mm Hg (torr)
- 1 psi = 68.95 mbar
- 1 psi = 0.0689 bar
- 1 psi = 6895 Pa (n/m²)
- 1 psi = 6.895 kPa
- 1 psi = 0.0069 MP